City of Portland

DRAFT
WATERSHED CHARACTERIZATION SUMMARY

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Introduction

REPORT PURPOSE

This report summarizes current conditions in Portland's watersheds, including the Willamette River, its tributary streams, and the portion of the Columbia River directly affected by activities in Portland. The conditions are summarized relative to four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvement in these four goal areas will improve overall watershed health and the capacity of watersheds to perform critical functions, such as providing clean water.

This summary report was developed from watershed characterization reports and supporting documents that contain a high level of technical detail. The purpose of the summary report is to condense and synthesize that information so it is accessible to a general audience. Resources used to develop this Characterization Summary is included in a bibliography in Appendix B.

This report is divided into the following chapters:

- Chapter 1 provides overall context, including the watershed approach, watershed planning, and the regional setting.
- Chapter 2 presents an overview of citywide watershed conditions.
- Chapters 3 through 7 give more detail for each of the five watersheds (Figure 1-1) within the topographic area of the lower Willamette River watershed and within the City of Portland's jurisdiction:[1]
  - Willamette River
  - Johnson Creek
  - Tryon Creek
  - Fanno Creek
  - Columbia Slough
- Chapter 8 briefly discusses the Lower Columbia River Watershed.[2]

Each chapter is written to stand alone to accommodate readers who may be interested in only certain portions of the report. For that reason, some repetition occurs among the chapters (e.g., explanatory information that is needed for context).

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[1] The Bull Run Watershed, which supplies water to the City of Portland, is part of the Sandy River watershed. It is not included in this report because it is part of a separate but similar planning process being conducted by the City's Water Bureau.

[2] In this report, the Lower Columbia River Watershed refers to the section of the Columbia River within the City of Portland and the land area that drains directly to the Columbia River. The Columbia River is covered in greater detail in the City of Portland Planning Bureau's River Renaissance Strategy.

Figure 1-1
Portland's Watersheds

WATERSHED CONTEXT

A watershed is a geographic area that drains to a river or stream. The waterway, adjacent riparian areas, and uplands are an integrated, interdependent system. Anything that occurs in one area affects the others; what people do on the land ultimately affects the water and all that depends on it. Healthy watersheds are therefore essential for clean and healthy rivers and streams.

Healthy watersheds also will help achieve many other City objectives, including quality of life, economic vitality, and health and safety. In addition, healthy watersheds will allow the City to meet its obligations under federal, state, and regional laws, such as the Clean Water Act, Safe Drinking Water Act, Endangered Species Act, and state and regional land use goals.

> Clean and healthy rivers and watersheds are important to many people for a variety of reasons. Some people place a high value on having rivers in which they can swim and fish. Others recognize the need to meet state and federal requirements for human health and safety. Still others find it important to achieve restored and properly functioning ecosystems.

The City is developing a watershed approach to planning that focuses on preventing new watershed problems, continuing to manage those that already exist, and restoring watershed health over time. For example, past efforts to control flooding in Johnson Creek focused solely on floods instead of on watershed functions. A rock-lined creek channel was built. As a consequence, habitat has been destroyed, fish and wildlife populations have suffered declines, and flooding still continues. Today, projects planned for Johnson Creek strive to mimic nature by reconnecting floodplains and allowing flooding to occur on carefully designed sites. This reduces risks to human safety and property while improving fish and wildlife habitat.

The watershed approach does not attempt to turn back the clock to recreate the landscape that existed before the City was built. It does not seek to stop development or go beyond regulatory requirements. Rather, the watershed approach means that Portland's development, economics, recreation, transportation, and other goals are implemented in ways that are less damaging to natural resources and may even help protect and restore watershed health.

WATERSHED PLANNING

Portland is preparing the Portland Watershed Management Plan to guide decisions about how best to protect and restore watershed health. The *Framework for Integrated Management of Watershed and River Health* describes the process being used to develop the plans. The *Framework* also provides the scientific foundation for watershed management. The scientific foundation summarizes the current understanding of how an ecosystem works and how this understanding can be applied to achieve watershed health goals. It provides a consistent and clearly defined approach to protection and restoration. This consistent scientific foundation will enable the City to draft, test, and refine the elements of the watershed plans (such as objectives, targets, and actions) over time.

Portland's watershed planning and management approach entails the four steps described below:

Step 1: Plan and Set Watershed Health Goals

The first step in watershed planning is to develop watershed health goals. The City defines a healthy urban watershed as one where hydrologic, water quality, and habitat conditions are suitable to protect human health, maintain viable ecological functions and processes, and support self-sustaining populations of native fish and wildlife species whose ranges include the Portland area. In accordance with this definition, the City has the following four watershed health goals, which this *Watershed Characterization Summary* report addresses.

- **Hydrology**: Move toward normative flow conditions to protect and improve watershed and stream health, channel functions, and public health and safety. (Normative flow has the magnitude, frequency, duration, and timing essential to support salmonids and other resources.)

- **Physical Habitat**: Protect, enhance, and restore aquatic and terrestrial habitat conditions to support key ecological functions and improved productivity, diversity, capacity, and distribution of native fish and wildlife populations and biological communities.

- **Water Quality:** Protect and improve surface water and groundwater quality to protect public health and support native fish and wildlife populations and biological communities.

- **Biological Communities**: Protect, enhance, and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Portland's watersheds.

In addition to these four watershed health goals addressed in this report, Portland has two other goals:

- **Public Participation:** Incorporate public values into watershed plan development, implementation, and refinement, and support long-term, community-wide commitment to improve and sustain watershed health.

- **Public Health and Safety**: Protect property and public health by planning, designing, developing, operating, and maintaining sanitary sewer and stormwater infrastructure.

Step 2: Characterize Watershed Conditions

The characterization reports (summarized in this report) describe the current and where possible historic conditions of the watersheds. They use existing data and identify data gaps. Each report describes:

- Landscape factors (such as topography and soils) and human influences (such as impervious surfaces) that affect the watershed.

- Watershed conditions relative to the six goals described above.

- The problems the watershed faces, the potential causes of the problems, and the impacts on the watershed. Restoration opportunities may also be identified.

