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Chapter 1 Introduction and Overview

Scope and Purpose of the Assessment

This assessment presents current and historic information on the physical, biological and cultural landscape in the Long Tom Watershed. Aspects of the watershed that were studied include physical stream conditions, hydrology, sediment transport, land and water use, vegetation, habitat, aquatic species and water quality. In general, this information is summarized by sub-basin. The maps in this assessment show the extent and general location of certain watershed features or human impacts, but they should not be considered precise enough to target a specific piece of property.

There are two main purposes of this assessment. First is to help council members understand how the watershed functions at an ecological level. This means bringing together all the pieces of the "watershed puzzle" in order to see how the local climate, underlying geography and soils, stream flow patterns, flooding, fire and eventually human modifications have influenced the composition of plants and animals (i.e. fish, wildlife, insects, birds, etc.) present. A recurring theme in this assessment is to describe the "ecological functions" that were historically provided by this combination of physical factors and to evaluate whether these functions are still present. For example, flooding provides many ecological functions in this watershed and in the past it was more extensive and frequent. Hence, we discuss how the reduction in flooding has influenced plants, humans and other animals.

The second objective of the assessment is to inform both council and individual actions. At a council level, we can use the assessment results to: 1) identify aspects of the watershed that warrant more detailed study and 2) identify ecological functions and habitat types that would benefit from restoration or enhancement. Lack of water quality data is an example of an area in need of further study. In this case, the council has already begun a water quality monitoring program in response to initial results from the assessment. The council can also use the information for education and outreach and to prioritize council sponsored restoration projects. Individuals may use the assessment results to inform land management decisions and/or implement habitat restoration or enhancement on their own property.

It is important to keep in mind that this assessment is not meant to pass judgement on any particular human land use or activity. Rather, it provides a scientific framework for understanding human impacts on the watershed so that people can make informed choices regarding land use, private property and personal action. In addition, not all perspectives may be represented in this document. Although considerable effort was made to solicit contribution and feedback from a wide variety of stakeholders in the watershed, it was not possible to reach everyone or incorporate everyone's personal perspective. Finally, although restoration strategies are frequently discussed and suggested, this assessment does not determine what types of restoration will be sponsored by the watershed council.

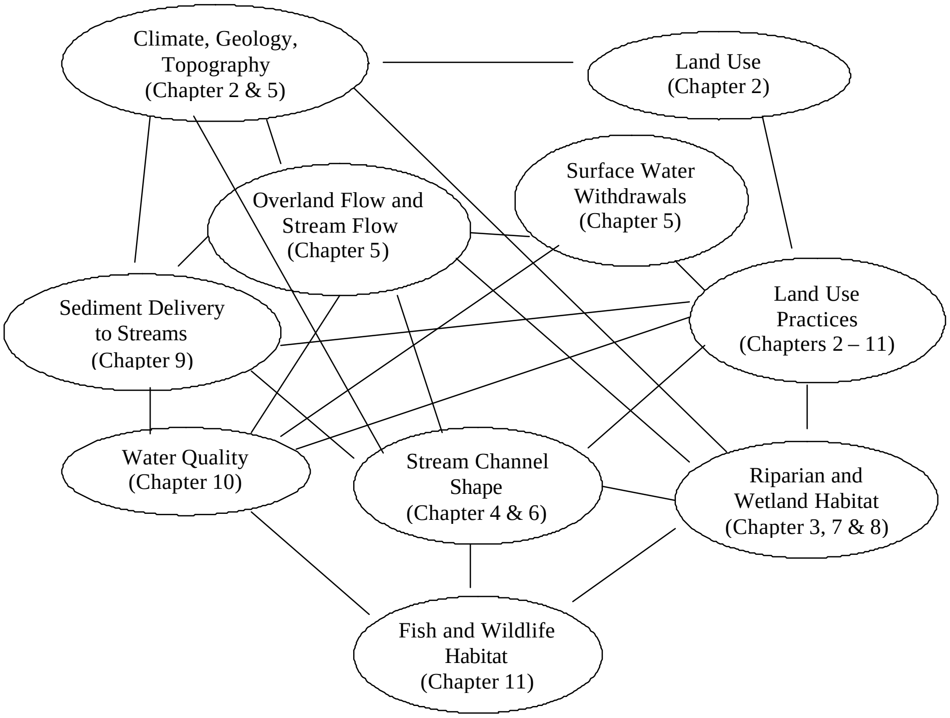

Figure 1.1 Relationship between Watershed Assessment Components

By emphasizing a basin-wide, "ecological functions" perspective this assessment raises our awareness of environmental issues in the watershed that may be difficult to see at a site-specific level. From this vantage point, it is also easier to identify and understand cumulative human impacts to the watershed. **Figure 1.1** provides a conceptual framework for the components of the assessment and illustrates cumulative impacts on fish and wildlife. It also highlights the fact that both human impacts and the local ecology interact to determine the water quality and habitat conditions within the watershed. The abundance of arrows connecting each component reflects the numerous interconnections within the watershed's ecosystem.

Chapter Descriptions

Chapter 2- Sub-basins, Ecoregions, Vegetation and Land use:
Provides a general description of the watershed, including its location, ecoregion, vegetation, population, land use and ownership patterns. This provides an important background for understanding the potential human influences on water quality and habitat.

Chapter 3- Historical Conditions:
Characterizes the watershed before Euro-American settlers arrived in the mid-1800s and documents changes caused by settlement and subsequent population growth in the watershed. This information may help determine appropriate standards or goals for water quality and habitat conditions and guide council restoration activities.

Chapter 4- Channel Habitat Types:
Describes stream channel morphology within the basin. Channels are categorized by their relative sensitivity to flow and channel modifications (either human or natural). Stream channels that are highly sensitive to these influences should be prioritized for protection or enhancement if they have been negatively impacted by human activities.

Chapter 5- Hydrology and Water Use:
Describes how local climate, geology, topography and land use influence stream flow patterns in the watershed. Data on stream flow and water use is presented in order to identify potential problems with peak and low flows. This information may be used to identify opportunities to minimize human caused peak flow enhancement and to target streams in potential need of instream flow protection.

Chapter 6- Stream Channel Modifications:
Documents change to stream channels due to channel straightening, bank reinforcement, gravel mining, road crossings, and dams or impoundments. These changes are then discussed in light of the effects they have on instream and riparian zone habitat.

Chapter 7- Riparian Zone Conditions:
Describes the current condition of riparian zones in the watershed and compares them with historic conditions. Specific information includes width, vegetation type, density and size of trees. This information will contribute to our understanding of how riparian zones may be affecting water quality and habitat in the Long Tom Basin and highlight areas for potential restoration.

Chapter 8- Wetland Types, Distribution and Functions:
Describes the type, functions and general location of wetlands in the basin and estimates the amount of wetland loss and potential restoration opportunities.

Chapter 9- Sediment sources:
Identifies the most likely sources of human caused sediment delivery to streams, which can be used to target activities that will reduce these sources.

Chapter 10- Water Quality:
Presents and analyzes current water quality data collected by several government agencies and lists streams that have been identified as water quality impaired by the Oregon Department of Environmental Quality.

Chapter 11- Fish and Wildlife:
Describes the types of fish found in the watershed, their habitat needs and current habitat conditions. This chapter also identifies wildlife species that depend on riparian zones and wetlands.

Chapter 12- Watershed Condition Summary:
This chapter summarizes and integrates information from each component of the assessment. This highlights the most significant sources of water quality and habitat degradation, which may be used by the watershed council to identify and prioritize actions to improve water quality and habitat with the basin.

Methods

The overall scope and methods used in this assessment were guided by the Oregon Watershed Assessment of Aquatic Resources Manual developed for the Governor's Watershed Enhancement Board (Watershed Professionals Network 1999). The manual offers a range of methods depending on time and resource availability. The manual methods are most appropriate for a watershed of about 50,000 acres. In most cases the assessment team closely followed the manual, however the size of the watershed (262,872 acres) and the extent of private land made some components impractical (e.g. field verification of sediment sources and wetlands). On the other hand, we were able to utilize information generated from geographic information systems (GIS) analyses, which enhanced our ability to integrate a large amount of information into meaningful conclusions. A more detailed methodology of channel habitat typing, riparian zone delineation and analysis, and sediment source analysis will be given in their respective chapters.

Geographic Information Systems

All of the maps and most of the quantitative information (e.g. percentage of land use/sub-basin, road density, etc.) presented in this document were created using geographic information systems (GIS). GIS is a computer-based mapping technique that compiles information about the landscape in "layers", similar to information presented on a map. 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 historic vegetation can be combined with a layer showing hydric soils (i.e. soils that are highly impermeable to water). This combination would produce a map showing the probable extent and type of historic wetlands given that most undisturbed areas with hydric soils in this basin have wetland vegetation. **Table 1.1** lists the GIS layers utilized for this assessment.

Table 1.1 Long Tom Watershed GIS Layers:

- Watershed and sub-basin boundaries
- Land use
- Land ownership
- Roads
- Streams
- Ecoregions
- Historical vegetation
- Current vegetation
- Human population
- Channel habitat types
- National Wetlands Inventory
- Soils
- Topography
- Riparian zone conditions
- Water quality monitoring sites

Public Outreach and Participation

The assessment process included short presentations at the council's monthly meetings on each portion of the assessment. In addition, one to two page summaries of some of the chapters and an executive summary of the entire assessment were sent to all council members through monthly newsletters. This allowed all council members to provide feedback and/or contribute personal knowledge on assessment information and maps. This format also created an ongoing dialogue about water quality, habitat conditions and human impacts within the watershed.

Many hours were spent in compiling and writing this assessment, which is a tribute to the cooperation and generosity of many agency personnel and watershed council volunteers. This cooperation ensured greater accuracy and scope, and helped to create understanding and trust between watershed council members. In addition, the assessment process provided a forum for watershed council members to share information and resources with each other as well as with land management agencies.

Contributors

Below is a list of people who contributed to this assessment. A brief description of each individual's work is given to illustrate the magnitude of effort and breadth of resources that went into this document. (If anyone's name has been forgotten it was not intentional.)

Jack Alley, South Eugene high school student: Helped organize and tabulate water quality data.

Ed Alverson, Nature Conservancy & watershed council steering committee: Helped design the riparian zone analysis method based on historical vegetation and provided many references on historic vegetation and wetlands within the watershed.

Andrea Ball, University of Oregon Infographics Lab: Provided technical assistance in developing GIS maps and analyses.

Doug Card, University of Oregon, Department of Sociology: provided extensive information for the Historical Conditions Chapter. Most of the quotes from early diaries are a result of his research. Dr. Card is a local historian and visiting professor at the University of Oregon.

Bill Clingman, GIS analyst, Lane Council of Governments: Created a map of 100-year flood plains within the watershed; Provided lists of the digitized wetlands types and soil types in the watershed.

Churchill high school students: Researched information on fish species within the watershed and helped map fish distribution.

Dana Erickson, Long Tom Watershed Council coordinator: Primary author of Chapter 5 Hydrology and Water Use. She also helped to ensure that the assessment process was open and educational for all members of the council.

Kyle Everett, watershed council member and budding electric guitarist: Helped catalogue information from Oregon Department of Fish & Wildlife fish trap data.

Matt Fidanque, South Eugene high school student: Spent over 30 hours interpreting riparian zone information from aerial photos.

Lita Furby, watershed council member: Helped to refine the riparian delineation method and spent over 100 hours interpreting riparian zone information from aerial photos.

Gary Galovich, fisheries biologist, Oregon Department of Fish & Wildlife: Wrote descriptions of sensitive fish species within the watershed and their habitat needs.
Chelsea Gibbons, South Eugene high school student: Spent over 40 hours interpreting riparian zone information from aerial photos.
Jennifer Gilden, sociologist, Oregon State University: Researched and provided a large amount of background information for the Historical Conditions chapter and interviewed residents regarding historical conditions.
Ted Gresh, University of Oregon student: Assessed, mapped and digitized channel habitat types.
Jim Godfrey, GIS analyst, State Service Center for Geographic Information Systems: Digitized riparian zone information, created maps of watershed land use and ownership, ran several key GIS analyses for the assessment.
Diane Henkels, watershed council member: Interviewed watershed residents for the Historical Conditions chapter.
Greg Hughes, University of Oregon Infographics Lab: Created maps of National Wetlands Inventory, and historic vegetation and hydric soils.
Lara Konig, volunteer, mapped and digitized channel modifications; created map for Channel Modifications Chapter.
Jim Meacham, Director, University of Oregon Infographics Lab: Provided technical assistance in developing GIS maps and analyses.
Frank Mifsud, University of Oregon Infographics Lab: Created a map of water quality monitoring sites for the Water Quality Chapter.
Josh Peters, University of Oregon student: Collected and organized information on precipitation and stream flow.
Samara Phelps, University of Oregon student: Spent over 40 hours interpreting riparian zone information from aerial photos.
Anita Ragan, watershed council steering committee: Helped to develop the assessment cover.
Larry Rhodes, watershed council member: Helped develop an interview on historical conditions.
Elliot Shuford, University of Oregon student: Assessed and mapped channel habitat types.
Cindy Thieman: Watershed assessment project manager and primary author of chapters 1-5 and 7-12.
Kellie Vache, research assistant, Oregon State University: Helped develop a model and map of potential erosion on agricultural lands; performed a GIS analysis of road density & proximity to streams; created a map of current vegetation; provided a population estimate for the watershed based on digitized census block information.
Alan Whiting, University of Oregon student: Compiled and mapped information on channel modifications.
Gary Wilkinson, Bureau of Land Management: Was instrumental in generating the map of channel modifications

In addition to the contributors listed above, there were many others who provided information for the assessment and we would like to extend our thanks to them!

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Chapter 2 Sub-basins, Ecoregions, Vegetation and Land Use

Location and Sub-basins

The Long Tom River Watershed drains 410 square miles of land at the southwestern end of the Willamette Valley. The headwaters of the upper Long Tom River originate on the eastern side of the Coast Range and flow south through forested hills and small farms until reaching Noti where the river turns east and is joined by Elk and Noti Creek. Several miles downstream of Noti the upper Long Tom drains into the southeast side of Fern Ridge Reservoir. Coyote Creek, which drains the southern portion of the basin, and Amazon Creek, which drains the eastern portion, also empty into Fern Ridge Reservoir. The lower Long Tom spills out the north end of the reservoir and flows north approximately 25 miles before joining the Willamette River at two locations, the original northern confluence and the channelized southern confluence at Norwood Island.

For this assessment, the watershed is divided into sub-basins in order to identify and focus on the specific landscape features and land uses that impact water quality, instream habitat and riparian zone conditions in a smaller drainage area. Sub-basin divisions also provide a framework for future water quality monitoring studies, prioritizing restoration activities and identifying other sub-basin specific issues. The 10 sub-basins were delineated based on drainage pattern, land use and size (see **Long Tom Sub-basins and Landuse map**). They include: 1) Upper Long Tom, 2) Elk Creek, 3) Coyote Creek, 4) Spencer Creek, 5) Fern Ridge, 6) Upper Amazon, 7) Lower Amazon, 8) Ferguson Creek, 9) Bear Creek, and 10) Lower Long Tom. Each sub-basin drains to a single point (except Upper Amazon, Lower Long Tom and Fern Ridge), is roughly the same size as the other sub-basins and has a predominant land use. Land use along the upper and lower portions of Amazon Creek is very different. Hence a division into two sub-basins (i.e. Upper Amazon & Lower Amazon) was made near Royal Avenue where Amazon Creek splits into the diversion channel, which empties into the reservoir, and the original channel, which empties into the lower Long Tom River west of Junction City.

In the following chapters information is presented in the context of both ecoregions and sub-basins. Both frameworks are important for interpreting conditions within the watershed, however rarely do the divisions between sub-basins and ecoregions correspond. The presence of multiple ecoregions in some of the sub-basins within the Long Tom Watershed highlights the need for a number of management goals and methods within each sub-basin.

Ecoregions

An ecoregion is defined by a unique combination of physical geography (stream patterns, elevation), geology (surface and bedrock composition), climate (temperature, precipitation), soils, vegetation and land use (Omernik & Griffith 1991). Ecoregion designations are an important tool for interpreting existing watershed conditions and setting appropriate goals for

Insert landuse map

Table 2.1 Ecoregions within the Long Tom Watershed

Ecoregion	**Mid-Coastal Sedimentary**	**Valley Foothills**	**Prairie Terraces**	**Willamette River and Tributaries Gallery Forest**
Physical Geography	Moderately sloping, dissected mountains with medium to high gradient, sinuous streams	Rolling foothills with medium gradient, sinuous streams	Nearly level to undulating river terraces with sluggish, meandering streams and rivers. Historically, seasonal wetlands and ponds were common. Many streams now channelized.	Floodplains with low gradient, incised, strongly meandering rivers and associated oxbow lakes
Geology	35-55 million year old sandstone, siltstone, mudstone & conglomerate* of marine origin	10 – 25 million year old andesitic basalt* and sandstone of marine origin	12 – 600 thousand year old sediment deposits from lakes and rivers	Present – 600 thousand year old sediment deposits from rivers
Soils	Very deep to moderately deep, clay loam to gravelly loam	Moderately deep to very deep, silty clay loam to silt loam	Very deep to deep, silty clay loam to silt loam.	Very deep to deep, fertile, silty clay loam to fine sandy loam
Rainfall	60-130 in./year	40-60 in./year	40-50 in./year	40-50 in./year
Potential Native Vegetation (trees)	Western hemlock, western red cedar, Douglas-fir	Douglas fir common; some western red cedar	Oregon white oak & prairies; In wetter areas: Oregon ash, Douglas fir	Cottonwood, alder, Oregon ash, bigleaf maple, Douglas-fir
Land use	Forestry, pastureland in valleys, some rural residential development	Rural residential development, pastureland, coniferous & deciduous forests, forestry, vineyards, Christmas tree farms, orchards	Grass seed, grain & row crop farming. Also urban/rural residential development & some forested riparian zones	Vegetable & fruit farming, pastureland, urban/suburban/ rural residential development, forested riparian areas, flood control

Adapted from Pater *et al.* 1998; *Definitions: Andesitic basalt- fine-grained rock resembling granite, volcanic in origin; Conglomerate- made up of rock fragments or pebbles cemented together by clay (Guralnik 1984)

instream habitat conditions, biotic indices (e.g. types & diversity of macroinvertebrates and fish), riparian zone conditions and water quality within different parts of the watershed. The Long Tom Watershed contains four ecoregions: Mid-Coastal Sedimentary, Valley Foothills, Prairie Terraces and Willamette River and Tributaries Gallery Forest (see **Table 2.1** & **Ecoregions**

map).[1] Each of these ecoregions will respond differently to land management and thus may require somewhat different management strategies and habitat/water quality goals.

The Mid-Coastal Sedimentary ecoregion and Valley Foothills ecoregion cover the steeper upland areas of the watershed. Headwater stream channels are confined within steep, narrow valleys, becoming more sinuous downstream where the valley widens. The underlying geology is mostly sedimentary (i.e. resulting from upland erosion as opposed to volcanic eruptions) with some basalt (i.e. volcanic) in the Valley Foothills region. The combination of soft sedimentary rock and high rainfall levels in these regions contributes to relatively high erosion rates. Native vegetation includes western hemlock, western red cedar, Douglas fir, and red alder, in addition to a variety of understory shrubs and flowering plants.

The Prairie Terrace ecoregion covers most of the low gradient valley lands except for a small portion along the lower Long Tom River, which is part of the Willamette River and Tributaries Gallery Forest ecoregion. Unmodified streams in these regions tend to meander across the valley, although humans have channelized many in order to protect farms, homes and businesses from flooding. In either case streams are often deeply entrenched in the thick sedimentary clay soils that were deposited by a series of massive floods thousands of years ago. The native vegetation types within the Prairie Terraces ecoregion are oak savanna (sometimes with scattered Douglas fir & ponderosa pine), ash swales and prairie (grasses and wildflowers), whereas the Willamette River Gallery Forest contains large stands of cottonwood, alder, Oregon ash, bigleaf maple and Douglas fir.

Current Vegetation

The **Long Tom Watershed Landuse/Landcover map** shows vegetation within the watershed in 1995. Vegetation categories include several forest types and stand ages, grassland, shrubland and many different agricultural crop types. Vegetation was determined by using satellite images of the Willamette Valley taken in 1995; aerial photos were used to verify and calibrate some of the satellite imagery data (Pacific Northwest Ecosystems Research Consortium 1999). The accuracy of crop type, location and acreage is not high at a site-specific level because vegetation was being categorized for the entire Willamette Valley. In addition, agricultural crops can change at a given site within one season, which makes it difficult to field or photo verify crop determinations based on satellite imagery. Nonetheless, the **Landuse/Landcover map** does illustrate the approximate distribution of major vegetation categories and the variety of agricultural crops in the watershed.

A variety of forest types and stand ages exist within the watershed. Forests generally cover the western and southern foothills of the watershed, as indicated by the dark and light green shading on the map. The light green areas, characterized by a mixture of hardwoods and conifers (on map: Forest semi-closed mixed & Forest closed mixed categories), trace the major stream networks in the forested portion of the watershed. This is because in upland areas hardwoods like bigleaf maple and Oregon ash are found primarily in riparian zones (i.e. adjacent to streams),

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[1] Ecoregions have been delineated at four different scales. Level I is the coarsest scale (delineates North America into 15 ecoregions). The ecoregions used in this document are Level IV, which delineates western Oregon and Washington into 55 different ecoregions (Pater *et al*. 1998).

Insert ecoregion map

Insert vegetation map

whereas upland areas that are not adjacent to streams are typically dominated by conifers like Douglas fir and western hemlock (on map: Forest Closed Conifer categories). In some areas this pattern is natural and in other areas it is a result of historic logging. In particular, conifers generally dominated riparian zones in forested headwater areas in the past. These were often the first trees to be logged because they were right next to a stream that could be used to transport the logs to a mill downstream. After clearcutting, hardwoods quickly overtook these newly opened riparian areas and shaded out conifer seedlings. This has had a negative impact on those streams because large conifers that fall into streams from adjacent riparian areas provide important benefits to fish and other aquatic organisms. Hardwoods are not as large and decay faster than conifers, thus when they fall into streams they do not remain as long, which limits their value to aquatic organisms. Current state forestry rules do not allow clearcutting in most riparian zones. However, hardwoods that have overtaken riparian zones in the past often prevent the growth of conifers now. Because of this, some local timber companies are actively recruiting conifer growth in riparian zones by removing hardwoods and planting conifers (Claassen 1998).

Agricultural land in the watershed occupies the lower foothills and valley bottomlands. Vineyards, orchards and Christmas tree farms are generally on the hillsides, where land is less suitable for crops. On the flatlands grow crops like grass seed, mint, corn, beans, sugar beet seed, hay and meadow foam. Crops that require regular irrigation in the summer are generally grown on land to the north of Fern Ridge Reservoir. This is because the majority of irrigation water in the basin is stored in the reservoir and withdrawn from the lower Long Tom in the summer. The **Landuse/Landcover map** shows that a large amount of grass seed (categorized as both grass seed and grass on the map), mint and row crops are grown on land downstream of the reservoir. (Unfortunately these categories do not show up very well on a map this size so the reader will have to trust the author on this point.)

Land use

Table 2.2 and the **Long Tom Sub-Basins and Landuse map** show the proportion of land use in each sub-basin according to zoning. Although some of the sub-basins drain into other sub-basins (e.g. Spencer Creek drains into Coyote Creek) the land use percentages and acreage calculations presented for each sub-basin do not overlap. For example, the information for Coyote Creek does not include the portion of its drainage area covered by Spencer Creek.

Sub-basins on the western and southern perimeter of the watershed are mostly forested. Consequently, most of the land use is forestry, especially in the Upper Long Tom and Elk Creek sub-basins. Coyote Creek, Spencer Creek, Ferguson Creek and Bear Creek are a mixture of forestry, agriculture, and rural residential land, although land zoned for forestry still covers the majority of these drainages. The sub-basins in the central and eastern portion of the watershed have gentler gradients, making them more suitable for agriculture and urban development. This is evidenced by the fact that the majority of the Lower Long Tom, Lower Amazon and Upper Amazon basins are either urban or agricultural. The Fern Ridge sub-basin, which is the reservoir and land area that drains directly into it (i.e. not into Amazon Creek, Coyote Creek or the Upper Long Tom first) is a fairly even split between agriculture, forestry, and water. However, the land now submerged by the reservoir used to be farmland.

Approximately 92% of the land within the watershed is privately owned (see **Table 2.3**). This is a significant social aspect of the watershed, which shapes the structure and membership of the council and has an impact on land management and restoration issues.

Table 2.2 Sub-basin Landuse

Sub-basin	Agri-culture	Forestry	Urban	Rural Resident	Parks & Rec.	Rural Indust	Other	Total Acres
Upper Long Tom R.	8%	80%	<1%	10%	2%	<1%	0%	35,605
Elk Cr.	9%	88%	0%	1%	0%	1%	0%	27,709
Coyote Cr.	31%	64%	0%	4%	2%	0%	0%	45,185
Spencer Cr.	22%	49%	1%	27%	<1%	0%	0%	21,320
Upper Amazon Cr.	6%	6%	80%	7%	<1%	0%	0%	19,710
Lower Amazon Cr.	62%	0%	21%	6%	<1%	0%	11%*	19,292
Fern Ridge	25%	20%	5%	20%	5%	0%	25%**	32,209
Bear Cr.	33%	57%	0%	10%	<1%	0%	0%	17,701
Ferguson Cr.	40%	59%	0%	<1%	0%	0%	0%	16,357
Lower Long Tom R.	81%	7%	1%	8%	2%	0%	<1%	27,784
Watershed Total (% & acreage)	**31% 81,490**	**46% 120,921**	**8% 21,029**	**9% 23,658**	**1% 2,628**	**<1% 3,834**	**4% 10,515**	**262,872**

*Large percentage is from "Public Facilities" land use category (mostly the Eugene Airport);
**includes Fern Ridge Reservoir

Table 2.3 Long Tom Watershed Ownership

Ownership	Acres	Percentage
Private	242,131	88%
BLM/ O & C Lands	20,650	8%
Army Corps of Engineers	12,000	4%
State Lands	66	<1%

Note: there is a discrepancy in the total watershed acreage between **Table 2.2 and 2.3**. The total given in **Table 2.2** is the most accurate. Acres in **Table 2.3** are approximate and are only meant to show the relative proportion of land ownership.

Agricultural Lands

The main agricultural crops in the watershed include annual and perennial grass seed, hay, mint, specialty seeds (flowers, radish, sugar beets), feed corn, wheat, sugar beets, vegetable crops (corn, green beans, beets), orchards, vineyards, berries, and Christmas trees (Block pers comm 1999). Farms vary in size from 10 – 15 acre hobby farms, to small family operations of 100 – 2000 acres, to 1,500 – 10,000 acre commercial operations.

The potential impact of farming on water quality and riparian habitat stems primarily from pesticide and fertilizer use, soil erosion from tilling, modifying stream channels to prevent flooding of fields, planting near streams, and planting on top of small seasonal drainages. These impacts can be mitigated with a variety of management practices, including leaving adequate buffer zones adjacent to streams, timing and reduction of fertilizer and pesticide applications, and irrigation management (see **Table 2.4**).

Table 2.4 Agricultural management practices that protect rivers and streams

- Stream buffers
- Hedgerows
- Riparian fencing
- Off-stream watering devices
- Manure management (treatment lagoons, sheds)
- Cover crops (to avoid exposed soil)
- Irrigation nozzle upgrades
- Pesticide and fertilizer application timing and minimization
- Pasture management to avoid compacted or eroded soil (rotational grazing, grassed filter strips)

Livestock, including cattle, sheep, goats and hogs, is also raised within the watershed. There are some large confined livestock operations within the basin, however the majority of livestock are raised in pastures or on lots of various sizes. The most significant potential impacts livestock have on stream health come from grazing or trampling the vegetation along streams and when manure reaches surface waters. The relative impact of these operations also varies significantly with management practices. For example, manure from a large confined livestock operation can pose a significant threat to water quality if allowed to enter nearby waterways via overland runoff (occurs during periods of heavy rain). However, many of these large operations are required to manage livestock waste with treatment lagoons or sheds. Smaller operations may have cattle, sheep or goat either on an adequate amount of pastureland or crowded onto an inadequately sized parcel with no manure management or riparian zone protection methods. Again, it is difficult to estimate the relative proportion of livestock owners who employ management practices to adequately protect rivers and streams.

Table 2.5 Management practices used by the City of Eugene to protect local streams

- Street sweeping
- Catchment basin cleaning
- Education programs
- Investigation and prevention of illegal discharges
- Issuance and monitoring of industrial stormwater permits
- Water quality monitoring
- Storm drain stenciling
- Acquisition of natural waterways and wetlands
- Riparian and wetland restoration
- Clean up after accidents and fires
- Litter pick up
- Street design standards
- Erosion prevention and construction site management program
- Household hazardous waste program
- Commercial/Industrial housekeeping practice
- Train Public Works Maintenance staff on Integrated Pest Management techniques in order to reduce pesticide use
- Remove non-native vegetation from wetlands and riparian areas

Urban Lands

Urban lands cover about 8% of the watershed. The largest proportion within the watershed is the City of Eugene, with a population of approximately 132,000 (only a portion of this population lives within the watershed boundary). All of Eugene’s treated wastewater discharges into the Willamette River, whereas stormwater from the land within the Upper Amazon sub-basin drains into the watershed. Smaller towns in the watershed include Veneta, Monroe, Elmira, Crow and Noti. In addition,

Table 2.6 State Forest management practices to protect river, streams, lakes and wetlands

- Written plans are required for harvest operations within 100’ of fish bearing streams, large lakes or streams supplying domestic water and within 300’ of significant wetlands. A plan “…describes how a forest operation will be conducted to meet the minimum standards for resource protection prescribed by the forest practice rules (Forest Practices Program, 1994).”
- Riparian management areas (RMAs) are designated for all water bodies except small, non-fish bearing streams. Width of RMAs ranges from 20’ to 100’ depending on size and type of stream.
- Within RMAs on fish bearing streams:
  - ➢ all understory vegetation within 10’ of stream must be retained
  - ➢ all trees within 20’ of stream must be retained
  - ➢ all trees leaning over the channel must be retained
  - ➢ all downed wood and snags in RMA must be retained
  - ➢ 30 to 40 live conifers/1000’ must be retained, which range from 8” – 11” dbh depending on stream size
- Similar rules govern RMAs for lakes, wetlands, medium and large non-fish bearing streams, and streams supplying

Junction City is near the eastern boundary of the watershed and during floods is often hydrologically connected to the lower Long Tom River.

The environmental impacts from urban areas are quite large, given the density of people and intensity of land use. Industrial and commercial businesses have been shown to deliver heavy metals and other toxic chemicals into waterways when these substances are not properly contained. Runoff from parking lots and streets contribute oil, grease, dirt and other debris from cars, people and domestic animals (data shown in **Chapter 10 Water Quality**). Residential areas degrade water quality when people apply fertilizers, pesticides or other household chemicals and some enters the storm drain system. Exposed soil at construction sites can also enter streams if not managed properly. Even treated effluent from municipal sewage treatment plants at times causes water quality problems; frequently wastewater discharge contains high levels of phosphorus.

Currently cities with populations over 100,000 are required to have a storm water management plan and program, which includes measures to protect water quality and aquatic habitat. The City of Eugene’s management practices, which are part of its stormwater program, are listed in **Table 2.5**. The next phase of the state’s urban stormwater program will soon be implemented, which will require any urbanized area with greater than 10,000 people or covering at least one square mile to obtain a stormwater discharge permit from the Department of Environmental Quality.

Forest Lands

Land zoned for forestry covers 46% of the watershed. Forestland ownership is a mixture of large commercial timber companies, federal forestland and small wood-lot owners. Compared to some of the timberlands in the Cascades or Western side of the Coast Range, the Long Tom Watershed has relatively few large tracts of timberland owned by a single company. A survey of nine large commercial operations in the basin indicated that these timber companies manage roughly 33,000 acres, with each company owning from a few hundred to several thousand acres. Roughly 20,000 acres of timberland is federally owned and managed by the Bureau of Land Management. Given that approximately 120,000 acres are zoned for forestry in this watershed, this means that about 67,000 acres are owned and harvested by small family trusts and other private woodlot owners.

Sediment delivery from forest roads and logging related landslides may be the most significant impact of forestry on aquatic resources in this watershed. The application of aerial fertilizer and spraying of pesticides also have the potential to impact streams if they accidentally reach nearby streams. The State Forest Practices Act, created in 1971, led to the development of a variety of rules and guidelines to protect waterways and wetlands near timber harvest operations. These are listed in **Table 2.6**.

Rural Residential Lands

Rural residential land covers roughly 9% of the watershed. Potential impacts to waterways caused by rural residents include runoff from fertilizer or pesticide use, small overstocked pastures, farm animals in streams or grazing in riparian zones, stream channel modifications and leaking septic systems. Because there is no oversight of rural residential land use like there is for forestry, agriculture and urban areas, it is difficult to assess the degree to which rural landowners impact water quality and aquatic habitat. In some cases rural residents may cause more damage on a per acre basis than agriculture, due to overuse of pesticides and fertilizers or by allowing a high density of domesticated animals near waterways. Another issue, particularly relevant to the Spencer Creek sub-basin, is the lowering of the water table from an increasing number of domestic wells.

Conclusions

Information on ecoregions, vegetation and land use point to several key issues:

- The presence of multiple ecoregions within the watershed calls for restoration and management strategies and water quality and habitat goals that reflect the unique nature of each region.
- The diversity of land use requires different management and resource conservation strategies.
- Private ownership of the majority of the watershed makes land use practices and management more difficult to assess and influence.
- Agricultural lands, residential areas and timberlands are divided into many private parcels, making it challenging to communicate and share information or concerns.
- A growing population will increase the challenges of natural resource management and protection in the future.

Chapter 3 Historical Conditions

Introduction

This chapter describes the major landscape changes that have taken place in the Long Tom Watershed from prehistoric times to the present. Studying historical conditions within the Long Tom Watershed serves several purposes. First, it shows us how climate, geology and finally human beings have created the landscape we see today. Second, it illustrates the ecological functions that have evolved over time, an important first step in determining whether these ecological functions still exist. Third, it highlights the amount and rate of change to the landscape, vegetation and wildlife.

Historical Climate and Geology

Although difficult to believe given today's cool wet climate, 50 million years ago the Pacific Northwest was tropical. At that time the Willamette Valley was completely submerged under the Pacific Ocean, which lapped against the foothills of the Cascade Mountains. Fossilized marine mollusks, crabs and sharks from this time period indicate warm, tropical seas (Orr *et al.* 1992). Data from ice cores and other sources indicate that global climate was on a cooling trajectory at this point, a trend that has been highlighted over the past few million years by a series of ice ages (Crowley 1996).

Between 40 and 25 million years ago the Pacific Ocean began to withdraw from the newly forming Willamette Valley as the Coast Range "lifted" from the ocean floor. Over time, this lifting caused portions of continental shelf that were one to two thousand feet below the Pacific Ocean to rise two or three thousand feet above the ocean! (This explains why marine sedimentary material is found high up in the Coast Range.) During this period the valley was a broad semi-tropical coastal plain, dotted with lakes that were formed in shallow depressions. Studies of fossilized pollen indicate the presence of both conifers and broadleaf plants, although most of these species are extinct today (Orr *et al.* 1992). Ironically, two tree species (Gingko and dawn redwood) that existed during this time but went extinct when the climate cooled have been reintroduced to this area by landscapers (the trees were still in existence in Asia).

Volcanic activity also shaped the landscape over time. Around 15 million years ago "…lava from fissures and vents in northeastern Oregon poured through the Columbia gorge and into the Willamette Valley where they reached as far south as Salem (Orr *et al.* 1992, 206)." A lava flow that solidified at the northern end of the Willamette Valley created the falls at Oregon City. These falls created a seasonal barrier to upstream fish passage and maintained a broad, relatively flat floodplain in the upper portion of the Willamette Valley (Aikens 1993).

Beginning two to three million years ago a series of ice ages descended on the region, at times creating continental ice sheets that spread from the Arctic to the northern edge of the Pacific Northwest. These ice ages were punctuated with interglacial periods characterized by warmer temperatures and higher sea levels (the latest of which we are presently in) (Crowley 1996). During this time the advance and retreat of glaciers from the northern part of the continent and Cascade Range left its mark on the Willamette Valley. Rivers laden with glacial meltwater deposited large quantities of silt and debris (Orr *et al.* 1992). To illustrate, sediment cores drilled in various parts of the watershed show that alluvial fill (i.e. sediment deposited by rivers) ranges from 200’ thick near Fern Ridge Reservoir to 250’ thick near the headwaters of Elk Creek (Baldwin & Howell 1949).

A series of particularly large floods occurred between 15,500 and 13,000 years ago in the Columbia River drainage. “The amount of water in a single flood, estimated at up to 400 cubic miles, is more than the annual flow of all the rivers in the world (Orr *et al.* 1992, 212).” These floods were caused when ice dams that blocked Lake Missoula in Montana were breached, causing the lake behind the ice dam to drain within a span of two days. Floodwater backed up into the Willamette Valley, carrying silt and debris as far south as Eugene. In addition to alluvial deposits, several glacial “erratics” (i.e. large boulders deposited by glaciers or glacial water) scattered around the watershed serve as evidence for these catastrophic floods (Orr *et al.* 1992).

Since the last ice age, which spanned approximately 100,000 to 10,000 years ago, the global climate has became considerably warmer and dryer, the

“The Long Tom, Former Tributary of the Siusilaw River”

In the late 1940s two local geologists, Ewart Baldwin and Paul Howell (1949), proposed that the Long Tom River, Coyote Creek, Spencer Creek and Bear Creek all used to flow into the Siusilaw. Their initial clues came from studying local topographic maps that showed many westward draining tributaries to these streams and other evidence that the direction of their drainage had been reversed. Later, evidence collected in the field confirmed that at some point in the late Pleistocene (12,000 – 200,000 years ago) the Long Tom, Coyote Creek and Bear Creek were “pirated” by tributaries of the Willamette River. Baldwin and Howell proposed that the original path of the upper Long Tom followed what is today Poodle Creek. Then, instead of flowing east near Noti it turned west into the valley that is presently drained by Elk Creek. After passing through what is today a divide between the Long Tom and Siusilaw Watersheds at the headwaters of Elk Creek, the “ancient” Long Tom joined with the Siusilaw. A convincing piece of evidence for this proposed drainage path is that the valley that drains Elk Creek is overly wide given the relatively small network of streams it now drains. This suggests that at one point a much larger river flowed through it.

The proposed path of ancient Bear Creek turned southwest instead of east near Goldson, and then joined the upper Long Tom just south of Alderwood State Park. Ancient Spencer Creek and Coyote Creek flowed west, instead of flowing south towards Fern Ridge, and joined the Long Tom River near Noti.

The likely causes of these rivers being diverted into the Willamette River Watershed are: 1) slight uplift and eastward tilting of the Coast Range, 2) piracy by a Willamette tributary and 3) a landslide or series of landslides that blocked the Long Tom near the present headwaters of Elk Creek. This combination of events is thought to have dealt the final blow, since one of these factors alone would probably not have brought about the change (Baldwin & Howell 1949).

Willamette Valley being no exception. Yet even within this relatively warm period, average global temperatures are thought to have fluctuated between 14° to 16° C, the warmest interval of which was between 9,000 to 7,000 years ago (Thompson *et al.* 1993). More recently, a "Little Ice Age" took place between the mid-1400s until the late 1800s (average temperatures estimated to be 0.5° – 1° C colder than present), a time when European explorers and immigrants were discovering North America (Crowley 1996). This latest event may have the greatest significance to us now because the lore of early explorers and settlers, to an extent, have shaped our perceptions of the landscape and climate. Yet, because we are coming out of a cooler period and have no true record of what it was like to live here before the "Little Ice Age" it is difficult for us to anticipate how this gradual (or not so gradual) warming trend will affect us. Will we have more floods of greater magnitude? Will we have more droughts? Will seasonal shifts interfere with our current system of agriculture? In short, climate change adds another layer to the complexity of environmental change brought about by humans.

Also during the last 10,000 years the major plant communities that we see in the watershed today began to develop. Marshlands and lakes receded in places, allowing the expansion of grasslands and oak. Douglas fir and western hemlock became established in the higher elevations of the Valley and grand fir and ponderosa pine along the foothills. In turn, this diversity of plant communities supported a variety of insects, frogs, reptiles, birds and mammals (Aikens 1993, Hansen 1942, Heusser 1960, Alverson pers comm 1999, Pearl pers comm 1999).

Ultimately, the geologic and climatic events of the last 50 million years have determined how humans utilized the landscape. The flat, broad valley and adjacent hills shaped by the uplift of the Coast Range, layers of volcanic basalt at the northern end of the valley and sediment deposited by eons of flooding created a diverse environment; ideal for hunting or gathering a wide range of animals and plants and later for farming, ranching and logging.

Early Human Inhabitants

Between 15,000 to 23,000 years ago, during the last ice age, sea levels lowered sufficiently enough that early humans were able to cross the Bering Strait (between present day Siberia and Alaska) and begin populating North and South America (Crowley 1996). Evidence of human inhabitants in the Long Tom Watershed begins approximately 10,000 years ago. At the time of early exploration and European settlement the Kalapuya were the main tribe that inhabited the middle to southern end of the Willamette Valley. However, it is not known whether this tribe lived in the area over the entire period, or whether other tribes existed here in the past.

To date, seven archaeological sites have been excavated in the Long Tom Watershed, including sites at Hannavan Creek, Perkins Peninsula, Upper Long Tom River (Oregon Country Fair grounds), Kirk Park, Inman Creek, and the Flanagan and Benjamin sites. The Hannavan Creek and Perkins Peninsula sites were strategically located near the four major vegetation zones in the area: prairie, marsh, deciduous riparian forests and woodland. Because these sites were on higher ground they were likely used year round. In contrast, other sites would have been flooded in the winter, so were presumably used for summertime hunting and gathering (Aikens 1993).

> Plant foods available in some quantity would have included camas bulbs, acorns, hazelnuts, tarweed seeds, sunflower seeds, cattail rhizomes, and a variety of berries. Large animals of the area were elk, deer, black bear, and grizzly bear. Smaller creatures included raccoons, rabbits, squirrels, beavers, and other rodents. Marsh birds included ducks, geese, and other water-loving species, as well as grouse, quail, and wild pigeon. Trout, suckers, freshwater mussels, and crayfish were available in the streams. Grasshoppers, yellowjacket larvae, and caterpillars were also endemic. All these species were characteristic foods of the Kalapuyan people who occupied the Willamette Valley during the early 19th century (cited in Aikens 1993, 194).

Excavations revealed various tools used for hunting and processing animals, including arrowheads, scrapers and knives. The remnants of tools used for grinding and pounding plant material were also found, as well as roasting ovens used to cook camas bulbs, acorns and other roots gathered from nearby prairie and marshes. "Hammerstones, anvils, cores, flaked stone debris, choppers, drills, spokeshaves, and gravers indicate the working of stone, bone and wood (Aikens 1993, 194)."

Reports from early explorers and settlers suggest that the Kalapuya set regular fires in the lower portions of the watershed. David Douglas, a British botanist travelling with an expedition from Ft. Vancouver, frequently complained in his journal of traveling for miles without finding adequate forage for their horses because the vegetation was completely burned. He also described what he had learned about the reasons for the prairie burning: "Some of the natives tell me that it is done for the purpose of urging the deer to frequent certain parts to feed, which they leave unburned, and of course they are easily killed. Others say that it is done in order that they might the better find wild honey and grasshoppers, which both serve as articles of winter food (Douglas 1959, 214)." Charles Wilkes also speculated on the reason the Kalapuya set fires: "They are generally lighted in Sept. for the purpose of drying the seeds of the [tarweed] which is then gathered and forms a large portion of their food (quoted in Boyd 1986, 71)."

Since then, many anthropologists have discovered or suggested additional reasons for Kalapuya burning. For example, the ground under oak trees was burned to facilitate the collection of acorns the following year, and perhaps the Kalapuya understood that by preventing the growth of understory trees and shrubs the oaks would produce larger acorn crops. Fire also promoted the growth of Hazelnut, berries and bulbs like camas and wild onion, which were important staples in the Kalapuya diet. Finally, the Kalapuya used fire to prepare ground for tobacco seeding, an agricultural practice not uncommon in the watershed today (Boyd 1986).

During the last quarter of the 18th century, the maximum Kalapuya population in the Valley is believed to have been roughly 13,500, about 50 people per 100 square miles. By 1841 Wilkes estimated that only 600 Kalapuya lived in the Valley. The main reason for this staggering loss was disease introduced by European explorers. Before 1806 two small pox epidemics had killed at least one third of the native population. Venereal disease also spread inland from the Columbia in the 1790s, after the first explorers' ships arrived. Then, beginning in the 1830s there were annual outbreaks of malaria, against which the Kalapuya had no immunity (Boyd 1986). Despite the deadly effectiveness of these introduced diseases, there were still a handful of Kalapuya when the first settlers arrived in the mid-1800s. Shortly thereafter, however, these people were forced onto the Grand Ronde reservation in Northeastern Oregon, their presence and practices being viewed as a threat and an infringement on the rights of new settlers.

Pre-settlement: Early 1800s

Europeans and Americans began to leave their mark on the Long Tom Watershed before the first Euro-American settler arrived in 1848. By transmitting disease to the Kalapuya they may have indirectly reduced fire in the Valley, at least the fire which appeared to be intentionally started by the Kalapuya. Wilkes comments, “Since the country has been in the possession of the whites it is found that the wood is growing up rapidly a stop having been put to the fires so extensively lighted throughout the country every year by the Indians (quoted in Boyd 1986, 71).” Mr. Cox, an early settler to the area, also noticed this effect.

> Elk were once very abundant along the placid stream and the ground was strewn with their cast antlers in every direction. Although well timbered this was all open woods when Mr. Cox first saw it [-1846]. There was no underbrush. One might ride a horse anywhere and a deer might be seen and followed without impediment…The country was kept thus open by the Indians who were compelled by the whites to quit burning it over; then the brush sprung up (quoted in Boyd 1986, 77).

European trappers also had an impact on the landscape by depleting or extinguishing some species of wildlife, most notably beaver (Johnson & Chance 1974). This is significant from an ecological perspective because the dams that beaver create form wetlands, which in turn influence the type of habitat available to fish, birds, amphibians and invertebrates (Alverson pers comm 1999, Pearl pers comm 1999). In addition, there is evidence that the collective effect of beaver dams in a watershed dampens the effect of flooding downstream and reduces the severity of summer drought.

Landscape and Vegetation

The main traffic through the Long Tom Watershed in the late 1700s and 1800s was along the “Old Trail” or “California Trail,” which is the approximate location of Territorial Highway today. This was the main route that early fur trappers and explorers took from Ft. Vancouver to Sacramento. The Applegate trail, an alternate route, was established in 1846 by a group of explorers who were heading to California from Polk County. This trail followed the Long Tom River as far as Monroe, crossed over it and traveled to Eugene along what is today River Road (Card 1999).