- Watershed assets—those characteristics or geographic areas of the watershed that are functioning well and are an opportunity for protection and potential restoration.

Step 3: Develop Objectives; Set Indicators, Targets, and Benchmarks; and Identify Actions to Achieve Watershed Health

The problem and asset statements developed in Step 2 lead to objectives.

Objectives are specific, measurable, outcomes in watershed functions and conditions that must be achieved to attain watershed health goals.

Indicators are the attributes that will be measured to track progress toward achieving an objective. Examples of indicators are temperature, biological diversity, and floodplain connection.

Targets are the desired watershed conditions that Portland will strive to achieve to meet watershed health goals and objectives. Targets are long-term.

Benchmarks are interim values that will be met on the way to meeting the targets.

Actions achieve the goals and objectives. Actions that best meet the goals and objectives are recommended for implementation.

Step 4: Implementation

The actions identified in Step 3 are implemented and monitored to determine how well they are moving toward achieving the watershed health goals. The actions may be changed over time, based on increased experience and information gained from monitoring.

Many individuals, groups, businesses, public agencies, non-profit groups such as watershed councils, and other entities are working hard to restore and protect watershed health. Appendix A provides a description of some of the activities the City of Portland and others are undertaking.

REGIONAL CONTEXT

The Willamette and the Columbia Rivers are part of geographic areas much larger than Portland. Watershed conditions exist within a regional context. For example, some conditions are influenced by local practices and can be addressed by local actions. In other cases, conditions are influenced by regional factors, and broader efforts will be required to address them. The impacts Portland has on watershed health at a regional scale requires greater study. The following description places Portland within this overall regional context.

- The Columbia River flows for more than 1,200 miles. The Columbia River Basin drains 259,000 square miles that include territory in seven states and one Canadian province. The tidally-influenced Columbia River estuary extends through Portland to Bonneville Dam at River Mile 148.

- The Willamette River is the second largest tributary to the Columbia River and the 13th largest river in the contiguous United States in terms of streamflow. The Willamette River Basin is 11,478 square miles in size and comprises 12 percent of the land area of Oregon.

- The Lower Willamette River—the reach that includes Portland—extends from the falls at Oregon City to the Willamette's confluence with the Columbia River. The Lower Willamette River is a part of the Columbia River estuary and is influenced twice daily by tidal flows.

- Portland's portion of the Willamette Watershed includes the last 17 of the Willamette River's 295 miles (from just south of the Sellwood Bridge to the Willamette's confluence with the Columbia River at Kelley Point) and comprises only about 0.5 percent of the Willamette River's total drainage area. However, this part of the river is the most urbanized portion in the state.

- The major tributaries to the Willamette River that pass through the City of Portland are Johnson Creek, Tryon Creek, Fanno Creek (via the Tualatin River), and the Columbia Slough.

- Rivers, streams, and their related watersheds seldom follow political boundaries. For example, Johnson Creek, which flows through southeast Portland, passes through six separate political jurisdictions between its headwaters in Clackamas County and its confluence with the Willamette River in the City of Milwaukie.

Portland is situated in a very important location. It affects—and is affected by—things that occur both upstream and downstream in both the Willamette and Columbia Rivers. For example, several different salmon populations migrate between the ocean and Willamette and Columbia River tributaries as they grow from juveniles to adults and return to the streams of their birth to spawn. Their journey takes them through Portland and its waterways. Therefore, the conditions of Portland's rivers, streams, and watersheds have an effect beyond the City's legal boundaries. Similarly, the Willamette River carries pollution and is sometimes too warm when it reaches Portland's boundaries. Another example is the extensive series of dams located upstream of Portland to manage the amount of water in the Willamette River. The river's altered flow patterns are one of the most important considerations in guiding successful restoration actions.

The cumulative effects of land use decisions and on-the-ground actions, hydropower and flood control systems, agriculture, and other human activities throughout the Willamette and Columbia watersheds are all connected with Portland's watershed health. In turn, Portland's ecological impact extends far beyond its boundaries. Improving watershed function in Portland is important not only for the City, but for the health of the entire river ecosystem. The City's watershed management approach incorporates an understanding of this larger context in assessing conditions and potential actions at the local level. Portland is actively working with other federal, state, regional, and local jurisdictions to address the many interrelated issues that transcend City boundaries.

CHAPTER 2
Citywide Overview

INTRODUCTION

Portland has undergone significant urban development over the past 150 years. While that development has created a highly livable city for humans, watershed health has suffered. Portland’s watershed approach is attempting to improve watershed health within the context of a thriving urban area.

This chapter provides a broad look at Portland’s watersheds. It discusses the factors that affect watershed health and functions, and describes the existing conditions of the watersheds today.

- **Section A** describes landscape factors, including location, climate, topography, and soil type. These factors shape the inherent aspects of a watershed and how it looks and functions. In general, they cannot readily be changed.

- **Section B** describes human influences on a watershed, including land use, population, the sanitary and stormwater infrastructure, and the transportation infrastructure. These influences can be changed, although such changes take time and must be done in concert with other City actions.

- **Sections C through F** describe current and historic (where information is available) conditions related to Portland’s four watershed goals: hydrology, physical habitat, water quality, and biological communities. These watershed conditions are affected by both landscape factors—the features that cannot easily be changed, and human influences—the characteristics that can be changed.

- **Section G** describes protection and restoration opportunities that could improve the health of Portland’s watersheds.

SECTION A: LANDSCAPE FACTORS

Landscape factors are fundamental characteristics that strongly influence the conditions within a watershed. They set constraints on, and in many ways determine, the form and function of a watershed. Understanding these factors helps interpret current and predicted watershed conditions. Landscape factors cannot be easily changed.

A-1: Location

Portland is situated near the confluence of the Columbia and Willamette Rivers, about 65 miles inland from the Pacific Ocean. Every salmonid migrating to and from every tributary of the Willamette River (and many Columbia River tributaries) must pass through Portland. Portland's climate is the result of its location. Portland lies midway between the low Coast Range to the west and the high Cascades Range to the east, each about 30 miles distant from the City.

A-2: Climate

Portland has a mild marine climate that is heavily influenced by the mountain ranges east and west of the City. The Coast Range protects the Portland area from Pacific storms, while the Cascades prevent colder air masses from reaching western Oregon. In winter, Portland's average temperature is 40° Fahrenheit (F), and the average minimum temperature is 34°F. In summer, the average temperature is 65°F, with an average daily maximum of 74°F to 78°F.

The Cascades lift moisture-laden westerly winds from the Pacific, driving local rainfall patterns. Average annual rainfall in the Portland area is approximately 37 inches. Nearly 90 percent of the annual rainfall occurs from October through May. Precipitation falls predominantly as rain, with an average of only five days per year recording measurable snow. Only nine percent of the annual rainfall occurs between June and September, with three percent in July and August. Native vegetation is adapted to these conditions of wet winters and dry summers. The relatively high amount of rainfall creates significant runoff from impervious surfaces. The runoff volume harms instream habitat. Also, the runoff picks up pollutants and carries them to Portland's streams.

A-3: Topography

Portland's topography varies greatly citywide, and is significantly different on the east and west sides of the Willamette River. It is generally flat on the east side of the Willamette River and along the Willamette and Columbia Rivers. Steep slopes exist on the outer west (West Hills) and southeast areas of the City. Several lava domes, including Mt. Tabor, Rocky Butte, and Powell Butte, dot the eastern boundary of the City.

In areas with flat topography, streamflow is relatively slow, and floodwaters tend to spread out into adjacent lands. Steep slopes increase stormwater runoff rates, which can increase erosion and sediment in water bodies, scour streambanks, and deposit sediments in downstream channels.

Because of the steep slopes in the west side, stormwater runoff (either directly or indirectly through the combined sewer system) travels faster and in a more dispersed fashion than on the east side. The steep slopes and soils types help produce the natural erosion and landslide problems that exist in the Northwest and Southwest Hills.

A-4: Soils

Soils on the west side of the Willamette River vary from clay loam with low permeability and relatively high erosion potential to gravelly loams, which are relatively well drained and moderately permeable. Because of landslide potential, stormwater infiltration may not be advisable in many parts of the West Hills; however, soils that provide the opportunity to infiltrate stormwater are scattered around the area. The flat areas along the west bank of the Willamette River are urban and highly disturbed, and many consist of fill.

On the east side of the Willamette River, soils are highly variable; similar to the west side, however, they are generally urban and highly disturbed. Much of the area along the Columbia River has been filled with dredged sand, which drains very well. In undisturbed areas along the Columbia River, percolation rates are very slow. Areas south of Columbia Boulevard have soils that drain well. In the southeast areas of the City, soils vary from moderate to low permeability. In areas with well-draining soil, it is possible to manage stormwater through infiltration.

Section B: MAJOR HUMAN INFLUENCES

B-1: Land Use

Portland is highly urbanized, with a variety of land uses: industrial, commercial, low- and high-density residential, and open space. Table 2-1 shows the percentages of the City zoned for various uses. While zoning is not actual land use, it provides a good overall depiction.

Table 2-1
City of Portland Zoning

Zoning Designation	Percentage of Land
Single-family Residential	43
Multi-family Residential	8
Commercial	4
Industrial	19
Rural	10
Open Space	11
Mixed Use	5

Source: Derived from Metro regional zoning information; should be considered approximate.

Because much of the City’s landscape is covered by human development, Portland’s watersheds have a high percentage of impervious surfaces, such as roads, parking lots, roofs, and sidewalks (Table 2-2).

Table 2-2
Impervious Area Coverage In Portland

Watershed	Total Impervious Area Coverage (%)
Willamette River	40
Johnson Creek	38
Tryon Creek	26
Fanno Creek	33
Columbia Slough	54

According to the Center for Watershed Protection, by the time impervious area in a watershed reaches 10 to 20 percent, stream ecosystems have begun to show evidence of degradation. Impervious coverage of more than 25 to 30 percent is associated with significant degradation. The negative impacts associated with impervious surfaces include:

- Stormwater runoff volumes and velocities increase and can cause erosion, flooding, channel incision, and habitat destruction.
- Stormwater runoff picks up oil, fertilizers and pesticides, metals, chemicals, sediments, bacteria, and other pollutants and carries them into rivers and streams.
- Stormwater runoff can also elevate water temperatures as it absorbs heat from impervious surfaces.
- Less stormwater infiltrates into the ground, reducing groundwater recharge. This in turn reduces base flows in streams, which is harmful to fish and aquatic organisms, especially in summer.
- Impervious areas replace vegetation that historically detained and cleansed stormwater, provided habitat for fish and wildlife, and shaded waterways to keep water temperatures cool.

Different land uses have different effects on watershed health. City analyses suggest that the transportation system in Portland and the heavily industrial, commercial, and dense residential sections of the City most likely present the greatest environmental management challenges. These areas are relatively impervious and generate significant stormwater runoff.

B-2: Population

The 2000 U.S. census shows the City of Portland's population at about 529,000. Metro (the regional planning agency) projects that Portland's population will reach about 589,000 by 2017.

This growth will be accommodated through infill, redevelopment, and development of currently open areas.

At the citywide scale, population growth and development are the leading causes of negative watershed health trends. Efforts to change the negative trends are underway, but are unlikely to keep pace with the effects of the Portland area's growing population. Since population growth and development will continue, additional resources will be required to counteract many of the effects of that growth, and it may not be feasible or possible to counteract all of the effects. This means that achieving healthy watersheds will be challenging, requiring significant resources and changes in how Portland develops and redevelops.

B-3: Sanitary and Stormwater Infrastructure

The City of Portland provides water quality management services for residents living within the 140-square-mile urban services boundary of the City of Portland. The City has four types of sanitary (wastewater) and stormwater infrastructure systems to protect Portland's surface water and groundwater: combined sewers, sanitary sewers, storm sewers, and wastewater treatment plants. Without this infrastructure, stormwater would flood roads and yards, and all sanitary sewage would either flow untreated to the Willamette River or go to septic systems that would contribute significant amounts of nutrients to the ground. Stormwater infrastructure prevents flooding, but carries greater quantities of stormwater and pollutants to waterways faster than if the stormwater percolated into the ground. It is important to know the extent and condition of stormwater and wastewater infrastructure in order to understand the potential impacts to watershed health and identify opportunities for improvement.