Fortunately, some of these trappers and explorers kept journals during their trips, which provide us with descriptions of the watershed's landscape at that time. Several recurring themes that are found in these diaries include: 1) the perceived effect of fires set by the Kalapuya, 2) the difficulty of winter travel due to extensive swamplands and muddy ground, 3) the steep sided banks of muddy streams that were challenging to cross, 4) the beauty of the open prairie and woodlands and 5) the excellent quality of the grass and woodlands.

Many early explorers commented on the extent and beauty of the prairies, which they speculated, would provide excellent forage for cattle and sheep. Native grasses of the time included tufted hairgrass, sloughgrass, Roemer's fescue, june grass, slender wheatgrass, California oatgrass and meadow barley (Christy *et al.* 1998, Alverson pers comm 1999). Charles Wilkes wrote, "We passed in going thither, several fine prairies, both high and low....The prairies are at least one-third greater in extent than the forest: they were again seen carpeted with the most luxuriant growth of flowers, of the richest tints of red, yellow and blue, extending in places a distance of fifteen to twenty miles (quoted in Boag 1992, 25)."

Long Tom or Lom-Tom-Buff?
by Doug Card

How did this river get its name? According to the classic Illustrated History of Lane County, Oregon the Long Tom was originally "Long Tom's Bath," after a tall fellow who fell off a mule and got wet (Walling 1884). Rubbish. As can be seen in various writings and diaries, the original Kalapuya name must have been something like "Lom-Tom-Buff," which Euro-Americans mutilated into Long Tom Bath, and finally the non-descriptive "Long Tom." Below are the spellings from various travelers' diaries:

Longtabuff: David Douglas, Botanist, 1826
Lum tum buff: Alexander McLeod, Scottish fur trapper, 1827
Nom tom ba: Alexander McLeod, 1828
L'ommitom ba: Alexander McLeod, 1828
Sam Tomeleaf: John Work, Hudson's Bay Co., 1834
Lam i Tam buff: John Work, 1834
Lamale: William Brackenridge, botanist, and 1841
Lum Tum buff: George Colvorcoresses, US officer 1841
Tom Beoff: James Clyman, trapper, 1845
Long Tom Bath: Virgle K. Pringle, settler, 1846
Lung Tum: Thomas Holt, US Emigrant Relief Party, 1846
Long Tom: George Ambrose, US Indian Agent, 1856

Although the expanse and beauty of the prairie was frequently written about, there was also a diversity of other plant communities. Savanna, containing primarily oak and sometimes a scattering of ponderosa pine and Douglas fir, covered higher ground that didn't flood in the winter. Along the larger streams riparian forests containing ash, poplar and willow flourished. On the surrounding hills and coastal mountains grew Douglas fir, grand fir, ponderosa pine and incense cedar, and in moist, cool areas western hemlock and western red cedar. Also on the foothills were hardwood trees like bigleaf maple, Oregon white oak and golden chinquapin. Shrubs included hazelnut, ocean spray and snowberry (Christy *et al.* 1998). Journal entries by William Brackenridge, a botanist exploring the Willamette Valley, and John Work, of the Hudson's Bay Company, describe some of these plant communities. In September of 1841 Brackenridge wrote:

> Struck into what our hunter (Guide) called the long prairie, at the entrance to which is Marshes Creek, a small still pond of water. The N. East side of this prairie is bounded for a considerable distance by the Lamale River [Long Tom], which is about 20 yds. broad and very still. On the banks grew Dogwoods, Spiraea, Willows, Alder, and Close by Clumps of a large Pinus, near to P. ponderosa…(Brackenridge 1931, 57).

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In describing their 1833 trip along Coyote Creek from Fern Ridge south, Work said,

> (t)he second valley through which we passed is watered by a fork [Coyote Creek] of the river which we left in the morning. Through all the hilly country through which we passed the land on the sides of the hills and in the intervening valleys appears to be of a superior quality, or at least the vegetation is more luxuriant than on the low flat plains even where they do not appear subject to inundation. There is also some timothy grass similar to what we have from England. The clover is of the white or red kind & grows most luxuriantly on the border of swamp or on the plains, where the ground is a little damp & springy. The timber today was mostly oak & a few other trees, & pine in the higher hills (Work 1923, 251-253).

Most of the prairie and oak savanna that covered the watershed in the early 1800s has been altered by the encroachment of trees, reduction in flooding or conversion to farmland (Alverson 1992, Christy *et al.* 1998). Viewed from an ecological function perspective, this means that the animals, birds, amphibians and invertebrates that utilize or rely on these habitats are threatened as well. Some researchers believe that regular fire set by the Kalapuya maintained the prairie and savanna and prevented forests from encroaching on these habitats (Johannessen *et al.* 1971, Towle 1974, Boyd 1986). As evidence, they cite the many descriptions by early explorers of the natives setting fire, the infrequency of lightning that would ignite fires naturally and the encroachment of shrubs and trees onto former prairie since the disappearance of the Kalapuya (Boyd 1986). However, it is also possible that grazing by deer and elk and flooding may have maintained the prairie in some places (Pearl pers comm 1999). In addition, climate change (e.g. recent departure of the Little Ice Age) may be causing a change in current vegetation patterns. Hence a lack of Kalapuya burning may not be the only historical explanation for the loss of prairie. In more recent times, the draining of wet prairie and the conversion of prairie and savanna to farm fields or urban development have also decreased these habitat types. All of these factors are significant because they influence how we view and approach restoration of prairie and savanna habitat. For example, although fire may be a highly effective restoration tool for some sites, other techniques (e.g. reintroduction of flooding, mowing, periodic grazing) may be more appropriate or feasible at other locations.

Wildlife

Diarists often mentioned the wildlife they saw along the way, especially if it related to a potential evening meal. Deer were sometimes difficult to find, although the presence of large expeditions accompanied by horses may have scared many a deer off. On November 12, 1826 Douglas noted that “at two o’ clock passed Longtabuff River, which falls in to the Multnomah [Willamette],” and continuing north reported that they “camped on the edge of a small lake, where there was an abundance of wildfowl (Douglas 1959, 236).” He also reported camping on the margin of an old beaver dam at a later point, which was probably north of Fern Ridge somewhere. Although these entries describe the types of wildlife present, their relative abundance is difficult to tell.

Predators were also abundant in the forests and prairies. Douglas (1959) described one of the trappers getting run up a tree, and almost killed by a grizzly bear at a point probably around Fern Ridge. And on September 10, 1841 Brackenridge wrote, "(t)he country today was much the same Character as yesterday, the soil rich but of a yellowish cast. The prairies we found swarming with Wolves (Brackenridge 1931, 57)."

Flooding

A frequent complaint in travelers' diaries was of the swampy bottomlands and difficult stream crossings. James Clyman, a famous fur trapper of the time known for his great writing and terrible spelling, described travelling through the Long Tom watershed in June of 1845. His narrative gives a vivid picture of how difficult it was to travel during certain times of the year and the great extent of wetlands and swamps in the watershed.

> Pased some fine Prarie lands and continued up the south Branch of Tom Beoff, a dull muddy stream nearly Bank full and not fordable crossed several deep cammace swamps and several deep muddy Brances of the main stream with difficulty at length we cleared the Tom Beoff intirely and assended the long slope of a ridge had a few miles of pleasant traveling the ridge was thinly clad with oak and pine our rout still lying near the Killamook mountains [Coast Range] we not being able to travel in the main vally on account of highness of the waters (Clyman 1960, 157).

The next day he continues:

> "…after leaving our low over flown camp we soon passed into a dirty mirey pond for nearly a mile Belly deep to our horses an hours plunging brought us to a dry ridge of considerable hight from which we had a view of nearly all of the upper Willhamet vally and from apearances seven Eights of the level vally was overflown during the winter rains continued up a small river [Long Tom] our course a little west of south made an etempt to pass over the creek and gain another trail more easterly with considerable difficulty we succeeded to cross the stream after getting over to our disapountment we fou[n]d our selves on a low sunken Island surrounded by Byous and sloughs and ware forced to cross back again through the same miry ford- continued our course up the stream through mud and mire a low pine ridge to our right and large extensive marsh to our left noticed a speces of Black oak to day (Clyman 1960, 158-159).

John Work's diary entry on June 3, 1833 provides another good description:

> Considerable portions of the plain are subject to inundation & parts of it are not so well clothed with grass as some of those we have already passed. Some places of it are also swampy. And parts of it gravelly which is the first soil of the kind we have seen since we started. This plain is 4 to 6 miles wide. The river here runs over a muddy bottom with steep clayey banks, so much so that it is difficult to water the horses. Where we left this morning [between Monroe and the north end of the Long Tom] would be an eligible situation for a settlement. On the E side of the river would serve for pasturage & the high ground on the W side for tillage & sheep walks; and the river could easily be made navigable (Work 1923, 251-253).

It is significant that all of these entries are written in June, which is not the time of year with highest stream flow or standing water in this watershed. This suggests that standing water was present throughout the winter and spring at low points within the valley bottomlands, perhaps drying out in August or September only to fill up again in November. In the winter, some lowland areas may have had frozen, shallow lakes. In regards to a particularly difficult winter James Collins wrote, “Between Spencer’s Butte and the cabin [Skinner’s cabin], Coyote creek [what we now call Amazon Creek] widened into a shallow lake, more than half a mile across; but it was frozen over, I thought, solid enough for me to cross it (Collins 1846).”

Evidence from both prehistoric times and journals of early explorers illustrates that flooding has influenced and shaped the landscape for millions of years. In particular, intermittent flooding and sediment deposition over thousands of years led to the development of hydric soils, which created extensive wetlands along valley bottomlands. In turn, the plants and animals that lived in this region evolved in response to the habitat flooding provided. A map showing the likely extent of historic wetlands can be found in Chapter 7.[2] The extent and location of wetlands can generally be inferred by hydric soils (area covered by diagonal lines on map). This is because hydric soils prevent surface water from draining quickly, resulting in standing water. When these conditions persist for more than a few days during the growing season it favors the growth of wetland plants (Mitsch & Gosselink 1993).

Most of the historic wetlands in the Long Tom Watershed were seasonal wet prairie, a native habitat that is now extremely rare. The majority of these prairie wetlands were located in the Amazon Creek, Coyote Creek, Fern Ridge, and Lower Long Tom sub-basins. Other common historic wetland types were ash swales and willow swamps, the latter often being created by beaver dams.

Settlement Period: 1848 – early 1900s

A combination of factors led to rapid settlement of the Long Tom Watershed beginning in the 1850s. The U.S. government, eager to establish jurisdiction over a land so rich with natural resources, passed the Donation Land Claims Act in 1850. This program lasted from 1850 – 1855 and granted each man 320 acres if he was single and 640 acres if he was married. Within five years over 2.5 million acres had been granted, most of which was in the Willamette Valley (Dicken & Dicken 1979).

Euro-American settlement began to change the Watershed’s environment in many ways. In addition, the relationship between humans and the land changed. The Kalapuya had led a subsistence lifestyle, moving with the seasons to harvest wild plants and hunt animals. Aside from deliberately setting fires, which seems to have had a significant effect on certain kinds of vegetation, it does not appear that they altered their environment in any other way. Their lifestyle and population had probably remained relatively stable or at least changed relatively slowly during their occupation of the Watershed. In contrast, the new settlers had a different way of working with the land. The introduction of agriculture was a significant event, and many farmers brought seeds, plants and animals from across the country. The settlers also possessed relatively sophisticated technology, which eventually evolved into tools that could significantly alter the environment. Finally, the surge in population encouraged by the Donation Land Claim

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[2] This map was created by overlaying two GIS maps; one of historic vegetation based on 1850s Government Land Office surveys and the other of hydric soils based on the 1990 Lane County Soil Survey.

Act placed new demands on the landscape. Between 1850 and 1900 the population of the Oregon Territory jumped from 13,294 to 413,536 (Dicken & Dicken 1979)!

Agriculture

> In the early days the tall, rank grass covered all this valley. We would turn out our cattle on the valley and they would immediately be lost in the tall grass, which reached higher than their backs. In looking for cattle it was impossible to find them by sight. It was necessary to listen for their bells, and when they were lying down to rest during the heat of the day, one might pass within a few feet without finding them (Unknown).

This was probably the experience of the first farmers who came to the Long Tom Watershed. John B. Ferguson established the first claim in the watershed in 1848 on Ferguson Creek. Within a few years his family and other settlers had established a small farming community along the Ferguson Creek. Likewise, most of the prime farmland along Coyote Creek and the Long Tom River was claimed within the first several years of settlement (Inman 1967).

Many homesteads consisted of "…one room log houses with vegetable gardens and a few acres planted in wheat. With little hard currency available, wheat was the primary medium of exchange (Oregon Archives 1990)." Mrs. Gregory Stroda relates "…that years ago they hauled their grain to Monroe to Wilhelm's grocery, feed and grist mill. They traded sixty pounds of wheat for forty pounds of flour and paid their groceries for an entire year, amount $60. She also relates that early shipping was done by boat…[from] the loading docks at Monroe (Inman 1967)."

For the first few decades settlers tried growing wheat and corn, since many were from the Midwest. Despite the relatively cool, wet climate, wheat became the most successful crop in the Valley during the late 1800s and early 1900s; it was used for local consumption and later as an export crop. Corn, however, was not suited to the cool summers and did not become an important cash crop. Oats, flax, hops, potatoes, fruit, nuts and vegetables were also cultivated (Dicken & Dicken 1979). In 1904, the Lane County Fruit and Vegetable Growers Association formed and began exporting fruit very successfully. New technology also allowed vegetable canning, which meant that more food could be grown and preserved for distant consumers. Cattle, sheep and pigs were an important part of many early homesteads. Cattle were first brought to the Willamette Valley in 1837 and sheep in 1843; thus livestock were likely introduced into the watershed around the same time as the first settlers (Dicken & Dicken 1979). Grazing was generally limited to higher ground and, based on the reports of early explorers, was quite nutritious and abundant given the wide expanse of prairie and savanna. Pigs, which were traditionally fed on corn in the Mid-west, were fed acorn mast that came from the prolific oaks (Evans 1985).

Although the introduction of agriculture provided significant advantages to local residents, it had several notable impacts on the local ecology. For instance, in areas that were farmed, non-native crops replaced native prairie species. Domesticated animals grazed on the native grasses, which sometimes damaged them enough to be outcompeted by more resilient, weedy species or non-native plants. An early writer noted that "(t)he cattle would summer and winter on the prairie and in the course of time this indiscriminate pasturing injured the grasses, and reduced them to shorter growth; though it is said that when the land is permitted to lie idle under fence they recover their old luxuriance (Victor 1872, 184)." Finally, Predatory wildlife such as grizzly bear, wolves, cougar and coyote were hunted and in some cases exterminated in order to protect humans and livestock.

Flooding

Annual flooding was a constant struggle for early settlers in the watershed. Old timers in the area recall regular, widespread flooding along the Long Tom River from Veneta to Monroe, the lower portions of Coyote Creek, and all along Amazon Creek (Smith 1999, Bentsen 1998). Ernest Smyth recalled that his Uncle Ned swam a horse from Bear Creek to Junction City some time in the late 1800s!

In an effort to reduce the effects of flooding, landowners would remove brush and trees from the creeks, and roads were covered with planks to control the loss of dirt and gravel (Smyth 1998). Sometime in the 1890s a bridge was built from Veneta to Elmira so that travelers could avoid the frequently flooded marsh below (Shaffer 1998). Over the course of decades many streams were straightened and deepened in order to drain the bogs and marshes to render them farmable.

Logging

Dense forests of fir and hemlock covered the hills on the southern and western portions of the watershed and settlers wasted little time in capitalizing on this resource. The first mill in the watershed was built in Monroe in 1850. By the 1870s many small mills were scattered throughout the basin (Farnell 1979). Because there were few roads in the late 1800s, many mills were by necessity small and mobile. These mills would be built and utilized for two or three years until the surrounding timber had been felled and processed, and then relocated to the next site. Locals called these mills "hillside beavers" because they were so numerous, especially after the turn of the century (Smith 1999).

Transporting logs off the site and to the mill was a challenge back then. Before steam power was introduced felled logs were dragged across the ground on skids by horse or oxen to a nearby stream or hand built flume. Skids consisted of poles laid perpendicular to the skid trail. "(T)he lead end of the log would be 'sniped' (tapered slightly with an ax), and lard or whatever was available would be applied to the skids to "grease the skids" (VanNatta 1999)." Steam donkeys, which became available around the turn of the century, were a tremendous boon to the industry.

> The donkey would consist of a steam boiler and steam engine connected to a winch all mounted on a 'sled' called a 'donkey sled'. The donkeys were moved by simply 'dragging themselves' with the winch line. The process evolved rapidly, but donkeys were used for both yarding (moving the logs from when the tree was cut to an assembly point) and also 'skidding' (dragging the log down the skid trail to the river.). Thus the loggers soon had 'yarders' and 'road donkeys', the latter being the name applied to donkeys strategically located along the skid road to drag the logs from point to point toward the river (VanNatta 1999).

After enough logs were accumulated in the river the men drove them downstream to the mill, a job that occasionally cost someone their life. "Small streams were made usable by constructing a splash dam, forming a pond into which the logs were dumped. The dam was then knocked out, allowing the logs to move with the flood to a larger stream…[T]he logs were stored in a pond or river near the mill until hoisted by the conveyor to the big band saw (Dicken & Dicken 1979, 128)." In addition, wing dams were built at certain points to strengthen the banks.

Table 3.1 Log Drives in the Long Tom Watershed

- Long Tom River: headwaters to Elmira (1870s – 1930)
- Noti Creek (1899 – 1906)
- Coyote Creek (1910)
- Elk Creek (1900 – 1920)
- Poodle Creek (1900 – mid 1920's)

The most intensive log driving and splash damming was on the upper Long Tom River and its tributaries (Farnell 1979). F.C. Walters described the effort and resources to maintain these streams for log driving in a letter addressed to the Dean Lumber Company (who was attempting to purchase the streams' right of ways and charge others wanting to use them) in July of 1918:

> Our company for the past eighteen years has been expending considerable money annually upon the Long Tom, Noti, Elk Creek and Poodle Creek, cleaning these streams of logs, stumps, drifts, blasting rocks, digging cuts, etc. to straighten creeks in places, building dams, cutting trees, brush, etc. along the banks, and doing all we could reasonably do to make these streams fit for driving logs. This work, in all, would run into many thousands of dollars…our mill at Elmira is entirely dependent upon this river and its tributaries for a log supply. Likewise the timber we have been securing for years along the these streams is dependent upon the streams for transportation to market (Farnell 1979,18)

"Soon …the trees near rivers large enough to float logs had been harvested and it was necessary to reach farther and farther out into the woods (VanNatta 1999)." In 1915 the Southern Pacific Railway completed a line between Eugene and Gardiner (near Florence). This railway mainly transported logs, lumber and other freight and made the forests along the western edge of the Watershed more accessible for logging operations (Dicken & Dicken 1979).

> As cable logging evolved loggers learned that uphill logging was best. Unlike early logging which involved attempting to use gravity to get a log to the water, with the introduction of steam to the woods there was plenty of power. Now the problem was with logs that would get snagged, or hooked behind stumps making them difficult to get out. The stumps were often cut 4 to 10 feet high to get above the but swell (they were sawing by hand) and to avoid the bind and pitch [which] was more plentiful in the stump area. If you are trying to drag logs downhill the stumps are all effectively 'fish hooks' frustrating the task, but if you are dragging the logs uphill, (the steeper the better) the geometry implicit in the task implies that the logs will 'pop over' the stumps, or if the hill is steep enough (overhanging cliff) swing free of the stumps. In the evolution of things, the railroads headed for the high ground (ridge tops) and skyline logging came to be (VanNatta 1999).

Like agriculture, timber was an essential resource in the newly settled territory and would soon become the number one industry in Oregon. Lumber was valuable for building local infrastructure (e.g. homes, schools, railways) and was also a highly lucrative export crop, which infused capital and money into the economy. Also like agriculture, it began to change the local ecology in several significant ways. Forests that once had closed canopies now had vast tracts open to the sky. Methods used to transport logs from the site to the mills gouged riparian areas and streams, which may have introduced sediment into the water. Splash damming and other techniques used to move logs down the stream removed organic matter and woody debris from the streams, sometimes causing the stream to be scoured down to bedrock.

It is important to recognize that, presumably, early farmers and loggers intended none of these negative impacts. Most people viewed the environment as a resource and themselves as stewards. Modifications to the landscape were generally seen as an improvement that enhanced their quality of life. Even the Kalapuya manipulated the environment to their advantage. The concepts of conservation and "environmental impacts" came much later in the Watershed's human story. Nonetheless, some of these environmental changes still influence the landscape today and are thus worth discussing and in some cases remedying.

Transportation

Early explorers and settlers arrived on foot, horseback and horse drawn wagons. This mode of transportation made the delivery of agricultural and timber products to outside markets slow and sometimes difficult compared to later transportation. Nonetheless, goods were hauled overland via the Oregon-California Trail and shipped down the Willamette, Columbia and finally to the Coast where they were barged south. The goldrushes in California (circa 1848) and Southern Oregon (circa 1851) fueled this transport and jumpstarted the Willamette Valley economy (Dicken & Dicken 1979).

The Long Tom was a difficult river to navigate before it was channelized. "Bill Hutchison, who lived in Monroe from 1890 on, said the river above Monroe was too choked with drifts to get even a skiff through when he was young (Farnell 1979, 10)." Despite the difficulty in navigation, steamboats did reach Monroe on several occasions. The first was on February 17, 1869. In the fall of 1899 the river was cleared between the old mouth and Monroe to allow for high water navigation. In the course of 3 months 590 snags and trees were cut, 1403 square yards of brush were cleared, 411 snags and trees were blasted, and 1460 cubic yards of gravel were blasted. Ironically, few steamboats traveled up the Long Tom after this Herculean effort and ten years later the river had again become choked with woody debris and sand bars (Farnell 1979). The Willamette River was comparatively easier for riverboats. The first one arrived in Eugene in 1857 and after this continued to reach Eugene during the 4- 6 months of high water on the Willamette. These boats were fueled with wood that was stacked on the banks for this purpose by local residents (Lane County Pioneer Historical Society).

In 1864 President Lincoln and Congress passed legislation, which granted public lands to the Northern Pacific Railroad Company in exchange for building a railroad from Lake Superior to the Pacific Ocean. The public lands were given for a railroad right-of-way and for Northern Pacific to sell to prospective settlers in order to raise the capital needed to build and maintain the railroad (Osborn 1995). In order to enhance the value of surrounding public lands, the land that was granted was distributed in alternating square miles, resembling a checkerboard. After several failed attempts and extended deadlines, the Northern Pacific Line to Tacoma, Washington via Vancouver (across the Columbia from Portland) was finally completed in 1883.

Similarly, in 1869 2.5 million acres of land in Oregon and California were granted in order to build a line between Portland and California. These lands are currently referred to as the Oregon and California Revested Lands (O & C lands). The companies in Oregon were quicker than their Mid-western counterparts and almost immediately began building lines between Portland and California, within the Willamette Valley and out to the Oregon Coast. The main Southern Pacific line from Portland to California arrived in Junction City and Eugene in 1871 (Dicken & Dicken 1979). This greatly facilitated the transport of timber and agricultural products, which meant that timber could be cut and moved faster, and crops could be diversified to meet the demands of a larger market. Increased access also encouraged more people to move into the watershed.

Onset of the Modern Era: early 1900's – present

Technology and population growth were the two major themes that shaped the watershed's environment during the 20th century. The creation of gasoline-powered equipment increased the extraction rate of natural resources and gave people the ability to travel long distances in a short time, which meant they could live farther out of town. New technology gave rise to synthetic fertilizers and pesticides, industrial and household chemicals, the silicon chip and antibiotics, among many other things. All of these events have contributed to an upward spiral of resource consumption and population expansion. In the Long Tom Watershed these changes can be seen across the entire landscape and in every sector of society. In approximately 150 years the watershed's population has gone from a few hundred in the early 1850s to an estimated 92,000 in 1990[3]. Future population growth will certainly have a significant impact on natural resources in the watershed.

Agriculture

Several discoveries in the first half of the 1900s began to dramatically change the nature of farming in the Watershed: 1) the success of grass seed farming, 2) the replacement of horse drawn ploughs with tractors and 3) the development of commercial fertilizers and pesticides. The cultivation of grass seed began in the early 1900s and dominated the landscape by the 1940s. Clover, vetch and oats, and cheat were the principal hay and seed crops in the 1920s. In addition, "(a)nnual ryegrass began to be sown for seed around 1920 and was followed by perennial ryegrass in the mid-1930s. It is the ryegrass on which the development of the grass seed landscape of the southern Willamette Valley was based (Reynolds 1977, 88)." The success of grass seed growing was mainly due to its ability to grow on Dayton soils and thrive in the hot, dry summers.

The replacement of horses for tractors meant that a "substantial amount of land once used for pasture, hay and feed grain could be cropped… Many farmers [at first] were reluctant to replace their horses, because they felt tractors would ruin the soil through compaction (Reynolds 1977, 90)." Despite this, the advantages of using tractors outweighed the potential side effects, and

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[3] This calculation was based on digitized census block information from the 1990 U.S. Census. A census block covers a specific section of the watershed. There are numerous census blocks that cover the Long Tom Watershed and each census block has a number (e.g. 600 people) associated with it. The population numbers from each census block, or portion of census block, that covered the watershed were added up to find the total population of the watershed in 1990.

"…tractors and heavier machinery had largely replaced horses by the late 1920's (Evans 1985, 3)." The combination of tractors and grass seed production led to larger, less diverse farms. Livestock, which were once a part of most small farms, became concentrated on feedlots and pastures as land became more valuable for growing grass seed.

Until the early 1900's, farms in the Long Tom Watershed tended to be small scale, diversified operations on which a variety of farm products were produced (Evans 1985). The resulting farmscape tended to support a mix of habitats, reflecting different agricultural management intensities. In addition to intensively managed croplands, pasturelands were also maintained to support livestock, and woodlots were maintained for building material and fuel. One well-documented site, located in the Muddy Creek drainage just north of the Long Tom, supported 55 species of native prairie plants in 1904 (Whitby 1904). Some of the plant species documented in this study are now considered threatened or endangered, and are seldom found because of habitat loss. In fact, few remaining sites of any type in the Willamette Valley support the number of native prairie species that were present on the Whitby farm in 1904. Since native prairie plants tend to be unable to recolonize areas that have been managed as cropland, intensively managed farmlands in the Willamette Valley usually support few or no native prairie species. At the present time, the Whitby farm site is intensively managed for grass seed production, and no native prairie species appear to still occur on the site.

As grass seed farming became more prevalent so did draining of fields with ditches and tiles and the use of fertilizers. Commercial fertilizers were introduced in the late 1930s. The boost in crop yield promoted the grass seed industry even more, and between 1950 and 1970 the amount of fertilizer that was being used in the area doubled (Reynolds 1977). Field burning began in the mid to late 1940s in response to blindseed disease in perennial ryegrass. This practice was common until recent environmental and political pressures limited its use.

Logging

"Prior to 1900 the lumber industry of Oregon rated a poor third to that of Washington and California. The main reason was inaccessibility of most of the Oregon forests to the kinds of transportation available at that time, as compared to Puget Sound with its hundreds of miles of shore (Dicken & Dicken 1979, 128)." But after the turn of the century, new rail lines, roadways and logging equipment enabled Oregon timber barons to vastly increase production.

Another factor contributing to Oregon's logging boom was the dwindling supply of timber in the upper Mid-west, which enticed large lumber companies to move to the Pacific Northwest. Several of these timber barons, most notably Frederick Weyerhauser, purchased millions of acres of railroad grant lands. A great deal of money was made logging these lands and selling off parcels to other companies. In the 1900s the federal government revested some of these lands due to illegal actions on the part of the railroad companies (Osborn 1995). In the Long Tom Watershed these are referred to as the O & C lands (i.e. Oregon & California Revested Lands) and are currently managed by the Bureau of Land Management for timber production and recreation.

Log driving on streams within the watershed phased out in the 1920s as the rail and road system expanded. The cessation of log driving certainly benefited these streams, although, from an ecological standpoint, the tradeoff was the development of numerous logging roads. A significant potential impact of logging roads is the delivery of sediment to adjacent streams from either surface erosion or by causing slope failures. New requirements for the construction of forest roads decrease this potential, however many old roads still exist on public and private timberlands.

After World War II gasoline-powered yarders replaced steam donkeys. In addition, a variety of new management practices were employed including the burning of logging slash, the use of herbicides on clear cuts (to suppress the growth of deciduous understory plants) and aerial fertilization. Currently burning slash is not common, however logging companies still occasionally use herbicides and fertilizers.

In 1973 the Oregon Forest Practices Act began to change timber practices and to encourage sustained yield on private lands. In addition, the Northwest Forest Plan has reduced cutting on federal lands, which has increased cutting on private lands to meet market demands. A 1989 Oregon State University Study reported that the logging rate on federal lands was well below the long-term sustainable yield estimate (i.e. not cutting as much as they could sustainably), whereas the rate on private lands was slightly below the long-term sustainable baseline harvest (Oregon Forest Resources Institute 1999).[4] As a local example, a Lane Council of Governments study in 1983 used aerial photo analysis to determine the rate of clear cutting within the sub-basins that drain into Fern Ridge Reservoir (i.e. upper Amazon, Coyote Cr., Spencer Cr., Elk Cr., upper Long Tom). The study estimated that between 1-2 % of the land currently zoned for forestry in these sub-basins was clear-cut between 1972 and 1982 (Lane Council of Governments 1983), a rate that the authors concluded to be fairly small. However, it is difficult to know whether this rate is representative of current logging. In addition, simply knowing the harvest rate does not necessarily imply an impact or lack of impact to streams or aquatic habitat from logging.

Urbanization and Population Growth

Urban and rural residential development came on the heels of transportation advances. An expanding population led to the creation of more roads and buildings, and some residents moved out into the country where they converted farmland to large rural estates or hobby farms. In the cities, impervious surfaces like sidewalks, paved streets, parking lots and roofs were created, which accelerated the transport of surface waters to local streams by preventing water from soaking into the ground.

Concentrations of city dwellers, commercial businesses and industry began having an impact on water quality as well. The U. S. Secretary of War wrote in 1938 “A serious pollution problem has developed on the lower Willamette River, as a result of the discharge into the river in an untreated state of domestic sewage and industrial wastes (Johnson 1938, 9).” However, the situation did not improve until a decade later when primary sewage treatment became mandatory. In 1949 Junction City installed a primary sewage treatment plant, followed by

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[4] A sustainable harvest rate is one that corresponds with tree growth rate. For example, a common harvest interval for a given site is 80 years; a point at which trees are large enough to harvest but not yet considered “old growth”. On a side note, it is not clear to the author what proportion of the state’s forests (both private and public) would be under a harvest rotation schedule in order to yield the statewide sustainable harvest rate cited in the Oregon State study.

Eugene in 1952 and Veneta in 1970. Eugene added secondary treatment to their plant in 1960.[5] In addition to requiring sewage treatment plants, industrial sites that discharged into streams were also regulated. Both sewage treatment plants and industrial discharges came to be known as "point sources", because their effluent generally came out of a pipe (i.e. a single point) before entering the stream.

As a result of sewage and industrial wastewater treatment, water quality in the Willamette River improved dramatically. Dissolved oxygen levels, which had been zero in Portland Harbor in 1950, returned to normal and noxious blooms of algae diminished. However, inevitable declines in water quality began to occur again a few decades later. This time the problem was "non-point" sources, a term referring to the fact that the source of pollution is diffuse and widespread in nature. Examples of non-point source pollution are surface runoff from agricultural land, rural residential land, highways and cities. These sources continue to be a challenge to regulate and mitigate because they are not easily monitored like discharge from a pipe. In response to declining water quality, the Oregon Department of Environmental Quality (under requirement of the Clean Water Act of 1970) has developed a list, which is updated biennially, of rivers and streams in the state that are considered "water quality limited". Local governments, state agencies and local residents are being encouraged, and in some cases required, to identify and remedy the sources that are causing the degradation of listed streams in their watershed.

Stream Channelization and Fern Ridge Reservoir

The construction of Fern Ridge dam and reservoir between 1940 and '41 marked the beginning of large-scale structural changes to some of the main stream channels in the watershed. The Army Corps of Engineers built the dam to control flooding in the area and to provide irrigation for farmlands below the reservoir. There have been several significant environmental consequences as a result of its construction. First, fish passage was blocked between the lower Long Tom and the tributaries above the reservoir. Second, stream flow patterns have been altered below the dam. Historically, the Long Tom River had very low summertime flows and intermittent high flows, which often overtopped the banks, in the fall, winter and spring. Currently streamflow is higher in the summer to provide downstream irrigation and unusually high during the reservoir draw down period in the fall. The latter event may prematurely trigger upstream migration by fluvial cutthroat trout at a time when water quality is still poor (i.e. high water temperature, low dissolved oxygen). Third, extensive swamps and wetlands are now covered by the reservoir. Finally, conditions within the reservoir have at times affected downstream water quality, especially temperature, dissolved oxygen and sediment levels (Lane Council of Governments 1983, also see Chapter 10 Water Quality).

Channelization of the Long Tom River below the dam occurred in the 1950s after it was discovered that flooding was still a problem downstream of the reservoir. Modifications included a levee on both sides between the dam and the river's mouth, rip-rap at weak points and culverts to drain adjacent fields. Several check dams were also placed between Fern Ridge and

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[5] Secondary treatment allows a large percentage of the organic matter to be removed (by bacteria and algae) from the wastewater before it is released into the receiving stream. This is important because wastewater that is discharged with high concentrations of organic matter places a large oxygen demand on the stream; ultimately bacteria in the stream would end up digesting the organic matter and in the process use up oxygen in the water.

Monroe. These modifications were fairly effective at preventing farm fields from being flooded during the winter.

Amazon Creek was also heavily modified due to its flooding of south Eugene and the farmlands north of the City.

> Prior to the first improvements and maintenance by the City [of Eugene] this drainageway was a shallow creek and slough no more than 5 or 6 feet deep upstream of Jefferson [St.]. The banks were moderately sloped, and peak storm discharges during heavy winter storms resulted in almost annual flooding in what are now South Eugene High School, Amazon Park, Civic Stadium, and the south part of the downtown area (Long 1992, 5-6)

Dredging of Amazon Creek began as early as 1912 when the City of Eugene "…authorized ditching Amazon Creek by horse teams pulling earth pan scrapers (Long 1992,1)." Then in 1925 the channel from 15th & Jefferson St. to 17th & Pearl St. was widened and deepened. In 1928 the segment between Chambers and Conger St. was also widened and deepened. No significant additional changes were made to the Creek until 1946, when Congress authorized the Army Corps of Engineers to further channelize and deepen the Amazon Creek. This phase, which took place between 1951 and 1958, included construction of the diversion channel to Fern Ridge reservoir, additional widening and deepening of the channel up to 33rd and Hilyard St., and the construction of the concrete channel between Jefferson and 24th St.

The result of these projects has been decreased flooding in the portions of Eugene adjacent to Amazon Creek. In turn a significant number of new buildings and homes have been constructed within the floodplain. There is an inherent danger in this however, because the capacity of the current channel configuration is now estimated to be adequate for a "25-year" flood event (Walch pers comm. 1999). Part of the reason for this lies in the fact that there are more impervious surfaces now than when the channel was originally re-constructed. Because there are more impervious surfaces, stormwater reaches Amazon Creek faster, resulting in a larger volume of water moving down the channel at once. Eventually, a large flood in the Amazon Creek sub-basin will probably cause a great deal of damage to personal and public property unless dramatic steps are taken to decrease impervious surfaces, increase the retention of stormwater and increase the capacity of the channel.

Conclusions

Examining historical events and change in the Long Tom Basin illustrates the complexity and magnitude of human impacts to the watershed's environment. As early as 10,000 years ago humans began utilizing the landscape. Manipulation of the environment probably began with Kalapuya burning and has accelerated over the last century. The arrival of settlers began a population boom in the area and at the same time intensive agriculture and logging began, which led to significant changes in terrestrial and aquatic habitat. Several decades later transportation and urban development also started to have an impact on streams, wetlands and upland areas. Rapid environmental change and population growth are hallmarks of this era, and have economic, cultural and ecological implications. For example, development within floodplains has occurred so quickly that there has not been sufficient time for it to reflect 100-year flood events. Eventually we may pay a large price for this lack of foresight.

From a cultural perspective, we are beginning to lose a historical landscape that attracted many settlers in the first place as rural areas are becoming increasingly dissected by new development and highways. Our relationship to the land has also changed. Both the Kalapuya and early settlers were self-sustaining; they grew and hunted for their own food and lived within the limits of their local environment. As new technology has arisen we have moved away from this regional sustainability and shifted to an export/import economy.

From an ecological perspective, changes introduced by settlers and the current population have altered most habitats to some degree. Because the change has been so rapid many native plants and animals have not evolved or adapted fast enough to survive these new conditions. In particular, wet prairie and other wetland types used to cover a large portion of the Valley floor. Today it is estimated that over 99% of historic wet prairies in the Willamette Valley are gone (Daggett *et al.* 1998). Many species of plants and animals rely on wet prairie and other wetlands for all or part of their life cycle; hence the loss of wetlands has caused a decrease in populations and local extinction.

Although we cannot completely turn the tide of history or progress, we can reflect on our path. Are we heading in the direction we want to? How have living conditions changed for ourselves and other species? Are there certain trends or developments that we would like to change, slow down or mitigate in order to protect habitat (for other species and humans) and water quality? Certainly we all would give different answers to these questions. Nonetheless, a shared awareness of both past conditions and the current types and rate of environmental change is essential if we are to make informed, collaborative decisions about our future.

Based on the information provided in this chapter the Watershed Council may wish to consider the following recommendations:

- Provide educational opportunities for students and Council members regarding historic conditions, habitats and ecological functions.
- Use knowledge of historic habitats and ecological functions to prioritize landscape/habitat restoration and conservation efforts sponsored by the Council
- Use knowledge of a site's historic vegetation and ecological functioning to guide restoration and conservation activities.

Chapter 4 Channel Habitat Types

Introduction

Identifying channel habitat types (CHTs) was a primary task in the watershed assessment process. Knowing the distribution and location of CHTs in the watershed will allow the Council to better understand stream channel responses to land use activities and help identify areas with the best potential for stream and riparian restoration projects. A channel habitat type (CHT) is defined by three factors: 1) **stream gradient**, 2) **stream size** and 3) **channel confinement** (Watershed Professionals Network 1999). **Stream gradient** is highest near headwaters and lowest along valley floors where the land is flat. **Stream size** depends on the amount of stream flow, which generally corresponds to the amount of land draining into the stream at a given point. **Channel confinement** is the degree to which a stream can move within its floodplain. Stream segments that run through steep sided valleys or canyons are more confined since the stream's ability to flood out of its banks and carve a new channel is restricted. When the valley is wider a stream has more opportunity to flood out of its banks and carve new channels across the floodplain. An exception is when streams in broad valleys have been channelized to prevent them from flooding or meandering. In this case a stream segment is confined by human modification as opposed to natural features of the landscape. **Table 4.1** describes the CHTs that have been identified in our watershed.

Table 4.1 Channel Habitat Types

Channel Habitat Type	**Gradient**	**Channel Confinement**	**Stream Size**	**Sensitivity**
Low gradient large floodplain (FP1)	<1%	Unconfined	Large	High
Low gradient medium floodplain (FP2)	<2%	Unconfined	Medium to large	High
Low gradient small floodplain (FP3)	<2%	Unconfined	Small to medium	High
Low gradient moderately confined (LM)	<2%	Moderately confined	Variable	High
Low gradient confined (LC)	<2%	Confined	Variable	Medium
Moderate gradient moderately confined (MM)	2 – 4%	Moderately confined	Variable	High
Moderate gradient unconfined (MU)	2 – 4%	Unconfined	Variable	High
Moderate gradient confined (MC)	2 – 4%	Confined	Variable	Medium
Moderate gradient headwater (MH)	1 – 6%	Confined	Small	Medium
Moderately steep narrow valley (MV)	3 – 10%	Confined	Small to medium	Medium
Bedrock canyon (BC)	≥1%	Confined	Variable	Low
Steep narrow valley (SV)	8 – 16%	Confined	Small	Low
Very steep headwater (VH)	>16%	Confined	Small	Low

There are two main reasons for identifying and mapping CHTs. First, it allows us to identify sensitive channel segments that may warrant special attention and protection (see Sensitivity, **Table 4.1**). A highly sensitive channel is more responsive to changes in peak flows, removal or addition of instream wood, stream bank modifications and inputs of sediment. The channel may respond to these changes by altering its pattern, location, width, depth and sediment deposition (Watershed Professionals Network 1999). Natural processes (e.g. floods) and/or land use activities can cause these changes. For example, land use that creates hard or non-vegetated surfaces can lead to more overland runoff, which creates higher stream flows (i.e. peak flows) during storm events and may lead to stream bed scouring. The placement of rip-rap to stabilize banks can change erosion patterns downstream. Human activities that add sediment to the stream can damage instream habitat by filling in pools and spawning gravel and making the channel shallower, which causes the stream to heat up faster in the summertime.

A second, and related, reason for identifying CHTs is that it enables us to identify how different types of channels may respond to restoration efforts. Often, channels with medium to high sensitivity will show the most response to restoration. It should be noted however, that this method of predicting restoration response has not been tested within the Long Tom watershed. Hence, field surveys and an assessment by local professionals is crucial before determining whether a site is appropriate for restoration. **Table 4.2** lists potential response of each CHT to restoration.

Table 4.2 CHT Restoration Potential

Channel Habitat Type	**Riparian enhancement opportunities**
Low gradient large floodplain (FP1)	Due to the unstable nature of these channels, the success of many enhancement efforts if questionable. Opportunities for enhancement occur… where lateral movement [i.e. meandering] is slow. [E]fforts to restrict [meandering] will often result in undesirable alteration of channel conditions downstream. Smaller side-channels may be candidates for efforts that improve shade and bank stability, but it is likely that these efforts may be more beneficial and longer-lived elsewhere in the basin.
Low gradient medium floodplain (FP2)	Same as FP1
Low gradient small floodplain (FP3)	The limited power of these streams [i.e. low stream flow] offers a better chance for success of channel enhancement activities than the larger floodplain channels. While the lateral movement [i.e. meandering] of the channel will limit the success of many efforts, localized activities to provide bank stability or habitat development can be successful.
Low gradient moderately confined (LM)	Like floodplain channels, these channels can be among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining landform features … help limit the destruction of enhancement efforts common to floodplain channels. Because of this, LM channels are often good candidates for enhancement efforts. In forested basins, habitat diversity can often be enhanced by the addition of …wood or boulders. Pool frequency and depth may increase, and side-channel development may result from these efforts. Channels of this type in nonforested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of

Table 4.2 continued

	this channel type, and fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.
Low gradient confined (LC)	These channels are not highly responsive, and in channel enhancements may not yield intended results. In basins where water-temperature problems exist, the confined nature of these channels lends itself to establishment of riparian vegetation. In nonforested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.
Moderate gradient moderately confined (MM)	Same as LM, except "[t]he slightly higher gradients impart a bit more uncertainty as to the outcome of enhancement efforts when compared to LM channels."
Moderate gradient confined (MC)	**Same as LC**
Moderate gradient headwater (MH)	These channels are moderately responsive. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In nonforested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.
Moderately steep narrow valley (MV)	**Same as LC and MC**
Bedrock canyon (BC)	These channels are not responsive, and are generally a poor site for enhancement efforts.
Steep narrow valley (SV)	These channels are not highly responsive, and in channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. This may also serve as a recruitment effort for large woody debris in the basin.
Very steep headwater (VH)	**Same as SV**

Source: Watershed Professionals Network 1999

Methods

All stream segments that were present on our 1:24,000 USGS topographic base-map were classified with a CHT. Stream segments that were not present at this map-scale were not classified. The first step in classifying CHTs was to divide each stream into segments according to stream gradient and size. Contour lines on the base map were used to determine gradient and the Oregon Department of Forestry classifications were used to determine stream size.[6] The second step in determining CHTs was to classify confinement for each segment. An initial determination was made based on valley steepness and channel sinuosity (i.e. how much the channel meanders from side to side). To verify this classification we field checked over 20 sites across the watershed that represented different kinds of CHTs. This enabled us to determine how accurate our map classifications of confinement were compared to field classifications.

In general, classifications based on the map agreed well with our field classifications in steep to moderately steep parts of the watershed. However, along the bottom of broad valleys it was more difficult to determine stream confinement using the map alone. This is because agricultural and urban development have modified many of these channels in order to prevent streams from meandering or coming out of their banks. Confinement of the larger streams (e.g. lower Long Tom R., Amazon Cr.) is obvious since their banks have been reinforced by levees and rip-rap. However, some of the smaller streams, especially in agricultural areas, may flood during the winter, which means they are not completely confined within their banks and thus have the opportunity to meander. Due to time constraints and private property rights it was not possible to field check every stream segment in these areas for evidence of flooding. Thus we classified these segments by applying what we were able to observe in the field to areas that we could not field check.

Results

Channel Sensitivity

The **Long Tom Watershed Channel Habitat Analysis map** shows the distribution of channels with low, moderate, and high sensitivity. Note the relationship between topography and channel sensitivity. Where streams are coming out of the mountains through steep, narrow valleys the sensitivity rating is low (indicated by black lines). In the low, broad valleys where streams have more opportunity to meander and flood the sensitivity is medium or high (indicated by orange or red lines). The distribution of medium and high sensitivity channels is important to consider in relation to land use. The areas in the Long Tom Watershed with the most sensitive channels correspond with areas primarily used for agriculture, rural residents and cities. **Figure 4.1** illustrates how land use activities in these areas can impact sensitive channels.

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[6] The Oregon Department of Forestry classifies stream size as small, medium and large. This determination is made by calculating the drainage area and annual precipitation above points along each stream.