Table 2-3
Sanity and Stormwater Infrastructure

Sewer Type	Length
Combination Sewers	4,548,000 l.f. (861 miles)
Sanitary-Only Sewers	4,921,000 l.f. (932 miles)
Total Wastewater Sewers	9,469,000 l.f. (1,793 miles)
Stormwater Sewers	2,251,000 l.f. (426 miles)
Total Length of all Sewers	11,720,000 l.f. (2,219 miles)

Combined Sewer System

The combined sewer system area is located in roughly the center half of the City along both sides of the Willamette River. The area is approximately 27,084 acres (42 square miles) in size and is generally bounded by the Columbia Slough on the north, Johnson Creek on the south, the Portland West Hills on the west, and 82nd Avenue on the east. It includes most of downtown Portland and many older residential areas, and is divided into 42 combined sewer basins.

The combined sewer system includes the network of pipelines and pump stations that collect and convey both stormwater and sanitary flows from urban streets and properties. During dry weather and light precipitation, combined sewage is transported to the Columbia Boulevard Wastewater Treatment Plan for treatment. During moderate to heavy precipitation, combined sewage flows overwhelm the system, and excess (untreated) combined sewer overflows (CSOs) are discharged through outfalls to receiving waters, principally the Willamette River.

The nature of combined sewers results in two fundamental concerns for the City:

- High rainfall intensities can cause sewer backups (also termed basement flooding) into homes and businesses.

- Combined sewer overflows contribute to some water quality standards being exceeded in receiving waters.

Under a 1991 agreement reached with the Oregon Department of Environmental Quality (DEQ), the City is working to control CSOs. By 2000, 99 percent of CSOs to the Columbia Slough were controlled. To date, over 40 percent of CSOs to the Willamette River have been controlled. When all projects are completed in 2011, at least 94 percent of CSOs to the Willamette will be controlled.

Sanitary Sewer System

The sanitary sewer system includes the network of pipelines and pump stations that collect and convey wastewater. The areas served by separated sanitary sewers are divided into 15 basins, totaling 66,726 acres (104 square miles). The sanitary flow from these basins is treated at the Columbia Boulevard Wastewater Treatment Plant, the Tryon Creek Wastewater Treatment Plant, or (for selected areas) through contract arrangement at facilities operated by Clean Water Services of Washington County or the City of Gresham.

Stormwater System

The stormwater system is designed and operated to collect and safely convey stormwater flow for discharge to local receiving waters. In addition to conveyance facilities, the stormwater system includes facilities that detain stormwater runoff to reduce high flows and facilities that remove pollutants. These facilities are changing the City's approach to stormwater management. Over time, stormwater management will more closely resemble the natural system of absorbing, filtering, and slowly discharging water to groundwater and streams.

In some areas of the city, stormwater is directed to sumps. Throughout the city, but mostly on the east side of the Willamette River, there are 8500 active sumps that handle stormwater.

Wastewater Treatment System

The City of Portland owns and operates two municipal wastewater treatment plants. The Columbia Boulevard Wastewater Treatment Plant, located in north Portland, serves most of the City. The Tryon Creek Wastewater Treatment Plant, located south of Portland in the City of Lake Oswego, serves a small portion of southwest Portland. Interceptors, the major pipelines that convey combined and sanitary flows to the treatment plants, are throughout the City.

Through contractual agreements with a number of neighboring jurisdictions, the City also accepts wastewater generated from some areas outside its urban services boundary. Similarly, Clean Water Services of Washington County and the City of Gresham provide wastewater treatment for certain areas within Portland's urban services boundary.

Unsewered Areas

Approximately three percent of properties in Portland are not connected to sanitary sewers. Onsite septic systems handle the wastewater from these properties. Of the 3,900 developed properties not connected to a sanitary sewer, 2,300 currently have sewer lines available and 1,600 do not. Most of the unsewered properties are on the east side of the Willamette River.

The average unconnected household discharges 150 gallons of untreated waste to the ground every day. Leaking and failed septic systems can contribute nitrogen and bacteria to surface waters, which impairs water quality in Portland's streams, and can contribute bacteria to the ground, which may pose a threat to human health.

Figure 2-1
Combined Sewer, Separated Sewer, and Unsewered Areas in the City of Portland

B-4: Transportation Infrastructure

The main transportation facilities include Interstates 5, 205, 84, and 405; many miles of collector and neighborhood streets; parking lots, and the Portland International Airport. Some residential sections of the City also have unpaved roads.

Impervious surfaces increase the amount of stormwater runoff that enters Portland's waterways. Automobiles deposit oil, grease, dirt, brake dust, vehicle parts, and heavy metals such as copper, lead, and zinc on roadways and parking lots. When it rains, stormwater runoff picks up these pollutants. Because transportation activities can significantly impact water quality, understanding the nature and extent of transportation-related pollution sources is critical to restoring watershed health.

Traditional curb and gutter systems collect and convey stormwater runoff effectively, but do not reduce pollutants. In some areas of the city, water quality facilities have been constructed to slow stormwater before it enters a water body and allow large particles and some pollutants to filter out. In other areas, stormwater is conveyed in open ditches instead of pipes, which can slow the velocity and allow some pollutant filtering to occur. Street sweeping is another method to reduce transportation-related pollutants.

Roadways are also significant barriers to the safe movement of wildlife throughout watersheds. Habitat connectivity gives wildlife access to many different habitats and is important to their survival. Large habitat areas and wildlife corridors become disconnected when a roadway bisects them. Further, culverts are generally put in when a roadway crosses a stream where they may prevent fish from moving between remaining high-quality habitats. Bridges, on the other hand, allow fish to pass safely under roadways, and terrestrial wildlife can safely cross roads by going under the bridges.

Sections C, D, E, and F describe current citywide conditions related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Section G then identifies protection and restoration opportunities that could help improve watershed health.

Section C: HYDROLOGY

C-1: Why Hydrology Is Important

Hydrology includes the volume, timing, and velocity of streamflow, which are all important to watershed health. Hydrology affects habitat, water quality, and the biological communities that inhabit streams and wetlands. Because water moves downstream in a watershed, both upland and instream conditions affect water flow.

Development in urban watersheds has changed historical stream hydrology. These changes in flow have reduced habitat diversity, decreased native biodiversity, increased non-native species, and exacerbated water pollution. An understanding of hydrology is essential to formulate effective management and restoration alternatives for restoring watershed health.

C-2: Conditions in Portland

Watersheds in Portland are characterized by two distinct hydrologic patterns. The first pattern is low-gradient (slope) river systems such as the Willamette River and the Columbia Slough, both of which are also influenced twice daily by tidal forces. The second pattern is higher-gradient, faster-flowing streams such as Tryon and Fanno Creeks. In general, the east side of the Willamette tends to have lower-gradient and the west side has steeper, faster-flowing streams.

The hydrology of nearly all Portland waterways has been affected by either direct channel changes (e.g., filling, dredging, and channelization) or indirect means (e.g., increased stormwater runoff from impervious surfaces). The key factors that affect flow in Portland's streams are impervious surfaces; loss of wetlands and floodplain disconnection; water withdrawals; and hydropower and flood control systems, as described below.

Impervious Surfaces

As discussed in section B-1, urbanization has increased Portland's impervious surfaces, such as roads, parking lots, roofs, and sidewalks. The impervious areas collect stormwater runoff and direct it to tributary streams faster than if the stormwater infiltrates into the ground, as in undeveloped conditions. This causes streams to become "flashy," meaning that the stormwater runoff enters the streams almost immediately after rainstorms instead of days, weeks, or even months later. These higher peak flows degrade habitat by increasing erosion and channel incision and decreasing bank stability. The degraded habitat can directly affect stream-dwelling organisms. Increased stormwater flow in streams also leads to flooding that imperils humans and structures.

In addition, impervious surfaces can decrease groundwater recharge of streams and consequently reduce summer base flows in the streams.

Loss of Wetlands and Floodplain Disconnection

The connection of a stream to its floodplain provides several key functions. Floodplains provide room for dynamic channel movement, water storage areas, and off-channel wetlands, which all reduce downstream flooding and improve watershed health. Floodplains also provide connections between habitat areas, safe refuges for fish, subsurface flows for streams, sediment transport and storage, and organic input to the stream. Floodplain vegetation filters pollutants from the stream, providing important water quality benefits.

In Portland, many streams have been disconnected from their floodplains, eliminating the flow, habitat, water quality, and fish and wildlife benefits that floodplains provide. Stream channelization, which concentrates streamflow in the main channel, has significantly reduced floodplain connection, increased erosion, and degraded instream habitat. Bank hardening (e.g., seawalls and riprap) contributes to disconnection in some areas. In addition, significant development has occurred within the floodplain in many places, further degrading the amount and quality of available floodplain and placing that development at risk during flooding.

Water Withdrawal

Water rights, permits, applications, and certificates currently exist for various uses. Water diversions and withdrawals from water bodies can reduce summer base flows, which negatively impacts hydrology and water quality in summer. In addition, water rights may require summer stream levels to be kept artificially high during the summer months. This is particularly so in the Columbia Slough.

Hydropower and Flood Control Systems

Reservoir and hydropower projects and flood control dams, dikes, levees and water control structures have significantly altered the hydrology of the Willamette River and Columbia Slough and affected ecological function and river/floodplain interaction. Seasonal flow patterns have been altered from the natural state: summer flows are higher and winter flows are lower than under historical conditions.

Section D: PHYSICAL HABITAT

D-1: Why Physical Habitat Is Important

Habitat is the combination of necessary resources and environmental conditions that promotes occupancy by individuals of a given species (or population) and allows those individuals to survive and reproduce. A habitat provides the necessary ecological functions and processes to preserve the biological communities that live within it. Changes to habitat can significantly affect the types and numbers of species that inhabit an area.

D-2: Conditions in Portland

With few exceptions, nearly all watersheds in Portland have severely impacted physical habitat. Alterations have resulted from channelization and/or widening of the waterway; bank hardening and disconnection of the waterway from its floodplain; filling of adjacent wetlands and small, intermittent headwater streams; placement of impassable culverts; sedimentation from erosion and untreated stormwater runoff; and urban development and loss of vegetation in the riparian (streamside) area. Portland's degraded habitat conditions have to be improved to recover and support desired native species, such as native salmonids.

The following text describes the many problems Portland's habitats face, but it is important to remember that areas with good habitat still exist. Large natural area parks such as Forest Park, Marquam Nature Park, and Smith and Bybee Wetlands Natural Area provide habitat for sensitive fish and wildlife species native to the region. Numerous smaller parks and undeveloped areas also provide habitat for more tolerant native fish and wildlife species as well as introduced species. Despite the many changes to habitat, a wide diversity of species still inhabit Portland's watersheds, as discussed in section F, below.

Instream Habitat

Generally, instream habitat in Portland's streams has been severely degraded and is generally rated as marginal to poor, although some good areas still exist as noted above. Numerous factors contribute to these conditions:

- Significant dredging, diking, removal of large wood, riprap along banks, and channelization of streams and rivers have occurred, reducing channel complexity. The mix of habitat types that exists in healthy streams is often reduced to a single habitat in lower-gradient streams. Roughness (the presence of large wood, rocks, and overhanging banks), which provides refuge areas, is lacking because of dredging and bank hardening.

- The rates and volumes of stormwater runoff have increased, primarily because of increased impervious area and the loss of wetlands, and has created flashy streams. The increased runoff rates and streamflows often lead to bank erosion and incision of streams within the stream channel, further disconnecting these streams from their floodplains.

- Streambank erosion and fine sediment particles in stormwater runoff have covered gravel and cobble beds important to macroinvertebrates (aquatic insects such as stone flies, mayflies, and dragonfly nymphs that are food sources for many aquatic species, including salmonids). Salmonids are not able to spawn in areas where gravels are covered. In addition, pollutants that bind to sediments can accumulate in the sediments, affecting fish behavior and causing stress in aquatic species.

- Culverts and road crossings prevent upstream fish passage and block fish from accessing high- or higher-quality habitat.