Insert map

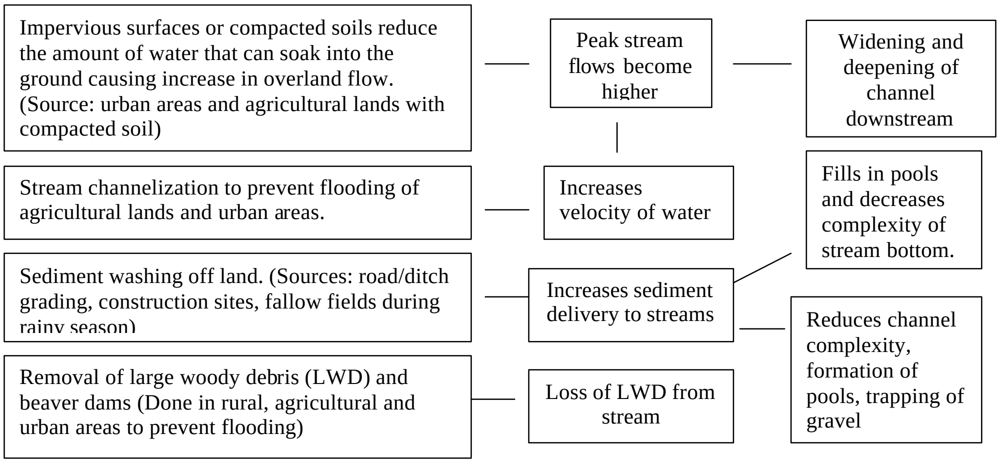
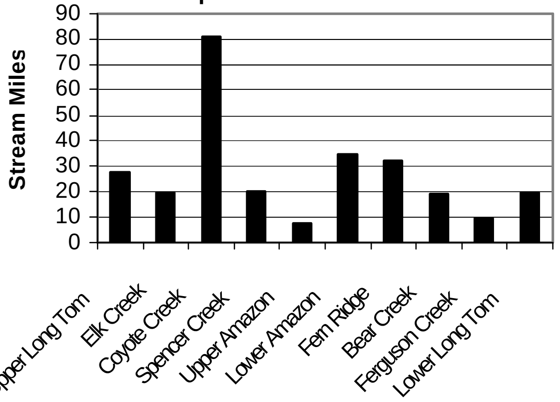


Figure 4.1 Impacts of Land Use Activities on Stream Channel Habitat

Restoration Opportunities

Stream segments identified as “low gradient small floodplain”, “low gradient moderately confined” and “medium gradient moderately confined” represent potential sites for successful riparian zone and instream restoration or enhancement projects. The bar chart in **Figure 4.2** illustrates the miles of stream in each sub-basin that fall under one of these classifications. This does not mean that these segments necessarily need restoration, rather that they would have a high likelihood of being successful if restoration were implemented. Information on channel habitat types should be used in *conjunction* with riparian zone data (presented in Chapter 7) and other factors to select restoration sites and strategies. Additional data on channel habitat types for each sub-basin are located in **Table 4.3**.

Figure 4.2 Stream Miles with High Potential for Riparian Restoration



Conclusions

The Long Tom Watershed has a relatively high proportion of sensitive channels because a large proportion of streams flow through broad, silt covered valleys. This enables streams to spread across their floodplain during periods of high stream flow and cut wide, sinuous patterns across the valley floor. Historically, there was an even greater proportion of highly sensitive channel habitat types. They were characterized by meandering, braided channels that created a mosaic of isolated high ground, streams and wetlands. A significant direct impact to these streams has been channelization (i.e. channel straightening, dredging and bank reinforcement) in order to prevent flooding of farmland and urban areas. In effect, these alterations have rendered these streams less "sensitive" (according to the CHT classification scheme) because they are now confined. The current channel habitat types that correspond with the most channelization in the watershed are "low gradient confined", "low gradient moderately confined", "low gradient medium flood plain" and "low gradient small flood plain". Stream segments that were classified as "low gradient confined" are primarily the mainstem of the lower Long Tom River and Amazon Creek, which were "low gradient medium or large floodplain" before they were channelized.

Despite the loss or alteration of many streams there still is opportunity to restore or protect sensitive channels. Channels that have become less sensitive due to human alteration still may have high potential for restoration because they used to be sensitive and still have the underlying valley and stream size that determined their sensitivity historically. Stream segments that are also candidates for riparian or wetland restoration are a good focus for council efforts since restoration would meet multiple objectives and have a higher probability of success. However, because the land along the bottom of the valley is so heavily developed and highly valuable for farming, finding landowners interested in actively restoring channels (which in some cases might mean allowing more flooding) will be a significant challenge. Nonetheless, there are good examples of restoration projects on both public and private land that have already taken place. One example is a wetland/riparian restoration project that took place on Amazon Creek in West Eugene during the summer of 1999. Levees were removed along a portion of the Creek in order to allow floodwater to spread into seasonal wetlands adjacent to the channel. In addition, native grasses and shrubs were planted along the riparian zone to provide habitat for wildlife and reduce bank erosion. Much smaller projects have also taken place in the watershed. One watershed council member used native plants and landscaping fabric to stabilize a stream bank on his property that had been damaged by past grazing. Another family restored their stream bank by planting willows and constructing a fence to exclude their livestock. In many cases landowners can receive partial funding through cost-share grants from the Oregon Department of Agriculture, Natural Resource Conservation Service and the Willamette Initiative.

Below is a list of land management practices and restoration activities that council members may wish to consider for protecting riparian habitat and sensitive channels:

- Protect riparian zones from livestock grazing
- Protect riparian zones from residential and urban development
- Replant riparian zones with native grasses, shrubs or trees in areas that 1) show signs of instability and 2) have a high potential for success
- Reintroduce flooding along some stream segments
- Where possible, allow streams to meander
- Avoid creating impervious surfaces
- Prevent human caused sediment from washing into streams
- Do not remove large, woody debris from stream banks or channel

Table 4.3 Miles of Stream Channel for each Channel Habitat Type by Sub-basin

CHT	Upper Amazon	Lower Amazon	Lower Long Tom	Upper Long Tom	Spencer Creek	Bear Creek	Ferguson Creek	Fern Ridge	Coyote Creek	Elk Creek	Total
FP1	0	1.67	0	10.85	1.76	2.47	2.3	2.09	2.76	10.66	34.56
FP2	0	1.78	2.28	11.59	3.33	8.23	0.96	8.52	22.79	4.53	64.01
FP3	2.15	22.82	14.19	8.15	2.15	7.24	1.86	10.44	26.49	8.77	104.26
LC	19.18	16.6	51.38	24.63	5.01	8.44	14.86	7.36	15.88	7.54	170.88
LM	4.97	11.76	4.21	10.53	15.14	7.25	6.41	20.86	20.58	8.61	110.32
MC	0	0	1.61	5.70	2.11	3.17	3.49	0	8.01	4.96	29.05
MH	0.84	0	0.79	0	0.54	1.22	0.65	1.82	1.31	0	7.17
MM	0.48	0	1.32	8.77	2.88	4.78	1.2	0.82	7.87	2.31	30.43
MU	0	0	0	0.71	3.21	2.70	1.32	2.07	0.40	1	11.41
MV	0.90	0	3.63	10.38	12.13	3.96	6.82	2.1	12.17	14.4	71.02
SV	3.52	0	0	9.99	12.22	5.57	4.64	0.51	24.99	2.95	64.39
VH	0.46	0	1.02	18.46	3.16	11.2	15.24	3.75	35.66	43.1	132.05
BC	0	0	0	0	0	1.48	0	0	0	0	1.48

FP1= low gradient large floodplain, FP2= low gradient medium floodplain, FP3= low gradient small flood plain, LC= low gradient confined, LM= low gradient moderately confined, MC= moderate gradient moderately confined, MH= moderate gradient headwaters, MM= moderate gradient moderately confined, MU= moderate gradient unconfined, MV= moderately steep narrow valley, SV= steep narrow valley, VH= very steep headwater

Chapter 5 Hydrology and Water Use

Introduction

Understanding the distribution and movement of surface and subsurface water (i.e. hydrology) in the Long Tom Watershed is an important part of protecting water quality, fish and wildlife habitat, and our ability to use surface and ground water. The Oregon Department of Environmental Quality has designated a number of "beneficial uses" of surface water. The primary beneficial uses in this watershed include industrial water supply, trout spawning and rearing habitat, habitat for other aquatic life, agriculture, recreation and aesthetic enjoyment (i.e. sightly or appealing to humans).

Peak and low flows are natural elements of the hydrologic cycle; but human activities or modifications can accentuate them. In turn, human caused changes to a watershed's hydrology can affect the instream habitat of fish and other aquatic life as well as other beneficial uses of surface water. Elevated peak flows increase the erosion of stream banks and scouring of stream beds. This can damage habitat for fish and other aquatic life, lead to loss of streamside property and increase sediment going downstream. Extremely high peak flows sometimes lead to flooding, which can damage personal property. Decreased low flows lead to slower flow rates and consequently higher water temperatures and lower dissolved oxygen levels. Low flows also concentrate nutrients, sediment and pollutants. Higher nutrient concentrations can in turn lead to more algal growth, which ultimately decreases oxygen as well (see Chapter 10 Water Quality). Sluggish, stagnant streams are also not attractive to local residents (e.g. Amazon Creek in the summertime).

Factors Influencing the Flow of Water

Natural conditions

♦ Soil types
♦ Vegetation
♦ Precipitation (amount, timing and type - rain, hail, or snow)
♦ Natural storage (wetlands, ponds)

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Human alterations

♦ Land use and changes in vegetation
♦ Impervious surfaces like pavement, compacted soil, roofs, etc.
♦ Water withdrawals
♦ Artificial storage (instream or offstream ponds, reservoirs)

=

Streamflow in watershed

♦ Amount of water
♦ Timing of flows
♦ Pollution and sediment carried with water

Precipitation and Infiltration

Precipitation can come in the form of rain, hail or snow. Our average monthly minimum temperatures are above freezing, and as we know, the majority of precipitation in this watershed comes as winter rain. The annual precipitation is between 35 to 74 inches, depending on the location, with daily maximums usually occurring in December and January. The lowest elevation in the watershed is 248 feet, the maximum is approximately 2,100 feet, and about 95% of the basin is below 1000 feet. These low elevations mean snow is not a significant part of our annual precipitation (Connolly *et al.* 1992), although occasionally a couple of inches will stick in the upper parts of the basin.

The majority of the precipitation falls from November through March. In general, precipitation corresponds with stream flow. However, the largest storms tend to come in November and December, whereas peak stream flows come in December and January. This is because in early winter the soils are not yet saturated with water. Thus there is not as much overland flow. Later in the winter they become saturated, which translates into higher stream flows in December and January (Armstrong 1999). The amount of water that runs off the surface of the ground depends on the vegetation, leaf litter and soil conditions. More vegetation will intercept more water, which will then slowly drip off, evaporate or be taken in by the plant, used and then transpired into the air as vapor. More leaf litter on the ground will capture and hold more water on the surface, which then evaporates or slowly moves down into the soil.

Soils

Soils in the Long Tom Watershed originate mostly from (1) marine sediments, (2) the deposits from volcanic eruptions and (3) silts and clays carried from headwater streams to lowland streams. There are two significant features of these soils to consider. First, they tend to be easily weathered and highly erodable, which partly explains why many streams in the watershed appear turbid or cloudy and why some streams have steep, down-cut banks. Second, the high percentage of silts and clays in these soils slows the infiltration of rainwater from the surface to the groundwater.

The infiltration rates of most soils in the basin range from 0 to 4 millimeters/hour (i.e. it takes one hour for rainwater to move that distance down through the soil). In comparison, during a typical winter storm in this watershed, rain can fall at a rate of 3.8 mm/hr. So if a particular piece of land can only absorb water at 2 mm/hr, then the remaining 1.8 mm/hr runs over the ground into the nearest creek. This surface runoff, or overland flow, contributes to peak flows and carries sediment and pollutants with it into the streams. The probability of overland flow occurring in undisturbed forest soils is very low as the infiltration rate of the soils is high relative to the hourly rainfall rates. In the urban and agricultural portions of the watershed however, this is not always true. Due to impervious surfaces and impermeable soils overland flow will occur during heavy rains.

Storage

Wetlands, lakes, ponds, and reservoirs can decrease the impact of heavy rains by slowing flow rates or storing the water. They can also augment streamflow during the summer. Wetlands do this by acting like a sponge that soaks up water and then releases it as the weather becomes drier. That sponge action also filters water to remove pollutants. In addition, wetlands provide habitat for many different types of wildlife. Historical accounts indicate that wetlands covered large parts of the basin's valley floor. While some wetlands still remain, most have been converted for agricultural, residential and commercial/industrial use. This loss affects the hydrology of the basin in that there is less natural storage of winter precipitation, which increases peak flows and cannot help to augment summer low flows[7]. It also decreases the number of wetlands able to

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[7] Currently, a group of OSU researchers is studying wetland loss and how that could affect peak flows and flooding.

filter water and provide habitat (this is discussed in Wetlands, Water Quality, and Fish and Wildlife Habitat chapters).

In the Long Tom watershed the site of largest water storage is Fern Ridge Reservoir, which can hold 116,800 acre-feet of water (over 4 billion cubic feet) and controls the flow in the lower portion of the Long Tom River. By impounding the water, we change the natural timing of its storage and release, which can block fish from moving up and downstream because no fish passage facilities are available at the dam.

Other small natural or human-made ponds and lakes are scattered throughout the basin with numerous small check dams and diversion structures in both agricultural and urban areas. These structures can help to decrease downstream flooding and provide water for irrigation of large and small properties. They can be managed to augment summertime low flows, and this is especially the case with Fern Ridge Dam. However, many of the smaller structures, such as check dams, hold what little summertime flow there is back from the stream. Please refer to the Channel Modification chapter for a description of impoundments.

Streamflow

In the Long Tom watershed, stream flow is high in the winter, especially after heavy storms, and low in the summer because we have little or no melting snowpack to feed it. Precipitation reaches our streams in three ways. A small amount falls directly into the river (it is “intercepted”) and immediately heads downstream. The majority of precipitation falls on land and will infiltrate down into the soil, becoming subsurface flow. If the precipitation is unable to infiltrate**,** it will become overland flow (surface runoff), appearing as a thin film or in small rills until it reaches the stream. If we set up a measuring gage downstream after a rainstorm, the stream level would rise first from direct interception, then surface runoff (overland flow), and finally from subsurface runoff.

Base flows and storm flows

The base flow of a stream is the water draining from the surrounding landscape to sustain streamflows in dry periods. In our watershed it comes mostly from groundwater but also from unsaturated zones right next to the stream, especially in steep areas (Satterlund & Adams 1992). Base flow is often the only water left during dry summer conditions, except in the lower Long Tom River where flow is augmented by releases from Fern Ridge Reservoir. Storm flow appears in the stream channel in direct response to precipitation, from mostly surface runoff and subsurface flow. The combination of heavy winter rains and soils with slow infiltration rates means that streams and rivers tend to respond quickly and dramatically to heavy rains.

Although understanding the sources of streamflow is important, we tend to care more about the *amount* of flow coursing down the channel[8]. We measure and graph streamflows because peak flows and flooding have always been important to people. Low flows have been traditionally

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[8] The stream gaging stations in our watershed are listed in Appendix 1.

important to water users and are becoming increasingly important as we learn about the survival needs of fish and other aquatic organisms.

Peak flows

Peak flows are the highest flow rates of water in a stream during any given period, often recorded annually. They are not necessarily floods**.** The process creating peak flows in our watershed is rain; "rain on snow" events that can lead to especially high river levels or extensive flooding are not significant in this watershed. Please see **Figure 5.4** for graphs of the peak flows in this century in three parts of the watershed, Amazon Creek, Coyote Creek, and Bear Creek.

What do peak flows do?

Peak flows can potentially modify stream channels. During a peak flow the potential for debris to be moved downstream is greater because more water is traveling down a stream system at higher velocities. This stream then has a great deal of hydraulic power and a corresponding capability to move material. By moving sediment, rocks and downed trees, peak flows can rearrange fish habitat in a stream system. The duration of a peak flow can be detrimental, as debris is forced farther downstream and eliminated from areas that may need it the most. Channels must have adequate structure, such as large pieces of wood in the stream, to be able to withstand these peak flows without losing their variety of habitats. (Armstrong 1999)

Except for some parts of the Long Tom Watershed, there is a lack of large woody debris within streams throughout much of the basin. Large woody debris decreases water velocity, allowing sediments to deposit and build up the flood plain and channel bottom. Large wood will also divert water flow towards the side of the channel, which will cause bank cutting and meandering. If the stream channel is ready to handle peak flows, there can be many benefits after they occur:

1. Deeper flood plain soils for water storage and plant growth;
2. Raised channels that reach the flood plain more often, exchange water with wetlands, and transfer water to riparian areas more efficiently;
3. Greater sinuosity (meandering) resulting in more stream-riparian contact, larger riparian areas, and slower velocities;
4. Changes in channel location that create backwaters and other aquatic habitat;
5. More and deeper pools;
6. Disturbance of the riparian area which enables new growth to take hold;
7. Higher base flows and less damage from peak flows;
8. More frequent local valley flooding and less frequent downstream flooding.

(Armstrong 1999)

Flooding

Over time we have confined streams to within their banks to prevent flooding. Increasingly, humans have chosen to use the floodplain area to establish roads, property and homes. Despite our effort, some years the river overflows its banks onto surrounding land. Unfortunately an intensive survey of flood history was beyond the scope of this assessment. Nonetheless, one aspect of flood history is clear. As we increase our intensive use of the land, especially by paving it or creating other impervious areas, we are forcing the water elsewhere and most likely expanding the extent of the floodplain (Armstrong 1999). For example, Fern Ridge Reservoir and Amazon Channel are estimated to accommodate 25-year floods (that is a flood with a one out of 25 chance in occurring each year, not the flood level we get every 25 years. In other words, we could get many 25-year floods in a row.). The intensive development within the floodplains of Amazon Creek and the lower Long Tom River will likely result in extensive damage when a flood of greater magnitude occurs.

Which Human Activities Increase Peak Flows?

The primary human-caused increases to peak flows in the Long Tom watershed are from the direct runoff from impervious surfaces and from stream channel straightening and deepening (i.e. channelization). Extensive channelization has been done for the agricultural and urban portions of the watershed: 62% in the Lower Amazon, 41% in the Lower Long Tom, and 36% in the Upper Amazon (Eugene area). We were not able to quantify the increases of peak flows from channelization, however, we know that by alleviating flooding in a local area, channelization sends the floodwaters faster downstream where they may cause flooding.

Urban and Rural Residential Areas

Research has shown that changes to peak flows is the leading cause of physical habitat changes in urban watersheds (May et al. 1997). Pavement on roads, parking lots and driveways, as well as buildings and even severely compacted soil **are impervious surfaces** which block water from reaching and filtering into vegetation and soil. If there is other permeable ground nearby, the water could flow there, yet often during storms this ground is already saturated and everything else becomes runoff. This surface runoff is routed to storm drains and heads straight for streams, quickly raising stream levels. Stormwater runoff is generally not treated and carries pollutants, trash and sediment from roadways, parking lots and construction sites with bare soil. The most significant impacts on peak flows from urban areas in this watershed come from Eugene, with a moderate amount from Veneta, Elmira, Monroe and other towns in the basin (see **Table 5.1**).[9]

Agricultural and Range Lands

Changes to vegetation patterns, soil and drainage can make water run faster off agricultural and range lands into streams. Crop type, treatment (i.e. straight rows, contours, terraced, crop residue cover), degree of soil compaction, and amount of tiled fields[10] affect the degree to which agricultural practices impact hydrology. For this assessment we looked at these factors and four hydrologic soil groups, A through D (USDA 1986). By analyzing the percentage change in runoff due to farming practices above what would naturally occur, we determined the potential risk of agricultural practices causing increased peak flows in each sub-basin.

Soil types A and B are the most permeable and therefore have the most potential to hold water. They comprise 15% of our watershed. Certain agricultural practices applied to types A and B can reduce the holding capacity of those soils and increase the runoff contributing to peak stream flows. Conversely, agricultural practices on types C and D have little potential to increase peak-flows because those soils are already relatively impermeable in their natural state. C and D soils

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[9] Stormwater from Junction City is routed directly to the Willamette River, but in high water situations it can mix with Long Tom River waters.

[10] Tiled fields route runoff directly into streams, bypassing riparian area buffer zones that could otherwise filter any pollutants and sediment carried with that runoff. We did not have information on tiled fields for this assessment.

cover over 85% of the Long Tom watershed. Therefore, there is a low risk in this watershed of agricultural lands increasing peak flows over undisturbed soil conditions.

Since impermeable soils tend to make farming more difficult, people often amend the soil structure by adding organic matter to maximize crop potential. This can also increase the water-holding potential of the soil and reduce runoff water, thereby reducing the pollutants (soil, chemicals, etc.) carried into the streams.

Forested lands and timber harvesting practices

The screen for potential forestry impacts on hydrology in this assessment focuses on how those practices can affect peak stream flows through "rain on snow events" (where relatively warm rain melts an accumulated snow pack, sending a flush of water to the streams). Since more than 95% of the precipitation in this basin comes in the form of rain there is low potential risk[11] of peak-flow enhancement from snow accumulating in clear-cut and bare areas and being part of rain-on-snow events.

Forest and Rural Roads

Road density, road surface type and the connectivity roads have with the streams all play a part in the effects roads have on streams. A Washington study found that when 3-4% of a watershed is covered in roads, they begin to have an effect on peak flows (Bowling and Lettenmaier1997). For the Long Tom, road density in forested areas was calculated for each subbasin and found to have low potential to impact peak flows. Rural road density was calculated and the potentials were also low, with Fern Ridge and Upper Long Tom sub-basins showing a moderate potential to increase peak flow.

The connectivity between streams and roads also has an effect on peak flows. The percentage of roads connected with streams in this watershed varies from 8-36%, depending on the sub-basin. If a large percentage of the road system is mid-slope, and if the road drainage system is hydrologically connected to the stream network, it can create an increase in the drainage density of the hydrologic system thus decreasing the time it takes for storm flow to reach the main channel. Then, if this flow happened to be arriving at the same time as flow from other drainages, it would cause an increase in the downstream peak flow. (Armstrong 1999). In addition, water that is delivered to the streams via roads and their ditches carries pollution and sediment down with it.

In summary, **Table 5.1** shows the degree to which certain land uses might potentially increase peak flows. Because this is a screening level assessment we did not quantify all the potential affects; the ability to determine the degree to which a land use affects peak flow would require more study. Individuals and the watershed council may wish to investigate these areas further.

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[11] The cutoff for "low potential" for peak flow enhancement by forests is 75% rain so our watershed is far above that at 95%.

Table 5.1 Findings of relative potential risk to increase peak flows in the Long Tom basin

Subwatershed	**Urban & Rural Residential Impervious Surfaces** *<4.2 = low* *4.2 – 5.5 = mod* *>5.5 = high*		**Forest Road Density*** *<4% = low* *4-8% = moderate* *>8% = high*		**Rural Road Density** *<4% = low* *4-8% = moderate* *>8% = high*		**Agricultural Practices** *0 – 0.5 = low* *0.5 – 1.5 = moderate* >1.5 = high	
	Density (mi/mi^2)	***Risk***	***%of area***	***Risk***	***%of area***	***Risk***	***Increased runoff (in)***	***Risk***
Bear Creek			2%	**Low**	3%	**Low**	0.1 - 0.3	**Low**
Coyote Creek			1%	**Low**	2%	**Low**	0.1 - 0.2	**Low**
Elk Creek			1%	**Low**	3%	**Low**	0.1 - 0.2	**Low**
Ferguson Creek			1%	**Low**	2%	**Low**	0.1 - 0.3	**Low**
Fern Ridge	7.9	**High**	2%	**Low**	4%	**Low/ Moderate**	0.1 - 0.2	**Low**
Lower Amazon	7.5	**High**	0%	**Low**	1%	**Low**	0.1 - 0.3	**Low**
Lower Long Tom	10	**High**	1%	**Low**	2%	**Low**	0.1 - 0.2	**Low**
Spencer Creek	8	**High**	1%	**Low**	3%	**Low**	0.1 - 0.2	**Low**
Upper Amazon**	11.8	**High**	1%	**Low**	2%	**Low**	0.1 - 0.2	**Low**
Upper Long Tom			1%	**Low**	4%	**Low/ Moderate**	0.1 - 0.2	**Low**

* There was no subbasin analysis done for timber harvest practices impact on peak flows because a watershed-scale analysis found almost no potential in the watershed due to rarity of rain-on-snow events, as discussed previously.

** A fancier way to compute urban impacts to streams is by adding up the total impervious area (instead of estimating it based on road density). It's also a more expensive way, so this method could be done for the Upper Amazon only and was 32%. Stream degradation occurs at relatively low levels of imperviousness - 10% - so this is a very high number (Schueler 1994).

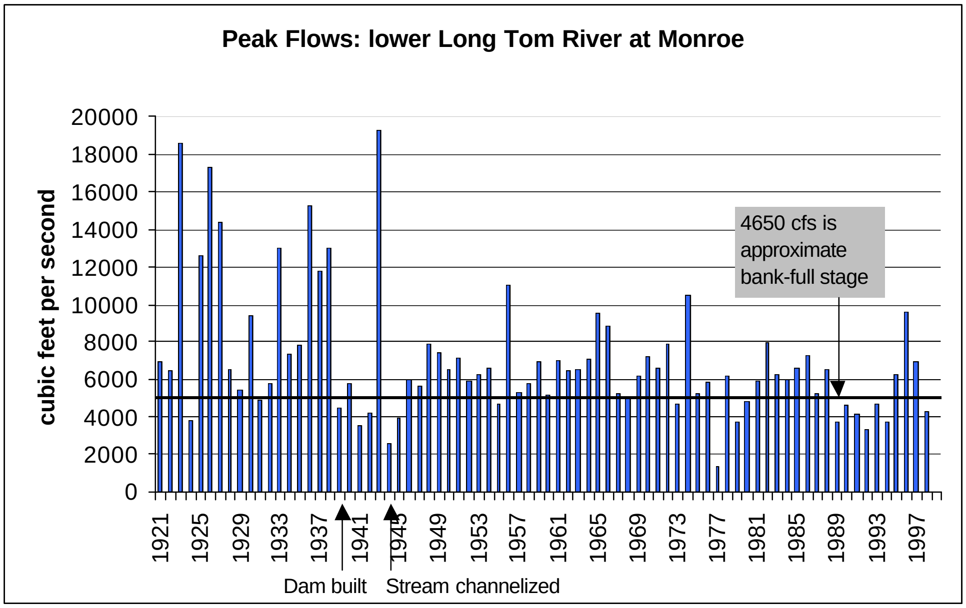

Figure 5.1. Peak flow history of the lower Long Tom River, measured at Monroe. Notice that after the dam was built in 1939-1941 there was a peak flow that we know from aerial photography reached flood stage. The newly built dam could not hold all the floodwaters. This prompted channelization of the 23.5 miles of lower Long Tom River below the dam during 1943-1951. The combined projects have significantly reduced peak flows since then.

How Do Human Activities Decrease Peak Flows?

The most significant effect humans have had on decreasing peak flows in this basin is of course Fern Ridge Dam and the channelization of 23.5 miles of the Long Tom River below it. This was to relieve flooding problems in land desired for agricultural production in the northern part of the watershed, and to store and redistribute that water during summer when natural flows were too low to irrigate from. **Figure 5.1** shows the peak flows in the Long Tom River before and after the dam and channelization.

Decreases in peak flows and flooding benefit many people who have built homes and created farm fields in areas that formerly flooded on a regular basis. However, from an ecological perspective, a decrease in flooding reduces the stream's interaction with its floodplain. This interaction historically provided soil deposition in the flood plain, the slowing and dampening of peak flows and the creation of floodplain habitat.

How do Human Activities Influence Low Flows?

Low flows are the opposite of peak flow; they are the lowest recorded flow rates for a given time period, often recorded annually. Low flows become a concern when people can't get the water they need, and when the stream level becomes too low to sustain the aquatic organisms because the lack of water increases temperature and decreases available oxygen. It is desirable to record low flows whenever they occur, not just once a year, since the duration can be the most harmful factor to stream life. Unfortunately, stream flow records do not record low flow amounts separately and it was too time-consuming to plot them for this assessment. However, one was done as an example, for the Long Tom River at Noti (**Figure 5.2**).

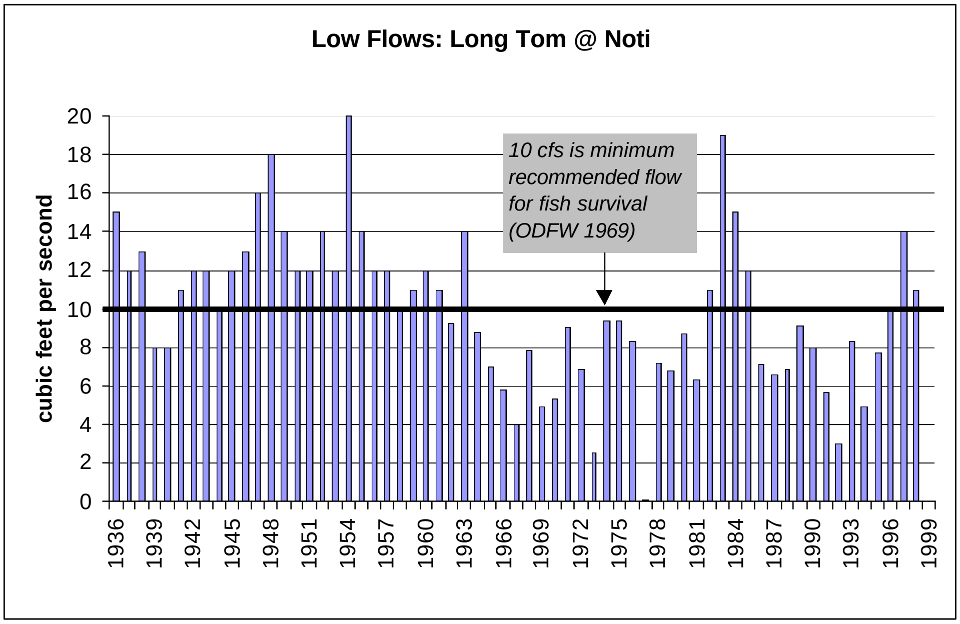

Figure 5.2. Low flows in the Long Tom River, measured at Noti. For each water year (Oct. 1 of previous year through Sept. 30 of labeled year), the lowest daily flow is shown (Data from USGS). The darker line at 10 cfs shows the minimum recommended flow for the months in which low flow occurred. One exception: in 1976 the low flow was in July and minimum rec. flow then is 15 cfs (Data from ODFW).

Minimum Stream Flows

Because of water rights and withdrawals, there is no guarantee that any stream will have water flowing in it throughout the dryer periods when it historically might have. One approach to determining how much water is reasonable to expect in a stream is to study how much was there historically and how much is minimally needed for the fish to survive, and then suggest an amount as a "minimum streamflow recommendation." The Oregon Department of Fish and Wildlife (ODFW) did this in 1969[12] after studying depths and velocities in the field at each stream location in **Table 5.2**. While, the Water Resources Department has not acted on these, both ODFW and the Oregon Department of Parks and Recreation can apply for instream water rights. ODFW has not yet chosen any areas in the Willamette basin as Streamflow Restoration Priority Areas.

Table 5.2 Minimum Stream Flow Recommendations[1] for several creeks in the Long Tom Watershed (Data and footnotes from ODFW, 1969)

Stream	**Location**	**Dec-May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
Long Tom River	River mile 50	25	12,8	4	4	4	4	15,25
Long Tom River	At Noti (gage 141665)[2]	75	40,25	15,10	10	10	10	50,75
Long Tom River	At Alvadore (gage 141690)[2]	30	30	30	30	30	30	30
Long Tom River	At Monroe (gage 141700)[2]	25	25	25	25	25	25	25
Bear Creek	1 mile above mouth	8	3,1	0.5	0.5	0.5	0.5	6,8
Ferguson Creek	3 miles above mouth	20	5,3	2,1	0.5	0.5	0.5	12,20
Noti Creek	Just above Poodle Creek	12	4,2	2,1	1	1	1	8,12
Poodle Creek	Just above Noti Creek	30	12,8	4,3	2	2	2	15,30

[1] These recommended minimum flows are not intended to be used as desirable flow releases below future impoundments. Recommended reservoir releases for fish life would require additional investigations.

[2] From listed gage down to mouth of that same stream

Note: If there are two flows given for one month, they are for the first and second halves of the month, respectively.

Water use

The quantity of water used in a basin is important because overuse can lead to dry streams. The sources of our current water use, by primary water right holders, is 99% surface water (mostly from storage), and less than 1% groundwater. Additional amounts of groundwater are not used under a water right; they are groundwater registrations made before 1955. Besides the quantity pumped from the ground or stream, the quality of the return flow is important and is tracked only in certain situations. Overall, the quantity and quality of the return flow depends on how the water is used. Here there is an opportunity for people to take personal responsiblity to make sure their return water is of good quality for their neighbors, downstream users,and aquatic life. For example, in 1999 members of the watershed council are beginning a two-year pilot study on surface runoff from select agricultural lands. This study is a partnership between the watershed council and participating landowners.

What we know about water usage in this basin is based on permitted water rights through the Water Resources Department (WRD). **Figure 5.3** shows a summary of these uses in the Long Tom Basin. Not included in this figure are uses that don't require a right, the largest being rural residential, and others using water without a permit. However, both of these additional uses amount to less than the small sliver of "other" in the graph.

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[12] After being established, the recommended flows have not been field verified again (Galovich 1999)

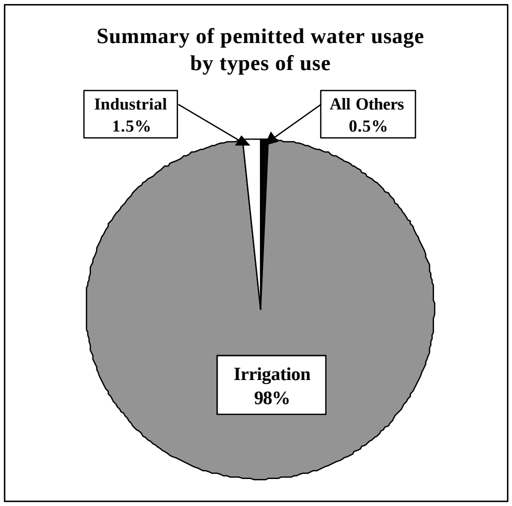

Figure 5.3. Summary of permitted Water Usage by Types of Use. Data from WRD.

Table 5.3 Irrigation by subbasin. The percentage of the total water used for irrigation in the entire Long Tom basin, shown by the subbasin it's used in.

Subbasin	% of basin's irrigation water
Upper Long Tom	5.4%
Elk Creek	3.6%
Spencer Creek	0.4%
Coyote Creek	9.4%
Upper Amazon	2.8%
Lower Amazon	10.0%
Fern Ridge	5.1%
Bear Creek	4.3%
Ferguson Creek	2.3%
Lower Long Tom	56.8%
Total	**100%**

Agriculture

Water use in the Long Tom watershed follows a pattern found in many watersheds, with irrigated agriculture placing the greatest demand on the water resources. In the Long Tom Watershed, irrigation accounts for a full 98% of surface, reservoir and ground water usage in the basin. **Table 5.3** shows the percentage of irrigation water used in each subbasin.

Urban

In urban settings, water provides for residential, commercial and some industrial uses. Water is diverted, treated and then distributed throughout the municipalities. Eugene, half of which is in the Long Tom basin, obtains its water from the McKenzie River. Eugene's wastewater is treated and returned to the Willamette River. Veneta obtains its drinking water from wells fed by Long Tom basin groundwater and returns its wastewater to the upper Long Tom River. Veneta is currently in the process of building a new treatment plant since there have been problems with effluent quality. Monroe has three wells near the lower Long Tom River and is currently planning to add a fourth well. Monroe's wastewater is returned to the Long Tom River after treatment. Junction City, on the eastern fringe of the watershed, draws water from six deep wells in the area's lower aquifer and routes wastewater and stormwater to the Willamette River.

Industrial water users can demand large quantities of water for operation of their facilities. Some have on-site treatment for their wastewater that recycles water and hence reduces the total amount of water they consume. Others send their wastewater to the local wastewater treatment plant.

Interbasin Transfers

There is one inter-basin transfer of water potentially affecting the Long Tom basin. This is a proposal by the newly formed Greenberry Irrigation District to transfer water from the lower Long Tom River into adjacent Muddy Creek watershed, part of the Marys River Watershed, to the west. At this time, the proposed amount to be withdrawn is not known.

Water availability

Water available for future use is determined by the Oregon Water Resources Department (OWRD) based on the natural streamflow minus consumptive use from both out-of-stream and in-stream water rights. Currently, no new permits are being issued in the Long Tom Watershed for withdrawal from natural surface flows (i.e. water that is not artificially stored) or hydrologically connected groundwater, with a few exceptions[13]. However, below Fern Ridge Reservoir there is an ample amount of stored water available, although prospective new users must first acquire a permit from the Water Resources Department and pay a fee to the Army Corps. New storage permits may also be issued to fill small, private reservoirs between November and June of each year.

Summary of Human Impacts on Hydrology

Throughout this chapter, both the natural and human influences on the watershed's hydrology have been incorporated into the discussion. This recognizes that humans are a part of the natural system. However, because we can do more to slow, prevent or mitigate human effects, they are summarized in **Table 5.4.** This review may help as readers prepare to make recommendations on areas where we can improve watershed conditions.

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[13] Domestic, commercial for customarily domestic purposes (e.g. motel, restaurant, not to exceed 5 gal per min), public stream uses, livestock, and wetland enhancement.

Table 5.4 Significant Human Impacts to Hydrology of Long Tom Watershed

Activity	Examples	Effect
Dams	Fern Ridge Dam and other numerous small check dams & diversion structures in both agricultural and urban areas	Prevents or decreases downstream flooding. Limits peak flows and disconnects stream from floodplain. Usually managed to augment summertime low flows but could also withhold water from the stream.
Stream channelization **Creation of roadside and farmland ditches**	Long Tom River below Fern Ridge and Amazon Creek were straightened and channelized in the 40's and 50's to speed the evacuation of floodwaters. Many smaller scale channel straightening projects exist throughout the watershed in order to divert water from land that was wanted for agriculture or urban development. Also for this purpose, ditches have been created to drain fields, and along most roads to keep water off of them.	Increase in surface & subsurface flows, less infiltration, increased runoff, decreased baseflow during summer. Prevents floodwaters from spreading out over the floodplain, which would otherwise deliver nutrients to the land, filter and slow floodwaters, and give aquatic organisms access to more habitat. Ditches carry water and pollutants from roadways and farmlands, and form part of the stream channel network but impact can go largely unrecognized.
Wetland loss	Majority of wetland loss has probably resulted from conversion to farmland; residential and industrial development have also contributed	Less local natural storage of winter precipitation (much is now provided by Fern Ridge). Loss of wildlife habitat. Increases peak flows and decreases summer low flows
Impervious surfaces	Paved surfaces and ground occupied by buildings; the most significant impact comes from Eugene; moderate amount from Veneta & Monroe	Prevents rainwater from soaking into ground; increases peak flows
Water Withdrawals	Many withdrawals from the basin's surface waters. Irrigation represents 98% of all withdrawals.	Can create flows too low to sustain stream life.

Conclusions

The council may wish to consider the following actions to help reduce human impact on the watershed's hydrology:

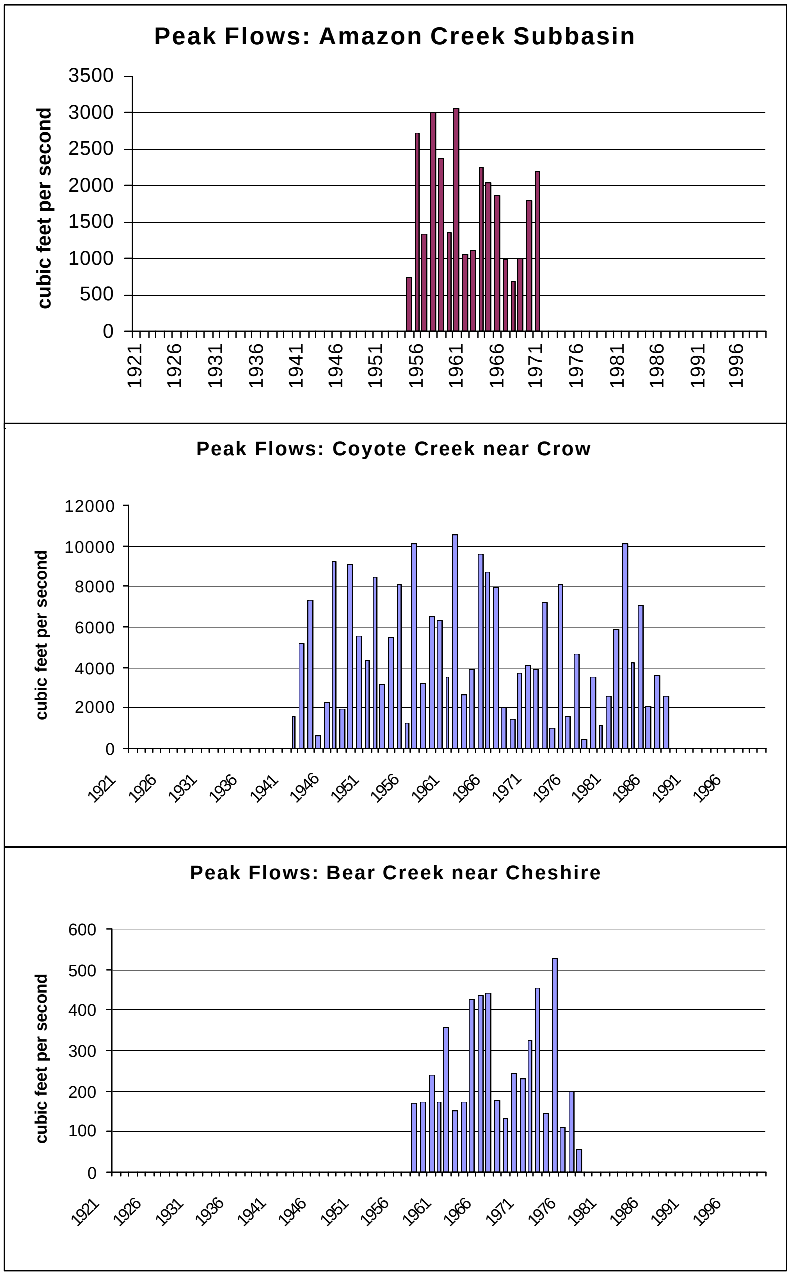
- Reduce or prevent the creation of more impervious surfaces
- Reduce or prevent the creation of more stream channelization
- Allow flooding into adjacent wetland habitat if in places where wetlands have become disconnected from streams. This option depends on landowner preferences as well as financial considerations.
- Alleviate impacts of small check dams by replacing (or removing where no longer needed).
- Monitor stream flow basin wide to become aware of seasonal low flow problems. The Council's water quality monitoring program is currently measuring flow, but only monthly.
- Also to address low-flow problems, calculate consumptive use by sub-basins. Lane County Watermaster reports that the OWRD has the data and capability to do this but the state office currently has other priorities. A request from the Council may expedite this.
- Promote conservation tillage

Table 5.5
Gages in the Long Tom Watershed

There are approximately 1410 miles of streams in the watershed. Very few of those have any flow measurement on them. There have been 13 gages in the watershed. Five are still active; three of them measure flow on the Long Tom River itself, one above and two below the dam. One other measures flow at Hulbert Lake Irrigation Project Canal and one just records elevation of Fern Ridge Reservoir. All were or are monitored by the USGS, except for the Hulbert Lake Irrigation Project gage, monitored by WRD and the Irrigation District.

Gage name (USGS)	Gage No.	Status	Years of Record	Data available
Long Tom River near Noti	14166500	**Active**	1936-1998	Historical daily values, peak flows
Long Tom near Alvadore	14169000	**Active**	1940-1998	Historical daily values, peak flows
Long Tom @ Monroe	14170000	**Active**	1920-1998	Historical daily values, peak flows
Coyote Creek near Crow	14167000	Inactive	1940-1987	Historical daily values, peak flows
Diversion to Coyote Creek below Fern Ridge near Alvadore	14168500	Inactive	1967-1985	Historical daily values only
Long Tom + diversion to coyote Creek near Alvadore	14169001	Inactive	1982-1985	Historical daily values, peak flows
Amazon Creek at Eugene (Amazon Pkwy. near Fox Hollow turnoff)	14169300	Inactive	1962-1974	Historical daily values, peak flows
Amazon Creek diversion to Fern Ridge Reservoir	14169400	Inactive	1967-1968	Historical daily values only
Amazon Creek near Eugene (at edge of city limits before the channel splits)	14169500	Inactive	1955-1981	Historical daily values, peak flows
Amazon Creek + diversion to Fern Ridge	14169501	Inactive	1955-1968	Historical daily values only
Bear Creek near Cheshire	14169700	Inactive	1957-1977	Peak flows only
Hulbert Lake Irrigation Project Canal *(monitored by WRD, District)*	14169810	Inactive	1969-1993	Historical daily values, peak flows
Fern Ridge Reservoir near Elmira *(monitored by USGS for Army Corps)*	14168000	Active		Elevation only (pool level)

Figure 5.4


Peak Flows: Amazon Creek Subbasin

Peak Flows: Coyote Creek near Crow

Peak Flows: Bear Creek near Cheshire

Chapter 6 Stream Channel Modifications

Introduction

Current stream channel modifications in the watershed include a wide range of alterations generally done to prevent the flooding and erosion of personal property or to provide irrigation water during the summer. From a habitat perspective, they can affect stream channels by eliminating meanders, altering the composition of streambed materials, reducing habitat complexity through the removal of organic debris, inhibiting flooding and/or, in the case of reservoirs, completely submerging the channel.

A common modification in this watershed is **stream channelization**, which entails deepening, widening, relocating and straightening streams. This is mostly done on streams flowing through urban and agricultural lands. To keep these channels in their modified form it is sometimes necessary to periodically **dredge** out accumulated sediment and reinforce the banks with **levees** and **riprap**. (A levee is an earthen berm placed adjacent to the waterway. A clear example of this is along the Long Tom River below Fern Ridge Dam. Riprap includes things like large rocks or wood used to stabilize banks and prevent them from eroding.) Other common modifications in our watershed are **dams and reservoirs.** This includes Fern Ridge Reservoir and Dam as well as numerous small impoundments for livestock watering, irrigation, private fishing and fire prevention.

A common practice in the past was **removing downed wood from rivers and streams**, especially after logging. It was originally thought that clearing streams of woody debris, especially slash generated from logging, benefited the fish and wildlife in the stream. More recently, biologists began to understand the importance of large woody debris and now recommend leaving large wood in streams (although in some cases it is appropriate to remove small twigs and branches from logging slash if the amount exceeds levels that would naturally be there). Because of this, logging operators no longer actively remove large wood from streams, and in some cases put large pieces of wood into streams in an effort to restore them. However, there are still some landowners, especially in agricultural and urban areas, that remove downed wood from streams running through their property in order to prevent localized flooding.

Roads that run parallel to streams and rivers and are within their flood plain are also potential channel modifications because they can limit the extent of flooding. In this respect they are similar to a levy. There are many roads within the 100-year flood plain of streams and rivers in our watershed. However, usually levees, channelization and dams are the primary modifications limiting flooding. **Culverts** and **bridge pilings** are another road related channel modification. Culverts have also been used to place streams underground, particularly in urban areas.

Sand and gravel mining in or near rivers or streams is also a channel modification. Mining can alter the shape of a stream channel and also alter its bottom substrate (i.e. gravel, rock, sand and silt). There are few mining operations that are near streams or rivers in the Long Tom Watershed.

All of these channel modifications may benefit humans in some way. City dwellers and farmers are especially dependent on dams and channelization to protect buildings and farmland from flooding. The numerous reservoirs in our watershed provide irrigation for crops and livestock during the summer among other things. In short, channel modifications have become an integral part of the infrastructure of our cities and rural areas.

Two potentially negative results can, and in some cases do, result from channel modifications. First, most of the dams and channelization in the Long Tom Watershed are not designed to accommodate 100-year floods[14]. However, we have built many houses and other structures in the 100-year floodplain that current dams and channelization may not be able to protect when a 100-year flood event occurs. For example, engineers with the City of Eugene estimate that most of Amazon Creek can handle up to a 25-year flood event (Walch 1999). Fern Ridge Reservoir is estimated to regulate up to a 25-year flood event (Beal 1999). Second, channel modifications can alter fish and wildlife habitat.

How do channel modifications affect fish and wildlife habitat?

Channelization and dams that control flooding have contributed to a reduction in wetland habitat and other benefits that flooding provides 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. Also, 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 also 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.

The timing and amount of release of water from large reservoirs can altar seasonal migration patterns. In the case of Fern Ridge Reservoir, early draw downs may trigger upstream migration of cutthroat trout when water quality in the lower Long Tom River is still relatively poor (e.g.

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[14] A 100-year flood event can happen at any time. It is described as a “100-year flood” because hydrologists estimate that a flood of this magnitude is likely to occur about every 100 years.

high water temperatures and low dissolved oxygen levels). In the wintertime, the *consistent* high flows may make it difficult for fish to move upstream past existing water control structures (Galovich 1999).

Straightening and deepening channels (i.e. **channelization**) modifies and reduces instream habitat in a number of ways. Dredging and moving streambed material from one place to another changes the composition of the stream bottom. Straightening channels decreases the amount of available instream habitat by actually shortening the total length of that channel segment. And when high stream flows do occur water tends to move faster through straightened channels, which helps prevent flooding but also may scour the stream bottom and prevent organic debris that contributes to habitat complexity from accumulating.

Removing instream woody debris reduces the benefits it provides. Large woody debris (i.e. entire trees, large trunks with roots still attached, branches) provides several important benefits to fish and wildlife. First, it alters and slows stream flow, which facilitates the creation of pools, quiet eddies, backwaters, side channels and increases stream interaction with the floodplain. These features provide important habitat for both fish and other aquatic organisms. It also causes gravel to be deposited and stored, creating spawning habitat. Wood debris and accumulations of wood create complex cover that provides important refuge from stream flows and predators, particularly for juvenile fish. Finally, large woody debris is the base of the food chain for most small, forested streams.

How did we assess channel modifications?

We used several sources of information to help us identify channel modifications.
Maps and records from the Army Corps of Engineers, Division of State Lands, Department of Geology and Mineral Industries, the City of Eugene and the Water Resources Department allowed us to locate and map:

- historic stream channelization
- stream bank reinforcements such as levees and riprap
- sediment removal and fill in streams and wetlands
- historic splash dams and log drives
- current and historic mining and quarry sites
- location of permitted reservoirs and dams

In addition to these documents we identified areas of channel straightening, small impoundments and road crossings by using current topographic maps (scale = 1:24,000; 2.5” = 1 mile) of the watershed. In order to verify our map assessment we field checked questionable sites and consulted with local residents.

We considered channel modifications to be current if we could see the modification on a recent map or document. It is possible that some formerly channelized stream segments or impoundments are no longer being actively maintained, however if they are still visible we assume that they are still having some influence on instream habitat and flooding.

There were a couple of limitations to our methods. Not all channelization or impoundments show up on topographic maps and we did not have the time to use aerial photos. In addition, it was not possible to field check stream segments that appeared channelized or impounded on the map if they were on private property and not visible from public roads. However, since our goals were to map the *majority* of channel modifications and characterize their general impact on the watershed, we feel our methods were sufficient.

Historic Modifications

Channel modifications began taking place relatively soon after settlers arrived in the 1850s. One of the first channel modifications was the use of rivers to transport logs from felling sites to the mills. To accomplish this, loggers sometimes used splash dams, which involved damming up the creek and then releasing it all at once in order to increase the flow enough to move logs downstream. Another task was to clear brush, logs, snags and sandbars from the channel, sometimes with dynamite. Both splash damming and snag clearing removed large woody debris from streams and led to stream bottom scouring. The earliest record of splash damming and log driving in the watershed was in the early 1870s on the Long Tom River from its headwaters to the mill at Elmira. The last recorded log drive on this portion of the river was in 1930. Sections of the upper Long Tom River are now scoured down to bedrock, probably because of these early log drives and stream cleaning efforts (Galovich 1999). Other streams that have recorded splash dams and log drives include Noti Creek (1899 – 1906), Coyote Creek (1910), Elk Creek (1900 – 1920) and Poodle Creek (1900 – mid 1920’s) (Farnell 1979).

In the valleys, where farming started, homesteaders began to drain flooded fields by ditching and straightening small streams that meandered across their homesteads. Initially, the lack of gasoline powered equipment probably limited the scope of these endeavors. It was not until later in the 1900s when tractors became available that more substantial straightening and relocation of streams began. In addition, small, earthen or wooden dams were built in order to store water for irrigation and livestock watering during low flow months in the summer.

Urban development around the City of Eugene led to frequent flooding of homes and businesses. Evidence from historic aerial photographs indicates that on numerous occasions floodwater left the Willamette River near what is today the River Road area and entered the Amazon Creek drainage, leaving a pattern of sinuous channels leading from the Willamette towards Clear Lake (Alverson 1999). This is one indication of how prevalent flooding was in this part of the watershed.

In 1913, the City had Amazon Creek ditched with teams of horses pulling earth pan scrapers in order to remove sandbars and vegetation.

> (P)rior to the first improvements and maintenance by the City this drainageway was a shallow creek and slough no more than 5 or 6 feet deep upstream of Jefferson. The banks were moderately sloped, and peak storm discharges during heavy winter storms resulted in almost annual flooding in what are now South Eugene High School, Amazon Park, Civic Stadium, and the south part of the downtown area (Long 1992, 6).

Between 1925 and 1958 Amazon Creek was widened and deepened between 24th & Hilyard St. and Fern Ridge Reservoir. In 1951 the "A" channel was constructed, which diverted a large portion of Amazon Creek's flow out of its original channel and into the newly formed reservoir. As more streets, homes and buildings were constructed, some urban streams were converted into underground storm drains.

The construction of Fern Ridge dam and reservoir between 1939 and 1941 was perhaps the single, largest channel modification in the Long Tom Watershed. The resulting reservoir now covers 9,360 acres[15] of former farmland and wetland. The reservoir's primary functions are flood control, recreation and irrigation for the lands below the dam. Between 1943 and 1951 the Long Tom River below the dam was straightened and leveed after discovering that the dam was not sufficient to prevent flooding downstream (Army Corps of Engineers 1999).

Current Modifications

Table 6.1 lists the types and quantity of channel modifications in each sub-basin of the watershed. Channelization (with the use of levees in some cases), impoundments and road crossings are the most extensive impacts to channel structure in the watershed. The sub-basins most heavily influenced by **channelization** are the Upper Amazon, Lower Amazon and Lower Long Tom. These were the areas most affected by flooding in the past and have the most agricultural and urban development. **Figure 6.1** shows the percentage of stream miles that are channelized in each sub-basin. The **Long Tom Watershed Channel Modifications map** shows channelized stream segments (i.e. straightened and deepened) and impoundments identified by the assessment. Red lines indicate channelization and blue dots indicate impoundments.

"**Roads next to streams**" refers to the miles of road that are within a stream's 100-year floodplain *and* are the primary factor preventing floodwater from spreading across the floodplain. In areas where streams are channelized we did not consider roads the primary factor limiting flooding and so did not include them in our "roads next to streams" total.
The sub-basins with the highest number of **impoundments** are Coyote Creek and Fern Ridge. Aside from Fern Ridge Reservoir, most of these appear to be small agricultural impoundments used for livestock watering, fishponds or unspecified domestic use. It is likely that there are other impoundments in the watershed that we could not locate because they were not visible on the map or in Oregon Water Resources Department records.

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[15] This is the acreage at full pool during the summer. During flood stage full pool covers over 10,000 acres.

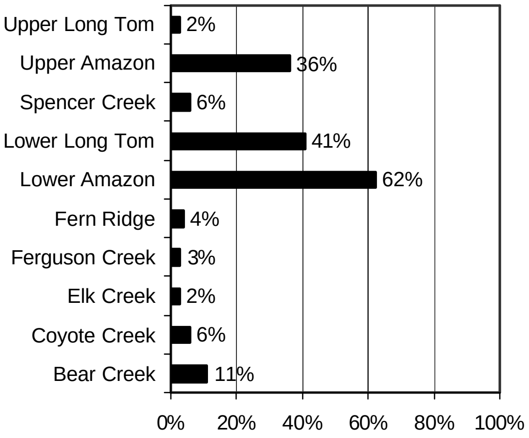
Table 6.1 Channel Modifications by Sub-basin

Sub-basin	Channelized (miles)*	Roads next to streams (miles)*	Reservoirs & impounds	Flow check dams	Levees (miles)*	Quarries	Road crossings /stream mile
Bear Creek	11.6	0.8	7	None docum.	0	0	1.74
Coyote Creek	18.5	2.4	15	None docum.	0	0	1.45
Elk Creek	4.9	1.4	7	None docum.	0	1	1.5
Ferguson Creek	3	0.7	1	None docum.	0	0	1.22
Fern Ridge	3.1	1	24	None docum.	0	0	2.02
Lower Amazon	43	0.3	4	None docum.	0	3	1.49
Lower Long Tom	61	0.3	4	8	24	7	1.06
Spencer Creek	4.2	0.9	3	None docum.	0	0	1.95
Upper Amazon	15.6	5.7	2	1	8.2	0	3.95
Upper Long Tom	5.6	1	6	None docum.	0	0	1.95

None docum. = none documented

*Mileage calculated with a map wheel

Figure 6.1 Percentage of Channelized Stream Miles



Most of the **flow check dams** are found on the Long Tom River below Fern Ridge Dam. They are used to slow the flow of water coming down the channel in order to prevent excessive erosion of the levees downstream. On Amazon Creek there is a small dam-like structure at 24th Avenue where the stream enters a concrete channel. It is likely that there are many other small dams throughout the watershed used to raise water levels in order to pump or divert water from the stream. However, these are generally not shown on topographic maps, which means they were not included in our calculation. A potential

Insert channel modifications map

impact of dams like this is the blockage of upstream fish passage during part or all of the year.

Levees are located along portions of Amazon Creek and the Long Tom River below Fern Ridge dam. These were constructed in the early 40s and 50s and are still maintained for flood control. On Amazon Creek levees extend from Fern Ridge Reservoir to Garfield St.. Upstream of here the creek flows through a concrete lined channel from 15th Ave. to 24th Ave., a distance of about 2.4 miles. On the Long Tom River levees extend from Fern Ridge dam to the river's confluence with the Willamette.

Gravel and rock **quarries** were mapped and counted if they were within 1/8 of a mile from a stream. Quarries near streams are not very common in this watershed, and consequently their impact relative to other modifications in the watershed is low.

The sub-basins with the highest **density of road crossings** are Upper Amazon, Fern Ridge, Spencer Creek and Upper Long Tom. These areas correspond with the highest densities of urban and rural residential development

Channel modifications not listed in **Table 6.1** are stream bank protection (i.e. riprap) and built-up areas in floodplains and wetlands. Although riprap is quite common in the watershed, we did not comprehensively map or quantify it. There are numerous places along the Long Tom River below Fern Ridge and Amazon Creek that are reinforced with rock or other stabilizing materials. In addition, in places where roads cross streams it is often necessary to reinforce the stream bank. Built-up areas in floodplains and wetlands also exist within the watershed. One example is the land on which the Veneta shopping center at the corner of Highway 126 and Territorial Rd. is located. Portions of Highway 126 near Fern Ridge Reservoir and Veneta are also built on top of old wetlands.

Conclusions

Channel modifications have a significant impact on water quality and aquatic habitat in the Long Tom Watershed. This is due to the significant number in the watershed and their multiple, indirect effects. In sum, channel modifications can:

- alter and reduce the total amount and quality of instream habitat,
- disconnect rivers 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.

Most of the streams that are channelized are currently or were historically "sensitive" channels (see **Chapter 4**). The current channel habitat types that correspond with the most channelization in the watershed are "low gradient confined", "low gradient moderately confined", "low gradient medium flood plain" and "low gradient small flood plain". All except "low gradient confined" are highly sensitive channel types. Stream segments that were classified as "low gradient confined" are primarily the mainstem of the lower Long Tom River and Amazon Creek, which were “low gradient medium or large floodplain” before they were channelized. These kinds of low gradient channels provide the best opportunities for lateral (i.e. side to side) stream movement, stream and floodplain interaction, accumulation of organic debris (e.g. wood, leaves), beaver activity and increased stream habitat complexity. Although fish spawning typically occurs in higher gradient areas, low gradient areas provide critical rearing habitat. In terms of restoration opportunities, low gradient areas are often the first places that should be investigated.

Despite the multiple impacts that channel modifications have on the watershed it would be incredibly difficult and expensive to totally remove them. Our cities, houses and farmlands depend on many of these modifications to protect them from flooding, among other things. Nonetheless, there may be places in the watershed where restoration is feasible (and desirable) for the landowner, and provides substantial benefits to fish and other aquatic organisms. Reconnecting streams with their historic floodplain (or at least part of it) should be given high priority if landowners are willing. Highly sensitive channels that have good potential habitat for fish and other aquatic organisms should also be a primary consideration. In addition, landowners should assess any impoundments on their land for their potential to block upstream fish passage.

In some cases, it may be possible to use passive restoration to improve channel conditions or upstream fish passage. Passive restoration allows natural processes to restore a site once whatever barrier to those processes is removed. It is less expensive and ultimately can be more effective since the work is accomplished by accommodating, rather than working against, natural processes. One example is the reintroduction of flooding in some areas. Allowing a small impoundment to drain that is no longer being used is another example. Beaver re-introduction, or at least tolerance, may also be an option.

Active restoration may be necessary or desirable in some situations. For example, crossings such as culverts that constrict channels can be removed or modified to not only allow fish passage but also allow for an active channel width. Restoring flow from channelized ditches to their historic channels is another option. In addition, long-term channel restoration includes restoration of riparian areas to provide the tools that, when combined with flow, help to speed along channel formation.

A recent example of a restoration project that reconnected a portion of stream with part of its historic floodplain was a project carried out by the City of Eugene, Army Corps of Engineers and Bureau of Land Management. The project involved removing a portion of the levee on either side of Amazon Creek in West Eugene. The goal of the project is to reestablish the connection between Amazon Creek and wetlands that were adjacent to the channel. Although this was a big budget, multi-agency effort there may be potential for smaller projects like this in other parts of the watershed. Potential exists on the lower Long Tom to reconnect the river with some of its old oxbows and, if landowners were willing, allow flooding of some areas. In order for this to be feasible it would need to be advantageous to both the landowner and the environment, which may mean offering adequate financial incentives. Similar “floodplain reconnection” projects could also be done on a much smaller scale on smaller and even seasonal streams.

Chapter 7 Riparian Zone Conditions

What is a riparian zone?

Early explorers to the Willamette Valley frequently described the landscape in their journals. During his visit to the Valley in 1841, George Emmons wrote: "…at an alt. (altitude) of about 1000 feet – had a grand panorama view…prairie to the south as far as the view extends – the streams being easily traced by a border of trees that grew up on either bank (quoted in Boyd 1986)." As he explored these borders of trees further he must have heard birds calling, insects humming, tree frogs singing, all thriving amid the rich vegetation, oxbow ponds and cool canopy of these riparian forests. Although not all riparian zones resemble the closed canopy "gallery" forests of the Willamette River, they all share some common features. First and foremost, they are defined by the stream or lake they border. Some riparian zones are broad and marshy, a result of seasonal floodwaters lingering during the winter. Other riparian zones consist of a small fringe along a steeply sided, fast moving mountain stream.[16] Each kind of riparian zone has a characteristic assemblage of plants, which share a common ability to tolerate waterlogged roots for a period of time. Common riparian zone plants in the Long Tom Watershed include Oregon ash, big leaf maple, willows, red twig dogwood, vine maple, sedges, rushes and grasses. Other plants, like Douglas fir and western hemlock, are fairly intolerant of submerged roots and consequently are found above the seasonal high water mark.

Riparian zones can provide a variety of benefits or "ecological functions". For example, they are an important place for rearing fish, amphibians and birds because they have an abundance and diversity of food sources. Forested riparian zones provide shade, which prevents streams from heating due to direct sunlight. Trees and branches that fall into the water contribute large woody debris (LWD), which creates cover for fish and helps form pools and trap gravel important for spawning habitat. Leaf litter, seeds, fruit and insects that drop into the water from the riparian zone form the base of the food chain for many streams. Vegetation in riparian zones can also filter out sediment and pollutants during certain times of the year, which prevents them from entering waterways. Finally, the roots of riparian vegetation can stabilize stream banks and help prevent erosion (Watershed Network Professionals 1999, Mitsch & Gosselink 1993, Horne & Goldman 1994).

What did riparian zones used to look like in the Watershed?

The topography and soil types within the Long Tom Watershed, as well as fire and flooding, led to a variety of historic vegetation types along streams and rivers. **Table 7.1** lists the historic vegetation types in the watershed based on 1850 Government Land Office surveys (Christy *et al.*

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[16] It is impossible to draw a precise "line in the sand" as to where a riparian zone ends. Riparian zones are the transition between water's edge and upland. Within them there is a range of soil moisture, soil chemistry and plant types. Riparian vegetation has varying degrees of tolerance to saturated roots and flooding; plants with more tolerance are generally closer to the water, and those with less are farther away. In broader terms, the riparian zone extends as far as stream processes (e.g. flooding, stream flow) influence ecological processes occurring on land adjacent to the stream.

Table 7.1 Historic Vegetation in the Long Tom Watershed

*Historic Vegetation Class	*Associated Plant Species	Ecological Functions Provided
Closed Forest Upland	Dense stands of Douglas fir, chinquapin, western hemlock, bigleaf maple, grand fir, red cedar, yew, ash, red alder, dogwood (understory: vine maple, hazel, red huckleberry, Oregon grape). Riparian zone trees were contiguous with upland forests.	❖ Large woody debris (LWD) ❖ Shade ❖ Habitat for animals, birds, amphibians, insects and other invertebrates adapted to closed canopy forests ❖ Bank stability
Closed Forest Bottomland	Dense ash swamps and swales, red & white alder, willow, bigleaf maple, white oak, black cottonwood. Trees sometimes extended for hundreds of feet away from the stream edge.	❖ Same as for closed forest upland ❖ Predominance of hardwoods is important habitat for some species
Woodland	Widely spaced Douglas fir, white oak, black oak (very brushy understory: vine maple, hazel, briars, bracken fern). Riparian zone trees were contiguous with woodland and upland forests.	❖ Some LWD and shade ❖ Habitat for animals, birds, amphibians, insects and other invertebrates adapted to woodlands ❖ Bank stability
Shrubland	Vine maple, red alder, willow, hazel, salmonberry	❖ Shade for *small* streams ❖ Bank stability ❖ Habitat for birds, animals and other wildlife
Prairie	Wet and dry prairie containing many species of native grasses and wild flowers, scattered ash in wet prairie, vernal pools	❖ Same as for shrubland ❖ Some plants and animals were particularly dependent on prairie habitat
Savanna	Widely spaced trees, either ash, Douglas fir, white oak, black oak, Ponderosa pine or some combination (understory: grasses and wildflowers).	❖ Same as for prairie ❖ Some plants and animals were particularly dependent on savanna habitat
Emergent Wetland	Pond lily, skunk cabbage, wapato & other marsh species	❖ Habitat for wetland animals, birds, amphibians, insects and other invertebrates ❖ Filters sediment from water

*From: Christy *et al*. 1998

1998). This table also lists the key species associated with each historic vegetation type and the ecological functions they provided.

The **Historic Vegetation and Hydric Soils of the Long Tom Watershed map** illustrates the distribution of historic vegetation in the watershed. Riparian zones in the steep, headwater areas had closed canopy forests of conifers and hardwoods (on map: Closed Forest Upland).[17] Streamside vegetation in the foothills was either closed forest upland or woodland. Occasional fires thinned the understory but probably left many of the large trees standing in these areas. Along the valley floor, riparian vegetation was either closed forest bottomland, savanna, shrubland, emergent wetland or prairie. Seasonal fires kept trees and shrubs sparse in many parts of the valley and encouraged the growth of prairie and savanna species. In places where fire had been absent for several years shrubs grew up. In areas with low relief, floodwaters created wide riparian zones consisting of plants tolerant of saturated roots (e.g. native prairie species, emergent wetland plants, ash, bigleaf maple, willow, red twig dogwood, scattered oaks).

Over the last 150 years there have been significant changes to the physical structure and vegetation of riparian zones in the watershed. Stream channelization allows water from winter storms to move downstream more quickly, and consequently has decreased floodplain width in some areas, resulting in a narrower strip of land that supports riparian and wetland vegetation. In some places riparian vegetation was removed in the process of rerouting channels and constructing levees. Past logging sometimes changed the size and type of trees in riparian zones from large conifers to smaller hardwoods. Roads, houses, lawns, urban development and livestock grazing have also changed riparian zones. The cumulative impact of all these activities has reduced the riparian zone's ability to provide habitat, shade, and woody material to the stream.

This chapter explores several questions relating to current riparian zone conditions in the Long Tom Watershed. First, ***how do current riparian zone conditions compare to historic ones*****?** More specifically, ***what ecological functions did these historic riparian zones provide and do current riparian zones still provide these functions*****?** A second and related question is, ***which riparian areas are in most need of restoration based on their loss of ecological function*****?**

How did we characterize current riparian zones?

In order to assess the current condition of riparian zones in the Long Tom Watershed, we used aerial photographs[18] to locate and characterize them. We visited over 20 sites that had different types and sizes of vegetation in order to train our eyes to correctly interpret the aerial photos. Our assessment was limited to streams present on 1:24,000 USGS topographic maps, which means very small or seasonal streams were not characterized.

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[17] Conifers are evergreen trees with needles, like Douglas fir. Hardwoods lose their leaves every fall, like bigleaf maple. The term "closed canopy" means that trees are dense enough to prevent much light from reaching the ground under the trees, which influences the type of understory vegetation that can grow.

[18] Photos taken at 12,000 feet in 1994 and 1995. 1" on photo = 1000' on the ground. Most of the photographs we used were color, although only black and white were available for the Upper Amazon Creek sub-basin and the lower portion of the Lower Long Tom sub-basin. Use of aerial photos was generously provided by of the Bureau of Land Management's Eugene District Office and the University of Oregon map library.

Insert historic veg map

We classified and mapped four aspects of riparian zones: 1) width of forested area (if trees were present), 2) vegetation type, 3) vegetation density and 4) size class of trees (if forested). Each aspect influences the ecological functions that section of stream can provide. For example, dense stands of large conifers and hardwoods are often an important component of headwater riparian zones because they provide shade and large woody debris. If the size or density of riparian trees changes, then the ecological functions the riparian zone provides also changes. **Table 7.2** lists the categories for each riparian zone aspect and describes the ecological functions they affect.

Table 7.2 Riparian Zone Attributes and Ecological Significance

Riparian Zone Attributes	Code Categories (in order of appearance in 4-digit code)	Affected Ecological Functions
Width of trees	**N**= none (e.g. concrete) **L**= ≤ 50' **G**= > 50'	A wide band of trees provides habitat for wildlife, insects & amphibians, travel corridors for animals and a sufficient area for LWD recruitment.
Vegetation Type	If trees cover over 50% of the riparian zone then vegetation is classified as either conifers, hardwoods, or mixed. **C**= ≥70 % of trees are conifers **H**= ≥70% of trees are hardwoods **M**= mixed conifer/hardwood **S**= > 50% shrub/brush **G**= > 50% grass **U**= urban (e.g. cement) **W**= wetland	Different types of vegetation provide different types of habitat and food (i.e. closed canopy forests have different plants and animals than prairie or savanna habitat). Also, tree type influences the quality of **large woody debris** (LWD). For example, large conifers are especially valuable as LWD because they are less likely to get washed down stream and take longer to decompose than hardwoods.
Density	**S**= sparse: > 1/3 ground exposed **D**= less than 1/3 ground exposed	Vegetation density influences habitat, the amount of material that falls into the stream (e.g. leaves, twigs, berries, insects, etc.), LWD recruitment potential, bank stability and shade.
Size Class	**S** = small, <12" dbh **M**= medium, ≥ 12" - < 20" dbh **L** = large, ≥ 20" dbh dbh = diameter at breast height	Tree size influences the quality of LWD and the amount of shade they provide. Large and medium conifers and hardwoods are the primary source of LWD.

Because riparian zone conditions can vary significantly up and down the length of a stream, we divided each stream bank into segments. Each segment was unique in that it differed from adjacent segments in its width, vegetation type, density and/or size class. Some segments were very long since these four factors remained relatively consistent for hundreds of yards or more along the stream. In contrast, other segments were very short because one or more of the factors changed.

The **width** category was only measured when trees and/or shrubs were the predominant vegetation immediately next to the stream. The measurement was made from the edge of the stream to 100' out and then classified as either less than 50' or greater than 50'. The reason we measured the width of shrubs and trees was because we were interested in assessing the potential for shade and LWD recruitment. When grass was the predominant vegetation the width was coded as "less than 50 feet", which was most often the case.[19] It is important to note that this measurement does not necessarily define the extent of the riparian zone. This would require field observations to identify species composition and evidence of seasonal flooding, which was not feasible for this assessment.

Within the strip of vegetation used to determine width we characterized the predominant **vegetation type**. For example, if the riparian zone extended 50' from the stream, then the vegetation in that zone was classified according to the categories listed in vegetation type in **Table 7.2**. The outer limit for vegetation classification was 100' even though in some cases the actual riparian zone may have extended farther.

The **density** estimate was made on the strip of vegetation used to determine width. When the vegetation was trees or shrubs, then density characterized the amount of ground that was covered by trees or shrubs. When the vegetation was grass then density characterized the proportion of ground covered by grass (or other vegetation) as opposed to bare ground. For example, when a segment was coded "less than 50', grass, sparse" it meant that over 50% of the vegetation was grass and over 1/3 of the area had exposed soil.

Size class rating only applied to trees. We estimated this by correlating crown size (viewed from the aerial photos) with the tree size class based on diameter. Our field checks allowed us to determine this correlation as well as verify the vegetation type.

Once all of the riparian zone vegetation had been classified and mapped this information was digitized using a computer based mapping program. In this way we could quantify the information that we had mapped and overlap the information on current riparian zone vegetation with information on historic vegetation.

How did we evaluate current riparian zone conditions?

Our evaluation of current riparian zones was based on whether they still provide the ecological functions they provided historically (see **Table 7.1**). Thus, if a current riparian zone section was located in an area that used to be prairie, we evaluated it based on the ecological functions provided by prairie habitat as opposed to forest habitat. This way of evaluating riparian zones

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[19] We chose to do this because it was sometimes difficult to decide where the riparian zone ended when it was grass (although it was obvious where mowed, irrigated or grazed fields abutted the riparian zone). In addition, we initially took the view that width was most significant in respect to shrubs or trees because of the shade and LWD these types of riparian zones provide and thus it was not important to assess the width of predominately grass riparian zones. In retrospect, we should have created a decision rule to differentiate between grass riparian zones that are less than 50' because of human impact vs. grass riparian zones that appear to have no human impact for greater than 50'.

placed a high value on the ecological functions historical conditions provided; an assumption based on the idea that species in the Long Tom Watershed have adapted to and come to rely on the conditions that existed in pre-settlement times. For example, riparian zones along Amazon Creek, which used to be wet prairie, provided habitat for many wetland plants and animals. During the winter, Amazon Creek "…widened into a shallow lake, more than half a mile across (Pioneer Boy)." These annual floods carried and deposited nutrients and sediment onto the floodplain before retreating in late spring. Many types of plants and animals adapted to this cycle. Juvenile fish could hide from predators in the shallow, vegetated floodplain. Waterfowl raised young and feasted on wetland plants and insects. In contrast, riparian zones in the Coast Range foothills provided different kinds of ecological functions. Their towering canopies provided shade, which helped to keep air and water temperatures cool. Large conifers that fell into the stream trapped gravel and slowed stream flow, which benefited native cutthroat trout.

We compared current and historic vegetation by overlaying digitized layers of historic vegetation and current vegetation. We also developed decision rules to rate current riparian vegetation based on how many ecological functions had been retained or lost compared to historic conditions. Our rating scale was 1) low loss of ecological function, 2) moderate loss of ecological function and 3) high loss of ecological function. **Table 7.6** lists the rating for each current combination of width, vegetation, size class and density under each historic vegetation class. The basis for rating current riparian vegetation as low, moderate or high loss of function is also listed.

In addition to rating ecological function, we assessed the potential that current riparian zones had to provide large woody debris (LWD) based on the amount and type of LWD historic vegetation provided. In areas that did not provide significant amounts of LWD historically, such as prairie, savanna or shrubland, we did not rate these areas as having insufficient LWD recruitment potential if there were currently no large trees. Riparian zones that currently have no trees, but used to be closed forest bottomland, closed forest upland and woodland, we rated as not having adequate LWD recruitment potential. In addition, riparian zones that have a forested area extending less than 50' from the edge of the stream and/or were sparse, and used to be in closed forest bottomland or upland, we considered not to have adequate LWD recruitment potential compared to historic times.

Results

An important thing to keep in mind when interpreting these results is that the loss of ecological function described in this chapter only describes function loss from general changes in vegetation (i.e. width of forested area, vegetation type, density and tree size). Loss of ecological function due to changes in channel structure or location, prevention of flooding or loss of certain native species is not taken into account. However, these features play important roles in riparian zone functioning and are discussed in other chapters (i.e. Chapter 6 Channel Modifications, Chapter 2 Ecoregions, Vegetation and Land Use).

Table 7.3 shows the condition of riparian zones in each historic vegetation category across the entire watershed. Riparian zones that used to be in **closed forest bottomland** show the greatest loss of ecological function compared to other historic vegetation types; 108 miles (46%) of these riparian zones have a high loss of ecological function, 94 miles of which is due to the absence of trees. These areas used to have dense stands of hardwoods and bordered medium and large streams such as the Long Tom River and Coyote Creek. Remnants of these forests still exist along these rivers, but they have been greatly reduced.

Table 7.3 Current Ecological Functioning within Historic Vegetation Types

	Closed Forest Bottomland Miles (%)	**Closed Forest Upland** Miles (%)	**Woodland** Miles (%)	**Savanna** Miles (%)	**Prairie** Miles (%)	**Shrubland** Miles (%)	**Emergent Wetland** Miles (%)
Low loss of function	80 (34%)	225 (45%)	140 (67%)	69 (31%)	174 (38%)	2 (17%)	1 (1%)
Moderate loss of function	46 (20%)	224 (45%)	32 (15%)	81 (36%)	251 (55%)	8 (66%)	8 (9%)
High loss of function	108 (46%)	52 (10%)	37 (18%)	74 (33%)	33 (7%)	2 (17%)	0 (0%)
Total miles	234	501	209	224	458	12	9

Riparian zone vegetation in **closed forest upland** is less altered compared to bottomland forests; 52 miles have a high loss of ecological condition, which is also mostly due to a lack of trees. Moderate loss of ecological function in closed forest upland is due to the small diameter of trees on 150 riparian zone miles and the narrowness of the forested area on 58 riparian miles. One aspect of these riparian areas that we could not determine is whether there are more hardwoods (compared to conifers) than in the past. It is likely that some riparian areas in closed forest upland have fewer conifers than they did 150 years ago. During the first 100 years or so of logging, there were no restrictions on cutting in riparian zones; consequently conifers were removed from these areas. Today, state forest practice rules restrict or limit cutting within a certain distance of streams. However, in some places hardwoods now dominate the riparian area, shading out conifer seedlings and making it difficult for them to reestablish. Some local timber companies are promoting the growth of conifers in their riparian areas by removing hardwoods and planting Douglas fir seedlings (Claassen 1998).

Historic woodland covered most of the foothills in the watershed. Woodland generally consisted of widely spaced trees and dense shrub understories. Tree type, size and density was variable, which is fairly similar to current conditions given that 67% of woodland riparian areas have low loss of ecological function. The 37 miles that account for high loss of ecological function are due to a lack of trees and the 32 miles that account for moderate loss are because of the narrowness of the riparian area that is forested.

Savanna and prairie covered a large portion of the watershed in the mid-1800s. The sparsity of trees and shrubs found in prairie and savanna may have been due to a combination of fire, flooding and grazing by deer and elk, which provided a unique kind of habitat that many plants, birds, animals and insects thrived on. For example, acorn woodpeckers benefited from the abundance of acorns produced by large oak trees, as did other cavity nesting birds and animals.[20]

Prairie and savanna have been altered in a number of ways. Many types of grasses and wildflowers were adapted to fire and lack of competition from dense trees and shrubs. Currently, trees or shrubs have invaded many areas that were former prairie or savanna. A decrease in fire from pre-settlement times may have allowed trees and shrubs to colonize riparian and upland areas that were previously kept open by fire. The decrease in flooding associated with settlement may have allowed some low-lying areas to also be invaded by trees and shrubs. The introduction of non-native plant species, either for agriculture, domestic landscaping or erosion prevention (e.g. Reed canary grass) has also altered prairie and savanna.

Dense vegetation in former prairie and savanna riparian areas is the primary reason for moderate and high loss of ecological function ratings in these habitats. In some areas, high densities of conifers or narrow, dense borders of shrubs next to streams is also responsible for a high loss of function rating. When interpreting these results it is important to keep in mind that our assessment of riparian areas was able to discern changes in general vegetation type (i.e. shrubs, conifers, hardwoods or grass) and density. However, we could not determine changes in plant species nor did we account for changes to channel structure or reduction in flooding when rating riparian areas. These factors significantly influenced the ecological functions that riparian zones in prairies and savanna provided in the past. Significantly, most of the streams that are currently affected by flood control, channelization and non-native plant introductions are located in former prairie or savanna. Thus, if one considers these cumulative impacts, the proportion of riparian areas in former prairie and savanna that have a high loss of ecological function is probably much higher than that listed in **Table 7.3**.

Shrubland consisted of "(b)rush fields or thickets established after forest fires, with few or no trees remaining (Christy *et al.* 1998)." The two miles of former shrubland that have a high loss of ecological function are due to a lack of shrubs in the riparian zone and the presence of exposed soil, which indicates a high potential for erosion. Moderate loss of function (9 miles) in former shrubland is due to the narrowness of the riparian area covered by shrubs (i.e. shrubs extend less than 50' from the edge of the stream). In contrast to closed forest bottomland and prairie or savanna riparian areas, there has been a significant increase in riparian areas dominated by shrubs and brush. Historic surveys showed 12 miles of riparian zones being within shrubland. Today, shrubs dominate over 200 miles of riparian zones in the watershed.

Historic emergent wetland included seasonally flooded ponds, sloughs or meadow and Wapato marshes. The reason that most of it is considered to have moderate loss of ecological function is because trees have overgrown these areas. It is not clear whether these riparian segments are forested wetland, or whether they have been filled and then colonized by trees.

Table 7.4 shows the proportion of riparian zone miles in each sub-basin that fall under each ecological function category. Across the entire watershed 42% of riparian zones have low loss of ecological function, 39% have moderate loss of ecological function and 19% have high loss of

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[20] Oak trees produce larger acorn crops when they are less crowded by other trees or shrubs (Alverson pers comm. 1999)

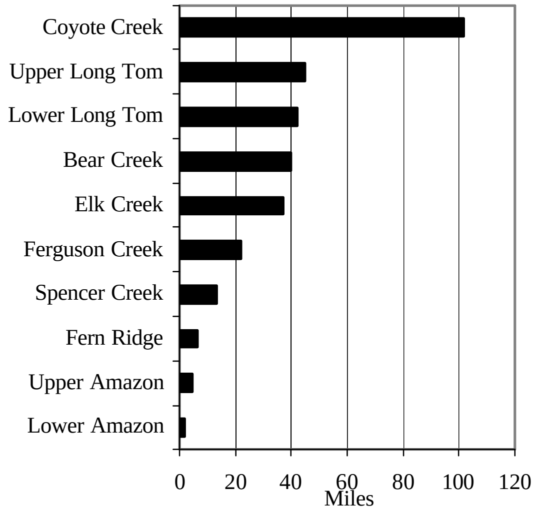
Table 7.4 High, Moderate or Low Loss of Ecological Function by Sub-basin

Sub-basin	**High loss of ecological function** miles (%)	**Moderate loss of ecological function** miles (%)	**Low loss of ecological function** miles (%)
Bear Creek	32 (23%)	45 (32%)	63 (45%)
Coyote Creek	97 (27%)	83 (23%)	182 (50%)
Elk Creek	17 (8%)	107 (50%)	92 (42%)
Ferguson Creek	21 (22%)	37 (39%)	37 (39%)
Fern Ridge	20 (15%)	49 (37%)	64 (48%)
Lower Amazon	15 (14%)	57 (53%)	35 (33%)
Lower Long Tom	45 (25%)	75 (43%)	56 (32%)
Spencer Creek	17 (15%)	51 (47%)	41 (38%)
Upper Amazon	15 (20%)	46 (60%)	15 (20%)
Upper Long Tom	26 (12%)	93 (41%)	106 (47%)
Watershed Total	**305 (19%)**	**643 (39%)**	**691 (42%)**

function. Although there is no formula to determine whether these proportions are bad or good, what these numbers highlight is that a large proportion of riparian zones in our watershed are in some need of protection or restoration *if* we are to maintain the ecological functions that riparian zones provided in the past.

Regardless of how each sub-basin ranks compared to the others, all of them have some loss of function. Understanding the reasons for this can help prioritize protection or improvement of riparian zones within each sub-basin. The high loss of function rating for the Bear Creek, Ferguson Creek, Coyote Creek, Elk Creek, Lower Long Tom and Upper Long Tom sub-basins is primarily due to a lack of trees in riparian areas that used to be densely forested. From an ecological function perspective this means that there is less shade and large woody debris (LWD) available in these sub-basins compared to historic times. **Figure 7.1** shows the miles of current riparian zones that do not provide adequate large woody debris compared to what was available historically.

Figure 7.1 Miles of Riparian Zone with Inadequate LWD Recruitment Potential



In addition to a lack of trees in riparian areas that used to be densely forested, Bear Creek has a particularly high percentage of forested riparian areas that extend less than 50' from the edge of the stream. In the past, these riparian areas have had dense stands of trees that extended well beyond 50' from the stream. These changes have reduced the amount of forested riparian habitat and potential LWD compared to what was historically available.

High loss of function in the Fern Ridge, Spencer Creek and Upper Amazon sub-basins is primarily due to the predominance of dense trees or shrubs in riparian areas that historically were savanna and prairie. Ferguson Creek and Bear Creek also have a fair amount of former savanna and prairie that have filled in with trees and shrubs. In addition to invasion by trees and shrubs, riparian areas in former prairie and savanna may be affected by non-native species and stream channel modifications. Therefore, the vegetation and overall ecological functioning of these areas has probably changed more than the ratings in **Table 7.3** reflect.

Riparian zones in the Upper and Lower Amazon sub-basins have been significantly changed in some areas by urban development. Concrete encases a total of 9 riparian zone miles and exposed soil affects 5 miles in these sub-basins.

Conclusions

The information presented in this chapter is a tool to help us understand which ecological functions have been compromised due to changes in riparian vegetation. The watershed council may use it to help prioritize restoration activities and individual landowners may use it to assess conditions on their own property. In some cases, changing the vegetation back to what it was historically would be very difficult or impractical for some landowners or situations. In other cases, restoration or enhancement could be accomplished through passive restoration or minor enhancement. Understanding the most significant impairments to riparian zone functioning in the Long Tom Watershed and sharing that information is the first step towards improving those conditions. **Table 7.5** summarizes the main ecological function losses in each sub-basin, which should be a focus for restoration or enhancement activities. However, specific restoration siting should be based on a thorough field analysis.

Other factors the council may wish to consider in regards to riparian restoration and enhancement include:

- Prioritize restoration that requires the least effort/money but has significant return. Passive restoration, like allowing trees to grow larger, excluding livestock from riparian zones, and reintroducing flooding in some areas, are some examples.
- Proportionally, savanna and prairie habitat have been the most altered compared to historical times. Removing shrubs in former prairie or savanna may be feasible for some landowners. Also, preventing noxious weeds, like Reed canary grass, to take over areas that have not already been heavily invaded is a possibility. Prescribed burning may be an option in some cases.
- Tree planting, although expensive and time consuming to maintain, is a long-term restoration activity that is warranted in this watershed, given the proportion of former closed forest bottomland and upland where trees are absent.