- Most off-channel habitat in Portland is no longer accessible to fish because of bank hardening, dredging, channel straightening, filling, channel incision, and riverfront development.

Some high-quality stream reaches are present within Portland. Natural area parks, areas that have been restored, and other areas that have generally been left alone continue to provide native fish and wildlife with complex instream habitat that provides food, large wood, riparian cover, and habitat for their life-cycle needs. (These areas are noted in each watershed chapter in this report.)

Riparian Habitat

Riparian areas are extremely important to a high percentage of native fish and wildlife species in the region and to the overall health and function of streams. These species depend on riparian areas for various stages of their life cycle, access to water, and safe travel along riparian wildlife corridors. Additionally, instream communities depend on healthy riparian areas for organic inputs, instream cover, deposits of large wood, shading, and hydrologic connection to groundwater.

In general, riparian areas in Portland have been heavily impacted by streamside development, fragmentation, and the invasion of non-native species. Development and filling have degraded the condition of floodplains and severed the connection between streams and their floodplains. Streams have been straightened, and no longer meander (change course) throughout the floodplain. In many places, riparian areas are composed of riverfront development, levees, and bank hardening, including seawalls, riprap, sheet pile, and other human-made structures. Riparian and floodplain wetlands that depend on seasonal overflows of banks have been isolated and/or filled, reducing habitat for fish and wildlife, eliminating floodwater and sediment storage capacity, and increasing downstream risks of flooding.

Upland Habitat

The Portland region historically contained extensive deciduous and coniferous forests on the hillsides; oak savannah and meadow habitats in the eastern portion of the City; forested buttes (lava domes) in the far east; and floodplain wetlands and riparian areas in the low-lying areas of the City. With development, significant areas were deforested. Some were replanted, such as Forest Park and Marquam Hill. Many replanted areas outside the City center remain, with second- or third-growth trees. Virtually all of the non-forested meadow areas and oak savannah areas that provided high-quality habitat have been converted to urban uses.

Urban parks, environmentally sensitive golf courses (several Portland area golf courses are Certified Audubon Cooperative Sanctuaries), and street tree/neighborhood habitats in the region continue to provide habitat for more tolerant wildlife species as well as stopover habitat for more sensitive migratory species. Some remaining protected natural areas provide high-quality habitat. Many of these areas provide temporary stopover and feeding habitat for migratory bird species that stop in the region to and from breeding grounds in the north while some provide important breeding habitat within the city. Most significant upland habitats in the region are extremely fragmented and lack wildlife corridors connecting them to other upland, riparian, or wetland areas.

Wetlands Habitat

Historically, most of the low-lying floodplain areas along the Lower Willamette River and Columbia River were composed of various wetland types (including forested, emergent, and scrub-shrub wetlands) and seasonally inundated wet prairie. The filling of wetlands began early in Portland’s history to develop downtown and make areas productive for agriculture. Significant wetland areas were eliminated to provide flood control measures for the City. Additional wetland areas were filled to accommodate industrial and residential development.

In some cases, seasonal wetlands have been removed or filled and replaced with perennial ponds (mitigation wetlands) that frequently do not provide the same functions and/or values as those they are intended to replace. For example, bullfrogs are an invasive and extremely destructive amphibian species that require perennially inundated ponds to reproduce. They have a voracious appetite for native amphibians, and often eliminate native populations if found in the same wetlands. Therefore, perennial ponds provide much less value to native amphibians and turtles than ephemeral wetlands.

Section E: WATER QUALITY

E-1: Why Water Quality Is Important

Good water quality is important for the health of all biological communities, including humans. People use Portland's waterways for swimming, canoeing, fishing, and other recreational activities and can be affected by water quality problems. Pollutants can accumulate in edible fish tissue and present a danger to the health of human consumers.

Fish and wildlife use the waterways for habitat and food, and impaired water quality can have significant negative impacts on these biological communities. For example, the growth, reproduction, and survival of native cold-water fish, such as salmon and trout, are adversely affected when water temperature is too warm. High levels of sediment in the water can cover spawning gravels, impair fish feeding and respiration, and diminish food sources.

E-2: Conditions in Portland

The State Department of Environmental Quality has placed nearly all of Portland's major water bodies (except Balch Creek in the Willamette Watershed) on the state's 303(d) list (Table 2-3). The 303(d) list identifies water bodies that are "water quality limited" because they do not meet water quality standards for certain parameters (e.g., bacteria, temperature, dissolved oxygen).

Table 2-4
Water Quality Limited Water Bodies in Portland

	WATER BODY				
PARAMETER	**Willamette River**	**Johnson Creek**	**Tryon Creek**	**Fanno Creek**	**Columbia Slough**
Temperature	X	X	X	X	X
Bacteria	X	X		X	X
Dissolved Oxygen				X	X
Aldrin	X				
Dieldrin	X	X			X
DDT/DDE	X	X			X
Pentachlorophenol	X				
PCBs (polychlorinated biphenyls)	X	X			X
PAHs (polycyclic aromatic hydrocarbons)	X	X			
Dioxin					X
Iron	X				X
Lead					
Mercury	X				
Manganese	X				

Phosphorus				X	X
Chlorophyll *a*					X
pH					X
Arsenic					
Skeletal Deformities	X				

Citywide water quality issues of concern are summarized below. Chapters 3 through 7 address issues specific to particular watersheds.

Temperature

Elevated summer water temperatures are a problem throughout Portland. The primary causes are decreased base flows in summer, lack of riparian vegetation to shade and cool the water, and changes in channel structure that increase ponding. In Johnson Creek and the Columbia Slough, other factors are low summer base flows and changes to the stream channel that result in wider, shallower channels and impounded water. The Columbia Slough's natural physical characteristics—it is a low-gradient, generally shallow body of water—also contribute to high temperatures. Much of the slough's banks are levees which are required to be free of trees which could shade the water.

Water temperature has a large impact on the types of organisms found in a water body. Cool water is a basic requirement for native salmon, trout, some amphibians, and other cold-water aquatic species. Only exotic species thrive in warm water. Temperature also plays a role in dissolved oxygen concentration, which is important for the survival of all aquatic organisms. The colder the water, the greater amount of oxygen that can be dissolved in it.