Table 7.5 Priority Riparian Zone Function Losses

Sub-basin	Vegetation Change
Bear Creek	• Lack of trees in former CFB • Narrow width of forested riparian zones in former CFB, CFU & WOOD • Dense vegetation in former savanna & prairie
Coyote Creek	• Lack of trees in former CFB, CFU & WOOD • Narrow width of forested riparian zones in former CFB, CFU & WOOD • Dense vegetation in former savanna & prairie
Elk Creek	• Lack of trees in former closed former CFU & WOOD • Narrow width of forested riparian zones in former CFU • Dense vegetation in former prairie
Ferguson Creek	• Lack of trees in former CFU • Narrow width of forested riparian zones in CFB • Dense vegetation in former savanna & prairie
Fern Ridge	• Lack of trees in former WOOD & CFU • Dense vegetation in former savanna & prairie
Lower Amazon	• Concrete replacing former riparian zone • Dense vegetation in former savanna & prairie
Lower Long Tom	• Lack of trees in former CFB • Narrow width of forested riparian zones in CFB • Dense vegetation in former savanna & prairie
Spencer Creek	• Lack of trees in former CFU & WOOD • Narrow width of forested riparian zones in CFU • Dense vegetation in former savanna & prairie
Upper Amazon	• Lack of trees in former CFB • Concrete replacing former riparian zone • Dense vegetation in former savanna & prairie
Upper Long Tom	• Lack of trees in former CFU • Narrow width of forested riparian zones in CFU • Dense vegetation in former savanna & prairie

CFB= closed forest bottomland, CFU= closed forest upland, WOOD= woodland

Table 7.6 Decision Matrix for Determining Ecological Function of Current Riparian Zones Based on Historic Vegetation

	Historical Condition: Closed Forest Upland	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/conifer/dense/large	Closely resembles historic conditions: Dense forests of medium/large conifer or hardwood
	Greater than 50'/conifer/dense/medium	
	Greater than 50'/mixed/dense/large	
	Greater than 50'/mixed/dense/medium	
	Greater than 50'/hardwood/dense/medium	
	Greater than 50'/wetland/dense	Some isolated pockets of forested wetlands or swamps were found in forested uplands.
	Greater than 50'/wetland/sparse	
Moderate loss of function	Less than 50'/conifer/dense/large	Narrow width of forested area
	Less than 50'/conifer/dense/medium	
	Less than 50'/mixed/dense/large	
	Less than 50'/mixed/dense/medium	
	Less than 50'/hardwood/dense/medium	
	Less than 50'/hardwood/dense/small	Narrow width of forested area, small diameter of trees
	Less than 50'/mixed/dense/small	
	Greater than 50'/mixed/dense/small	Small diameter of trees
	Greater than 50'/conifer/dense/small	
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/conifer/sparse/large	Sparsity of trees
	Greater than 50'/conifer/sparse/medium	
	Greater than 50'/hardwood/sparse/medium	
	Greater than 50'/mixed/sparse/medium	
	Greater than 50'/mixed/sparse/small	Sparsity of trees, small diameter of trees
	Greater than 50'/hardwood/sparse/small	
	Greater than 50'/conifer/sparse/small	
High loss of function	Less than 50'/conifer/sparse/medium	Narrow width of forested area, sparsity of trees
	Less than 50'/hardwood/sparse/medium	
	Less than 50'/mixed/sparse/medium	
	Less than 50'/conifer/sparse/small	Narrow width of forested area, sparsity of trees, small diameter
	Less than 50'/hardwood/sparse/small	
	Less than 50'/mixed/sparse/small	
	Greater than 50'/shrub-brush/dense	No trees
	Greater than 50'/shrub-brush/sparse	
	Less than 50'/shrub-brush/dense	
	Less than 50'/shrub-brush/sparse	
	Less than 50'/grass/dense	
	None/urban	No vegetation/concrete
	Less than 50'/grass/sparse	No trees, exposed bare ground

	Historical Condition: Closed Forest Bottomland	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/mixed/dense/medium	Closely resembles historic conditions: Dense stands of medium/large hardwood, with occasional conifers.
	Greater than 50'/mixed/dense/large	
	Greater than 50'/hardwood/dense/medium	
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/mixed/dense/small	
	Greater than 50'/wetland/sparse	Forested wetlands were a common feature of these areas
	Greater than 50'/wetland/dense	
Moderate loss of function	Less than 50'/mixed/dense/large	Narrow width of forested area
	Less than 50'/mixed/dense/medium	
	Less than 50'/mixed/dense/small	
	Less than 50'/hardwood/dense/medium	
	Less than 50'/hardwood/dense/small	
	Greater than 50'/conifer/dense/large	No hardwoods
	Greater than 50'/conifer/dense/medium	
	Greater than 50'/conifer/dense/small	
	Greater than 50'/shrub-brush/dense	No trees
	Greater than 50'/hardwood/sparse/medium	Sparsity of trees
	Greater than 50'/hardwood/sparse/small	
	Greater than 50'/mixed/sparse/medium	
	Greater than 50'/mixed/sparse/small	
High loss of function	Less than 50'/shrub-brush/dense	Narrow width of area in shrub, no trees
	Less than 50'/shrub-brush/sparse	Narrow width of area in shrub, no trees, sparsity of shrubs
	Less than 50'/hardwood/sparse/medium	Narrow width of forested area, sparsity of trees
	Less than 50'/hardwood/sparse/small	
	Less than 50'/mixed/sparse/medium	
	Less than 50'/mixed/sparse/small	
	Less than 50'/conifer/dense/large	Narrow width of forested area, no hardwoods
	Less than 50'/conifer/dense/medium	
	Less than 50'/conifer/sparse/medium	Narrow width of forested area, sparsity of trees, no hardwoods
	Less than 50'/conifer/sparse/small	
	Greater than 50'/conifer/sparse/large	No hardwoods, sparsity of trees
	Greater than 50'/conifer/sparse/medium	
	Greater than 50'/conifer/sparse/small	
	Less than 50'/grass/dense	No trees
	None/urban	No trees, concrete
	Less than 50'/grass/sparse	No trees, exposed bare ground
	Greater than 50'/shrub-brush/sparse	No trees, sparse vegetation

	Historical Condition Three: Savanna	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/conifer/sparse/large	Similar to savanna habitat: widely spaced trees amid prairie grasses and wildflowers. Tree density was low and shrubs were scarce because of frequent fire. Trees extended beyond 50' from edge of stream.
	Greater than 50'/conifer/sparse/medium	
	Greater than 50'/hardwood/sparse/medium	
	Greater than 50'/hardwood/sparse/small	
	Greater than 50'/mixed/sparse/medium	
	Greater than 50'/mixed/sparse/small	
	Greater than 50'/conifer/sparse/small	
	Less than 50'/grass/dense	
	Greater than 50'/wetland/dense	Small pockets of wetlands within savanna
	Greater than 50'/wetland/sparse	
Moderate loss of function	Greater than 50'/hardwood/dense/medium	Density of trees
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/mixed/dense/large	
	Greater than 50'/mixed/dense/medium	
	Greater than 50'/mixed/dense/small	
	Greater than 50'/shrub-brush/sparse	Shrubs dominate
	Less than 50'/shrub-brush/sparse	
	Less than 50'/hardwood/sparse/small	Narrow width of forested area
	Less than 50'/mixed/sparse/medium	
	Less than 50'/mixed/sparse/small	
	Less than 50'/conifer/sparse/medium	
	Less than 50'/conifer/sparse/small	
	Less than 50'/hardwood/sparse/medium	
High loss of function	Greater than 50'/conifer/dense/large	Dense conifers
	Greater than 50'/conifer/dense/medium	
	Greater than 50'/conifer/dense/small	
	Less than 50'/grass/sparse	Exposed soil
	Greater than 50'/shrub-brush/dense	Shrubs dominate, density of vegetation
	Less than 50'/shrub-brush/dense	
	Less than 50'/hardwood/dense/medium	Narrow width of forested area, density of trees
	Less than 50'/hardwood/dense/small	
	Less than 50'/conifer/dense/large	
	Less than 50'/conifer/dense/medium	
	Less than 50'/mixed/dense/large	
	Less than 50'/mixed/dense/medium	
	Less than 50'/mixed/dense/small	
	None/urban	No vegetation/concrete

	Historical Condition: Woodland	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/mixed/dense/medium	Closely resembles historic conditions: Widely spaced hardwoods or conifers; generally with a very brushy understory.
	Greater than 50'/mixed/dense/large	
	Greater than 50'/hardwood/dense/medium	
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/mixed/dense/small	
	Greater than 50'/hardwood/sparse/medium	
	Greater than 50'/hardwood/sparse/small	
	Greater than 50'/mixed/sparse/medium	
	Greater than 50'/mixed/sparse/small	
	Greater than 50'/conifer/dense/large	
	Greater than 50'/conifer/dense/medium	
	Greater than 50'/conifer/dense/small	
	Greater than 50'/conifer/sparse/large	
	Greater than 50'/conifer/sparse/medium	
	Greater than 50'/conifer/sparse/small	
	Greater than 50'/wetland/sparse	Some forested wetlands were found in these areas.
	Greater than 50'/wetland/dense	
Moderate loss of function	Less than 50'/mixed/dense/large	Narrow width of forested area
	Less than 50'/mixed/dense/medium	
	Less than 50'/mixed/dense/small	
	Less than 50'/hardwood/dense/medium	
	Less than 50'/hardwood/dense/small	
	Less than 50'/conifer/dense/large	
	Less than 50'/conifer/dense/medium	
	Less than 50'/conifer/sparse/medium	
	Less than 50'/conifer/sparse/small	
	Less than 50'/hardwood/sparse/medium	
	Less than 50'/hardwood/sparse/small	
	Less than 50'/mixed/sparse/medium	
	Less than 50'/mixed/sparse/small	
High loss of function	Less than 50'/shrub-brush/dense	Narrow width of area in shrub, no trees
	Less than 50'/shrub-brush/sparse	
	Less than 50’/grass/dense	No trees
	Less than 50’/grass/sparse	No trees, exposed ground
	Greater than 50’/shrub-brush/sparse	No trees
	None/urban	No vegetation/concrete

	Historical Condition: Prairie	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/conifer/sparse/large	Similar to prairie habitat; trees, which were generally hardwood, were widely spaced, understory vegetation was dominated by grasses, wildflowers and sometimes bracken fern.
	Greater than 50'/conifer/sparse/medium	
	Greater than 50'/hardwood/sparse/medium	
	Greater than 50'/hardwood/sparse/small	
	Greater than 50'/mixed/sparse/medium	
	Greater than 50'/mixed/sparse/small	
	Greater than 50'/conifer/sparse/small	
	Less than 50'/grass/dense	
	Less than 50'/hardwood/sparse/medium	
	Less than 50'/conifer/sparse/small	
	Greater than 50'/shrub-brush/sparse	
	Less than 50'/shrub-brush/sparse	
	Less than 50'/hardwood/sparse/small	
	Less than 50'/mixed/sparse/medium	
	Less than 50'/mixed/sparse/small	
	Less than 50'/conifer/sparse/medium	
	Greater than 50'/wetland/sparse	Pockets of wet prairie and vernal pools were common in prairie habitat
	Greater than 50'/wetland/dense	
Moderate loss of function	Greater than 50'/shrub-brush/dense	Density of shrubs
	Less than 50'/shrub-brush/dense	
	Greater than 50'/hardwood/dense/medium	Density of trees
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/mixed/dense/large	
	Greater than 50'/mixed/dense/medium	
	Greater than 50'/mixed/dense/small	
	Less than 50'/hardwood/dense/medium	
	Less than 50'/hardwood/dense/small	
	Less than 50'/mixed/dense/large	
	Less than 50'/mixed/dense/medium	
	Less than 50'/mixed/dense/small	
High loss of function	Greater than 50'/conifer/dense/large	Density of trees, no hardwoods
	Greater than 50'/conifer/dense/medium	
	Greater than 50'/conifer/dense/small	
	Less than 50'/conifer/dense/large	
	Less than 50'/conifer/dense/medium	
	Less than 50'/grass/sparse	Exposed soil
	None/urban	No vegetation/concrete

	Historical Condition: Shrubland	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Greater than 50'/hardwood/dense/small	Provides similar functions to historic conditions
	Greater than 50'/mixed/dense/medium	
	Greater than 50'/wetland/dense	Small pockets of wetlands within shrubland
Moderate loss of function	Less than 50'/shrub-brush/sparse	Narrow width of area covered by shrubs
	Less than 50'/shrub-brush/dense	
	Less than 50'/hardwood/sparse/small	Narrow width of forested area
	Less than 50'/hardwood/dense/small	
	Less than 50'/mixed/dense/medium	
	Less than 50'/grass/dense	No shrubs
High loss of function	Less than 50'/grass/sparse	Exposed soil

	Historical Condition: Emergent Wetland	
	Current Riparian Zone Condition	**Basis for Decision**
Low loss of function	Less than 50'/grass/dense	No infilling by trees or shrubs
	Greater than 50'/wetland/dense	Small pockets of wetlands within savanna
Moderate loss of function	Less than 50'/shrub-brush/sparse	Infilling of shrubs
	Greater than 50'/shrub-brush/dense	
	Less than 50'/shrub-brush/dense	
	Greater than 50'/hardwood/dense/medium	Infilling of trees
	Greater than 50'/hardwood/dense/small	
	Greater than 50'/mixed/dense/small	
	Greater than 50'/conifer/dense/medium	
	Less than 50'/hardwood/dense/small	

Chapter 8 Wetland Types, Distribution and Functions

What are wetlands?

Wetlands form in the presence of two key factors: 1) a source of water and 2) hydric soils (i.e. soils that drain very slowly, like clays). The sources of water supplying wetlands vary. "Most are in low lying areas that collect rain and runoff. Some are in places where the groundwater is at or near the surface and so are fed from below. Others are near rivers or other bodies of water that regularly overflow their boundaries (Windham *et al.* 1996)." Beaver dams can also form wetlands by backing up streams and causing water to flood the land behind them. The combination of a water supply and hydric soils leads to saturated (i.e. water-logged) soils during part or all of the growing season. These conditions favor the growth of wetland plants, which have special adaptations that allow them to survive in soils that are saturated during portions of the growing season (Mitsch & Gosselink 1993).

How do they function ecologically?

Wetlands in this watershed provide ecological functions that benefit many species, including humans. Wetlands can:

- slow the flow of runoff after storms, which can reduce flooding downstream and improve water quality by giving time for suspended sediment to settle out and nutrients to be taken up by wetland plants. (In fact, an area of forested wetland is being restored near Veneta and will be tested for its ability to "polish" the summertime secondary effluent of the Veneta sewage treatment plant.).
- provide habitat for wetland plant species that are specifically adapted seasonally or permanently saturated soils (e.g. Bradshaw's lomatium, tufted hairgrass).
- provide winter habitat for fish, amphibians and invertebrates
- enhance groundwater recharge by giving surface water more time to percolate down to aquifers (Watershed Professionals Network 1999).

What types of wetlands are in the Long Tom Watershed?

There are three general categories of wetland in the watershed: lacustrine, riverine and palustrine. Lacustrine wetlands include freshwater lakes, reservoirs and ponds. Wetland plants are either completely submerged or float on the surface of the water throughout the entire year. Riverine wetlands are contained within a stream channel. Because of continuous or occasional strong currents and/or shifting channel locations these areas generally have non-permanent vegetation (Morlan 1990).

Palustrine wetlands in this watershed include freshwater marshes, vernal pools and wet prairie. Trees, shrubs or emergent plants (e.g. grasses, wildflowers, reeds, bulrushes) typically dominate this wetland type (Morlan 1990). The amount of time they are inundated with water ranges from temporary seasonal pools that dry up in May or June to permanent water bodies that never completely dry. In addition, the depth to which water saturates or inundates the ground varies from sub-surface to standing water. On the following page are brief descriptions of the main palustrine wetlands in the watershed.

Wet Prairie: Wet prairie is characterized by highly impermeable clay soils that cause seasonal ponding of water but, but not significant inundation (i.e. deep standing water). Tufted hairgrass is a key, native indicator species of these wetlands. "Some sites (in the watershed) support a diverse, high quality native wet prairie plant community, while other sites, due to their history of disturbance, support only tufted hairgrass and a variety of non-native grasses and forbs (Alverson 1992, 3)." In addition, trees (particularly Oregon ash) and shrubs have invaded many sites (Alverson 1992). Therefore, some of the sites identified as scrub-shrub in the National Wetlands Inventory data presented in the next section may be historic wet prairie.

Emergent Wetland: Emergent wetland includes vernal pools and marshes that are inundated from several weeks of the year to permanently. Plants that are typically found in wetlands that are inundated during parts of the year include spike rush, pennyroyal, cattail, softstem bulrush and reed canary grass. Sites with permanent standing water often have floating aquatic plants (Alverson 1992).

Forested Wetlands: "Oregon ash is the most common tree of the forested wetlands, though other species, including black cottonwood, Pacific willow, Oregon white oak and even ponderosa pine may be found…. (O)ften associated with these tree species are numerous species of small trees or tall shrubs…include(ing) hawthorn, serviceberry and cascara. (The) hydrology of most forested wetlands is similar to the wet prairie (Alverson 1992, 4)."

Scrub-shrub Wetlands: Scrub-shrub wetlands in this area are typically dominated by spiraea, willows, rose, hawthorn and serviceberry (Alverson 1992). They often represent former wet prairie that is being invaded by woody plants.

Table 8.1 shows the acres of different wetland types that are shown on the **National Wetlands Inventory (NWI) map**. Only a portion of the NWI maps for the watershed have been digitized (i.e. converted into a computerized form, which can be used with geographical information systems (GIS)). The area highlighted in blue on the inset map (upper right corner) indicates the current extent of *digital* NWI maps. Fortunately, this area includes the majority of wetlands in the watershed.

Most of the wetlands are located in the low gradient, low elevation portion of the watershed. Smaller wetlands also exist in low gradient areas at higher elevations in the watershed (although these are not shown on the map). The 6,591 acres of lacustrine wetland are primarily Fern Ridge Reservoir. Historically, deepwater wetlands were not common in the watershed. One exception is Clear Lake, which is connected to the Amazon Creek drainage. Oxbow ponds, formed by abandoned sections of the Long Tom River when it was channelized in the 1940s, also provide lacustrine and emergent wetland habitat.

Insert NWI map

Table 8.1 Acreage of Digitally Mapped Wetlands

Wetland Type	Total Acres[21]	Acres diked or impounded	Acres partially drained/ditched	Acres excavated
Riverine (i.e. contained within a stream channel)	1,137	0	0	378
Lacustrine (e.g. lakes, reservoirs, ponds)	6,591	6,591	0	0
Emergent (includes palustrine emergent & aquatic bed/ unconsolidated bottom, and some wet prairie)	5,961	2,619	421	496
Forested	3,207	424	0	10
Scrub-shrub	566	145	0	49
Watershed total	17,461	9,779	421	933

Around the perimeter of Fern Ridge reservoir, especially the eastern edge, are extensive emergent wetlands and some shrub and forested wetlands. These are connected to the West Eugene Wetlands, an area that is currently managed by the Bureau of Land Management, Nature Conservancy and City of Eugene. The West Eugene Wetlands contain some of the best remaining examples of wet prairie in the entire Willamette Valley. Many other isolated pockets of wetlands are scattered throughout the watershed, often near the main stems of the larger tributaries such the Long Tom, Coyote Creek, Spencer Creek, Bear Creek and Ferguson Creek.

Agriculture and urban development have altered a large percentage of wetlands in the watershed, which is reflected in the acres of wetland that have been diked, drained and excavated. Historic wet prairie, which once covered over 30,000 acres in the watershed, has been the most altered and diminished. For example, 2,619 acres of emergent wetland have been diked or impounded; a large percentage of this probably reflects the dikes along the lower Long Tom River, which separate the river from its historic wetland floodplain.

Local Wetland Inventories

Extensive wetland surveys have occurred in west Eugene and near the City of Veneta. The Veneta wetland inventory, conducted in 1998, assessed wetlands within Veneta's urban growth boundary, and land to the northwest of the city along the Long Tom River. Many of the wetlands surveyed are near the Long Tom River and the North Fork of Coyote Creek. A total of 22 wetland units, totaling approximately 200 acres, were surveyed. A map of the surveyed area and wetland parcels can be found in the *City of Veneta Natural Resource Study* (Lane Council of Governments 1999a).

Wetlands were surveyed using the 1996 Oregon Freshwater Wetland Assessment Methodology. This method ranks wetlands according to the ecological functions they provide and their educational value. Ecological functions include a diversity of wildlife habitat, intact fish habitat,

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[21] The area of wetlands that were featured as lines on NWI maps were calculated by assuming a width of 10 ft. and multiplying this by the length of the wetland. Square feet were subsequently converted to acres. Based on this method of calculation there were 696 acres of "linear" wetlands.

intact water quality and intact hydrologic control (hydrologic control refers to the wetlands ability to slow storm water runoff and thus reduce flooding downstream). Surveyors may also need to consider whether the wetland contains any rare plants or threatened/endangered species, and whether the wetland has a direct connection with a stream supporting salmonids (Lane Council of Governments 1999a).

Table 8.2 shows the summary results for the survey. Of the 203 acres surveyed, 180.5 acres were considered locally significant based on the fact that they received a high score (i.e. 1) for at least one of the ecological functions they provide. Eighty-five percent of the acres surveyed had a high score for intact water quality, 80% for intact hydrologic control, 60% for diverse wildlife habitat and 6% for intact fish habitat.

Table 8.2 Veneta Local Wetlands Inventory Determination of Locally Significant Wetlands

Wetland unit	Acres	Artificially created (acres)	Diverse wildlife habitat	Intact fish habitat	Intact water quality	Intact hydrologic control	Locally significant
A	16.31	13.86	2	2	2	2	No
B	27.61	1.44	2	2	1	1	Yes
C	3.94	No	2	NA	1	1	Yes
D	0.56	No	2	NA	3	3	No
E	96.49	No	1	2	1	1	Yes
F	3.46	2.41	2	2	2	2	No
G	8.08	6.46	2	NA	1	2	Yes
H	0.58	No	2	2	2	2	No
I	0.09	No	2	2	2	3	No
J	0.2	No	2	NA	2	2	No
K	0.45	No	2	NA	2	1	Yes
L	0.67	No	2	2	1	2	Yes
M	9.34	No	2	2	1	1	Yes
N	13.3	No	1	1	1	1	Yes
O	2.53	No	2	2	1	2	Yes
P	7.45	No	2	2	2	1	Yes
Q	1.27	No	2	2	2	2	No
R	1.64	No	1	2	1	2	Yes
S	3.85	No	1	2	1	1	Yes
T	4.89	No	1	2	1	2	Yes
U	nd	No	2	2	1	2	Yes
V	1.07	No	1	2	1	1	Yes

Source: Lane Council of Governments 1999a
Rating: 1 – 3; 1 indicates highest value
nd= acreage not determined

“The West Eugene Wetlands Project is a cooperative venture managed by the Eugene District Bureau of Land Management to protect and restore wetland ecosystems in the Southern Willamette Valley (Bureau of Land Management *et al.* 1997, 1).” This management area includes wetland within the lower Amazon Creek and Coyote Creek sub-basins. Key goals of this project are protecting scarce remnants of Willamette Valley wet prairie and other endangered plant communities, improving habitat for invertebrates, birds and wildlife, and providing environmental education opportunities. Activities have included extensive surveying of wetland (over 1,500 acres) to determine wetland functions and values, purchasing wetland, and enhancing or restoring wetland. As of 1999, the Bureau of Land Management, City of Eugene, Nature Conservancy, Lane County and Oregon Department of Transportation collectively own almost 2000 acres of protected wetland in West Eugene (Bureau of Land Management 1999, Lane Council of Governments 1997). Approximately 66 acres have been restored or enhanced as of December 31, 1998 (City of Eugene Public Works 1999, 48). Restoration methods primarily consist of excavation of fill in former wetland sites, restoring hydrologic connections if necessary and reseeding with native grasses and wildflowers. Enhancement generally entails removing non-native plants followed by re-seeding in order to improve the growth of native species (Hoover pers comm. 1999).

Wetland types in the West Eugene area include wet prairie, emergent/open water, scrub-shrub, forested, farmed wetlands and old pastures. These wetlands provide a variety of ecological functions (see p. 8-1) and provide habitat for a number of listed species or species proposed for listing on state or federal threatened or endangered species lists (see **Table 8.3**). Extensive information on quality and functioning of individual wetland sites can be found in several survey publications (Lev & Zika 1988, City of Eugene Planning & Development 1993).

Table 8.3 Listed and Proposed Species Found in or near the West Eugene or Veneta Wetlands

Plant Species	**State Listing**	**Federal Listing**
Bradshaw's lomatium	Endangered	Endangered
Willamette daisy	Endangered	*Endangered
White-top aster	Threatened	Species of concern
Shaggy horkelia	Candidate	Species of concern
Kincaid's lupine	Threatened	*Threatened
Howell's montia	Candidate	Species of concern
Insects, Amphibians and Birds		
Fender's blue butterfly	Potential Endangered	*Endangered
Western pond turtle	Critical Species	Species of concern
Painted turtle	Critical Species	No status
Northern red legged frog	Vulnerable Species, Undetermined	Species of concern
Bald eagle	Threatened	Threatened

(Sources: Lane Council of Governments 1999a, Oregon Natural Heritage Program 1999)
*Updated with current listings, January 26, 2000

These local wetland inventories highlight some key issues concerning wetlands and wetland protection in the watershed:

- There are still high value wetlands within the watershed, which present protection and enhancement opportunities.
- Many wetlands have been filled by agricultural and urban development activities; some of these may have the potential for enhancement or restoration.

- There are a number of threatened, endangered and candidate species and species of concern that rely on wetlands in this watershed.
- An exceptional amount of local expertise exists in wetland assessment, planning and protection, which is a unique asset to the council.

Historic Wetland Conditions

Historic wetlands are estimated to have covered over 40,000 acres in the watershed. **Table 8.4** lists the estimated acres of each historic wetland type. These calculations were based on the location and amount of hydric soil. The map on page 7-4 (Chapter 7) indicates the distribution of hydric soils with brown, diagonal lines overlaying the historic vegetation. As described at the beginning of this chapter, hydric soils and a source of water are the key components characterizing wetlands. The source of water for these wetlands was precipitation, groundwater discharge, overland flow and the seasonal flooding of the Willamette River, Amazon Creek, Coyote Creek and Long Tom River.

Table 8.4 Historic Wetlands in the Long Tom Watershed[22]

Wetland Type	**Acres**
Wet prairie	34,570
Forested (includes upland and bottomland)	6,164
Scrub-shrub	322
Emergent & open water	310
Total	**41,366**

Wet prairie was the dominant kind of wetland historically (approximately 85%). Today, it is the least common. There are *approximately* 1000 acres of wet prairie in the watershed (estimate based on local wetland inventories and professional judgement), about 600 of which are in the West Eugene Wetlands (Alverson pers comm.1999). Significantly, the acreage in the Long Tom watershed probably represents more than half of what exists in the entire Willamette Valley today. Most known wet prairie sites are on public land, although additional sites probably exist on private land.

“The wet prairie community was historically maintained by fire, but with fire suppression, many sites have been invaded by trees (particularly Oregon ash) and shrubs (Alverson 1992).” In addition, large portions of former wet prairie have been converted to farmland and pasture. In some places tile drains (i.e. porous pipes buried in the ground) allow these areas to be farmed by draining saturated soils more quickly. Grazing in some places has altered the plant composition from native wet prairie species to non-native plants well adapted to disturbed soil.

> Some examples of the non-native species commonly found in these sites include velvet grass (*Holcus lanatus*), redtop (*Agrostis tenuis*), tall fescue (*Festuca arundinacea*), oxeye daisy (*Chrysanthemum leucanthemum*), St. John’s wort (*Hypericum perforatum*), and parentucellia (*Parentucellia viscosa*). Without direct intervention, most native wet prairie species will never become established in such sites. Similar weedy vegetation is found on sites where fill has been placed in wetlands (such as filling old log ponds) or the

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[22] GIS was used to calculate the amount of hydric soils within each historic vegetation category.

> soil surface has been mechanically altered, but wetland hydrological conditions are still present. All these sites would…be appropriate candidates for restoration to re-establish native vegetation (Alverson 1992).

Historic scrub-shrub wetlands were often willow swamps caused by beaver dams. Many of these were located at the base of streams draining the coast range such as Bear Creek, Ferguson Creek, Elk Creek and the upper Long Tom River. Forested swamps were extensive under what is now Fern Ridge Reservoir. Many of these were ash swamps, sometimes with willow and alder (Christy *et al.* 1997).

Conclusions

Wetlands were once a significant element of the Long Tom Watershed's environment. Their extent is evident from current knowledge of hydric soil distribution, historic vegetation, and accounts given by early explorers to the area. Although wetlands played an integral role in the ecological processes occurring in the watershed, they were generally viewed as a nuisance to travelers and homesteaders and a waste of potentially useful land. The effort to drain and convert these wetlands to farmland and urban areas was considerable.

Historically, wetlands in this watershed influenced the intensity of peak flows during floods and provided thousands of acres of wildlife habitat. Groundwater recharge and water quality enhancement were also likely functions of many wetlands in the area. Fire played a key role in shaping the kind of wetland habitat that was available to plants and animals in some parts of the watershed. A reduction in both wetland extent and possibly fire has thus reduced the kind of habitat these conditions created.

As council members decide how to use this information here are some key points to consider:

- Wetland enhancement and restoration has the potential to offer numerous benefits to humans and other species.
- Wetland restoration adjacent to streams will also serve to improve riparian zone conditions and provide winter fish habitat.
- Although extensive wetland surveys have been conducted in west Eugene and the Veneta area, the rest of the watershed only has information provided from the National Wetlands Inventory (NWI). NWI information is based on aerial photo interpretation. Some types of wetland are difficult to identify with this method (e.g. wet prairie) and wetlands under two acres are not classified (Alverson pers comm1999).
- There are currently no proposed plans for wetland assessment, protection or restoration for areas outside of West Eugene, Fern Ridge and Veneta.
- Wet prairie is the most endangered habitat in the entire Willamette Valley; the Long Tom Watershed currently has the largest amount of remaining wet prairie compared to other 5th field watersheds in the Willamette Basin.
- A great deal of local expertise on wetland surveying, planning and protection exists, due to the long-term work on the West Eugene Wetlands Program. This may be highly valuable to council members if they are considering wetland enhancement or restoration on their property. The council might also consider soliciting input from local experts on how to prioritize council sponsored actions related to wetlands.

Chapter 9 Sediment Sources

Erosion that occurs near streams and on surrounding slopes is a natural part of any watershed. Fish and other aquatic organisms in a region are adapted to deal with a range of sediment amounts that enter streams under normal ranges of disturbance. The amount of erosion in a watershed and the sediment load in the streams vary considerably during the year, with most sediment moving during the few days that have the highest flows.

In addition, to natural levels of erosion, human-induced erosion can occur. Separating human-induced erosion from natural erosion can be difficult because of the highly variable nature of natural erosion patterns. While 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, 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, VI-3).

What natural features in the watershed affect sediment delivery to streams?

Slope: High gradient areas are limited to the forested fringe surrounding the watershed, specifically, the headwaters in the Coast Range and the hills surrounding Coyote Creek. Steep slopes increase the risk of landslides and the amount of sediment that washes off roads in these areas.

Soil type: The erodibility of soils largely depends on their texture. Soils with a high clay or sand content are less erodible than soils with a large proportion of silt (Luce & Black 1999).

Precipitation: Heavy precipitation can contribute to sediment delivery in two significant ways: 1) increasing runoff in roadside ditches and 2) saturating soils to the point at which they lose their cohesion and begin sliding (Slope and soil properties are very important in determining how much sliding occurs).

Vegetation: Vegetative cover decreases sediment delivery to streams from surface erosion. Also, well-developed root networks can decrease the potential for landslides (Burroughs & King 1999).

Potential Sources of Human Caused Sediment Delivery to Streams

Rural Road Instability

Rural roads include those located within land used for forestry, agriculture and rural homes. Rural road instability consists of wash outs or road failures and mainly occurs in steeper areas.

> Improper maintenance of inboard road ditches can cause saturation of the roadbed, leading to mass wasting [i.e. landslides]. Road washouts also can occur when a road adjacent to the stream is undercut and a portion of the road drops into the stream, or at stream crossings during a high flow where there was either an undersized or plugged culvert or bridge. In steeper terrain, road washouts can create shallow landslides on unstable fill or cut-slope failures (Watershed Professionals Network 1999, 20)

Public agencies that maintain rural roads in this watershed are the Oregon Department of Transportation (ODOT), the Bureau of Land Management (BLM) and Lane County. Reports of rural road instability during the past several years from these sources include:

- Road wash out on Highway 36 near Alderwood State Park. "Less than 10 yards of material fell into the Long Tom at that point. This was repaired with rock fill. The cause of the slip was thought to be where an alder tree was under washed in high water and then fell into the creek causing the debris around the root system to destabilize the bank (Joll pers. comm. 1999)."
- Road bank slippage at several places along Highway 126 near the causeway channel of Coyote Creek. "This (has been) an ongoing problem for several years and has been repaired several time. An estimate of 50 plus yards of material have been lost at these sites. When there is a high water event there are several places that water will go across the road (Joll pers. comm 1999)."
- After the 1996 floods there were over a dozen sites on state highways where water ran across the road and did damage to the shoulder. "An estimate of over 1000 yards of material was needed to rebuild those areas and a lot of material was recovered from the ditch (Joll pers comm. 1999)."
- The Bureau of Land Management reported needing to repair two road failures because of flooding during 1996. In one case, 400 yards of slide material was removed from the ditch and a new culvert was installed. In the other case a culvert was replaced and rock fill was placed on a road bank that was slipping. Neither of these sites was adjacent to a stream and no slide material entered streams directly. Some sediment may have reached streams further down the slope via road ditches (Bureau of Land Management 2000).

These examples provide only a snapshot of the types of road failures in the watershed. Because most forestlands in the watershed are in private ownership, the majority of road washouts and instability happens on private land. In some cases, private landowners may not be able to afford to upgrade their roads and replace culverts, and therefore may experience more frequent road instability than on public lands where road maintenance is strictly regulated. Rural road instability on private lands may be a significant source of sediment to local streams.

Little publicly available data on culverts exist in the watershed. The culvert survey data given in the Oregon Department of Fish and Wildlife database, described in Chapter 11, did not include culvert capacity so it was not possible to determine whether these culverts have a high potential for contributing to road washouts. This is an area that may warrant further investigation by the council. Currently the Eugene Northwest Youth Corps is submitting a grant to the Environmental Protection Agency to survey culverts in the watershed.

Slope Instability Unrelated to Roads

Slope instability can result in shallow or deep landslides and debris flows. Slope failure and debris flow analyses for the watershed have been conducted by the Bureau of Land Management (1999) and the Oregon Department of Forestry (1999).

According to the BLM analysis, shallow landslides are the predominant type of slope failure in the watershed. A "(r)eduction in root strength following timber harvest and site preparation activities is likely a significant cause of landsliding outside the area of road construction. Areas most sensitive to loss of root strength and subsequent landsliding usually are steep (>75%) slopes in concave positions over hard bedrock in areas of high rainfall (Bureau of Land Management 1999)." **Table 9.2** lists the acres and percentage of slope failure potential in the watershed.

Table 9.2. Slope Failure Potential in Long Tom Watershed

Slope Failure Potential	**Acres**	Percent of Watershed
Low	237,188	90.3
Moderate	12,482	4.7
High	4,085	1.6

Source: Bureau of Land Management 1999

Risk of debris flow is also fairly low in the watershed. Approximately 13.5% of the watershed has a moderate hazard for debris flow and 1.7% has a high hazard. High hazard areas are located on the western fringe of the watershed, up near Low Pass (Mills 1999 pers com).

Rural Road Runoff

"Sediment produced by forested roads through surface erosion is an important component of the sediment budget in forested basins. Roads are one of the few sites of surface erosion in most forested landscapes because they are generally maintained in a vegetation-free condition and have nearly impermeable surfaces (Luce & Black 1999)." Roads located in agricultural and rural residential areas also have the potential to deliver sediment. Key differences between typical forest roads and farm or rural residential roads in this watershed are: 1) farm/rural residential roads are mostly in portions of the watershed that are less steep than areas with forest roads and 2) farm/rural residential roads are often unsurfaced or surfaced with gravel, whereas forest roads generally are surfaced with crushed rock.

The amount of sediment that enters streams from road surface erosion depends on road conditions (i.e. vegetative cover on ditch and cutslopes, road surface, traffic), its steepness, length and connectivity to streams. Connectivity relates to the proximity of the road to streams and a direct link between a road and stream (e.g. ditch drains directly into stream). Connected roads have the potential to deliver sediment to streams. A road is considered "connected" if it is within 200' of a stream, according to Washington State Forest Practices Board (1993).

A local study of sediment delivery from forest road surfaces found significant differences in the mean amount of sediment delivered by roads depending on the soil type and vegetative cover in the road ditch and cutslope. They found that "(c)leaning ditches and removing the cutslope vegetation caused a dramatic increase in sediment production (Luce & Black 1999, 21)." The average sediment production for roads plots that were undisturbed or graded was 50 kg and 57 kg, respectively. Roads that were graded, had their ditch cleaned and cutslope stripped of vegetation (shortly before the study period) produced an average of 377 kg. (The time period for this amount of sediment accumulation was approximately one year (Black 1999 pers com).) A comparison of two study sites located on different soil types showed that the site at Low Pass, with silty clay loams, produced over 9 times more sediment than the site at Windy Peak, with gravelly loam (Luce & Black 1999).

The Bureau of Land Management (BLM), Oregon Department of Transportation (ODOT) and Lane County all maintain their ditches by keeping them free from blockage and debris accumulation. However, their methods vary. Roads in the Long Tom Watershed maintained by ODOT generally have wide corridors and shallow-sloped ditches. The shallow slopes of the road shoulder allow them to mow their ditches on a regular basis to prevent vegetation from clogging the drainage-way. They avoid grading the ditch down to bare dirt in most cases, although they keep the area that is four to eight feet from the pavement free from vegetation (probably with pesticide application). A vegetation barrier is left between the bare shoulder material and the ditch to filter out sediment. Joll estimates that about a mile of state highways within the watershed require ditching annually. "When the ditch line is cleaned material is removed from the existing or old ditch line. (T)hey try not to disturb vegetation on the far bank [cutslope] of the ditch but the vegetation in the ditch line is removed (Joll pers comm. 1999)."

The BLM also sweeps out brush and vegetation (with a blade) as a primary means of keeping ditches clear of obstructions, although occasional blading to bare ground is required. This strategy became emphasized about four years ago. Before that time ditches were bladed down to bare dirt on a standard basis. Other BLM road maintenance includes grading the surface of roads that are covered with crushed rock and cleaning culverts by digging out catch basins next to culverts with a back ho (Bureau of Land Management 2000).

Lane County ditch maintenance primarily consists of completely removing vegetation from the ditch line. The County is not able to use mowing as a regular maintenance strategy because most of the ditches along county roads are narrow and have very steep sides, making it impossible for a mower arm to maneuver through. Like the BLM, the County also maintains its rock-surfaced roads by grading. This component of road maintenance happens only during the winter months when the roads are soft enough (from precipitation) to be re-shaped with a grader blade (Putschler pers comm. 2000). Unfortunately this corresponds with times when surface runoff is the highest and newly disturbed road sediment has a greater opportunity to wash down the ditch and into a nearby stream.

Table 9.1 lists the miles of road and percentage that are within 200' of a stream for each sub-basin. Road connectivity varies from 8% in the Upper Amazon sub-basin to 36% in the Coyote Creek sub-basin. The sub-basins with the greatest proportion of agricultural and urban land have slightly less road-stream connectivity on average than sub-basins where forestry is present. For example, Ferguson Creek, Elk Creek, Bear Creek, Coyote Creek and the Upper Long Tom are the sub-basins with forestry in the watershed; all of their connectivity percentages are at or above 30%. This is an important consideration, since it suggests greater connectivity of forest roads, which are located in steeper portions of the watershed.

Table 9.1. Road Connectivity to Streams

Sub-basin	Stream crossings per stream mile	Miles of road within 200' of a stream*	Percent of roads within 200' of a stream
Lower Long Tom River	1.06	25	22%
Ferguson Creek	1.22	37	34%
Coyote Creek	1.45	89	36%
Lower Amazon Creek	1.49	18	12%
Elk Creek	1.50	65	33%
Bear Creek	1.74	30	30%
Upper Long Tom River	1.95	78	33%
Spencer Creek	1.95	13	20%
Fern Ridge	2.02	17	12%
Upper Amazon	3.95	30	8%

*These values were determined by overlaying a digital road layer (developed by the Ecosystems Research Consortium 1999) and stream layer (developed by the Eugene District Bureau of Land Management 1999). A 200' buffer was placed on all streams; miles of road segments within the buffer were then calculated by sub-basin.

A road survey conducted by the Bureau of Land Management (1999) of the higher elevation, forested parts of the watershed found that 12% of the roads are connected to streams and thus have the potential to deliver sediment. This is low compared to the statewide connectivity average, which is estimated to be between 25 and 45% (Mills 1999). This estimate is also low compared to the connectivity percentages by sub-basin, although the percentages in **Table 9.1** cannot be directly compared with the BLM calculation because the boundaries of the study area differ from the sub-basin analysis. In addition, the methods of assessment were entirely different; one being a field based inventory and the other a GIS based analysis (although both consider roads within 200' of streams to be connected).

In addition to determining road connectivity to streams, the BLM inventory assessed the condition of roads that were connected. They found that 85% of connected roads are rock surfaced (which reduces sediment delivery), cut banks contribute sediment on 7% of connected roads, fill slopes with less than 80% vegetative cover are rare, and traffic levels are low on connected roads. Taking all of these factors into account they determined that the annual sediment yield from forest roads in their study area is equal to 41 lbs./acre/year (Bureau of Land Management 1999). If roads were determined to be more connected, as the data in **Table 9.1** suggest, this sediment yield would be higher. An analysis using a GIS based road sediment delivery model may help clarify this issue.

Lack of information on road conditions for other parts of the watershed make a sediment yield estimate from these roads impossible at this time. However, the council may be able to collaborate with researchers from Oregon State University during the coming year to calculate a sediment yield estimate for the entire watershed using newly developed road sediment models.

Urban Runoff

Sediment from urban areas originates from wind-deposited soil on streets and other impervious surfaces, degrading pavement and erosion from yards and construction sites (Watershed Professionals Network 1999). The type of urban land use influences the amount of sediment yield. "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 highest amounts occur in areas that are actively being developed (Watershed Professionals Network 1999, V1-27)."

> A particular problem with sediment from urban areas is that pollutants are often attached to the sediment particles. Many heavy metals, toxic compounds, nutrients, and bacteria readily attach to sediment particles derived from urban sources. Of major concern are zinc, copper, oil and grease, yard pesticides, and phosphorus (Watershed Professionals Network 1999, V1-27).

The City of Eugene has developed *preliminary* sediment load estimates using a land use based model developed by Woodward-Clyde consultants.[23] The model assumes that sediment yield from a particular type of land use is relatively consistent. For example, industrial land is estimated to generate "x" pounds of sediment/year.

The annual sediment load estimate from the Amazon sub-basin, within the City's jurisdictional limit, ranges from 188 – 364 lbs./acre/year, depending on the sub-basin (Lane Council of Governments 1999b).[24] These include Willow Creek, the mainstem of Amazon Creek, Bethel-Danebo and part of River Rd./Santa Clara. It is important to note that these sediment contributions do not fully account for best management practices the City of Eugene has implemented. These include street cleaning, catch basin cleaning, and public education, among other things. Thus the actual sediment yield from the urban portions of the Amazon Creek sub-basin are probably lower than this.

Surface Erosion from Cropland and Pastures

Surface erosion from cropland and pastureland was estimated using a model based on the Universal Soil Loss Equation (USLE). This equation was developed with sediment production measurements on agricultural lands. The equation is:

Tons/acre/year of sediment = rainfall intensity x erodibility x slope/length x cover x condition

Where:
Erodibility (of soil) = k-factor
Slope/length = steepness and length of slope
Cover = crop type
Condition = soil condition (i.e. conservation tillage vs. no conservation tillage)

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[23] Data from local analyses of land use contributions to suspended sediment in surface water were used to calibrate this model.

[24] The model is still being fine-tuned; hence the final output value may be somewhat different than the number presented here.

The calculation for sediment erosion was made by overlapping three map layers: 1) crop type, 2) digital elevation model and 3) soil types.[25] Annual precipitation was assumed to be 40" and no conservation tillage was assumed. These assumptions are not true for all parts of the watershed, hence these assumptions should be taken into account when evaluating these data. For example, if conservation tillage occurred on every acre of farmland the estimated sediment yield would be lower. Also, crop types change from year to year. However, the model used crop distribution for 1995. The assumption here is that, although crop locations change, the total amount of each crop type remains relatively consistent within the watershed. The crop coverage used may reflect some years more accurately than others. **It is important to note that we do not know yet how much of this surface erosion is predicted to actually reach the stream**. The model must be calibrated with actual sediment levels in local streams and estimates of sediment filtration by riparian vegetation must be made.

Based on the USLE model, agricultural lands in the watershed erode an average of 105 1bs./acre/year (total: 7,237,894 1bs./yr.). Three crop types/conditions are responsible for almost 75% of the total erosion. Areas in grass seed-grain-meadow foam rotation contribute 2,740,000 lbs./yr. at a rate of 143 lbs./acre/yr. Bare/fallow land contributes 1,598,000 lbs./yr. at a rate of 2000 lbs./acre/yr. And Christmas tree farms contribute 1,006,000 lbs./yr. at a rate of 379 lbs./acre/yr. The **Erosion Potential from Agricultural Areas in the Long Tom River Basin map** shows agricultural areas in three erosion level categories.

Conclusions

The information presented in this chapter highlights two general issues the council may wish to act upon. First, there are several potentially significant sources of sediment to streams in the watershed (rural road instability, surface erosion from rural roads and surface erosion from cropland) that are suggested by data presented in this chapter. Second, information on these sources of sediment production is lacking and may warrant pursuit by the council.

Insufficient information includes:

- Information on culvert capacity
- Information of road washouts on private land
- A comprehensive and publicly available road inventory that could inform an analysis of surface erosion potential from all roads in watershed
- Water quality data on turbidity and suspended sediment from many parts of the watershed, which could be used to calibrate the model of sediment contribution from agricultural lands.

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[25] Crop type was mapped and digitized using information from satellite imagery; satellite images used were from 1995(?). A digital elevation model is a topographic map that is digitized, allowing a computer to calculate three dimensional slopes on specified pieces of land. Soil types were digitized from the Lane County Soil Survey, Natural Resource Conservation Service.

Insert agricultural erosions potential map

The council may wish to facilitate the collection of some of this information. As mentioned earlier, a grant was recently submitted to fund the North West Youth Corps to survey culverts in the watershed. In regards to water quality data on turbidity, the council's current water quality monitoring program collects monthly data on turbidity and flow, which will, among other things, provide information to verify sediment model predictions.

Potentially significant sources of sediment delivery in the watershed that council members may be able to reduce include:
- Erosion from surfaces and ditches of rural roads and driveways
- Slope failure from forest roads
- Sediment from urban areas
- Erosion of agriculture land

Although more information is needed on sediment contributions from rural roads, there are clear guidelines on relative risk of sediment delivery depending on various aspects of the road. Some landowners may wish to apply this information to their own property. For example, reducing connectivity on obviously eroding road segments, surfacing problem road segments and avoiding the use of unsurfaced roads during the wet season.

Small woodlot owners and local timber companies may wish to utilize the maps for high slope failure (available through the BLM) and debris flow potential (State Department of Forestry 2000) if they do not already have access to this information. These maps can help guide choices regarding location and methods of logging.

Council members living in urban areas can take various steps to reduce erosion and sediment delivery from their property, including preventing soil from washing into gutters during construction projects and keeping leaves and other debris off the sidewalk and gutters.

Farmers and ranchers may be interested in experimenting with conservation tillage approaches (if they have not already) to reduce sediment production from agricultural lands.

Chapter 10 Water Quality

Introduction and Background

The term "water quality" has many aspects. It is reflected in the chemical and physical characteristics of water, and by the organisms living in the water. Physical and chemical measures of water quality include temperature, dissolved oxygen, turbidity, chlorophyll, nutrients, and toxins such as heavy metals, pesticides and other chemicals. Biological measures of water quality include the type and amount of bacteria, algae, macroinvertebrates and fish. Chemical and physical measurements of water quality provide a useful momentary snapshot. However, the organisms that live in the water often provide a good indicator of what water quality has been over the past several months or even years.

Each of these water quality characteristics has a different significance to the organisms living in the water. Below is a brief summary of the primary characteristics that are commonly measured in a water-monitoring program. This should help the reader interpret the data that is presented in the results section.

- **Dissolved oxygen**: Obviously humans can't breathe in water, but we all know that fish do. And just like humans are sensitive to the amount (or partial pressure) of oxygen in the air (e.g. mountain climbers notice the lack of oxygen at high altitudes), fish and other aquatic species experience some degree of stress or death at dissolved oxygen levels below 8 to 10 mg/l. One factor affecting the amount of dissolved oxygen in water is temperature. The higher the temperature, the less oxygen water can hold. Another factor is the amount of biological activity. For example, if a lake or stream has a lot of algae and bacteria, this leads to a great deal of oxygen being generated *and* consumed. Both the overall low levels of dissolved oxygen and the large fluctuations in daily oxygen levels (high during mid-day from algal photosynthesis, low at night when there is no light for photosynthesis) are stressful and sometimes deadly to fish and other aquatic life.
- **pH**: This measurement reflects the relative acidity of a liquid, and is measured on a scale of 1 to 14 (1 = highly acid, 7 = neutral, 14 = highly basic). The pH of rainwater in the Pacific Northwest is between pH 5 and 6. The pH of rainwater increases once it hits the ground and intercepts soil particles and other substances. Most aquatic organisms can tolerate a range from pH 6.5 to 8.5. The pH in a river or lake can be influenced by human activity (e.g. industry, automobile exhaust, etc.), the soil and rock types in the watershed, and even the amount of photosynthetic activity of algae in the water.
- **Heavy metals**: These include elements like Cadmium, Copper, Lead and Zinc, which can be toxic to both humans and aquatic life at relatively low levels. In the Pacific Northwest we tend to have "softer" waters, which makes these metals even more toxic. Heavy metals can enter waterways from commercial and industrial sites, streets, roof tops, and residential yards.
- **Nutrients:** The most significant nutrients impacting water quality are nitrogen and phosphorus, because they are the ones that tend to limit plant growth. High levels of either of these nutrients can lead to large blooms of algae, which in turn lead to lower dissolved oxygen levels. Sources of nutrients include (1) decaying plants or animals in the water, (2)

discharge from wastewater treatment plants, (3) leaking septic systems, (4) fecal matter/manure from wild animals and livestock that wash into the water during storms, and (5) fertilizers or detergents that runoff from urban, rural and agricultural land.

- **Fecal coliform bacteria**: A well known example of this kind of bacteria is *E. coli.*, the culprit that has recently caused sickness in humans, and in some cases death, from the ingestion of poorly stored meat or unpasteurized apple juice. As the name implies, this type of bacterium often originates from fecal matter. Common sources that can contaminate surface waters include runoff carrying livestock manure, fecal matter from wildlife or domestic pets, and human sewage from leaking septic systems.
- **Macroinvertebrates**: Technically this word means animals with no vertebrae (i.e. backbone) that are not microscopic. Typical macroinvertebrate indicators of water quality include the aquatic larval stage of insects like Caddisflies, Mayflies and Stoneflies, as well as various aquatic worms. A large diversity and abundance of macroinvertebrates generally indicate good water quality and habitat conditions.
- **Temperature**: In addition to affecting the amount of oxygen water can hold (the higher the temperature, the lower the amount of dissolved oxygen it can hold), elevated temperatures can also weaken or kill fish, especially salmonids, which include both trout and salmon. Salmonids are especially sensitive to temperature before they hatch and during their early stages of life.
- **Sediment:** This includes dissolved and suspended soil particles in the water column and is commonly measured as total suspended solids, total dissolved solids and/or turbidity. High levels of suspended sediment are detrimental to fish because it can damage their gills, fill in spawning gravels, and impair the ability of sight-feeding fish to see their prey. The same processes that introduce sediment into the water also brings nutrients, pesticides and metals into the water. Therefore, reducing the amount of sediment that enters the stream from overland runoff can reduce the amounts of other pollutants entering the stream.
- **Pesticides:** This includes any chemical used to prevent the growth of unwanted insects, plants or plant diseases like fungus or bacteria. The terms herbicide, insecticide and fungicide are all included in the term pesticide. When these chemicals get into surface waters they can cause weakness, deformities or death of both plants and animals inhabiting the water or riparian zone.

Table 10.31 (end of chapter) describes additional water quality characteristics that are sometimes measured and lists state criteria or guidelines from other sources if established. In Oregon the Department of Environmental Quality and Department of Agriculture regulate water quality and are required to implement and enforce the guidelines set out in the Federal Clean Water Act. Part of this enforcement includes setting criteria or standards for water quality that protect freshwater-aquatic life and human health. The Long Tom Watershed assessment uses the evaluation criteria created for the protection of freshwater-aquatic life because the data presented are from surface waters. Criteria developed for the protection of human health generally apply to drinking water, which is beyond the scope of this assessment.