Bacteria

Bacteria levels in most of the City's waterways sometimes do not to meet state standards. Human contact with bacteria through activities such as swimming and boating can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.

Current potential sources of bacteria in the city include both human sources (sanitary sewer overflows, illegal sanitary connections and dumping to storm drains, and failing septic systems) and non-human sources (birds, dogs, cats, raccoons, and other animals).

Combined sewer overflows (CSOs) are a major source of bacteria in the Willamette River in Portland. CSOs occur when combined sewer pipes, which carry both sanitary (wastewater) and stormwater flows, overflow during rainstorms and discharge untreated sewage, along with other pollutants, into the river. The City is currently in its tenth year of implementing the CSO Program to reduce CSOs to the Willamette River. To date, 40 percent of CSOs have been controlled. When all projects are completed in 2011, at least 94 percent of CSOs will be controlled. Monitoring has also shown that high bacteria concentrations exist upstream of Portland. Upstream bacteria sources are not known, but may include some contribution from sanitary sewer systems, agriculture, and pulp and paper operations.

CSOs were historically the largest source of bacteria in the Lower Columbia Slough. The CSO Program has controlled the discharge of over 99 percent of CSOs to the Columbia Slough as of December 2000, and bacteria levels have been greatly reduced. Other sources of bacteria exist in the Slough watershed including the human and non-human sources listed above.

Sedimentation

Sediments are a concern in Portland's waterways. Sedimentation can have a variety of causes, including vegetation removal, ground-disturbing activities, streambed and streambank erosion caused by increased stormwater runoff, and landslides. Sediments can carry pollutants (such as oil, grease, metals, pesticides, and other toxic compounds) into the water body. When suspended in the water, sediments cause breathing problems in fish and decrease sunlight availability to aquatic life. When sediments settle to the bottom of streambeds, the attached contaminants can be consumed by microorganisms and enter the food chain. As was discussed in Section D: Physical Habitat, sediments also have negative impacts on aquatic habitat by damaging critical salmonid spawning areas.

Stormwater Runoff

Stormwater itself is not a pollutant, but it carries pollutants from many different sources to water bodies and is a significant concern in all the City's watersheds. As discussed above, stormwater runoff contributes to elevated water temperatures and carries bacteria and sediments. It also contains a range of pollutants, such as metals, oil, grease, and organic toxic compounds such as polyaromatic hydrocarbons (PAHs), from residential, commercial, institutional, and industrial land uses.

The State Department of Environmental Quality has issued over 300 NPDES permits for point sources within the City of Portland. These permits limit the amount of pollution that can be discharged from the permitted point source. There are two main categories of permits: those that address stormwater and those that address process wastewater.

Table 2-5
Point Source NPDES Permits Issued in the City of Portland

Permit Type	Number of permits
Individual Process Wastewater Permits	22
General Stormwater Permits	Approx. 250
Classes of General Wastewater Permits	
➢ Non-contact cooling water	20
➢ Boiler Blowdown	4
➢ Groundwater Remediation	18
➢ Wash Water	4
Total NPDES Permits	318

Section F: BIOLOGICAL COMMUNITIES

F-1: Why Biological Communities Are Important

Biological communities are assemblages of organisms that live within or use a particular habitat(s) for their range of life functions. These organisms depend on the availability of resources and ecological processes to maintain their viability. In complex, natural ecosystems, biological diversity (or biodiversity) is generally high. In disturbed, simplified systems, fewer types of native organisms are found. Habitat complexity and biodiversity are indicators of a healthy watershed.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health. In addition, the City evaluates aquatic insect communities and native fish communities other than salmon (e.g., species as peamouth and sculpin) to evaluate broader aspects of stream health and evaluate areas where salmon do not occur.

F-2: Conditions in Portland

Portland has a relatively high diversity of species, especially bird species. However, non-native, invasive species constitute a large part of the biological diversity. Population abundance of native species has been significantly reduced as a result of development and diminished habitat. Some native species of fish are extinct. Introduced non-native species often occupy native species' habitats or compete with them for food, cover, and other habitat features.

Fish

Both native and introduced species of both warm-water and cool-water fish inhabit the Lower Willamette River today. Common native species include sucker, reticulate sculpin, and various minnows including northern pikeminnow, and introduced species including smallmouth bass, black crappie, white crappie, and mosquito fish. Reticulate sculpin and redside shiner were the most predominant in Portland's streams. Lamprey eel is a species of concern.

The Willamette River in Portland is a gateway to the vast basin stretching southward. Likewise, the Columbia River at Portland impacts all the species that migrate inland. Thousands of anadromous salmonids, including steelhead, chinook salmon, and coho salmon, swim through Portland on their way to spawning beds upstream, and their offspring return as they travel out to the Pacific Ocean. Subyearling salmon are present in the Lower Willamette River year round, indicating that salmonids use the Lower Willamette and Lower Columbia Slough for rearing. Two populations of salmonids are found in Johnson and Tryon Creeks. Cutthroat are the most abundant salmonid species in Portland streams.

Salmonid populations in Portland are much less abundant and diverse than those that previously existed in the area. Chinook and steelhead are listed as threatened under the federal Endangered Species Act.

Macroinvertebrates

Benthic (bottom-dwelling) macroinvertebrates are the base of the food chain for fish and other aquatic life and therefore support higher organisms. Throughout Portland, the diversity and numbers of benthic macroinvertebrates are low because of a lack of suitable habitat, degraded water quality, and altered hydrologic conditions.

Birds

Birds represent the majority of vertebrate diversity in the region, and 209 native bird species regularly occur in the Portland area. About half of these native bird species depend on riparian habitats for their daily needs, and 94 percent of the species use riparian habitats at various times during their lives.

Mammals

Diversity of mammals in Portland is relatively good, with 54 native species. However, this is the terrestrial group with the highest number of non-native species (eight species, or 13 percent, of total species). Of the native species, 28 percent are closely associated with water-based habitats, and another 64 percent use these habitats at various points during their lives. Six out of nine bat species and three native rodent species are listed as state or federal species at risk. Extirpated species in the Portland region include the grizzly bear and gray wolf, likely due to hunting and human encroachment early in the city's history.