To date, criteria that protect freshwater aquatic life have been established for only some of the conventional measures of water quality, including water temperature, dissolved oxygen, nitrates, total dissolved solids and pH. Many other water quality measurements do not have established criteria. This is particularly true for pesticides. For example, of the 21 pesticides that have been detected in the Long Tom Watershed during short term studies conducted by the U.S. Geological Survey, only one has an established U.S. Environmental Protection Agency (USEPA) criteria for the protection of freshwater-aquatic life. In fact, "…none of the herbicides or fungicides currently used in United States agriculture have USEPA-established criteria (Larson *et al.* 1997, 275)." The Canadian Council of Resources and Environmental Ministers has designated criteria for some of these pesticides, which could serve as guidelines but have no regulatory power in the U. S. (Gilliom *et al.* 1998). Furthermore, research suggests that very small concentrations of pesticides in streams and lakes may have sub-lethal but damaging effects on fish (Ewing 1999). Another issue to consider is that no guidelines exist for the combined or cumulative effects of pesticides. So even if an individual pesticide does not exceed its established criteria, the total amount of all pesticides in the water at a particular moment may be toxic to organisms living there. In addition, other characteristics of water quality (e.g. temperature, dissolved oxygen) at that moment may be stressful to aquatic organisms. The take home message is that we currently lack sufficient knowledge about the combined effects of pollutants and water quality characteristics that impact the plants and animals living in the water.

In order to evaluate the significance of individual characteristics of water quality it is important to consider the multiple benefits surface waters provide. The Oregon Department of Environmental Quality (DEQ) has designated numerous beneficial uses of surface water in the Long Tom Watershed. Part of the challenge watershed councils face is to address the multiple demands for water in the Basin. These include:

- Industrial Water Supply
- Irrigation
- Livestock Watering
- Salmonid Fish Rearing
- Salmonid Fish Spawning
- Resident Fish & Aquatic Life
- Fishing
- Boating
- Water Contact Recreation (e.g. swimming)
- Wildlife & Hunting
- Aesthetic Quality (e.g. scenic beauty)
- Salmonid fish rearing and spawning (in the Long Tom this applies to trout and white fish)

Salmonid fish rearing and spawning is considered the most sensitive beneficial. This does not necessarily mean that it is the most important, rather it means that salmonids are more sensitive to poor water quality and instream habitat degradation than other beneficial uses. Because of this, the standards for water quality and instream conditions are geared towards assuring adequate quality for salmonids, which will also assure adequate quality for other beneficial uses.

The remainder of this chapter describes the results of chemical, physical, and biological assessments that have been conducted in the Long Tom Watershed over the past 10 years. Most of the information pertains to the chemical and physical aspects of surface water quality, although some sampling and identification of aquatic insects and algae have occurred. Information on chemical and physical characteristics is limited to basic indicators of water quality. For example, dissolved oxygen levels are presented but not biological or chemical oxygen demand; total phosphorus levels are given, but ortho-phosphorus levels are not. In addition, results from groundwater monitoring are not presented in this assessment. However, information on nitrate levels from well logs within the Basin can be obtained from the Oregon Health Division (OHD) or Department of Environmental Quality (DEQ).[26]

At the end of this chapter we will consider the following questions:

1. **What are the main water quality problems in the watershed from a regulatory standpoint?**
2. **What effect do these water quality problems have on the designated beneficial uses in the basin?**
3. **What human impacts may be contributing to these problems?**
4. **What options exist to improve water quality in the watershed?**

Water Quality Monitoring in the Basin

Currently there are three agencies conducting regular water quality monitoring in the Long Tom Basin. The DEQ samples one site on the Long Tom River near Monroe every two months. The City of Eugene samples at several locations within the Upper Amazon Creek sub-basin every two months and after large storm events. The Army Corps of Engineers (ACE) monitors sites on Fern Ridge Reservoir and several of its tributaries every two weeks.

In addition to regular monitoring, there have been many short-term water quality studies conducted by various agencies, including the U. S. Geological Survey (USGS), DEQ, City of Eugene and Lane Council of Governments (LCOG). **Table 10.1** summarizes the current and past water quality studies that have occurred within the Long Tom watershed.

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[26] OHD contact: Dennis Nelson (541)-726-2587; DEQ contact : Amy Clark-Zimmerly (503)-229-6883

Table 10.1 Current and Past Water Quality Studies within the Long Tom Basin

Agency	Locations	Frequency	Characteristics*
USGS	Amazon Cr., Long Tom R., Ferguson Cr., Bear Cr.	Short term studies (1990 – 1994)	temperature, conductivity, DO, pH, N, P, C, heavy metals, pesticides & other organic compounds
City of Eugene	Amazon Cr. Basin	Bi-monthly (1996 – present)	TSS, TDS, BOD, COD, hardness, P, N, NO3, metals, *E. coli*, pH, conductivity, DO, grease & oil
DEQ	a. Long Tom River @ Monroe b. Other sites in watershed	a. Quarterly (1950 – present) b. Number of sampling times varies (1950 – present)	*E. coli*, DO, TSS, turbidity, N, P, pH, temperature, conductivity, BOD, COD, macroinvertebrates, chl a
LCOG	Fern Ridge Reservoir, Amazon Cr., Coyote Cr., Upper Long Tom R.	Monthly (1981-82)	Temperature, flow, turbidity, transparency, conductivity, DO, BOD, COD, pH, alkalinity, residue, NH3, NO2-NO3, P, ortho-P, hardness, chloride, sulfate, arsenic, Fe, Pb, Total coliform, fecal coliform, chl-a
ACE	Fern Ridge Reservoir, Coyote Cr., Spencer Cr., Amazon Cr., Lower Long Tom R., Upper Long Tom R., Hannavan Cr., Inman Cr., Warren Slough	Bi-weekly (1996 – present)	temperature, DO, turbidity, transparency, suspended solids, P, pH, chl a, *E. coli*

*These are the most common characteristics measured by each agency. However, some sites do not have measurements for all of these characteristics because it depends on what the objective for monitoring was at each site. DO = dissolved oxygen, N = nitrogen, P = phosphorus, C = carbon, TSS = total suspended solids, TDS = total dissolved solids, BOD = biological oxygen demand, COD = chemical oxygen demand, NO3 = nitrates, Fe = iron, Pb = lead, chl-a = chlorophyll a

Water Quality Conditions, 1990 to Present

In order to understand both the differences and similarities in water quality issues among the sub- basins within the watershed, the results will be presented and discussed for each sub-basin separately. Summary tables for each sub-basin include (a) the number of samples, (b) the mean, median, and range of values for each water quality characteristic, (c) criteria for the protection of freshwater aquatic life, and (d) the percent of samples that do not meet current criteria for that water quality characteristic. The number of **samples** (i.e. sampling times) allows one to judge how representative the data are for a particular stream. Generally speaking, the larger the number of samples, the more representative the data will be for that stream. The **mean** (i.e. average), **median** (i.e. the middle number when all the values obtained are ordered from lowest to highest), and the **range** of values (i.e. lowest and highest) provide a summary of the values obtained for each characteristic measured. These data are averages for all seasons. Therefore the mean values in the tables mask seasonal variation. However, the range can provide an indication of seasonal variation, especially for water temperature and dissolved oxygen. The **criterion** for each characteristic shows its acceptable level according to state standards, or standards provided by other sources. For example, water temperatures above 17.8° C (or 64° F) and dissolved oxygen levels below 6.5 mg/l (or 5.5 mg/l if the waterway is considered "warm water" habitat) are in violation of DEQ standards for the protection of freshwater-aquatic life. The **percent exceedance** for a given water quality characteristic is the percent of samples at a particular location that do not meet DEQ or other recommended standards. For example, if the DEQ monitored a site on the Long Tom River 100 times, and on 40 of those occasions the water temperature exceeded state standards, then the percent exceedance would be 40%.

The data presented in the tables for each sub-basin come from studies conducted over the past 10 years by the Department of Environmental Quality (DEQ), Army Corps of Engineers (ACE), City of Eugene and U. S. Geological Survey. These studies represent the majority of the data collected within the watershed during this time. Results from several studies have not been included in the summary tables because they were either conducted prior to 1990, or the number of sampling times was relatively small and the results did not differ from larger datasets already presented for that sub-basin. In cases where very little data had been collected at a given site, the results were presented even if it only amounted to two or three sampling times. Results from the Fern Ridge Clean Lakes Study in 1981 and 1982 (Lane Council of Governments 1983), the Water Quality report from the Willow Creek Basin Plan (City of Eugene & Woodward-Clyde 1996) and macroinvertebrate assessments in Amazon Creek and Flat Creek (Anderson *et al.* 1997, Kerst 1996) are discussed in the text under the relevant sub-basin.

Because different agencies do not always conduct the same tests, some streams or monitoring sites have data on fewer characteristics than others. Under each table the agency that collected the data and the time period for sampling are listed. The **Water Quality Monitoring Sites map** shows the locations of these sites and the relative average water temperature and dissolved oxygen levels.

Insert map

Upper Long Tom

The Upper Long Tom sub-basin originates on the east side of the Coast Range and drains a total of 56 square miles. This basin primarily consists of land zoned for forestry (81%) and rural residential (10%). It has been monitored at three sites between its headwaters and the mouth at Fern Ridge Reservoir. A comparison of water quality information from these sites provides a useful picture of how water quality changes as the river collects runoff from an increasingly larger area of land. Very little monitoring has been done near the headwaters, but what little has been done shows no water quality impairment when compared to DEQ's freshwater aquatic life standards (**Table 10.2**). With so few samples taken to date, however, no conclusions should be drawn. The sites at Noti and Elmira, which are farther downstream and have been monitored on numerous occasions, show some degree of impairment for water temperature, total phosphorus and dissolved oxygen (**Table 10.3 & 10.4**). The Veneta sewage treatment plant is located between the Noti and Elmira sites, hence the plant's effluent has the potential to affect water quality between these sites. However, phosphorus levels are not significantly different between the Noti and Elmira sites. To date, no data collected on bacteria levels at Elmira have violated state standards.

The DEQ evaluated a site on the Upper Long Tom in 1995 for aquatic habitat conditions. Based on a collection and analysis of macroinvertebrates they determined that habitat conditions for macroinvertebrates and fish in this section were a potential concern.

Table 10.2 Water Quality Data: Upper Long Tom near Headwaters

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)	TDS (mg/l)	Turbidity (NTU)
samples	6	2	2	2	2	6	5
range	8.5 - 14	10 – 10.6	7.2 - 7.7	.02 - .03	0.11 - 0.17	26 - 55	5 - 14
mean	10.2	10.3	7.5	0.025	0.14	44	10.6
median	9.3	10.3	7.5	0.025	0.14	47	10
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 30	≤ 100	≤ 50
% exceed	0%	0%	0%	0%	0%	0%	0%

Data source: DEQ; Sampling period: 1995 – 1997
DO = dissolved oxygen, TP = total phosphorus, NO3 = nitrates, TDS = total dissolved solids

Table 10.3 Water Quality Data: Upper Long Tom at Noti

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Turbidity (NTU)
samples	56	56	50	20	46
range	6.2 - 20.4	5.9 -17.8	4.5 - 8.3	0 - 0.1	3.5 - 49.5
mean	12.5	9.1	7.0	0.04	10.3
median	12.0	8.7	7.1	0.04	7.9
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	≤ 50
% exceed	11%	11%	4%	40%	0%

Data source: ACE; Sampling period: 1996 - 1998

Table 10.4 Water Quality Data: Upper Long Tom at Elmira

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Bacteria (cells/100 ml)	Turbidity (NTU)
samples	58	58	53	26	8	47
range	6.3 - 22	3.6 - 13	6.2 - 8.5	0.01-0.09	4 -276	4.34 - 812
mean	13.4	8.3	7.1	0.04	87.3	27.2
median	12.2	7.8	7.0	0.04	79.5	8.3
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 406	≤ 50
% exceed	21%	26%	6%	35%	0%	4%

Data source: ACE; Sampling period: 1996 – 1998
Bacteria = *E. coli*

Data collected during 1981 and 1982 (Fern Ridge Clean Lakes Study) show that water temperature was slightly lower (mean = 12.3 ° C, median = 10 ° C), dissolved oxygen was higher (mean = 9.3 mg/l, median = 9.5 mg/l), and total phosphorus was higher (mean = 0.05 mg/l, median = 0.05 mg/l) compared to 1996 – 1998 data from the Upper Long Tom at Elmira. Because the testing methods for bacteria and turbidity were different between the two studies, a direct comparison of these results cannot be made. However, the 1981- 82 study did report that fecal coliform levels sometimes exceeded state standards. The report also noted relatively high nitrate concentrations, which the authors attributed to the Veneta sewage treatment plant's effluent (Lane Council of Governments 1983). Current data on nitrate concentrations in the Upper Long Tom are not available, so it cannot be determined if this is still a problem.

Coyote Creek

Coyote Creek drains a total of 104 square miles (including the Spencer Creek drainage). Landuse in this area is primarily forestry (59%), agriculture (28%), and rural residential (11%). Both Coyote Creek sites show some degree of impairment for temperature and dissolved oxygen, and very high impairment for total phosphorus. The one site tested for bacteria (Cantrell Rd.) shows significant problems for this parameter as well. The farthest upstream site is at Petzold Road (**Table 10.5**), just above the confluence of Spencer and Coyote Creek. The downstream site at Cantrell Road shows slightly poorer water quality (**Table 10.6**). Researchers with the Army Corps of Engineers have suggested that phosphorus loading is occurring somewhere between the confluence of Spencer Creek and the site at Cantrell Road, which might explain the higher levels of total phosphorus seen there (Sytsma 1997).

Table 10.5 Water Quality Data: Coyote Creek at Petzold Road

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Turbidity (NTU)
samples	59	59	59	22	28
range	5 - 22.8	3.4 - 13.5	6.9 – 8.0	0 - 0.17	12.4 - 129.4
mean	13.6	8.6	7.4	0.08	29.0
median	12.6	8.4	7.5	0.08	21.3
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	≤ 50
% exceed	25%	20%	0%	82%	7%

Data source: ACE; Sampling period: 1996 - 1998

Table 10.6 Water Quality Data: Coyote Creek at Cantrell Road

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Bacteria (cells/100 ml)	Turbidity (NTU)
samples	59	59	60	27	8	49
range	4 - 26.9	3.7 - 14	6.6 - 8.4	0.02 - 0.22	144 - 1733	6 - 135
mean	14.4	8.5	7.4	0.10	555	31
median	12.7	8.0	7.3	0.08	355	24
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 406	≤ 50
% exceed	34%	20%	0%	92%	50%	12%

Data source: ACE; Sampling period: 1996 - 1998
Bacteria = *E. coli*

The Fern Ridge Clean Lakes study (Lane Council of Governments 1983) also monitored water quality at Cantrell Road. A comparison between this study and data from current monitoring shows that water temperature was slightly lower (mean = 12.3 ° C, median = 10.3 ° C), dissolved oxygen was slightly higher (mean = 8.4 mg/l, median = 9.8 mg/l), and total phosphorus was higher (mean = 0.28 mg/l, median = 0.11 mg/l) than current levels. The study reported that Coyote Creek had average values for turbidity and fecal coliform that often exceeded state standards. After the first heavy rains in the fall of 1981, fecal coliform levels were especially high (greater than 100,000 cells/100 ml) and were accompanied by high concentrations of ammonia and extremely low dissolved oxygen levels. Upon investigation, staff from the Soil and Water Conservation District discovered a confined dairy operation that had recently expanded and no longer had an adequate capacity to manage its manure (Lane Council of Governments 1983). Steps were taken to remedy this problem and current monitoring does not show bacteria levels as extreme as those reported in 1981/82. However, bacteria levels are still relatively high.

Spencer Creek

Spencer Creek, a tributary of Coyote Creek, drains 33 square miles. The primary landuses in this sub-basin are forestry (49%), rural residential (27%) and agriculture (22%). Water temperature, dissolved oxygen and turbidity show some degree of impairment, and total phosphorus shows substantial impairment (**Table 10.7**). No information has been collected on bacteria for this creek.

Table 10.7 Water Quality Data: Spencer Creek at Crow Rd.

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Turbidity (NTU)
samples	47	47	46	16	38
range	4.1 - 26.8	5.5 - 14.1	6.9 - 8.3	0 - 0.22	7 - 133
mean	12.5	9.5	7.5	0.09	35
median	11.5	9.7	7.5	0.06	29
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	≤ 50
% exceed	30%	9%	0%	75%	18%

Data source: ACE; Sampling period: 1996 - 1998

Upper Amazon Creek

The Upper Amazon Creek sub-basin originates at the base of Spencer's Butte in Eugene and extends to Fern Ridge Reservoir. The drainage area is 31 square miles and the major landuses are urban (80%) and rural residential (11%). There are several monitoring sites within the Upper Amazon sub-basin. The site at 29th and Amazon is the furthest upstream, and primarily receives runoff from the residential area of South Eugene. Willow Creek is a small tributary that feeds into Amazon Creek near Beltline Road in West Eugene. This site is also mainly influenced by runoff from residential areas, although its lower reaches run through a reserve that is managed by The Nature Conservancy. Amazon Creek sites at Royal Avenue and Fir Butte Road are downstream of downtown Eugene and receive runoff from the industrial section of town as well as commercial and residential areas.

Nitrates show no problems in the Upper Amazon sub-basin, and pH shows some impairment at the upstream site, and potentially the furthest downstream site (**Tables 10.8, 10.9, 10.10**). Two characteristics, temperature and dissolved oxygen, show some degree of impairment, but their levels remain similar at all three sub-basin locations. Several samples particularly high in bacteria levels at Amazon Creek at 29th St. (i.e. *E. coli*) may be due to the fact that this monitoring site is adjacent to a dog park, and pet owners are not always good about "scooping up" after their animals. Total phosphorus and total dissolved solids show a very high degree of impairment throughout the sub-basin, although the TDS levels seem to decline as one moves downstream.

Amazon Creek at Royal Ave. was also monitored in the 1981/82 Fern Ridge Clean Lakes study. Water temperatures were much lower (mean = 12.8° C, median = 11.3° C), dissolved oxygen levels were higher (mean = 8.3 mg/l, median = 8.6 mg/l), and total phosphorus was lower (mean = 0.095 mg/l, median = 0.09 mg/l) than levels reported from current monitoring. Although the method for measuring bacteria and sediment differed between the 1981/82 study and current monitoring, the Clean Lakes Report did note that Amazon Creek at times exceeded average state standards for both fecal coliform and total dissolved sediment levels. The report also pointed out that chemical spills, industrial pollutants, extremely low oxygen levels and fish kills were witnessed at various times during the study (Lane Council of Governments 1983).

Table 10.8 Water Quality Data: Upper Amazon Creek at 29th Ave.

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)	Bacteria (cells/ 100 ml)	Turbidity (NTU)	TDS (mg/l)
samples	16	16	16	16	16	16	11	16
range	4.2 - 21.7	7 - 12.4	5.8 - 9.4	0.02 - 0.29	0.075 - 0.66	20 - 7500	4 - 1235	120 - 219
mean	12.9	9.4	7.5	0.11	0.33	1074	30	166
median	12.2	8.7	7.7	0.09	0.33	335	35	171
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 30	< 406	≤ 50	≤ 100
% exceed	19%	0%	13%	94%	0%	44%	18%	100%

Data source: City of Eugene; Sampling period: 1996 – 1998; Bacteria = *E. coli*; TDS = total dissolved solids

Table 10.9 Water Quality Data: Willow Creek

	Temp (°C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)	Bacteria (cells/ 100 ml)	Turbidity (NTU)	TDS (mg/l)
samples	11	11	11	11	11	11	11	11
range	3.2 - 27.9	6.2 - 11.4	6.5 – 8.0	0.02 - 0.2	0.02 - 0.63	10 - 3300	7 - 72	96 - 1560
mean	13.5	8.5	7.2	0.09	0.11	582	29	291
median	10.9	8.0	7.4	0.06	0.05	380	19	170
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 30	< 406	≤ 50	≤ 100
% exceed	27%	18%	0%	82%	0%	36%	18%	91%

Data source: City of Eugene; Sampling period: 1996 – 1998; Bacteria = *E. coli*

An important issue to consider when interpreting data on Willow Creek is that in the summer the upper portion dries up and the lower segment has no flow. Therefore, pollutants become concentrated in stagnant pools, which makes for poorer water quality in the summer (at least in respect to some pollutants). However, during this time Willow Creek does not contribute any flow to Amazon Creek, which means that it is not "loading" pollutants into another stream even though conditions within its pools may be poor.

Table 10.10 Water Quality Data: Upper Amazon Creek (Royal Ave, Fir Butte Rd.)

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)	Bacteria (cells/100 ml)	Turbidity (NTU)	TDS
samples	98	99	99	69	35	56	78	32
range	3.2 - 27.4	3.1 - 13.8	6.2 - 8.4	0.02 - 0.78	0.02 -1.3	0 - 4100	3 - 88	67- 253
mean	15.7	7.7	7.35	0.14	0.37	483	31	139
median	15.2	7.3	7.4	0.12	0.30	389	24	116
criteria	≤ 17.8 °	> 6.5	6.5 - 8.5	≤ 0.05	< 30	< 406	≤ 50	≤ 100
% exceed	42%	37%	4%	93%	0%	36%	23%	75%

Data source: City of Eugene, ACE; Sampling period: 1996 – 1998; Bacteria = *E. coli*

Data on heavy metals (**Table 10.11**) indicate potential problems with lead and copper at the 29th Ave. site, but no problems exist at Willow Creek (**Table 10.12**). In contrast, both copper and lead have exceeded state standards for the protection of freshwater aquatic life on numerous occasions at two sites (not same sites as Royal Ave./Fir Butte Rd.) in the lower, industrial portion of the sub-basin (**Table 10.13**). These data are not surprising considering the concentration of people and commercial and industrial businesses that impact this sub-basin.

Table 10.11 Heavy Metals Data: Upper Amazon Creek at 29th

	Lead (µg/l)	Zinc (µg/l)	Copper (µg/l)	Mercury (µg/l)	Cadmium (µg/l)	Silver (µg/l)
samples	16	16	16	16	16	16
range	0.35 - 10	6.3 - 92.7	2.2 - 11	ND- 0.004	ND – 0.06	ND – 0.09
mean	2.05	22.7	5.0	N/A	N/A	N/A
median	2	16.3	5	0.002	0.03	0.01
% exceed	6%	0%	6%	0%	0%	0%

Data source: City of Eugene; Sampling period: 1996 – 1998; ND= Level is non-detectable; NA: Cannot calculate a mean because some of the samples are reported as less than the detectable limit. Median represents middle value of *detectable* measurements.

Table 10.11 Heavy Metals Data: Willow Creek

	Lead (µg/l)	Zinc (µg/l)	Copper (µg/l)	Mercury (µg/l)	Cadmium (µg/l)	Silver (µg/l)
samples	11	11	11	11	11	11
range	0.15 - 2.2	2.9 - 40.3	1.1 - 6	ND – 0.004	ND – 0.015	ND – 0.016
mean	1.1	15.6	3.6	N/A	N/A	N/A
median	0.3	5.3	2.7	0.001	N/A*	0.01
% exceed	0%	0%	0%	0%	0%	0%

Data source: City of Eugene; Sampling period: 1996 – 1998**;** *Calculating a median is not valid because there is only one detectable measurement from this dataset.

Table 10.13 Heavy Metals Data: Upper Amazon Creek (A & A3 Channel)

	Lead (µg/l)	Zinc (µg/l)	Copper (µg/l)	Mercury (µg/l)	Cadmium (µg/l)	Silver (µg/l)
samples	32	32	32	32	32	32
range	0.5 - 8.7	5 - 83	2.3 - 9	ND – 0.0145	ND – 0.042	ND – 0.06
mean	3.6	33.5	8.2	N/A	N/A	N/A
median	2.8	22	5.5	0.006	0.02	0.02
% exceed	44%	0%	19%	3%	0%	0%

Data source: City of Eugene; Sampling period: 1996 – 1998

Pesticides and other pollutants (e.g. pyrene, napthalene) have been measured in both Amazon Creek and the A-3 Channel during short-term studies conducted by the U.S. Geological Survey. None exceeded criteria set for the protection of freshwater aquatic life by the Canadian Council of Resources and Environmental Ministers or the DEQ, although three of the compounds have no established criteria (**Tables 10.14, 10.15, 10.16**). Since pesticide levels in surface waters vary dramatically (sometimes on a weekly or even daily basis), the number of samples in this study is too small to draw any conclusions. The same may be true for other pollutants.

A survey of Willow Creek's macroinvertebrates in 1996 reflected a range of stream conditions along eight sites between the headwaters and the confluence with Amazon Creek (City of Eugene & Woodward-Clyde 1996). Stream health was assessed by surveying habitat conditions and also identifying and counting the individual macroinvertebrate species. The number of different species, the proportion that are tolerant to pollution, and the ratio of mayflies, stoneflies, and caddisflies (groups that are particularly sensitive to pollution) are commonly used as indicators of water quality, habitat diversity, and/or habitat availability. The habitat survey of Willow Creek indicated problems along some segments due to channelization, bank erosion and sparse riparian zone vegetation. The macroinvertebrate survey indicated poor to fair habitat and water quality conditions depending on the site. This evaluation was based on species richness, the proportion of pollution tolerant species and other calculations of the relative abundance and proportions of particular species.

A study of macroinvertebrates and habitat availability on Amazon Creek was done during the summer of 1996 (Anderson *et al.* 1996). Surveyors reported poor habitat for macroinvertebrates due to a lack of woody debris and rocky substrate (e.g. cobbles). Specifically, habitat scores for the four study sites ranged from 14 to 17 out of 42 possible points. Poor water quality was also suspected of limiting the abundance and diversity of macroinvertebrates. The types of aquatic insects that are considered less tolerant of pollution (e.g. mayflies, caddisflies, stoneflies) were not as abundant as types considered more tolerant (e.g. Chironomids, Diptera). The surveyors also observed high densities of algae and aquatic plants and decomposing plant and animal matter, which contributes to lower dissolved oxygen levels in the water.

Table 10.14 Detected Pesticides in Amazon Creek

Name	Samples	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	* Criteria Source
2,4-D	4	0.07 - 0.75	0.31	0.2	0	4	Canadian
2,4,5-T	4	ND - 0.01	n/a	< 0.01	n/a	none	
Picloram	4	ND - 0.01	n/a	< 0.01	0	29	Canadian
Dicamba	4	ND - 0.15	n/a	0.02	0	10	Canadian
Diazinon	4	0.01	0.01	0.01	0	0.08	Canadian

Data source: Rinella 1993 (USGS); ND = not detectable by analytical methods available at the time of sampling; *Canadian = Canadian Council of Resources and Environmental Ministers

Table 10.15 Detected Pesticides in the A-3 Channel of Amazon Creek

Name	Samples	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	* Criteria Source
2,4-D	4	ND - 0.02	n/a	0.01	0	4	Canadian
Silvex	4	ND - 0.01	n/a	< 0.01	n/a	none	
Picloram	4	ND - 0.03	n/a	0.015	0	29	Canadian
Diazinon	4	ND - 0.01	n/a	< 0.01	0	0.08	Canadian

Data source: Rinella 1993; *Canadian = Canadian Council of Resources and Environmental Ministers

Table 10.16 Detected Semi-volatile Priority Pollutants in A-3 Channel of Amazon Creek

Name	Samples	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	* Criteria Source
pentachlorophenol	4	ND - 5.4	n/a	2.3	0	13	DEQ
napthalene	4	ND - 0.08	n/a	n/a	0	620	DEQ
pyrene	4	ND - 0.08	n/a	n/a	n/a	none	

Data source: Rinella 1993; *DEQ= Oregon Department of Environmental Quality

Fern Ridge Reservoir

A total of 271 square miles drain into Fern Ridge Reservoir, which collects all of the water from the Upper Long Tom, Coyote Creek, Amazon Creek and smaller tributaries that flow directly into it. Consequently the water quality in the reservoir is affected by the water quality of these tributaries. The shallow nature of the lake can either amplify or decrease these problems. For example, the reservoir's temperature, dissolved oxygen and total phosphorus levels are slightly worse than its tributaries, whereas bacteria and turbidity are either lower or about the same (**Tables 10.17, 10.18, 10.19**). Reasons for the comparatively low bacteria levels may be due to dilution of bacteria-laden water with less contaminated water, higher pH levels and longer residence time of water in the reservoir[27]. Summertime turbidity levels are relatively low. However, during the winter they are much higher, especially during and after storm events.

Table 10.17 Water Quality Data: Fern Ridge Tributaries*

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Turbidity (NTU)
samples	143	144	131	38	111
range	4.4 - 26.9	3.1 - 26.8	6.2 - 9.2	0 - 0.14	5 - 92
mean	14.3	9.0	7.3	0.05	18
median	13.2	8.7	7.2	0.04	15
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	≤ 50
% exceed	32%	17%	5%	47%	5%

Data sources: ACE; Sampling period: 1996 – 1998; Bacteria = *E. coli;* *Tributaries include: Hannavan Creek, Inman Creek, Warren Slough

Table 10.18 Water Quality Data: Fern Ridge Lake Stations

	Temp. (C)	DO (mg/l)	pH	TP (mg/l)	Bacteria (cells/100 ml)	Turbidity (NTU)
samples	337	339	177	106	61	141
range	5.1 - 26.5	2.3 - 12.5	6.6 - 9.7	0 - 0.58	0 - 99	4 - 156
mean	18.2	7.6	7.7	0.069	4	20
median	19.3	7.10	7.6	0.055	1	13.5
criteria	≤ 17.8 °	> 5.5*	6.5 - 8.5	≤ 0.05	< 406	≤ 50
% exceed	60%	5%	1%	58%	0%	5%

Data sources: ACE; Sampling period: 1996 – 1998; Bacteria = *E. coli;* *Fern Ridge is considered "warm-water aquatic habitat", thus the standard under DEQ regulations is slightly lower for dissolved oxygen.

Table 10.19 Water Quality Data: Fern Ridge Spillway

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	Turbidity (NTU)
samples	44	44	42	13	28
range	5.2 - 23.3	4.5 - 12.7	6.3 - 8.9	0.02 - 0.15	6 - 124
mean	14.8	8.3	7.4	0.1	24
median	16.2	7.8	7.4	0.06	16
criteria	≤ 17.8°	> 5.5	6.5 - 8.5	≤ 0.05	≤ 50
% exceed	39%	7%	7%	84%	4%

Data sources: ACE; Sampling period: 1996 - 1998

A comparison of the data from the 1996-98 Army Corps study with the Fern Ridge Clean Lakes study indicates some degree of water quality degradation in the Reservoir over the past 15 years (Sytsma 1997). This conclusion was based primarily on increases in total phosphorus and chlorophyll a levels (an indication of the amount of algae), which means that Fern Ridge is receiving an increased amount of nutrients (particularly phosphorus) and consequently more algae are growing. Water leaving the reservoir may be a significant source of downstream temperature pollution and phosphorus loading.

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[27] *E. coli* that comes from fecal matter/manure only survives a short amount of time once it has entered the water. So this type of bacteria will eventually die off after it has been in the water for several days. New sources of contamination are what keep *E. coli* levels high in a stream or lake.

Ferguson Creek & Bear Creek

Ferguson and Bear Creek are adjacent sub-basins, which originate in the foothills of the Coast range and flow into the Lower Long Tom below Fern Ridge Dam. Ferguson Creek drains 26 square miles of land, which is mostly used for forestry (59%) and agriculture (40%). Bear Creek drains 28 square miles and also supports forestry (57%) and agriculture (33%). In addition, land zoned for rural residential use covers 10% of the area.

The data available for Ferguson and Bear Creek comes from a relatively few number of sampling times. This makes it difficult to evaluate conditions in these tributaries. The data in **Tables 10.20 and 10.21** point to potential temperature, dissolved oxygen and phosphorus problems, which would be in line with problems noted in other sub-basins in the watershed. However, more data is needed before any conclusions are made. The same is true for data collected on pesticides (**Tables 10.22 & 10.23**). Although the pesticides detected were very low, two samples are not sufficient to determine whether these and other pesticides sometimes occur at levels that threaten organisms living in the water.

Table 10.20 Water Quality Data: Ferguson Creek

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)
samples	4	4	4	4	4
range	12.5 - 19.8	8.6 - 10.3	7 - 7.4	0.01 - 0.08	0.05 - 0.19
mean	15.9	9.8	7.2	0.045	0.12
median	15.6	10.1	7.2	0.05	0.12
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	< 30
% exceed	50%	0%	0%	50%	0%

Data source: USGS; Sampling period: 1994

Table 10.21 Water Quality Data: Bear Creek

	Temp (C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)
samples	2	2	2	2	2
range	16 - 25.7	7 - 9.7	7 - 7.4	0.02 - 0.08	0.07 - 0.15
mean	20.9	8.4	7.2	0.05	0.1
median	20.9	8.4	7.2	0.05	0.1
criteria	≤ 17.8°	> 6.5	6.5 - 8.5	≤ 0.05	< 30
% exceed	50%	0%	0%	50%	0%

Data source: USGS; Sampling period: 1994

Table 10.22 Pesticides Detected in Ferguson Creek

Name	Samples	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	Source
deethyl atrazine	2	ND - 0.003	n/a	n/a	n/a	none	
atrazine	2	0.022 - 0.063	0.042	0.042	0	2	Canadian

Data source: USGS; Sampling period: 1994; Canadian = Canadian Council of Resources and Environmental Ministers

Table 10.23 Pesticides Detected in Bear Creek

Name	Samples	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria
deethyl atrazine	2	0.002	0.002	0.002	0	none
EPTC	2	ND - 0.003	n/a	n/a	n/a	none

Data source: USGS; Sampling period: 1994

Flat Creek

Flat Creek is a small stream flowing parallel and just to the east of the Lower Amazon Creek sub-basin, and is heavily impacted by agriculture and residential land. The stream has also been modified for flood control. Consequently, the channel has been straightened and very little riparian vegetation exists. Although Flat Creek is not officially within the boundary of the Long Tom Watershed (topographic maps show it mainly drains into the Willamette R.), water from this creek may mix with surface waters in the Lower Amazon and Long Tom during periods of flooding. In addition, this creek is not included in the boundary of any other watershed council, so reviewing information on its water quality in this assessment is warranted.

Flat Creek shows especially high levels of total phosphorus. However, *E. coli* concentrations, pH and nitrates did not exceed state standards for any of the samples (**Table 10.24**). The number and concentrations of pesticides found in this creek were high compared to Bear and Ferguson Creek (**Table 10.25**). One pesticide, diazinon, was twice the acceptable concentration recommended by the International Joint Commission (1977). However, the fact that five of the nine pesticides detected in this creek have no recommended exceedance criteria, and that there was only one sampling period, make it impossible to determine the true impact of pesticides in this stream. The high level of diazinon and the presence of eight other pesticides warrant further investigation.

A survey of macroinvertebrates along six sites on Flat Creek showed that many of the species found are fairly tolerant to organic pollution (Kerst 1996). In addition, the habitat and water quality conditions that are associated with the type of macroinvertebrates found are poorer than those reported for the macroinvertebrate surveys on Willow and Amazon Creek.

Table 10.24 Water Quality Data: Flat Creek

	Temp (C)	DO (mg/l)	pH	NO3 (mg/l)	TP (mg/l)	E-coli (cells/100 ml)
samples	1	1	36	36	26	32
range	18.7	5.4	6.8 – 8.0	0.02 – 5.0	0.03 - 0.45	0 - 169
mean	n/a	n/a	7.3	2.0	0.1	45
median	n/a	n/a	7.2	0.9	0.1	31
criteria	≤ 17.8	> 6.5	6.5 - 8.5	< 30	≤ 0.05	< 406
% exceed	100%	100%	0%	0%	92%	0%

Data source: City of Eugene; Sampling period: Feb. – Apr. 1996

Table 10.25 Pesticides Detected in Flat Creek

	Samples (µg/l)	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	Source
simazine	1	0.009	n/a	n/a	0%	10	Canadian
deethyl atrazine	1	0.022	n/a	n/a	0%	none	
fonofos	1	0.006	n/a	n/a	0%	none	
diazinon	1	0.17	n/a	n/a	100%	0.08	IJC
atrazine	1	0.21	n/a	n/a	0%	2	Canadian
terbacil	1	0.037	n/a	n/a	n/a	none	
EPTC	1	0.077	n/a	n/a	n/a	none	
tebuthiuron	1	0.022	n/a	n/a	0%	1.6	Canadian
carbaryl	1	0.47	n/a	n/a	n/a	none	

Data source: USGS; Sampling period: 1994; Canadian = Canadian Council of Resources and Environmental Ministers; IJC = International Joint Commission 1977

Lower Long Tom

The Lower Long Tom receives runoff from the entire watershed (410 sq. miles) before finally draining into the Willamette River about 10 miles north of Monroe. The proportions of land use in the watershed are 46% forestry, 31% agriculture, 9% rural residential, 8% urban, and 6% other uses (e.g. parks and recreation, rural industrial, water). The Lower Long Tom itself (i.e. section that flows from the reservoir to the confluence with the Willamette) is surrounded almost entirely by agriculture. Consequently, water quality near the mouth of the river is impacted by both the cumulative water quality problems of the entire watershed, and the land use immediately surrounding the Lower Long Tom. Another consideration is that water quality at this site reflects the degree to which the Long Tom impacts water quality in the Willamette River. Given the recent listings of spring chinook and winter steelhead in the Upper Willamette, the water quality problems of its major tributaries may come under regulatory scrutiny.

Water quality data collected by the DEQ over the past 10 years indicate potential problems with pH and bacteria and definite impairment from high water temperature, phosphorus and sediment (reflected by turbidity and total dissolved solids) (**Table 10.26**). In addition, 14 different pesticides were detected during four sampling periods in 1994 (**Table 10.27**). Compared to other streams in the watershed sampled by the USGS, this site (i.e. Lower Long Tom at Bundy Bridge) had the highest number and concentrations of pesticides. None of the pesticides detected exceeded available recommended exceedance criteria. However, only 5 of the 14 actually have recommended criteria, and of those only one is a criteria set by the U.S. Environmental Protection Agency. Similar to other pesticide monitoring in the watershed, the fact that this data is based on only four sampling times makes it difficult to draw any conclusions about the overall impact of pesticides on water quality here.

Table 10.26 Water Quality: Lower Long Tom River

	Temp (°C)	DO (mg/l)	pH	TP (mg/l)	NO3 (mg/l)	Bacteria (cells/100 ml)	Turbidity (NTU)	TDS (mg/l)
samples	45	45	43	43	42	42	41	43
range	4 - 27.4	7 - 13	6.5 - 8.6	0.04 - 0.25	0.02 - 2.2	5 - 1600	7 - 104	0 - 126
mean	15	10.4	7.4	0.10	1	165	23.5	81
median	15.0	10.5	7.4	0.09	0.4	60	19	81
criteria	≤ 17.8	> 6.5	6.5 - 8.5	≤ 0.05	< 30	< 406	≤ 50	≤ 100
% exceed	36%	0%	2%	98%	0%	5%	5%	16%

Data source: DEQ; Sampling period: 1990 - 1998

Table 10.27 Pesticides Detected in the Lower Long Tom River

Name	Samples (µg/l)	Range (µg/l)	Mean (µg/l)	Median (µg/l)	% exceed	Criteria (µg/l)	Source
simazine	4	ND - 0.122	n/a	n/a	0	10	Canadian
prometon	4	ND - 0.005	n/a	n/a	n/a	none	
deethylatrazine	4	ND - 0.006	n/a	n/a	n/a	none	
fonofos	4	ND - 0.016	n/a	n/a	n/a	none	
chlorpyrifos	4	ND - 0.009	n/a	n/a	0	0.04	USEPA
metolachlor	4	ND - 0.02	n/a	n/a	0	8	Canadian
atrazine	4	0.026 - 0.11	0.07	0.07	0	2	Canadian
triclopyr	4	ND - 0.29	n/a	n/a	n/a	none	
diuron	4	ND - 0.12	n/a	n/a	n/a	none	
dinoseb	4	ND - 0.06	n/a	n/a	0	1.75	Canadian
terbacil	4	ND - 0.105	n/a	n/a	n/a	none	
EPTC	4	ND - 0.008	n/a	n/a	n/a	none	
pronamide	4	ND - 0.006	n/a	n/a	n/a	none	
carbaryl	4	ND - 2	n/a	n/a	n/a	none	

Data source: USGS; Sampling period: 1994; Canadian = Canadian Council of Resources and Environmental Ministers; USEPA= U.S. Environmental Protection Agency

Watershed Summary

Overall water quality conditions in the Long Tom Watershed can be interpreted in a number of ways. A regulatory perspective might focus on the percentage of water samples not meeting criteria or recommendations set by the DEQ or the GWEB assessment manual for a particular characteristic (e.g. dissolved oxygen, temperature, etc.). A second perspective is the degree to which beneficial uses are being impacted. For example, how does water quality in the various tributaries and main stem of the Long Tom impact cutthroat trout and whitefish (i.e. salmonids), which are considered the most *sensitive* of the beneficial uses in the watershed? A third perspective, and one that is most difficult to address, is the degree to which water quality has changed from human activities. In addition to humans, the unique soil types, riparian vegetation, stream gradients, and amount of rainfall also influence water quality in the Long Tom Watershed. Because no historical data on water quality is available it is difficult to judge the relative contribution of humans or determine how water quality has changed.

Regulatory Perspective

The DEQ has created a statewide list (the "303d list") which contains streams or segments of streams that do not meet water quality standards and are considered "water quality limited". Typically this list is developed from a review of past and present water quality monitoring studies conducted by a number of agencies. In the Long Tom Watershed, studies done by the Lane Council of Governments (1981, 1983), US Geological Survey (1993, 1995), and Department of Environmental Quality (unpublished data) were used to determine whether a stream was listed. Data from the current monitoring programs conducted by the City of Eugene and ACE were not considered in the listing decisions for 1998 (Rick Kepler, DEQ, pers. com. 1999). Because the information presented in this chapter is based on a larger and more current set of data than the 303d list, only some of the water quality problems evident in Tables 10.2 through 10.27 are on the DEQ's list of water quality limited streams (**Table 10.28**).

Although it is important to know what streams are considered "at risk" by regulatory agencies, the watershed council should also focus on streams or water quality problems that may not be listed but show potential problems based on the information presented in this chapter. One way of prioritizing water quality characteristics or sub-basins to focus on is by dividing them into categories. GWEB has developed the following categories for determining levels of water quality impairment in streams:

No impairment:	< 15 % of samples do not meet water quality standards
Moderate impairment:	15 – 50% of samples do not meet water quality standards
Impaired:	> 50% of samples do not meet water quality standards

Table 10.29 summarizes the levels of impairment for water temperature, dissolved oxygen, phosphorus, bacteria, heavy metals and sediment for each sub-basin. Water quality characteristics that did not meet recommended or state mandated criteria between 15 and 50% of the time are labeled **moderate**, whereas those that did not meet them more than 50% of the time are labeled **impaired**. Characteristics that did not meet criteria less than 15% of time are indicated by an **"ok"** in the table.

Table 10.28 List of Water Quality Limited Streams in Long Tom Watershed

Sub-basin	Characteristic	Listing Status	Season
Amazon Creek	*PAH's, Phthalates in sediment	Potential concern	None specified
Amazon Creek	Cadmium, Copper, Lead, Zinc in sediment	Potential concern	None specified
Amazon Creek	DDT, Chlordane in sediment	Potential concern	None specified
Amazon Creek	Dioxins, Furans in sediment	Potential concern	Year around
A-3 Channel (Amazon sub-basin)	1,1 dichloroethylene & tetrachloroethylene,	**Listed**	Year around
A-3 Channel (Amazon sub-basin)	Arsenic	**Listed**	Year round
A-3 Channel (Amazon sub-basin)	Pentachlorophenol in sediment	Potential concern	None specified
A-3 Channel (Amazon sub-basin)	PAH's, Phthalates in sediment	Potential concern	Year around
A-3 Channel (Amazon sub-basin)	DDT, Chlordane, 2,4-D in sediment	Potential concern	Year around
A-3 Channel (Amazon sub-basin)	Trace metals in sediment (An, Ar, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Si, Zn)	Potential concern	Year around
A-3 Channel (Amazon sub-basin)	Dioxins & Furans in sediment	Potential concern	Year around
A-3 Channel (Amazon sub-basin)	Trace metals in water (Cr, Cu, Fe, Pb, Mn, Zn)	Potential concern	Year around
Amazon Creek Diversion Channel	Bacteria	**Listed**	Year around
Amazon Creek Diversion Channel	Dissolved oxygen	**Listed**	May 1 – Oct. 31
Fox Hollow Creek	Biological criteria	Potential concern	None specified
Fern Ridge Reservoir	Turbidity	**Listed**	Not specified
Fern Ridge Reservoir	Bacteria	**Listed**	Fall/winter/ spring
Coyote Creek	Dissolved oxygen	**Listed**	Summer
Coyote Creek	Bacteria	**Listed**	Year around
Upper Long Tom	Biological criteria	Potential concern	None specified
Lower Long Tom	Temperature	**Listed**	Summer
Lower Long Tom	Bacteria	**Listed**	Fall/winter/ spring

*Information on toxins in stream bottom sediment is beyond the scope of this assessment and is therefore not presented in the text.

Table 10.29 Levels of Impairment for Streams in the Long Tom Watershed

Monitoring Site	Water Temp	Dissolved Oxygen	Total Phosphorus	Bacteria	Heavy Metals	Sediment (turbidity or TDS)
Upper Long Tom headwaters	ok	Insufficient data	Insufficient data	Insufficient data	No data	ok
Upper Long Tom @ Noti	ok	ok	Moderate	No data	No data	ok
Upper Long Tom @ Elmira	Moderate	Moderate	Moderate	ok	No data	ok
Coyote Creek @ Petzold Rd.	Moderate	Moderate	Impaired	No data	No data	ok
Coyote Creek @ Cantrell Rd.	Moderate	Moderate	Impaired	Impaired	No data	ok
Spencer Creek	Moderate	ok	Impaired	No data	No data	Moderate
Upper Amazon @29th	Moderate	ok	Impaired	Moderate	ok	Impaired
Upper Amazon @ Royal Ave, Fir Butte Rd.	Moderate	Impaired	Impaired	Moderate	Moderate (lead & copper)	Impaired
Willow Creek	Moderate	Moderate	Impaired	Moderate	ok	Impaired
Fern Ridge Lake	Impaired	ok	Impaired	ok	No data	ok
Fern Ridge Tributaries	Moderate	Moderate	Moderate	No data	No data	ok
Flat Creek	Insufficient data	Insufficient data	Impaired	ok	No data	No data
Lower Long Tom	Moderate	ok	Impaired	ok	No data	ok
Ferguson Creek	Insufficient data	Insufficient data	Insufficient data	Insufficient data	No data	Insufficient data
Bear Creek	Insufficient data	Insufficient data	Insufficient data	Insufficient data	No data	Insufficient data
Lower Amazon Creek	No data	No data	No data	No data	No data	No data
Elk Creek	No data	No data	No data	No data	No data	No data

Information on pH, nitrates, pesticides and semi-volatile priority pollutants is not included because, with one exception, none of the streams monitored are considered impaired for these characteristics based on the impairment criteria above. The one exception is the presence of the pesticide diazinon in Flat Creek. For some streams there were not enough sampling times to accurately assess impairment or no data has been collected. In the table below, any site that did not have at least 5 sampling times is labeled with "insufficient data". Those sites where no sampling has occurred are labeled "no data".

Based on the recommended or regulatory criteria listed in the data tables many of the streams in the Long Tom Watershed are moderately impaired or impaired for water temperature, phosphorus and dissolved oxygen. Amazon Creek and Willow Creek are moderately impaired for *E. coli* and Coyote Creek is considered impaired for *E. coli*. Sediment levels are a problem in the Spencer Creek drainage (moderate) and Amazon and Willow Creek (impaired). Finally, certain heavy metals, and possibly other chemical contaminants that have been found in stream bottom sediment, are a problem in the Upper Amazon Creek sub-basin.

It is important to keep in mind that these conclusions are based on *available* data. Some streams in the watershed have had little or no monitoring, so conclusions cannot be made for these areas. In addition, pesticides and heavy metals have only been measured in certain parts of the basin. In the case of heavy metals this may be appropriate since the majority of sources are urban, which is where current monitoring is occurring (i.e. Amazon and Willow Creek). Pesticides, on the other hand, are widely used across the basin for road maintenance, agricultural, and residential purposes. However, relatively little data has been collected on pesticides or other chemical pollutants.

Impact on Beneficial Uses

The impacts of these water quality problems on the beneficial uses of surface water in the Long Tom Watershed are summarized in **Table 10.30**. The beneficial use affected is in bold face.

Table 10.30 Summary of Potential Human Impacts on Water Quality

Water Quality Characteristics Influenced by Humans		**Effect**
High water temperatures	→	Primarily impact the **rearing and spawning of trout and whitefish, and other resident fish and aquatic life**, which in turn negatively effects **fishing**. Trout and whitefish, the most sensitive fish in the watershed, require cooler temperatures and higher dissolved oxygen levels than other types of fish, especially while spawning.
Low dissolved oxygen	→	Same as above
Elevated sediment levels	→	Can clog **fish** gills and fill in spawning gravel. May also cause problems with **livestock watering**.
High phosphorus levels	→	Stimulates the growth of algae. This can decrease the **aesthetic value** of a stream or lake, and also lead to lower dissolved oxygen in the water, which impacts **rearing and spawning of trout and whitefish**.
E. coli	→	Mainly impacts **humans who are in contact with the water**, although other types of bacteria that are associated with fecal matter (which means they may also be in surface waters) may cause sickness to **livestock that are watered from local streams**.
Heavy metals	→	Can be toxic to humans who ingest contaminated fish (negatively impacts **fishing**) and **resident fish and aquatic life.**

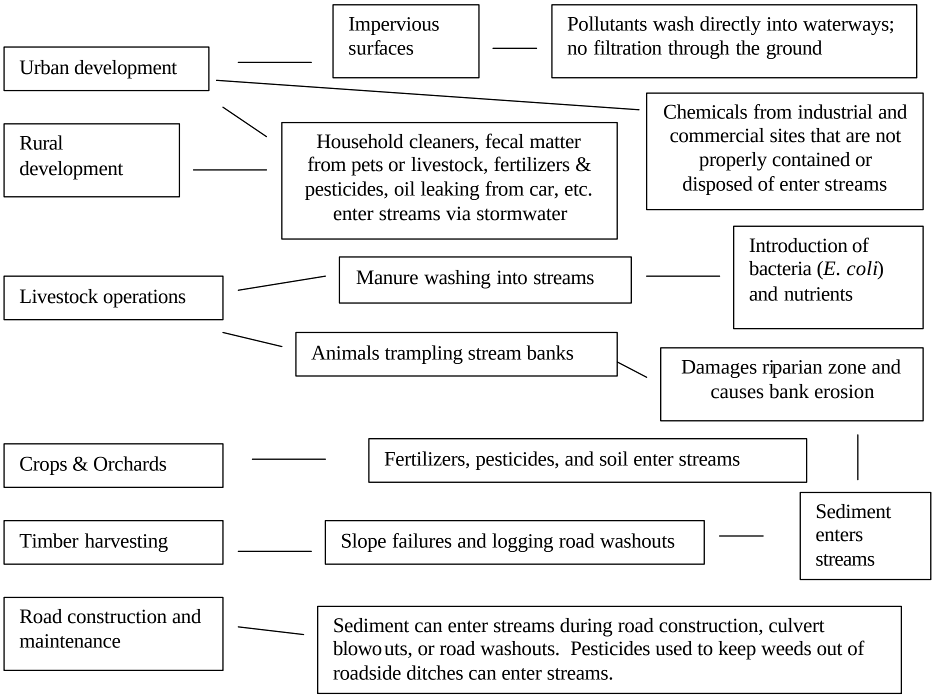

Figure 30.1 Potential Human Impacts to Water Quality

Human Impacts on Water Quality

It is often difficult to distinguish between natural background levels and human effects on water quality. For example, warmer water temperatures and low dissolved oxygen levels result in part from warmer air temperatures and summer low flows. Turbid, silty water results in part from the large proportion of sedimentary soils found in the lower elevations of the Long Tom Watershed. A type of clay soil that originates in the Coyote, Spencer and Amazon Creek sub-basins remains suspended in water for a prolonged period of time (Lane Council of Governments 1983). These fine clays and silts are more likely to bind with nutrients like phosphorus. As a result, when sediment erodes into the water it carries phosphorus with it.

Natural features and conditions in the watershed should be taken into account when setting goals for water quality and planning restoration or enhancement projects in the watershed. However, some human impacts on water quality can be controlled. **Figure 30.1** outlines potential sources of human impact and their specific effect on water quality.

Conclusions

Given the widespread nature of pollutant sources in the watershed there are many possible solutions or strategies to protect and improve water quality. Below is a list of some of the actions the council might want to consider.

- Expand monitoring in the watershed to include more areas. For example, Ferguson Creek, Bear Creek, Lower Amazon Creek, Elk Creek, Noti Creek, and headwater sites.
- Identify a reference site to provide a comparison for data from watershed monitoring. Sites in the Mary’s River watershed and Ferguson Creek have been suggested by local agencies as possible candidates because they are relatively healthy and unaltered by humans. The Mary’s River site would provide a reference for comparing valley bottomland water quality data.
- Implement constant temperature monitoring and more frequent *E. coli* sampling. This will enable the council to more accurately assess the extent of these apparent problems.
- Investigate sources of *E. coli* contamination through new techniques developed by researchers at Oregon State University.
- Form an Amazon working group to help facilitate the implementation of best management practices suggested in Eugene’s storm water management plan.
- Form an Agriculture working group to help facilitate the implementation of successful management practices identified by the Extension Service, Soil and Water Conservation District and from local knowledge.
- Form a Rural homeowners working group to facilitate the implementation of successful management practices identified by relevant agencies or by the watershed council.
- Identify pesticides currently being used in the watershed for agriculture, transportation and residential uses.
- Implement more regular pesticide monitoring.
- Evaluate information supplied by the Toxics Right to Know list for possible contaminants to surface waters in the Amazon Creek sub-basin.
- Educate citizens in the watershed about the water quality problems the council has identified.

Table 10.31 List of Water Quality Constituents, Definitions, and Standards

Chemical & Physical Characteristics	**Definition**	**Criteria for the protection of freshwater species**[28]
Water temperature	See text	≤64° F or 17.8° C
Conductivity	Measures the concentration of salt in the water (includes many kinds of salts, not just table salt).	None
Dissolved Oxygen	See text	> 6.5 mg/l for cool water aquatic life; >5.5 for warm water aquatic life
pH	See text	pH 6.5 - 8.5
Nitrogen (N, NO3, NO2, NH3)	Important plant nutrient; in water usually occurs as nitrate (NO3) or ammonia (NH3).	< 30 mg/l
Phosphorus (P, PO4)	Important plant nutrient; in water usually occurs as PO4.	< 0.05 mg/l*
Pesticides	See text	Each pesticide has a different standard; many do not have established standards
Heavy metals	See text	Each metal has a different standard; often depends on water hardness
Organic compounds	Compounds containing carbon; some can be highly toxic.	Each compound has a different standard
Total suspended solids (TSS)	Fine particles that are suspended in water; includes silts, clays, & microscopic algae.	None
Total dissolved solids (TDS)	Non-particulate material dissolved in the water.	<100 mg/l
Biological oxygen demand (BOD)	Reflects the amount of carbon in the water; high carbon concentrations = high BOD.	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
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.	<50 NTU*
Transparency	Measured by lowering a painted metal disc into the water and seeing how far below the surface of the water it can be seen.	None

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[28] These standards show the acceptable range for each parameter. Those characteristics that have an asterisk are recommendations from the Governor's Watershed Enhancement Board Watershed Assessment Manual. Those without are official DEQ standards.

Alkalinity	Measures the concentration of carbonate, bicarbonate and hydroxide ions in the water;	None
Biological Parameters		
Bacteria (*E. coli*)	Bacteria group used as an indicator of human or animal feces.	• > 406 cells /100ml: single sample • > 126 cells: log mean of at least 5 samples over 30 days
Chlorophyll-a	Measures the amount of algae in the water; chl-a is the primary photosynthetic pigment in plants.	None
Macro-invertebrates	Aquatic insects and larvae commonly used to assess stream health.	None

Chapter 11 Fish and Wildlife

Introduction

This chapter will describe and discuss the fish and wildlife species within the Long Tom Watershed. Specifically, fish species will be listed and discussed in regards to their distribution within the watershed and habitat requirements. Information from several fish and habitat surveys will be presented, as well as a discussion of how this information correlates with land use. A list of wildlife (i.e. mammals, birds, reptiles & amphibians) thought or known to exist in the Long Tom Watershed is also provided. A detailed examination of these species, their status and habitat needs was not within the scope of this assessment. However, information on wildlife that are dependent on aquatic habitat and are currently listed on the federal or state's list of threatened and endangered species will be briefly discussed.

Long Tom Watershed Fish Species

Abundant and healthy fish populations in a watershed are a good sign that its rivers and streams are functioning to provide good habitat and water quality conditions. In the Long Tom, changes in the watershed environment have threatened some species of fish. One of our tasks as a council is to identify the most significant threats to sensitive fish in the watershed and focus our efforts on improving conditions and habitat for these species. Ensuring sufficient habitat and water quality conditions for sensitive fish species will also benefit less sensitive fish species and other aquatic organisms, as well as serve human needs for clean water.

Currently there are no fish in the Long Tom Watershed that are on the federal list of Threatened and Endangered Species. Historically, Oregon chub inhabited the watershed. However, no existing chub populations in the Long Tom have been identified. In addition, spring chinook, which is also listed, may use portions of the Lower Long Tom for winter rearing habitat.

A list of fish species found in the Long Tom Watershed is shown in **Table 11.1**, along with information on which species are native or introduced by humans and their relative tolerance to poor water quality (i.e. high water temperature, elevated nutrient and sediment levels, habitat modification). Note that most of the native species are intolerant or have intermediate tolerance to poor water quality, whereas all of the introduced species are more tolerant of it. Also, native species are less tolerant of habitat change (e.g. caused by stream channel straightening, dredging, loss of riparian vegetation, etc.), whereas many of the exotics can adapt to altered aquatic habitats. Therefore, introduced species have a competitive advantage over native fish in lakes or streams where habitat has been altered and water quality is poor.

Habitat Requirements of Sensitive Native Species

Below are brief descriptions of the sensitive native species within the watershed. The Oregon Department of Fish & Wildlife considers some of these species to be "stocks of concern". Information on Oregon chub is included because until relatively recently they were found in the Long Tom Watershed and suitable habitat may still exist within the basin.

Table 11.1 Fish Species in the Long Tom Watershed

Species	Origin	Sensitivity to Poor Water Quality
Paiute sculpin, Riffle sculpin, Torrent sculpin, *White sturgeon, Cutthroat trout, Mountain whitefish, Pacific lamprey	Native	Sensitive
Western brook lamprey, Chiselmouth, Peamouth, Longnose dace, Leopard dace, Speckled dace, Prickly sculpin, Mountain sucker, Sand roller	Native	Intermediate
Northern pikeminnow, Redside shiner, Reticulate sculpin, Largescale sucker, Threespine stickleback	Native	Tolerant
Channel catfish, Brown bullhead, Yellow bullhead, Mosquitofish, Common carp, Pumpkinseed, Warmouth, Bluegill, Largemouth bass, *Smallmouth bass, White crappie, Black crappie	Introduced	Tolerant

(Sources: Altman 1997, modified by Galovich 1999)
*Presence not documented but other evidence suggests their presence at times in the lower Long Tom is likely (Galovich 1999).

Cutthroat Trout

Cutthroat trout in the Long Tom Basin display two life history patterns. Some are considered to be “resident” and will spend their entire lives in a given stream. Others will migrate between the Long Tom and other streams or rivers such as the Willamette. These fish are called “fluvial”. Fern Ridge Dam is a barrier that prohibits upstream migration into the basin above the reservoir. Most often, the migration into the Long Tom from the Willamette is of adult trout returning to smaller streams to spawn (i.e. lay & fertilize eggs). Spawning can occur over a broad period beginning in late fall and continuing through spring. Like all salmonids, cutthroats prefer cooler temperatures with high dissolved oxygen levels. The population living downstream of Fern Ridge Reservoir, however, appears to be adapted to slightly higher temperatures than most other trout species.

Declines in water quality and the loss of habitat have led ODFW to designate Willamette cutthroat trout as a “stock of concern”. Despite the loss and degradation of historic stream habitat, cutthroat trout still inhabit most of the tributaries and main stem of the Long Tom River. However, seasonal and perhaps year-round distribution may be limited in some streams by poor habitat and water quality, or barriers to fish passage like culverts and dams.

Whitefish

Whitefish are a close relative of both salmon and trout and have similar habitat requirements. They prefer cool or cold flowing water and will usually lie along the bottom of deeper pools but occasionally can be found in the riffle areas of streams. Much like the cutthroat trout, they rely on clean stream gravel as a source of the immature aquatic insects that feed upon as well as for spawning. Spawning usually occurs during the late fall with the eggs then hatching by early spring.

Sculpin

There are four species of sculpin living in the Long Tom basin. They are all characterized by small size, spines, mottled coloration and good camouflage. Their flat bellies make them good for hugging the bottoms of streams and lakes where they hide from predators and lie in wait for food to drift or swim by. Sculpin will feed on a variety of aquatic organisms including other small fish but in turn can be an important food source for larger fish.

Piute Sculpin: Although Piute sculpin, like other freshwater sculpin, are most commonly found in the riffle areas among cobble and large gravel they tend to prefer larger streams of low to moderate gradient. They can also be more tolerant of higher water temperatures and have been found in water that exceeds 60° F or even 70° F. Spawning takes place in the late spring and early summer with egg masses laid on the undersides of larger rock.

Torrent Sculpin: This sculpin generally inhabits larger streams with, as its name implies, swift currents and gravel/cobble bottoms, or beach areas in lakes. It spawns in late spring and early summer producing juveniles that will rely on plankton (i.e. microscopic organisms) and aquatic insects for food. Although immature aquatic insects will remain a mainstay of its diet, the larger torrent sculpin will also prey upon smaller fish and even the eggs of other sculpin.

Riffle Sculpin: Riffle sculpin can be found in a variety of habitats but are most common in the smaller, steeper streams where other species of sculpin become less numerous. Although they do prefer the cooler flowing water found in riffles they tend to avoid areas where the current is too swift. Like the other sculpin, they seek out gravel areas where they forage for a variety of foods. Spawning typically occurs in early spring after which the males will stay to guard the eggs and fry (i.e. newly hatched fish).

Pacific Lamprey

Like salmon, Pacific Lamprey are anadromous, meaning they are born in freshwater and migrate to the ocean to spend part or all of their adult life before returning to freshwater to spawn. Spawning typically takes place during the late spring with eggs laid in small depressions dug into the gravel. Eyeless and without teeth, the juvenile lamprey (or “ammocoete”) will rear for up to several years and filter-feed while buried in the fine silt bottoms found in the backwaters and eddies of streams. While at sea, the adult lamprey become parasitic, feeding on blood and body fluids while clinging to their host fish. After returning to freshwater to spawn, the spent adults die. The National Marine Fisheries Service considers Columbia River Basin Pacific Lamprey a candidate for listing on the federal Threatened and Endangered Species List.

Sand roller

The sand roller is a small fish that inhabits the quiet backwaters or undercut banks along a stream margin. They are secretive and seek out areas that offer a great deal of cover, often only venturing into open areas to feed on plankton, crustaceans and aquatic insects during the darkness of night. Sand rollers are considered by ODFW to be a “stock of concern” due to their declining numbers, a result of the widespread loss of stream backwaters and habitat on the floodplain that used to be accessed when the valley floor was flooded.

Oregon chub

Oregon chub were historically found in many of the sloughs, beaver ponds, oxbows and slow moving side channels associated with streams and rivers in the lowland Willamette Valley. These areas offer cover from predators as well as an abundant food source of zooplankton (i.e. tiny freshwater invertebrates) and freshwater invertebrates (i.e. animals with no backbones, larger than zooplankton). To spawn they prefer the relatively warm water and vegetation found in shallow areas. The straightening and simplifying of stream channels and decreasing of flooding have resulted in a loss of slow backwaters, meanders and shallow ponds connected to the streams, which are the type of habitat chub require. Competition and predation from exotic fish species has also had an impact on chub and has limited opportunities for reestablishing populations. Oregon chub were listed as a federally endangered species in 1993. At this time, no existing chub populations have been identified in the Long Tom basin. However, a recent restoration project in the Lower Long Tom sub-basin involved creating a pond suitable for chub habitat.

Table 11.2 summarizes water temperature requirements for the sensitive native fish species in the watershed. Sufficiently low water temperatures are especially important during spawning and hatching of juvenile salmon or trout. However, high temperatures can still negatively affect fish outside of the spawning season by making them more susceptible to disease, lowering their growth rate and decreasing their ability to compete for food (especially with introduced species that are more tolerant of warmer temperatures).

Table 11.2 Spawning and Rearing Temperature Requirements for Sensitive Species

Species	**Spawning Time**	**Preferred Spawning Temperature (°F)**	**Preferred Rearing Temperature (°F)**	**Lethal Water Temperature (°F)**
Cutthroat	April – May[1]	40°-55°[2]	50°[2]	72°[3]
Whitefish	October – December[1]	41° - 54°[1]	48°-52°[5]	ND
Riffle, Torrent & Piute Sculpins	February – June[2]	45° - 59°[2]	45° - 68° [4]	86° [4]
Pacific Lamprey	April – July[2]	ND	ND	ND
Sand roller	May – June[2]	ND	ND	ND
Oregon Chub	May – June[2]	>64°[5]	>64°[5]	ND

[1]Armantrout 1979, [2]Everest *et al*. 1985, [3]Armantrout pers comm. 1999, [4]Bond pers comm. 1999, [5]Galovich pers comm 1999; ND = no data found

A summary of temperature ranges during the spring and summer for a set of regularly monitored stream sites within the watershed is presented in **Table 11.3**. Water temperatures during the spring and early summer can affect the distribution and spawning of cutthroat trout, sculpin, Pacific lamprey, sand rollers and Oregon chub. Water temperatures during the summer and early fall affect both the rearing of young fish and the survival of adults. **Table 11.3** shows the percentage of summer temperature measurements (July – September) that were potentially lethal to cutthroat trout (i.e. ≥ 72° F). High water temperature, especially at or above 72°, is stressful and sometimes lethal to fish due to the combination of elevated metabolic rates (i.e. fish burn up more calories in warmer water) and low dissolved oxygen levels (also caused by high water temperature). Cutthroat do not necessarily die immediately upon exposure to 72° water. However, prolonged exposure to this or higher temperatures can eventually be lethal (Armantrout pers comm. 1999)

Table 11.3 Stream Temperatures for Selected Sites within the Long Tom Watershed

Site	April – June Temperature Range	July – September Temperature Range	# Measurements Potentially Lethal
Long Tom R. @ Noti	46° - 63° F	55° - 68° F	0 out of 17 (0%)
Long Tom R. @ Elmira	47° - 64°	57° - 72°	2 out of 19 (1%)
Long Tom R. near Monroe	52° - 71°	64° - 81°	7 out of 11 (64%)
Amazon Cr. @ 29th	59° - 63°	59° - 71°	0 out of 4 (0%)
Amazon Cr. @ Fir Butte Rd.	52° - 79°	63° - 81°	16 out of 21 (76%)
Spencer Cr. @ Crow Rd.	48° - 68°	63° - 81°	3 out of 10 (30%)
Coyote Cr. @ Cantrell Rd.	48° - 75°	61° - 81°	12 out of 18 (66%)
Coyote Cr. @ Petzold Rd.	49° - 68°	57° - 73°	4 out of 20 (20%)

*Note: the state regulatory limit for surface waters is 64° F (seven-day average). Water temperatures above this violate state standards for the protection of freshwater organisms.

Because the temperature measurements shown in **Table 11.3** come from single as opposed to continuous measurements it is difficult to know what the average temperatures are in these streams. Furthermore, daily temperature fluctuations can be significant, which may allow more sensitive species to survive even if potentially lethal temperatures are reached in the afternoon. Nevertheless, the upper limits of the temperature ranges shown by these single point measurements are undesirable for spawning and rearing of cutthroat trout and the other sensitive native species listed in **Table 11.2**. In addition, a high percentage of temperature measurements potentially lethal to cutthroat trout have occurred on the Long Tom River near Monroe, Amazon Creek at Fir Butte Rd. (West Eugene), Spencer Creek at Crow Rd. and Coyote Creek at Cantrell Rd. and Petzold Rd.. This indicates that there may be periods during the summer when the main stem of these streams cannot provide adequate habitat and water quality for species like cutthroat trout.

Fish Distribution

Intensive, long term fish surveys have been sparse in our watershed, so it is difficult to quantify species abundance and the extent of their distribution. Nevertheless, knowledge of habitat requirements and information from surveys done by ODFW, Bureau of Land Management and U.S. Geological Survey gives us a fairly good idea of where different species are found in the watershed. Information from the previous section shows how the distribution of fish species is dependent on habitat in the stream and water quality. In turn, fish habitat conditions and water quality are correlated with land use. In general, sensitive native species are more likely to be found in forested tributaries where there has been less habitat modification and water

Table 11.4 Fish Distribution at Four Sites in the Long Tom Watershed

Species	**Origin/ Pollution Tolerance**	**Number of each species**			
		Long Tom at Bundy Bridge	Bear Cr. at Territorial	Ferguson Cr. at Territorial	Ferguson Cr. at Ferguson Rd.
Cutthroat trout	Nat/Sen	0	0	**1**	**15**
Torrent sculpin	Nat/Sen	0	0	**1**	**35**
Speckled dace	Nat/Int	**1**	0	0	0
Prickly sculpin	Nat/Int	0	**1**	**6**	0
Western brook lamprey	Nat/Int	0	**1**	**1**	0
Redside shiner	Nat/Tol	0	0	**1**	0
Reticulate sculpin	Nat/Tol	0	**20**	**94**	**32**
Largemouth bass	Non/Tol	**6**	0	0	0
Warmouth	Non/Tol	**2**	**2**	0	0
Bluegill	Non/Tol	**1**	**1**	0	0
Mosquito fish	Non/Tol	**6**	**1**	0	0
Carp	Non/Tol	**3**	0	0	0
Yellow bullhead	Non/Tol	**72**	**5**	0	0

Source: USGS data from Wentz *et al*. 1998 Nat= native, Non= non-native, Sen= sensitive to poor water quality, Int= intermediate tolerance of poor water quality, Tol= fairly tolerant of poor water quality

temperatures are cooler. Pollution tolerant species are found in the lower portions where streams have been channelized and riparian zones altered. A survey of four sites in the Long Tom Watershed conducted by the U.S. Geological Survey demonstrates this pattern (**Table 11.4**) (Wentz *et al.* 1998).

The Long Tom River at Bundy Bridge is located near the confluence with the Willamette River. Consequently, water quality at this site is influenced by all of the land uses in the basin. This site showed the greatest impairment for fish habitat, which was illustrated by the high percentage of non-native, pollution tolerant species; only one native fish was caught. In addition, many of the fish had external lesions and anchor worms (i.e. not healthy). Although nutrient and pesticide concentrations have tested low, monitoring has found water temperatures to be high, dissolved oxygen low and riparian habitat degraded. The role of pesticides in fish health at this site and other locations is unknown. Although 14 different pesticides have been detected in the water, their peak concentration remains unknown since testing has occurred only on four occasions. Furthermore, concentration levels for these 14 pesticides are hard to interpret since freshwater aquatic-life standards do not exist for most of them, and also because scientists are discovering sub-lethal effects that have not been incorporated into those standards that do exist (Ewing 1999).

The sites at Bear Creek and Ferguson Creek at Territorial Highway represent a mixture of forest, rural residential and agricultural lands. The majority of fish at both sites were pollution tolerant. In addition, a high percentage of introduced species, external lesions and anchor worms were found on fish at Bear Creek. The surveyors attributed the fish assemblage in lower Bear Creek to high stream temperatures, low dissolved oxygen and poor riparian habitat (Wentz *et al.* 1998). In contrast, stream surveys in the upper reaches of Bear Creek indicate the presence of cutthroat trout and some relatively high quality habitat (Galovich pers comm.1999).

Ferguson Creek at Ferguson Road showed a fairly healthy fish assemblage. A significant number of cutthroat trout and torrent sculpin were found, indicating that stream temperature and dissolved oxygen were favorable. Land use above this site is primarily forestry.

Although the streams surveyed represent only a portion of the Long Tom Watershed, the distribution patterns found are likely to be similar in other parts of the Basin. Fish surveys in other parts of the Watershed support this theory (see **Table 11.5**).

Fish Habitat in the Long Tom Watershed: Ferguson & Bear Creek Surveys

In 1995 ODFW surveyed Bear Creek, Ferguson Creek and several tributaries of Ferguson Creek. Results from these surveys are given in **Tables 11.6 through 11.9** at the end of the chapter. These surveys assessed four major aspects of the streams: 1) riffle habitat, 2) large woody debris in the stream 3) pool habitat and 4) riparian habitat conditions. Each stream was divided into one or more segments (or "reaches") in order to summarize stream conditions. A given reach is defined by a relatively consistent stream flow, gradient and topography. Numbering begins at the mouth (e.g. "Ferguson Cr. 1" begins at the mouth and ends at river mile 3.5).

Below is a summary of pool and riffle habitat, large woody debris and riparian habitat for the surveyed streams:

Riffle habitat was evaluated by measuring the width to depth ratio of the channel and the proportion of different substrate types (i.e. gravel, sand, silt, etc.). The width to depth ratio is important because streams that are too wide and shallow heat up more quickly. Substrate is significant because gravel provides important spawning habitat and too much sand and silt can smother spawning beds.

The results for riffle habitat on the surveyed streams were as follows: 1) the width to depth ratio was rated fair or good on all of the surveyed streams, 2) the amount of gravel was below desirable levels for the first reach on Ferguson Creek and South Fork Ferguson Creek, and the last reach on Bear Creek and 3) silt and sand levels were too high on almost all stream segments (**Table 11.6**).

Large woody debris (LWD) includes tree trunks, root wads and large branches that fall into the stream from adjacent riparian zones or uplands. Large conifers (e.g. Douglas fir, pine, etc.) provide the best LWD because they decay more slowly and, because of their size, are less likely to wash downstream. LWD in the stream helps create pools by focusing water in certain parts of the stream. It also slows stream flow, which decreases scouring of the stream bottom and subsequent loss of gravel when high flows occur. Finally, LWD provides a food source for aquatic insects.

In the surveyed streams the number of LWD pieces was rated fair or good for all stream reaches except one in Bear Creek (**Table 11.7**). However, the total volume of wood was poor in the lower reaches of all the streams. This means that *large* pieces of wood are scarce or absent in these lower reaches. This makes sense for two reasons. First, riparian vegetation on the valley floor is often grass, shrubs or small hardwoods, which do not contribute significant amounts of large woody debris to streams. Second, land use along the lower portions of these streams is primarily agriculture and large wood was removed in the past (and perhaps in the present as well) in order to speed water passage through the channel and prevent fields from flooding.

Pool habitat was evaluated by measuring the total pool area, frequency and depth. In general, a high frequency of deep pools is beneficial to fish because they provide resting places and refuge from high water temperatures in the summer. Pool habitat was rated as fair or good on all stream reaches except one, the last reach of Ferguson Creek (**Table 11.8**).

Riparian habitat was evaluated by measuring the amount of shade and by counting the number of conifers greater than 20” or 35” in diameter within 30 meters of the stream. Shade is significant because it prevents streams from heating due to direct sunlight. Large, riparian zone conifers are important because they are a crucial source of LWD. All of the surveyed streams were deficient in large conifers, even along the upper, forested reaches (**Table 11.9**). This means that over the next several decades there will be fewer large trees that fall into the stream and hence less LWD. Shade, on the other hand, was generally good on all stream reaches. Presumably the hardwoods (e.g. trees like bigleaf maple, Oregon ash) are large enough on many segments to provide sufficient shade.

Barriers to instream movement and migration

Dams and culverts often pose barriers to fish attempting to migrate upstream. In the Long Tom Watershed the largest and most obvious barrier to fish passage is Fern Ridge Dam. This effectively blocks the migration or movement of fluvial cutthroats and other fish from the lower Long Tom to habitat in sub-basins above the reservoir. In addition, upstream migration from the Willamette River into Bear and Ferguson Creek is made difficult by two water control structures on the lower Long Tom, one of which is the Monroe Dam. Numerous irrigation dams, flow checks and aesthetic or recreational ponds are scattered throughout the watershed, and some of these also prevent fish from passing upstream.

Recent surveys of culverts on publicly owned land (i.e. state, county, or city) revealed that 36 out of the 73 examined did not provide adequate fish passage (Oregon Department of Fish & Wildlife 1998). Almost all of the culverts that were determined to prohibit upstream passage to fish were estimated to have fair or good fish habitat upstream of the culvert. This sample represents only a small fraction of the total culverts in the basin given that there are approximately 2,275 road/stream intersections, a significant proportion of which are culverts.

Wildlife

Table 11.10 lists mammals, birds, reptiles & amphibians known or thought to occur in the Long Tom Watershed at the present time. A number of these species have been identified by state and federal agencies as potentially in danger of extinction. Both the U.S. Fish and Wildlife Service (USFWS) and Oregon Department of Fish & Wildlife (ODFW) maintain a number of "special status" lists of species threatened or endangered with extinction. Species that are listed as threatened or endangered by the federal government are afforded various protections. Among them, it is illegal to kill, deliberately or otherwise, an endangered or threatened species and it is also illegal to destroy known habitat of endangered species. Regulations concerning state-listed species are only actively applied on state land. **Table 11.11** lists the species in the Long Tom Watershed with special federal and state status (see **Table 11.11** for categories). These include the Clouded salamander, Northern red-legged frog, Tailed frog, Southern seep salamander, bald eagle, purple martin, Northern spotted owl, pallid bat, Pacific western big-eared bat, painted turtle, Northwestern pond turtle and sharptail snake.

Many species are highly dependent on rivers, lakes and/or wetlands for habitat. Below is a brief discussion of vertebrate species that are both highly dependent on aquatic habitat and have a special status listing by the state or federal government.

"Western pond turtles were once common to all wetland habitats of the Willamette Valley but have since declined by as much as 96 – 98% since the beginning of the century (Ecosystems Northwest 1999)." Western pond turtle nests are particularly vulnerable to predation because they are dug in open fields where it is easy for opossum, raccoons and other animals to dig up eggs or pick off hatchlings. Furthermore, adults and juveniles live in ponds and warm quiet sloughs in the valley lowlands, a type of habitat that has been altered by urban, residential and agricultural development. Finally, introduced species like bass and bullfrog prey on young turtles. The cumulative impact of these factors has led to their estimated decline over the last century (Holzhauser & Work 1999). Considerable potential exists to conserve and enhance pond turtle populations in the Long Tom watershed. Information on how landowners can improve habitat conditions for turtles on their property is available on ODFW's web page at www.odfw.state.or.us/springfield.html.

Red-legged frogs are found near ponds, marshes and slow moving streams usually in or near forested areas. They favor areas with dense ground cover. Egg masses are the size of an orange, can be found in slack water attached to aquatic vegetation in February and March and are often easier to find than the frogs themselves. Bullfrog and warm water game fish predation is believed to be one of the main causes of their decline in the Willamette Valley and foothills. Where bullfrog populations can be controlled it is sometimes possible to restore red-legged frogs (Castillo pers comm 1999).

Tailed frogs inhabit cold, fast flowing streams. This species is intolerant to decreases in vegetative cover, increases in water temperature and to siltation. Some populations may exist in the upper, headwater portions of the watershed, but most of the basin does not contain the kind of habitat these frogs require (Castillo pers comm 1999).

Purple martins have shown declines in the Willamette Valley, which is mostly attributed to nest-site competition with introduced European starlings. Fern Ridge Reservoir has a healthy population of purple martins supported by nest boxes that have been attached to snags along the edge of the lake.

Southern seep salamanders are found in headwater streams and small cool seeps, generally in steep areas heavily forested with conifers. They are at risk from forestry operations, siltation and water temperature warming. Other kinds of salamanders (e.g. Northwestern and long-toed salamander), that are not listed, but considered sensitive by local wetland biologists, rely on wetland and marshes for habitat. Wetland conversion or loss and the introduction of bullfrog and warm water game fish threaten these salamanders (Pearl pers comm. 2000).

Spotted frogs require warm water marshes for habitat. The last known siting of a spotted frog was at the Finley Wildlife Refuge, however they are now assumed to be extirpated from the Willamette Valley and much of their range west of the Cascades. Their loss is probably due to habitat loss, reduction of flooding and introduced predators (e.g. bullfrogs, fish) (Pearl pers comm. 2000).

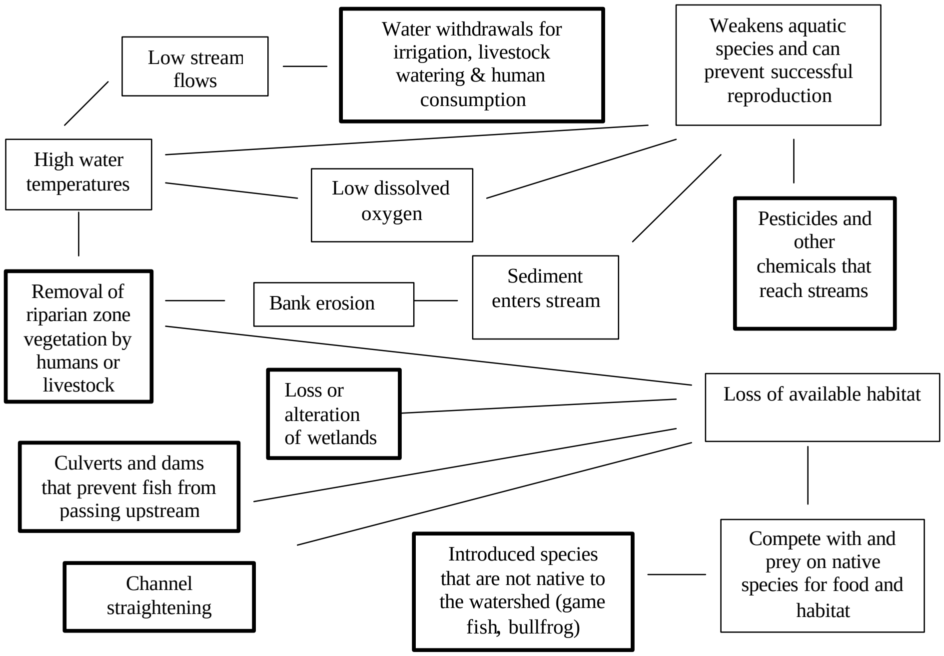

Figure 11.1 Threats to Aquatic Species

Threats to Fish and Aquatic Species in the Long Tom Watershed

It is difficult to show *how much* each human activity affects fish and other aquatic species in our basin. However, the characteristics diagrammed in **Figure 11.1** are either known to or are very likely to have an impact on aquatic species in our watershed. Boxes with heavy outline show human impact.

Steps the Council can Take to Improve Fish Habitat and Survival

There are several factors to keep in mind as the Council prioritizes restoration and enhancement activities. First, information presented in this chapter and in the riparian zone, wetland, and water quality chapters indicates that water quality, instream habitat and riparian zone conditions are poorer in the non-forested lowland areas where urban development, agriculture and residential land predominates. Furthermore, these areas have the potential to be important aquatic habitat. Wetlands, side channels and oxbows provided extensive winter habitat for amphibians, turtles and young fish before many of these areas were either drained or channelized. Second, forested uplands provide important refuge during the summer when stream temperatures in the main stem of rivers become too high for some species. In order to maintain or improve fish habitat in these areas more large trees should be left in riparian zones. Third, the presence of impassable dams and culverts blocks access to important fish habitat. Fourth, high water temperature and low dissolved oxygen levels severly impact sensitive fish and amphibians, especially in areas of low stream flows and sluggish current.

Below is a list of activities the Council could undertake to improve habitat for aquatic species:

- Prioritize restoration and enhancement activities in portions of the watershed that have the best potential for fish, amphibian and turtle habitat. Use channel habitat type information as an initial screening tool followed by site visits and consultation with a fisheries & wildlife biologist.
- Facilitate riparian and/or instream improvement projects at sites with potential for high quality fish and amphibian habitat
- Facilitate wetland restoration to increase habitat for wetland dependent amphibians and reptiles. Restoration could include converting permanent ponds into ephemeral wetlands, which do not favor introduced species like bullfrog.
- Encourage creation of pond turtle habitat where landowners are interested and willing. Old oxbow segments of the lower Long Tom River are especially valuable potential sites.
- Control of exotic plants and animals in some or all parts of the watershed. Bullfrog are paticularly problematic and are also not valued for recreational purposes as are warm water game fish. Reed canary grass has taken over many riparian zones and wetlands.
- Promote land management (all inclusive: residential, industrial, agricultural & forest land) practices that protect aquatic habitat and water quality (e.g. protection of riparian zones, preventing sediment and synthetic chemicals from entering streams).
- Survey culverts to identify barriers to fish passage. Priority streams are urban creeks with no prior surveys, tributaries below Fern Ridge dam, Noti Creek, Poodle Creek, Spencer Creek, and Coyote Creek.
- Locate funding to upgrade culverts that block upstream fish passage; prioritize sites with high quality upstream fish habitat
- Locate funding to upgrade undersized culverts that may cause road washouts and sediment input to streams. Partner with Lane County Road Maintenance on these projects.
- Provide landowners with an opportunity to participate in a survey of other fish passage barriers (recreational or livestock ponds that may be in-channel, etc.) and cost-share efforts to improve problem sites.
- Provide landowners with an opportunity to participate in a survey of those water diversion sites that may pose a risk to young fish; cost share programs available to assist with screening.
- Collect information on stream flow for sub-basins with no previous information in order to more specifically target low flow problems.
- Participate in ODFW's Salmon Trout Enhancement Program (fish monitoring, habitat improvement projects, community education)

Table 11.5 Fish Survey Data

Stream	**Agency**	**Date**	**Species (#)**
Ferguson Cr.	BLM	8/26/98	Sculpin (41), Cutthroat trout (44), Rainbow trout (7), Lamprey (3)
North Fork Ferguson Cr.	BLM	8/27/98	Cutthroat trout (40)
Owens Cr. (Bear Cr. sub-basin)	BLM	8/3/98	Sculpin (93), Cutthroat trout (30), Lamprey (4)
Camas Cr. (Coyote Cr. sub-basin)	BLM	9/1/98	Sculpin (68), Cutthroat trout, (7) Redside shiner (4), Lamprey (9)
Brush Cr.	BLM	9/9/98	Sculpin (70), Cutthroat trout (12), Lamprey (3)
Lower Long Tom R.	ODFW	8/16 – 20/79	Largemouth bass, White crappie, Largescale sucker, Bluegill, Common carp, Brown bullhead, Black crappie, Yellow bullhead, Warmouth
Davidson Cr. (Ferguson Cr. sub-basin)	ODFW	4/24/89	Cutthroat
Davidson Cr. (Ferguson Cr. sub-basin)	ODFW	11/19/95	Cutthroat, Lamprey, Sculpin
Upper Long Tom	ODFW	8/15-19/78	Cutthroat, Sculpin
Hays Cr. (Upper Long Tom sub-basin)	ODFW	8/24/73	Cutthroat
Upper Poodle Cr. (Upper Long Tom sub-basin)	ODFW	8/9/73	Cutthroat
Pitney Cr.	ODFW	4/24/89	Cutthroat
Cedar Cr.	ODFW	9/27/90	Cutthroat
Hill Cr.	ODFW	6/7/88	Cutthroat
Powell Cr.	ODFW	3/21/91	Cutthroat
Noti Cr.	ODFW	8/15/78	Cutthroat, Sculpin

Table 11.6 Riffle Habitat Summary

Stream reach	Width:depth		Gravel (% area)		Silt-sand-organics		Overall rating
	Ratio	*Rating*	*Percent*	*Rating*	*Percent*	*Rating*	
Ferguson Cr. 1	6	Good	13	Poor	84	Poor	Poor
Ferguson Cr. 2	7.5	Good	55	Good	35	Poor	Good
Ferguson Cr. 3	15.6	Fair	35	Good	12	Fair	Fair
Ferguson Cr. 4	15	Fair	59	Good	23	Poor	Fair
Ferguson Cr. 5	11.5	Good	59	Good	25	Poor	Good
Ferguson Cr. 6	10	Good	61	Good	32	Poor	Good
Ferguson Cr. 7	6.75	Good	70	Good	18	Fair	Good
So. Fork. Ferguson Cr. 1	3.2	Good	12	Poor	79	Poor	Poor
So. Fork Ferguson Cr. 2	15	Good	52	Good	44	Poor	Good
Davidson Cr. 1	7	Good	53	Good	23	Poor	Good
Davidson Cr. 2	8	Good	55	Good	28	Poor	Good
Pitney Cr.	10	Good	47	Good	18	Fair	Good
Bear Cr. 1	5	Good	31	Fair	58	Poor	Fair
Bear Cr. 2	8.4	Good	62	Good	30	Poor	Good
Bear Cr. 3	15.6	Fair	30	Fair	55	Poor	Fair
Bear Cr. 4	18.4	Fair	14	Poor	69	Poor	Poor

Table 11.7 Woody Debris Habitat Condition Summary

Stream reach	LWD pieces/100 m		Volume LWD/100 m		Overall LWD rating
	Pieces	*Rating*	*Volume*	*Rating*	
Ferguson Cr. 1	12	Fair	12	Poor	Fair/Poor
Ferguson Cr. 2	10	Fair	9	Poor	Fair/Poor
Ferguson Cr. 3	11	Fair	18	Poor	Fair/Poor
Ferguson Cr. 4	16	Fair	29	Fair	Fair
Ferguson Cr. 5	24	Good	62	Good	Good
Ferguson Cr. 6	24	Good	37	Good	Good
Ferguson Cr. 7	37	Good	102	Good	Good
So. Fork. Ferguson Cr. 1	17	Fair	12	Poor	Fair/Poor
So. Fork Ferguson Cr. 2	26	Good	44	Good	Good
Davidson Cr. 1	14	Fair	15	Poor	Fair/Poor
Davidson Cr. 2	24	Good	54	Good	Good
Pitney Cr.	26	Good	47	Good	Good
Bear Cr. 1	12	Fair	8	Poor	Fair/Poor
Bear Cr. 2	12	Fair	12	Poor	Fair/Poor
Bear Cr. 3	9	Poor	10	Poor	Poor
Bear Cr. 4	16	Fair	16	Poor	Fair/Poor

Table 11.8 Pool Habitat Condition Summary

Stream reach	**CHT***	**Length (m)**	**Land use****	**Gradient (%)**	**Pool area**		**Pool frequency**		**Residual Pool depth (m)**		**Overall pool rating**
					% pool	***Rating***		***Rating***		***Rating***	
Ferguson Cr. 1	LM	5785	AG/LG	0.5	62	Good	11	Fair	0.8	Good	Good
Ferguson Cr. 2	FP3	3393	AG/LG	0.6	75	Good	9	Fair	0.7	Good	Good
Ferguson Cr. 3	MV	440	LT/ST	11.2	12	Fair	15	Fair	0.3	Fair	Fair
Ferguson Cr. 4	MM	1641	ST/TH	2.4	66	Good	8	Good	0.4	Fair	Good
Ferguson Cr. 5	MH	478	LT/ST	6.4	22	Fair	15	Fair	0.4	Fair	Fair
Ferguson Cr. 6	MH	567	LT/TH	2.9	65	Good	20	Fair	0.5	Fair	Fair
Ferguson Cr. 7	MV	368	MT/LT	16.5	6	Poor	143	Poor	0.3	Fair	Poor
So. Fork. Ferguson Cr. 1	FP2	2059	LG/RR	0.8	95	Good	30	Poor	0.3	Fair	Fair
So. Fork Ferguson Cr. 2	FP2/ MC	2164	LT/YT	4.6	68	Good	15	Fair	0.5	Fair	Fair
Davidson Cr. 1	LC	971	LT/ST	1.6	29	Fair	16	Fair	0.4	Fair	Fair
Davidson Cr. 2	MM	976	LT/ST	4.9	62	Good	26	Poor	0.4	Fair	Fair
Pitney Cr.	MV	1109	LT/ST	2	25	Fair	15	Fair	0.3	Fair	Fair
Bear Cr. 1	LM	2465	LG/AG	0.5	76	Good	23	Poor	0.8	Good	Good
Bear Cr. 2	LM	1389	LG/RR	0.9	76	Good	12	Fair	0.8	Good	Good
Bear Cr. 3	MC	1037	ST/RR	4.7	56	Good	8	Good	0.8	Good	Good
Bear Cr. 4	LC/FP 2/WU	3694	LG/RR	0.6	95	Good	9	Fair	0.6	Good	Good

*LM = low gradient, moderately confined, FP3 = low gradient, small floodplain, MV = moderately steep narrow valley, MM = moderate gradient, moderately confined, MH = moderate gradient headwater, FP2 = low gradient, medium floodplain, MC = moderate gradient confined, LC = low gradient confined, WU = wetland

** AG= agriculture, LG = light grazing, LT = large timber, ST = second growth timber, TH = timber harvest, MT = mature timber, RR = rural residential, YT = young timber

Table 11.9 Riparian Habitat Condition Summary

Stream reach	# of conifers > 20” dbh*	# of conifers > 35” dbh	Rating	Shade score	Rating	Bank erosion score**	Percent secondary channels**
Ferguson Cr. 1	0	0	Poor	152	Good	82	2.2
Ferguson Cr. 2	12	0	Poor	162	Good	61	1.4
Ferguson Cr. 3	0	0	Poor	168	Good	0	1.9
Ferguson Cr. 4	0	0	Poor	140	Good	16	3.1
Ferguson Cr. 5	ND	ND	Fair/Poor	170	Good	23	0
Ferguson Cr. 6	0	0	Poor	158	Good	10	13.4
Ferguson Cr. 7	91	0	Poor	174	Good	73	2.6
So. Fork. Ferguson Cr. 1	0	0	Poor	156	Good	60	1.1
So. Fork Ferguson Cr. 2	107	30	Poor	162	Good	64	2.3
Davidson Cr. 1	183	61	Fair/Poor	171	Good	56	4.1
Davidson Cr. 2	0	0	Poor	165	Good	41	1.1
Pitney Cr.	91	61	Poor	171	Good	46	2.3
Bear Cr. 1	0	0	Poor	151	Good	84	3.9
Bear Cr. 2	244	0	Fair/Poor	165	Good	86	0
Bear Cr. 3	122	0	Poor	168	Good	15	0
Bear Cr. 4	61	0	Poor	159	Good	44	3.6

*dbh = diameter at breast height

**Benchmarks do not exist for these parameters, however they provide some interesting information on general observed conditions.

Table 11.10 Birds, Mammals, Amphibians and Reptiles Likely to Occur within the Long Tom Watershed
Source: Oregon Natural Heritage Program, July 29, 1999

Scientific name	Common name
Birds	
Podilymbus podiceps	pied-billed grebe
Aechmophorus occidentalis	Western grebe
Phalacrocorax auritus	double-crested cormorant
Botaurus lentiginosus	American bittern
Ardea herodias	great blue heron
Butorides virescens	green heron
Branta canadensis	Canada goose
Aix sponsa	wood duck
Anas platyrhynchos	mallard
Anas discors	blue-winged teal
Anas cyanoptera	cinnamon teal
Lophodytes cucullatus	hooded merganser
Mergus merganser	common merganser
Oxyura jamaicensis	ruddy duck
Cathartes aura	turkey vulture
Pandion haliaetus	osprey
Elanus leucurus	white-tailed kite
Haliaeetus leucocephalus	bald eagle
Circus cyaneus	Northern harrier
Accipiter striatus	sharp-shinned hawk
Accipiter cooperii	Cooper’s hawk
Buteo jamaicensis	red-tailed hawk
Falco sparverius	American kestrel
Phasianus colchicus	ring-necked pheasant
Dendragapus obscurus	blue grouse
Bonasa umbellus	ruffed grouse
Callipepla californica	California quail
Oreortyx pictus	mountain quail
Rallus limicola	Virginia rail
Porzana carolina	sora
Fulica americana	American coot
Charadrius vociferus	killdeer
Actitis macularia	spotted sandpiper
Gallinago gallinago	common snipe
chlidonias niger	black tern
Brachyramphus marmoratus	marbled murrelet
Columba livia	rock dove
Columba fasciata	band-tailed pigeon
Zenaida macroura	mourning dove
Tyto alba	barn owl

Otus kennicottii	Western screech-owl
Bubo virginianus	great horned owl
Glaucidium gnoma	Northern pygmy-owl
Strix occidentalis	spotted owl
Strix varia	barred owl
Asio flammeus	short-eared owl
Aegolius acadicus	Northern saw-whet owl
Chordeiles minor	common nighthawk
Phalaenoptilus nuttallii	common poorwill
Chaetura vauxi	Vaux`s swift
Calypte anna	Anna`s hummingbird
Selasphorus rufus	rufous hummingbird
Ceryle alcyon	belted kingfisher
Melanerpes formicivorus	acorn woodpecker
Sphyrapicus ruber	red-breasted sapsucker
Picoides pubescens	downy woodpecker
Picoides villosus	hairy woodpecker
Colaptes auratus	Northern flicker
Dryocopus pileatus	pileated woodpecker
Contopus cooperi	olive-sided flycatcher
Contopus sordidulus	western wood-pewee
Empidonax traillii	willow flycatcher
Empidonax difficilis	Pacific slope flycatcher
Tyrannus verticalis	Western kingbird
Eremophila alpestris	horned lark
Progne subis	purple martin
Tachycineta bicolor	tree swallow
Tachycineta thalassina	violet-green swallow
Stelgidopteryx serripennis	Northern rough-winged swallow
Petrochelidon pyrrhonota	cliff swallow
Hirundo rustica	barn swallow
Perisoreus canadensis	gray jay
Cyanocitta stelleri	Steller`s jay
Corvus brachyrhynchos	American crow
Corvus corax	common raven
Poecile atricapillus	black-capped chickadee
Poecile rufescens	chestnut-backed chickadee
Psaltriparus minimus	bushtit
Sitta canadensis	red-breasted nuthatch
Sitta carolinensis	white-breasted nuthatch
Certhia americana	brown creeper
Thryomanes bewickii	Bewick`s wren
Troglodytes aedon	house wren
Troglodytes troglodytes	winter wren
Cistothorus palustris	marsh wren
Cinclus mexicanus	American dipper

Regulus satrapa	golden-crowned kinglet
Salia mexicana	Western bluebird
Sadestes townsendi	Townsend`s solitaire
Ctharus ustulatus	Swainson`s thrush
Trdus migratorius	American robin
Ioreus naevius	varied thrush
Camaea fasciata	wrentit
Bombycilla cedrorum	cedar waxwing
Surnus vulgaris	European starling
Vireo solitarius	solitary vireo
Vireo huttoni	Hutton`s vireo
Vireo gilvus	warbling vireo
Vireo olivaceus	red-eyed vireo
Vermivora celata	orange-crowned warbler
Vermivora ruficapilla	Nashville warbler
Dendroica petechia	yellow warbler
Dendroica coronata	yellow-rumped warbler
Dendroica nigrescens	black-throated gray warbler
Dendroica occidentalis	hermit warbler
Oporornis tolmiei	Macgillivray`s warbler
Geothlypis trichas	common yellowthroat
Wilsonia pusilla	Wilson`s warbler
Icteria virens	yellow-breasted chat
Piranga ludoviciana	Western tanager
Pheucticus melanocephalus	black-headed grosbeak
Passerina amoena	lazuli bunting
Pipilo maculatus	spotted towhee
Spizella passerina	chipping sparrow
Pooecetes gramineus	vesper sparrow
Passerculus sandwichensis	savannah sparrow
Melospiza melodia	song sparrow
Zonotrichia leucophrys	white-crowned sparrow
Junco hyemalis	dark-eyed junco
Agelaius phoeniceus	red-winged blackbird
Sturnella neglecta	Western meadowlark
Xanthocephalus xanthocephalus	yellow-headed blackbird
Euphagus cyanocephalus	Brewer`s blackbird
Molothrus ater	brown-headed cowbird
Icterus bullockii	bullock’s oriole
Carpodacus purpureus	purple finch
Carpodacus mexicanus	house finch
Loxia curvirostra	red crossbill
Carduelis pinus	pine siskin
Carduelis psaltria	lesser goldfinch

Carduelis tristis	American goldfinch
Coccothraustes vespertinus	evening grosbeak
Passer domesticus	house sparrow

Mammals

Didelphis virginiana	Virginia opossum
Sorex vagrans	vagrant shrew
Sorex pacificus	Pacific shrew
Sorex bendirii	Pacific water shrew
Sorex trowbridgii	Trowbridge`s shrew
Sorex bairdi	Baird`s shrew
Sorex sonomae	fog shrew
Neurotrichus gibbsii	shrew-mole
Scapanus townsendii	Townsend`s mole
Scapanus orarius	coast mole
Myotis lucifugus	little brown myotis
Myotis yumanensis	yuma bat
Myotis evotis	long-eared bat
Myotis thysanodes	fringed bat
Myotis volans	long-legged bat
Myotis californicus	California myotis
Lasionycteris noctivagans	silver-haired bat
Eptesicus fuscus	big brown bat
Lasiurus cinereus	hoary bat
Corynorhinus townsendii	Townsend`s big-eared bat
Antrozous pallidus	pallid bat
Sylvilagus bachmani	brush rabbit
Sylvilagus floridanus	eastern cottontail
Lepus americanus	snowshoe hare
Lepus californicus	black-tailed jackrabbit
Aplodontia rufa	mountain beaver
Tamias townsendii	Townsend`s chipmunk
Spermophilus beecheyi	California ground squirrel
Sciurus griseus	Western gray squirrel
Sciurus niger	Eastern fox squirrel
Tamiasciurus douglasii	Douglas` squirrel
Glaucomys sabrinus	Northern flying squirrel
Thomomys bottae	botta`s pocket gopher
Thomomys mazama	Western pocket gopher
Thomomys bulbivorus	camas pocket gopher
Castor canadensis	American beaver
Peromyscus maniculatus	deer mouse
Neotoma fuscipes	dusky-footed woodrat
Neotoma cinerea	bushy-tailed woodrat
Clethrionomys californicus	Western red-backed vole

Arborimus albipes	white-footed vole
Arborimus longicaudus	red tree vole
Microtus townsendii	Townsend`s vole
Microtus longicaudus	long-tailed vole
Microtus oregoni	creeping vole
Microtus canicaudus	gray-tailed vole
Ondatra zibethicus	muskrat
Rattus norvegicus	Norway rat
Mus musculus	house mouse
Zapus trinotatus	Pacific jumping mouse
Erethizon dorsatum	common porcupine
Myocastor coypus	nutria
Canis latrans	coyote
Vulpes vulpes	red fox
Urocyon cinereoargenteus	common gray fox
Ursus americanus	black bear
Procyon lotor	common raccoon
Martes americana	American marten
Mustela erminea	ermine
Mustela frenata	long-tailed weasel
Mustela vison	mink
Spilogale gracilis	Western spotted skunk
Mephitis mephitis	striped skunk
Lutra canadensis	Northern river otter
Felis concolor	mountain lion
Lynx rufus	bobcat
Cervus elaphus	elk
Odocoileus hemionus	black-tailed deer

Reptiles and Amphibians

Rana catesbeiana	bullfrog
Aneides ferreus	clouded salamander
Thamnophis sirtalis	common garter snake
Plethodon dunni	Dunn`s salamander
Ensatina eschscholtzii	ensatina
Rana boylii	foothill yellow-legged frog
Pituophis melanoleucus	gopher snake
Ambystoma macrodactylum	long-toed salamander
Elgaria coerulea	Northern alligator lizard
Thamnophis ordinoides	Northwestern garter snake
Ambystoma gracile	Northwestern salamander
Dicamptodon tenebrosus	pacific giant salamander
Hyla regilla	pacific treefrog
Chrysemys picta	painted turtle

Coluber constrictor	racer
Rana aurora	red-legged frog
Diadophis punctatus	ringneck snake
Taricha granulosa	roughskin newt
Charina bottae	rubber boa
Contia tenuis	sharptail snake
Elgaria multicarinata	Southern alligator lizard
Rhyacotriton variegatus	Southern seep salamander
Ascaphus truei	tailed frog
Sceloporus occidentalis	Western fence lizard
Clemmys marmorata	Western pond turtle
Crotalus viridis	Western rattlesnake
Plethodon vehiculum	Western redback salamander
Eumeces skiltonianus	Western skink
Thamnophis elegans	Western terrestrial garter snake

Table 11.11 Rare, Threatened & Endangered Animals Known or Thought to Occur within the Long Tom Watershed

Source: Oregon Natural Heritage Program, July 26, 1999

Scientific Name	Common Name	State listing	Federal listing
Aneides ferreus	clouded salamander	SU	none
Ascaphus truei	tailed frog	SV	SOC
Rana aurora aurora	Northern red-legged frog	SU/SV	SOC
Rhyacotriton variegatus	Southern seep salamander	SV	SOC
Haliaeetus leucocephalus	bald eagle	LT	LT
Progne subis	purple martin	SC	none
Strix occidentalis caurina	Northern spotted owl	LT	LT
Antrozous pallidus	pallid bat	SV	none
Corynorhinus townsendii townsendii	Pacific western big-eared bat	SC	SOC
Chrysemys picta	painted turtle	SC	none
Clemmys marmorata marmorata	Western pond turtle	SC	SOC
Contia tenuis	sharptail snake	SV	none
Icaricia icarioides fenderi	Fender's blue butterfly	PE	*LE

Federal list categories: **LE** = Listed Endangered; **LT** = Listed Threatened ; **PE** = Proposed Endangered; **PT** = Proposed Threatened; **SoC** = Species of Concern; **C** = Candidates for listing
State list categories: **LE** = Listed endangered; **LT** = Listed threatened; **SC** = Critical Species: species which may be listed as threatened or endangered if immediate conservation actions are not taken; **SV** = Vulnerable Species: listing is not imminent, may be avoided with additional consideration; **SP** = Peripheral Species: species that are naturally rare or whose Oregon populations are on the edge of their ranges; **SU** = Undetermined: Species of concern whose status is unclear due to lack of information. (*Listed 1/26/00)

Chapter 12 Watershed Condition Summary

The Long Tom Watershed is a diverse basin, both ecologically and socially. Opportunities exist for a wide array of fish and wildlife habitat *and* human land use. The presence of multiple ecoregions within the watershed calls for restoration and management strategies and water quality and habitat goals that reflect the unique nature of each region. In addition, the diversity of land use requires different management and resource conservation strategies.

Private ownership of the majority of the watershed means that land management decisions and restoration is the responsibility of many individuals and corporations who have different perspectives and levels of "on the ground" experience with watershed restoration projects. This assessment provides an opportunity for all council members to have access to currently available information on water quality and the condition of aquatic and riparian habitat. It also provides a process for evaluating how well a watershed is "working" from an ecological perspective.

Chapters 2 through 11 present a detailed look at various aspects of the watershed. This chapter briefly reviews the key findings from each chapter and discusses the overall condition of the aquatic-riparian system. This will provide a framework for prioritizing council actions and individual decisions by highlighting the most significant issues from an ecological perspective. The next step of deciding how and what to prioritize rests with council members.

Chapter Summaries

Chapter 2 Sub-basins, Ecoregions, Vegetation and Land Use

1. 10 sub-basins were designated based on drainage pattern, land use and size: Coyote Creek, Spencer Creek, Upper Long Tom, Elk Creek, Upper Amazon, Lower Amazon, Fern Ridge, Lower Long Tom, Bear Creek and Ferguson Creek.
2. Four ecoregions are present in the watershed: Mid-coastal sedimentary, Valley Foothills, Prairie Terraces and Willamette River and Tributaries Gallery Forest. These regions vary in rainfall, geology, soils and vegetation, which influences water quality and habitat, among other things.
3. Approximately 90% of the watershed is in private ownership. Federal land in the watershed amounts to 12%. The Bureau of Land Management owns or manages 8%; the O & C lands may up the bulk of their land. The Army Corps of engineers owns and operates Fern Ridge Reservoir, which accounts for the remaining 4%. State lands account for less than 1%.
4. Primary watershed land use based on general zoning: Forestry = 46%, Agriculture = 31%, Rural Residential = 9%, Urban = 8%.
5. Agriculture = ~81,500 acres. Primary crops are mint, grass and other seed crops, Christmas trees and row crops.
6. Forestry = ~121,000 acres; divided between large timber companies, federal forestlands and small woodlots or family trusts.
7. Urban and rural residential land = ~45,000 acres; Eugene, Veneta, Monroe, Junction City are the primary cities.

Chapter 3 Historical Conditions

1. Wetlands were once extensive along the valley bottomlands, which significantly shaped the habitat types (e.g. wet prairie, emergent wetlands) available to plants and animals.
2. Wet prairie and oak savanna covered large portions of the Long Tom Watershed; they are now the most endangered habitats in the basin.
3. The arrival of Euro-American settlers began a population boom in the area. Agriculture and logging were introduced, which led to significant changes in terrestrial and aquatic habitat including channel modifications, changes in vegetation, introduction of exotic species, hunting.
4. In the early 1900s transportation and urban development began to alter streams, wetlands and upland areas (flood control, roads, building in flood plains, human sewage). The introduction of the internal combustion engine speeded resource consumption and led to an extensive road network.
5. Other advances in technology began to have a negative impact on water quality such as the use of pesticides and fertilizers and toxic waste from industrial development.
6. Knowledge of historical conditions can provide an appreciation for the complexity and magnitude of human impacts on the watershed environment.
7. Understanding historic ecological functions can guide restoration and conservation endeavors.

Chapter 4 Channel Habitat Types

1. Highly and moderately sensitive channels are found in the valley bottomlands. Sensitive channels are more responsive to changes in peak flows, removal or addition of instream wood, stream bank modifications and inputs of sediment. These channels may respond to these changes by altering their pattern, location, width, depth and sediment deposition The Long Tom Watershed has a relatively high proportion of sensitive or formerly sensitive channels because a large portion of the watershed has a low gradient. The most significant direct impact to these channels has been the channelization, dredging and bank reinforcement of streams in order to prevent flooding.
2. Despite the loss or alteration of these streams there still is opportunity to restore or protect sensitive channels. Places that are also in need of riparian or wetland restoration may be a good focus for Council efforts because one restoration tool for sensitive channels is riparian zone planting.

Chapter 5 Hydrology and Water Use

1. In the Long Tom Watershed stream flow is high in the winter, with peak flows occurring after storm events, and low in the summer (except for the portion of Long Tom River that is fed by the reservoir) because there is no melting snowpack.
2. Impervious surfaces and stream channelization elevate peak flows in Amazon Creek.
3. Stream channelization and loss of wetlands in other parts of the watershed have increased peak flows.
4. Fern Ridge dam helps to prevent flooding downstream, which has contributed to wetland loss and influenced water quality in the Long Tom River below the dam.
5. Small check dams on lower Long Tom (and probably elsewhere in watershed) may impede fish passage.

6. Most of the soil in the LT watershed is type C or D, which means the soil does not allow water to percolate down as quickly compared to soil types A & B. This leads to comparatively more rain water flowing overland directly into streams during heavy storms.
7. Overall, forestry and agriculture in the watershed have a low potential to increase peak flow.
8. Surface water withdrawals are primarily used for agriculture. The majority of irrigation is below Fern Ridge Reservoir, thus most of the water withdrawn has been stored in the reservoir.

Chapter 6 Channel Modifications

1. Channelization (with reinforcement by rip rap and levees in some cases), impoundments and road crossings are the most significant channel modifications in the watershed. These can significantly affect aquatic habitat and water quality.
2. The sub-basins most affected by channelization are Coyote Creek, Upper Amazon, Lower Amazon and Lower Long Tom, which were the areas that flooded in the past and have the most agriculture and urbanization.
3. The sub-basins most affected by impoundments are Coyote Creek and Fern Ridge.
4. The sub-basins most affected by road crossings are Upper Amazon, Fern Ridge, Spencer Creek and Upper Long Tom
5. Channel habitat types that correspond with the most channel modifications are “low gradient confined”, “moderate gradient confined” and “small, medium and large low gradient flood plain”. Streams in the valley bottomlands that have been channelized used to be small, medium or large low-gradient floodplains (highly sensitive channels); thus there has been a loss of sensitivity because of confinement.

Chapter 7 Riparian Zone Conditions

1. Our evaluation of current riparian zones was based on whether they still provide the ecological functions they provided historically; these include shade, large woody debris, bank stability, & habitat.
2. Across the entire watershed 42% of riparian zones have low loss of ecological function, 39% have moderate loss of ecological function and 19% have high loss of function.
3. Riparian zones in former closed forest bottomland show the greatest loss of ecological function compared to other historic vegetation types; 108 miles (46%) of these riparian zones have a high loss of ecological function, 94 miles of which is due to the absence of trees. 46 miles of closed forest bottomland (20%) have a moderate loss of ecological function.
4. Riparian zone vegetation in former closed forest upland is less altered compared to bottomland forests; 52 miles (10%) have a high loss of ecological function, which is also mostly due to a lack of trees; 224 miles (45%) have a moderate loss of ecological function.
5. Dense vegetation in former prairie and savanna riparian areas is the primary reason for moderate and high loss of ecological function in these habitats. 33 miles (7%) of former prairie have high loss and 251 miles (55%) have moderate loss of ecological function. 74 miles (33%) of savanna have high loss and 81 miles (36%) show moderate loss.

Chapter 8 Wetland Conditions

1. Wetlands provide key ecological functions in this watershed: habitat for wetland dependent species, peak flow reduction, water quality improvement & ground water recharge.
2. Historically wetlands covered over 40,000 acres. Current levels are about ½ this.

3. Wetlands have been altered or reduced primarily due to urban and agricultural development.
4. Wet prairie was the dominant wetland type, occupying approximately 35,000 acres within the watershed. Current levels are estimated at 1,000 acres, thus there has been a disproportionately greater loss of wet prairie than other types of historic wetland. Some wet prairie has been converted to other types of wetlands.

Chapter 9 Sediment Sources

1. Potentially significant sources of sediment delivery in the watershed include erosion from surfaces and ditches of rural roads, slope failure from forest roads, sediment from urban areas, & erosion of agriculture land.
2. Rural roads: The greater the connectivity of roads to streams the more opportunity there is for sediment delivery. Road connectivity varies from 8% in the Upper Amazon sub-basin to 36% in the Coyote Creek sub-basin.
3. Slope Instability: (a) potential for shallow landslides- 1.6 % of the total land area of the watershed is at high risk, 4.7% is at moderate risk; (b) potential for debris flow- 1.7% of watershed is at high risk, 13.5% is at moderate risk.
4. It is estimated from a landuse based sediment model that urban lands in the Amazon Creek basin have the potential to deliver between 188 – 364 lbs. of sediment/acre/year to streams in the Upper Amazon sub-basin. However, this does not take into account some of the sediment removal practices currently employed by the City of Eugene.
5. Surface Erosion from agricultural land in the watershed has been estimated from a model based on the Universal Soil Loss Equation, but it has not yet been calibrated with actual stream sediment data. The model estimates that roughly 100 lbs./acre/year erode off agricultural lands in the watershed; Grass seed-grain-meadow foam rotation, barrow-fallow fields, and Christmas tree farms accounted for 75% of estimated erosion. This number represents surface erosion, not the amount of sediment that actually reaches the stream.
6. We need a more accurate understanding of the magnitude of sediment delivery from rural road runoff in the watershed.

Chapter 10 Water Quality

1. There is a lack of water quality data for several sub-basins within the watershed (Ferguson Creek, Bear Creek, lower Amazon Creek, Elk Creek & Noti Creek) and for certain potential pollutants such as pesticides and *E. coli*. This is currently being addressed by the council's water quality monitoring program.
2. Phosphorus, *E. coli*, dissolved oxygen, temperature, turbidity and several heavy metals are currently identified problems in various parts of the watershed.
3. Phosphorus levels exceeded 0.05 mg/L (the state accepted limit) in over 50% of samples in Coyote Cr., Spencer Cr., upper Amazon Cr., Fern Ridge, & the lower Long Tom R. High phosphorus levels increase the growth of algae & other aquatic plants, which can ultimately lead to lower levels of dissolved oxygen.
4. Water temperature exceeded 64° C (the state accepted limit) in over 15% of samples in the upper Long Tom R., Coyote Cr., Spencer Cr., upper Amazon Cr., and lower Long Tom R. In Fern Ridge Reservoir over 50% of samples exceeded 64° C. Water temperatures above 64° C negatively impact trout and other aquatic species requiring low water temperatures and high dissolved oxygen.

5. Dissolved oxygen fell below 6.5 mg/l (the state accepted minimum for cool water aquatic life) in over 15% of samples in the upper Long Tom R., Coyote Cr., Spencer Cr., upper Amazon Cr., & lower Long Tom R. Dissolved oxygen levels below 6.5 mg/l negatively impact trout and other aquatic species.
6. *E. coli* (bacteria) levels exceeded state standards in over 50% of samples in Coyote Cr. and in over 15% of samples in upper Amazon Cr. High levels of *E. coli* in surface waters are a threat to human health and correlate with the input of sediment and nutrients to streams.
7. The Oregon Department of Environmental Quality water quality limited streams in this watershed: Amazon Creek (A-3 channel): chloroethylene compounds & arsenic; Amazon Creek (diversion channel): bacteria & dissolved oxygen; Fern Ridge Reservoir: turbidity & bacteria; Coyote Creek: dissolved oxygen & bacteria; Lower Long Tom: temperature & bacteria.

Chapter 11 Fish Habitat and Populations

1. Water quality and fish studies in the watershed indicate that high summer temperatures, low dissolved oxygen, stream habitat modification and perhaps other factors (e.g. pesticides) in certain tributaries impair sensitive native fish species.
2. Numerous exotic species exist in the watershed, which compete with native fish and decrease their population numbers.
3. Limited culvert data indicate known and potential passage barriers to fish from culverts. Several dams in the watershed are also known to pose passage barriers. Impoundments may also create upstream and downstream passage barriers.

Table 12.1 lists key pieces of information by sub-basin.

Table 12.1 Currently Identified Watershed Conditions by Sub-basin

Sub-basin	Identified water quality problems	Wetland conditions	Riparian conditions	Sediment sources	Channel modifications	Hydrology/ water use
Bear Creek	Very little data	No field surveys; some loss of wet prairie	Lack of trees in former CFB Narrow width of forested riparian zones in former CFB, CFU & WOOD Dense vegetation in former savanna & prairie	Some cropland, grazing; Christmas tree farms Rural roads: 30% connectivity, some slope failure potential	Channelized= 11.6 miles; 7 impoundments	Low potentials for peak flow enhancement; Uses 4.3% of basin irrigation
Coyote Creek	E. coli water temp. DO phosphorus	Some field surveys; wetland in West Eugene of good quality; loss of wet prairie	Lack of trees in former CFB, CFU & WOOD Narrow width of forested riparian zones in former CFB, CFU & WOOD Dense vegetation in former savanna & prairie	Cropland, grazing; some Christmas tree farms Rural roads: 36% connectivity, some slope failure potential	Channelized= 18.5 miles; 15 impoundments	Low potentials for peak flow enhancement; Uses 9.4% of basin irrigation
Elk Creek	Very little data	No field surveys; historic wetlands were willow/beaver swamps	Lack of trees in former closed former CFU & WOOD Narrow width of forested riparian zones in former CFU Dense vegetation in former prairie	Christmas tree farms Rural roads: 33% connectivity; some slope failure potential	Channelized= 4.9 miles; 7 impoundments	Low potentials for peak flow enhancement; Uses 3.6% of basin irrigation
Ferguson Creek	Very little data	No field surveys; loss of wet prairie	Lack of trees in former CFU Narrow width of forested riparian zones in CFB Dense vegetation in former savanna & prairie	Some cropland & grazing; Christmas tree farms Rural roads: 34% connectivity, some slope failure potential	Channelized= 3 miles; 1 impoundment	Low potentials for peak flow enhancement; Uses 2.3% of basin irrigation
Fern Ridge	water temp. phosphorus	Some remaining wetland on perimeter of reservoir; loss of wet prairie and ash swamps	Lack of trees in former WOOD & CFU Dense vegetation in former savanna & prairie	Cropland & grazing Christmas tree farms Rural roads: 12% connectivity; low slope failure potential	Channelized= 3.1 miles; 24 impoundments	high potentials for peak flow enhancement from impervious surfaces; low/moderate from rural road density; Uses 5.1% of basin irrigation
Lower Amazon	Need more data	No field surveys; extensive loss of wet prairie	Concrete replacing former riparian zone Dense vegetation in former savanna & prairie	Croplands & grazing Rural roads: 12% connectivity; low slope failure potential	Channelized= 43 miles; 4 impoundments	high potentials for peak flow enhancement from impervious surfaces; Uses 10% of basin irrigation

Lower Long Tom	water temp. phosphorus	No field surveys; extensive loss of wet prairie	Lack of trees in former CFB Narrow width of forested riparian zones in CFB Dense vegetation in former savanna & prairie	Croplands & grazing Christmas tree farms Rural roads: 22% connectivity; low slope failure potential	Channelized= 61 miles; 4 impoundments 8 flow check dams 24 miles levee 7 quarries	high potentials for peak flow enhancement from impervious surfaces; Uses 57% of basin irrigation
Spencer Creek	water temp. phosphorus sediment	No field surveys; some loss of wet prairie	Lack of trees in former CFU & WOOD Narrow width of forested riparian zones in CFU Dense vegetation in former savanna & prairie	Croplands & grazing Rural roads: 20% connectivity; some slope failure potential	Channelized= 4.2 miles; 3 impoundments	high potentials for peak flow enhancement from impervious surfaces; Uses <1% of basin irrigation
Upper Amazon	*E. coli* water temp. DO phosphorus sediment chemicals	Many field surveys; extensive wetland restoration; loss of wetland in upstream sections of basin	Lack of trees in former CFB Concrete replacing former riparian zone Dense vegetation in former savanna & prairie	Impervious surfaces construction sites Roads: 8% connectivity; some slope failure potential	Channelized= 15.6 miles; 2 impoundments 8.2 miles levee	high potentials for peak flow enhancement from impervious surfaces; Uses 3% of basin irrigation
Upper Long Tom	Insufficient data on DO, phosphorus, bacteria	No field surveys; most historic wetlands were willow/beaver swamps	Lack of trees in former CFU Narrow width of forested riparian zones in CFU Dense vegetation in former savanna & prairie	Christmas tree farms Rural roads: 33% connectivity; some slope failure potential	Channelized= 5.6 miles; 6 impoundments	low/moderate potential for peak flow enhancement from rural road density; Uses 5% of basin irrigation

DO= dissolved oxygen, CFB= closed forest bottomland, CFU= closed forest upland, WOOD= woodland

Where is more information needed?

There are some questions that the assessment could not answer because of insufficient existing data. Missing data that the council may wish to collect is listed below.

- Water quality data on Ferguson Creek, Bear Creek, Lower Amazon Creek, Elk Creek, Noti Creek, and headwater sites.
- Constant temperature data, more frequent *E. coli* sampling and pesticide monitoring.
- Sources of *E. coli* contamination
- Culverts surveys that can identify barriers to fish passage and undersized culverts. Priority streams are urban creeks with no prior surveys, tributaries below Fern Ridge dam, Noti Creek, Poodle Creek, Spencer Creek, and Coyote Creek.
- Stream flow data, in order to assess the extent of low flow problems.
- Information on surface erosion potential from all roads in watershed.
- Information on potential sediment delivery to streams from agricultural land
- Information on impact of rural residential land on habitat and water quality
- A more detailed analysis of shade provided by riparian areas

What is the overall condition of the riparian and aquatic system?

River-floodplain disconnection in the valley bottomlands

The combination of extensive flooding and fire in the past created a unique landscape. Wetlands covered large portions of the valley bottomland and significantly shaped the habitat and ecological processes present at that time. There was a diverse range of habitat: forested upland where tall conifers shadowed the forest floor, woodland and savanna with scatterings of oak and shrubland, and wide expanses of prairie. Because of this habitat diversity, many kinds of plants and animals lived here. The bottomland riparian forests were especially productive and rich in species. Fire, flooding and perhaps grazing by wild animals kept the prairie and savanna open, which created habitats to which some species were especially adapted.

Extensive, regular flooding created a connection between the river and adjacent land. When the river overtopped its banks water spread out over the floodplain, allowing sediment to settle out and nutrients from the floodwater to be taken up by wetland plants. The river's inhabitants benefited too. They had access to more habitat during the period of time flooding occurred. Plant material and insects were picked up from the land and provided food for creatures in the water. Also, floodwaters spread out instead of being focused into a narrow channel. This dampened the flow downstream and caused less erosion in the stream channel itself. Ponds and marshes caused by beaver dams stored winter rains and slowly released water during the summer, which may have prolonged the flow of small streams during the summer.

Stream channelization and the major dam we have created to prevent flooding has compromised many of the ecological functions and habitat that these wetlands provided historically. Densely forested riparian areas along the Long Tom River and Coyote Creek have been largely reduced, which means there is less riparian habitat, shade and potential for large woody debris to enter the stream.

Uplands

The forested uplands have been somewhat less altered than other parts of the watershed. The cutting of trees from riparian zones in the past and log drives that took place from the 1850s to the 1920s have left their mark. Current human impacts are the sediment that reaches streams from rural roads and logging related landslides. In some upland areas trees have been completely removed, perhaps to clear land for a homestead or pasture.

Protecting the ecological functions these riparian zones provide (shade, bank stability, and large woody debris) benefits species living in this habitat and influences water quality down stream. Two important protection and restoration strategies for forested upland areas are to prevent or reduce road surface erosion from entering streams and to allow riparian trees to get big and fall into the stream.

Water Quality

Another major impact we have on the watershed is what we let run off into the water. Every individual who lives in the watershed influences water quality in some way, whether it is washing their car, changing its oil in the driveway, using fertilizers on their lawn or field, or driving down a dirt road. These activities have a cumulative effect, which means the farther downstream you go the bigger the problem gets. This is one reason water quality at the mouth of the Long Tom is some of the worst in the basin.

There is also a cumulative effect of polluting water *and* changing riparian and wetland habitat. Wetlands in particular can act as a buffer between sources of pollution (especially sediment, nutrients, and in some cases heavy metals) and the stream. Riparian areas with big trees keep the sun from heating up water in small and medium sized streams. And in some cases riparian areas can also filter out pollutants from surface runoff before it reaches the stream.

We do not know exactly what water quality was like in the past. Historical accounts of the Long Tom River and Coyote Creek described them as “muddy” and slow moving in the summer (which allowed some degree of heating). This shows that at least part of the winter turbidity and warm water in the summer is natural. But we also know that riparian areas provided shade and that species like cutthroat trout and sculpins found sufficient cool water year round. Restoring the conditions that influenced water quality in the past is one approach to improve or restore populations of sensitive, native fish. This would include preventing human generated pollutants from entering streams and setting goals for restoring riparian and wetland conditions that can buffer and shade streams.

A Parting Question

The state of Oregon has a budget of over 26.6million dollars for monitoring, habitat protection and on the ground restoration for the next two years. If 1 million dollars of that was spent in the Long Tom Watershed and it was up to *you* to decide how it was spent, how would you allocate it given what you now have learned from this assessment? Let the council know your answer to this. We will be compiling them on an ongoing basis to help prioritize our actions.

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Appendix A. Confidence Evaluations for each Assessment Component

Chapter 3 Historical Conditions

1. Resources used: Interviews were conducted with local residents and resource professionals to characterize historic flooding, wildlife, land use practices and way of life in the Long Tom Watershed at the beginning of the 20th century. Extensive research was conducted of early explorer and settlers diaries as well as more recent literature on historic vegetation, early humans and Euro-American settlement.

2. Confidence in accuracy of historical channel and riparian modification *descriptions*: Moderate to high: used information from agency records or from other descriptions (note: did not map all historic channel modifications; instead described). It is likely that we did not find all locations of splash damming or log driving or channelization since many may not have been documented.

3. Expertise of researchers: Anthropologist from Oregon State University (Jennifer Gilden) with previous experience in historical research; local historian and sociologist (Douglas Card) with extensive experience in historical research; botanist with the Nature Conservancy (Ed Alverson) with extensive experience researching historical vegetation; graduate student in biology (Cindy Thieman) with no previous experience but a true fascination for the subject.

Chapter 4 Channel Habitat Types

1. Resources used: Topographic maps, Oregon Department of Forestry stream size maps, field verification, Oregon Department of Fish & Wildlife stream surveys.

2. Confidence in accuracy of mapping: High, used (available) field surveys and field verified many segments of all channel habitat types. Primary difficulty was in determining channel confinement.

3. Expertise of researchers: Undergraduate student in geology (Elliot Shuford) with knowledge of stream processes; graduate student in planning (Ted Gresh) with some background in stream channel processes; graduate student in biology (Cindy Thieman) with prior stream survey experience with the Forest Service. All had a solid understanding of methods.

Chapter 5 Hydrology and Wateruse

1. Resources used: USGS web site, USGS Open file report 90-118, OWRD regional personnel, Oregon Climate Service Web site, OWRD web site, OWRD local watermaster, NOAA hydrologist, ODFW minimum stream flow recommendations

2. Confidence in assessment: Moderate: understood and followed procedures; very little current stream gauge data available; did not collect any field data.

3. Expertise of researcher: Masters degree in resource geography (Dana Erickson) with research experience in hydrology

Chapter 6 Channel Modifications

1. Resources used: topographic maps, FEMA floodplain maps, historical records, DOGMI mining records, local knowledge, field verification, Army Corps of Engineers personnel & documents, OWRD map of impoundments and channel modifications, City of Eugene maintenance records

2. Confidence in mapping: Moderate to high: Understood and followed procedures; used many resources for mapping; some field verification; suspect some modification activities not known.

3. Expertise of researchers: graduate student in biology (Cindy Thieman) with prior experience stream surveying and interpreting stream channel changes on topographic maps; recent environmental studies graduate (Lora Konig) with prior experience mapping channel modifications using the OWEB manaual.

Chapter 7 Riparian Zone Conditions

1. Resources used: topographic maps, map of historical vegetation (circa 1850), color aerial photographs (1:12,000), BLM staff with prior experience with aerial photo interpretation of vegetation, ODFW stream survey information, field verification, GIS for digitization of riparian characterization

2. Confidence in mapping: Moderate to high; high confidence in assessment procedure and personal skills, access to experts for help and review, some areas field verified, some potential for conditions to have changed since aerial photos taken.

3. Expertise of researchers: limited prior experience with aerial photo interpretation; spent many hours learning to interpret aerial photos, calibrating our aerial photo assessments with field observation and ensuring that riparian vegetation was characterized the same by all team members; (riparian vegetation research team: Cindy Thieman, Lita Furby, Matt Fidanque, Chelsea Gibbons, Samara Phelps).

Chapter 8 Wetlands

1. Resources used: National Wetlands Inventory, local wetland inventories, local experts (Ed Alverson, Christopher Pearl)

2. Confidence in description and mapping: no new wetland maps created for this project; NWI map was used; high confidence in wetland descriptions

3. Expertise of researcher: graduate student in biology (Cindy Thieman); previous coursework in wetland ecology, soils and plants.

Chapter 9 Sediment Sources

1. Resources used: BLM, County, City and ODOT road maintenance information, BLM forest road runoff field inventory and model estimates, BLM model of landslide risk in watershed, ODF model of debris flow potential in watershed, BLM digital road layer for watershed, digital County soils map, 30 meter digital elevation model, BLM digital stream network map, City of Eugene sediment load estimate from a landuse based model, surface erosion estimate from agricultural lands based on USLE model (Oregon State University, Bioresource Engineering Dept.)

2. Confidence in description and mapping: high confidence in interpretation of available data; overall low confidence in assessing actual sediment sources to streams, especially from agricultural lands and other rural areas, due to lack of available data and field verification (main limitation is the fact that most of the watershed is on private land so field verification is difficult and size of watershed makes extensive field study prohibitive); moderate confidence in BLM and ODF landslide/debris flow potential map (no field verification in watershed); moderate confidence in City of Eugene urban runoff sediment load estimate (model is still being fine tuned); low confidence in agricultural erosion potential map being able to predict sediment delivery to streams (model is still being developed and needs calibration with field data).

3. Expertise of researchers: graduate student in biology (Cindy Thieman) with limited prior knowledge of sediment transport mechanisms; graduate student and professor in Bioresource Engineering (Kellie Vache, John Bolte) with extensive background in engineering, hydrology and modeling.

Chapter 10 Water Quality

1. Resources used: water quality data from USGS, DEQ, City of Eugene, Army Corps of Engineers, Lane Council of Governments, local experts

2. Confidence in assessment: high confidence interpreting available data; lack of data in many parts of the watershed and in several parameters (nutrients, pesticides, *E. coli*) result in low to moderate confidence in assessing overall water quality for basin.

3. Expertise of researcher: graduate student in biology (Cindy Thieman) with extensive background in water quality monitoring and fresh water biology.

Chapter 11 Fish & Wildlife

1. Resources used: ODFW, BLM, USGS fish surveys, ODFW habitat surveys, ONHP list of wildlife species and Threatened and Endangered species, ODFW & BLM personnel, ODFW Long Tom Basin Management Plan

2. Confidence in descriptions high. Confidence in distribution map moderate degree of accuracy-some data on fish presence/absence were available & used in conjunction with ODF fish presence/absence map.

3. Expertise of researcher: some prior experience of researcher with fish surveys and habitat (Cindy Thieman); relied on expertise and contributions of local fisheries biologists.

Appendix B. Glossary of Terms and Acronyms

Terms

Anadromous: Fish that move from the sea to fresh water for reproduction.

Biotic: Something that is living, or pertaining to living things.

Canopy cover: the overhanging vegetation over a given area.

Channel complexity: A term used in describing fish habitat. A complex channel contains a mixture of habitat types that provide areas with different velocity and depth for use by different fish life stages. A simple channel contains fairly uniform flow and few habitat types.

Channel confinement: Ratio of bankfull channel width to width of modern floodplain. Modern floodplain is the flood-prone area and may correspond to the 100-year floodplain. Typically, channel confinement is a description of how much a channel can move within its valley before it is stopped by a hill slope or terrace.

Channel habitat types (CHT): Groups of stream channels with similar gradient, channel pattern, and confinement. Channels within a particular group are expected respond similarly to changes in environmental factors that influence channel conditions.

Channel pattern: Description of how a stream channel looks as it flows down its valley (for example, braided channel or meandering channel).

Cohesive: when describing soil, tendency of soil particles to stick together. Examples of soils with poor cohesion include soils from volcanic ash, and those high in sand or silt.

Conifer: Cone-bearing tree, generally evergreen (although certain exceptions occur), having needle-like leaves. Examples include pines, Douglas fir, cedar and hemlock.

Connectivity: The physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and these water sources.

Cut slope: The sloping excavated surface on the inside bank of a road.

Debris flow: A type of landslide that is a mixture of soil, water , logs and boulders which travels quickly down a steep channel.

Discharge: Outflow; the flow of a stream or canal.

Downcutting: when a stream channel deepens over time

Ecology: A branch of science that studies the inter-relationships of organisms with their environment.

Ecological function: A function that is the result of natural processes (e.g. physical and biological), which create habitat, conditions or resources (e.g. food, water) that local organisms have adapted to and come to rely on. For example, flooding is a process that provides habitat for wetland dependent species. Another example, certain plants are adapted to fire and require it in order to germinate or highly benefit from it.

Ecoregion: land areas with fairly similar geology, plants and animals, and landscape characteristics that reflect a certain ecosystem type.

Evapotranspiration: the amount of water leaving to the atmosphere through both evaporation and transpiration (i.e. through plant leaves).

Fill slope: The outer edge of a road that extends downhill of the road surface.

Flood attenuation: When flood levels are lowered by water storage in wetlands, lakes or reservoirs.

Floodplain: The flat area adjoining a river channel constructed by the river in the present climate, and overflowed at times of high river flow.

Fluvial fish: Fish that rear in larger rivers and spawn in smaller river tributaries.

Fry: The early life stage of salmon and trout after the yolk sac is absorbed.

Gaging station: A selected section of a stream channel equipped with a gage, recorder or other facilities for measuring stream discharge.

Geographic Information System: A computer system designed for storage, manipulation and presentation of geographical information such as topography, elevation, geology, etc.

Habitat: The place or type of site where a plant or animal naturally or normally lives and grows.

Hardness: A measure of the calcium and magnesium concentrations in water; used to select the appropriate criteria for heavy metals.

Hardwood: Non cone-bearing tree, always deciduous (i.e. loses its leaves every fall). Examples include maple, oak and willow.

Hydric soils: A soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic (no oxgyen) conditions in the upper part of the soil profile.

Hydrologic cycle: The circulation of water around the earth, from ocean to atmosphere and back to ocean again.

Hydrology: The study of surface and ground water movement from the atmosphere and through the soil.

Impairment: When violation of exceedance criteria (e.g. water quality criteria) or poor instream habitat conditions indicates that a beneficial use of surface water is harmed.

Impervious surface: surface (such as pavement) that does not allow, or greatly decreases, the amount of infiltration of precipitation into the ground.

Infiltration: The rate of water movement from the atmosphere into the soil

Invertebrate: Animals with no vertebrate (i.e. backbone); they can be microscopic or visible to the human eye. Examples include insects, worms, snails and freshwater mussels.

Juvenile: The early life stage of salmon or trout, usually the first and second years.

Large woody debris (LWD): Logs, stumps, or root wads in the stream channel, or nearby. These function to create pools and cover for fish, and to trap and sort stream gravel.

Low flows: The minimum rate of stream flow for a given period of time.

Mass wasting: Downslope transport of soil and rocks.

Meandering: When a stream channel moves from side to side across its valley (e.g. snake like pattern).

Morphology: A branch of science dealing with the structure and form of objects. Geomorphology as applied to stream channels refers to the nature of landforms and topographic features.

Oxbow lake: A bow-shaped river bend that has been isolated from its former channel.

Peak flow: The maximum instantaneous rate of flow during a storm or other period of time.

Precipitation: The liquid equivalent of rain, snow, sleet or hail.

Rain-on-snow event: When snowpacks are melted by warm rains, causing peak flow events.

Recruitment potential for large woody debris: The amount or size of large trees in a riparian area that could potentially fall in (i.e. be recruited) to the stream channel. Mechanisms for recruitment include small landslides, bank undercutting, wind throw during storms, individual trees dying of age or disease and transport from upstream.

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 area: Area bordering streams and rivers.

Riparian zone: An administratively defined distance from the water's edge that can include riparian plant communities and upland plant communities. Alternatively, an area surrounding a stream, in which ecosystem processes are within the influence of stream processes.

Riparian vegetation: Vegetation growing on or near the banks of a stream or other body of water in soils that are wet during some portion of the growing season. Includes areas in and near wetlands, floodplains, and valley bottoms.

Salmonid: Fish of the family *Salmonidae*, including salmon, trout, char, whitefish, ciscoes and grayling. Generally the term refers to salmon, trout and char.

Sediment: Fragments of rock, soil and organic material transported and deposited into streambeds by wind, water or gravity.

Spawning: Term used to describe the reproduction of fish; involves females laying eggs in gravel or mud at the bottom of a lake or stream and male fertilizing eggs.

Species: A biological classification comprised of related organisms or populations potentially capable of interbreeding. Species names are immediately preceded by genus names (e.g. *Homo sapiens*, where *Homo* is the genus name and *sapiens* is the species name; this is the scientific name for humans).

Splash damming: Historical practice where a small dam was built across a stream to impound water and logs. The dam was then removed (usually with explosives) to release the impounded logs and water, causing scouring of stream substrate downstream.

Stream reach: A section of stream possessing similar physical features such as gradient, flow and confinement.

Substrate: Mineral or organic material that forms the bed of a stream.

Surface runoff: Water that runs across the top of the land without infiltrating the soil.

Upland vegetation: Vegetation typical for a given region, growing on drier upland soils. The same plant species may grow in both riparian and upland zones.

Acronymns

ACE:	**Army Corps of Engineers**
BLM:	**Bureau of Land Management**
cfs:	**cubic feet per second**

CHT:	**channel habitat type**
dbh:	**diameter at breast height**
ESA:	**Endangered Species Act**
GIS:	**Geographic Information System**
GWEB:	**Governor’s Watershed Enhancement Board**
LWD:	**large woody debris**
NTU:	**nephalometric turbidity unit**
NWI:	**National Wetlands Inventory**
ODA:	**Oregon Department of Agriculture**
DEQ:	**(Oregon) Department of Environmental Quality**
ODF:	**Oregon Department of Forestry**
ODFW:	**Oregon Department of Fish and Wildlife**
ONHP:	**Oregon Natural Heritage Program**
OWRD:	**Oregon Water Resources Department**
SWCD:	**Soil and Water Conservation District**
SSCGIS:	**State Service Center for GIS**
USGS:	**US Geological Survey**