Amphibians

A number of amphibian species inhabit the Portland area. The bullfrog was introduced and places considerable pressure on native species. In Portland, 69 percent of native amphibian species (salamanders, toads, and frogs) rely exclusively on stream- or wetland-related riparian habitat. Another 25 percent use these habitats during their life cycle. Six amphibian species are state-listed species at risk; four species are considered at risk at the federal level.

Reptiles Thirteen native reptile species inhabit the Portland area. The western pond turtle and painted turtle are state and/or federal species at risk, largely due to loss of wetlands and backwater habitats and introduced species. Two non-native turtle species, the common snapping turtle and red-eared slider, have established breeding populations in Portland and compete with native turtle species.

Non-Native Species

Portland is home to many non-native bird, mammal, fish, invertebrate and plant species, some of which have become invasive (taken over areas and out-competed native species). Invasive bird species include the European starling, house sparrow, and rock pigeon. Invasive mammal species include nutria, Virginia opossum, eastern cottontail rabbit, eastern gray squirrel, black rat, Norway rat, house mouse, and others. Invasive fish species include carp, bass, bullhead, mosquitofish, goldfish, sunfish, warmouth, piranha, crappie, perch, and several others. Invasive invertebrate species are on the rise in the Columbia and Willamette rivers and should be monitored closely. Many of these noxious species are introduced when shipping vessels dump ballast water from overseas in local rivers. Invasive terrestrial plant species include Himalayan blackberry, English ivy, clematis, Japanese knotweed, giant knotweed, teasel, reed canarygrass, purple loosestrife, deadly nightshade, and tree of heaven. Invasive aquatic plant species include parrot feather, yellow-flag iris, and hydrilla. These species thrive in urban areas where habitats are fragmented. Their presence makes it difficult for native species to survive and flourish.

Section G: PROTECTION AND RESTORATION OPPORTUNITIES

The best available science suggests that protecting areas that currently function relatively well is one of the most effective ways to contribute to watershed health. This implies that those areas should be assigned high priority for protection, using a variety of policy and management tools, to keep these areas from degrading. Work is underway to identify the areas in, along, and draining to Portland's rivers and streams that provide the greatest watershed benefits under current conditions and would provide the best opportunities for watershed protection initiatives.

Because watershed conditions in Portland are degraded, just protecting existing healthy areas will not achieve the City's watershed goals. Restoration actions will also be necessary as will addressing the causes of degradation. A variety of incentives, regulations, partnerships, actions, and projects can be used to make improvements—for example, tax credits; required changes in the design and development of sites, buildings, streets, storm and sanitary sewers; on-the-ground habitat restoration projects; and public education and stewardship. Work is being conducted to identify areas that would provide the greatest restoration opportunities and the specific attributes of these areas that require management actions.

One of the most significant challenges to realizing clean and healthy watersheds is stormwater runoff and the variety of watershed health problems it creates, as discussed previously. Managing stormwater effectively requires actions not just along rivers and streams, but across the entire landscape.

The summary sections of Chapters 3 through 7 identify possible protection and restoration opportunities for each watershed.

CHAPTER 3
Willamette Watershed

INTRODUCTION

This chapter begins with a summary of current conditions in the Willamette River Watershed. The summary describes the watershed's current assets and problems, and identifies opportunities to protect and restore watershed health.

The following sections then provide more detailed information to support the summary. Section A presents landscape factors (topography and soils), and Section B discusses human influences (land use, population, and infrastructure) that affect watershed health. Sections C through F describe existing conditions related to each of Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities.

The summary is written to stand alone for readers who do not wish to read the entire chapter. For that reason, some repetition occurs between the summary and the sections that follow it.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health.

SUMMARY OF WILLAMETTE RIVER WATERSHED

Setting

The Willamette River Basin is the largest river basin in Oregon, covering more than 11,000 square miles. Thirteen major tributaries join the Willamette as it stretches 187 miles from its headwaters to its confluence with the Columbia River at Kelley Point. The river passes through forests, small towns, large cities, and farmland that extends to the river's edge. Urbanization, dam building, timber harvesting, and agriculture have greatly altered the basin over the past 175 years.

The City of Portland sits at the downstream end of this large basin. Seventeen river miles pass through Portland, from just south of the Sellwood Bridge to the Columbia River confluence at Kelley Point, comprising approximately nine percent of the river's length. Portland's Willamette Watershed covers about 44,000 acres (69 square miles) within Portland that drain directly to the Willamette River, and includes those areas of Portland not in the Johnson Creek, Tryon Creek, Fanno Creek, or Columbia Slough Watersheds (Figure 3-1).

Portland's Willamette Watershed occupies about 0.5 percent of the river's total drainage basin, but is the most highly urbanized portion and serves as a gateway to the entire upper basin. For example, thousands of anadromous salmon, steelhead, and lamprey swim through Portland on their way to spawning grounds upstream, and their offspring migrate through the City as they travel to the Pacific Ocean. Even though Portland's contribution to the flow of the Willamette River is small relative to upstream sources, improving watershed function in the Portland watershed is important for the health of the entire river ecosystem.

Portland's Willamette Watershed includes Forest Park, the downtown commercial core, industrial districts on both sides of the river, and the City's most densely populated residential neighborhoods. Topography distinguishes the west and east sides of the Willamette River in Portland. The west side is characterized by the West Hills rising from a narrow terrace along the river. The east side is relatively flat, except for a few volcanic buttes such as Mt. Tabor and Rocky Butte.

For planning and analytical purposes, Portland's Willamette Watershed is divided into 27 subwatersheds and the following four river segments:

- **North Segment** (River Mile [RM] 0-6): The north segment begins at the confluence of the Columbia and Willamette Rivers and extends upstream six miles to the St. Johns Bridge. This section contains the downstream portion of the Portland working harbor (Portland Harbor). A dredged channel and a mixture of docks and riprap, with a few sandy river beaches, characterize this segment. Banks in this segment are generally steep and composed of fill and riprap. A portion of the Multnomah Channel, the river segment that runs along the south edge of Sauvie Island and joins the Columbia farther downstream, is within this segment.

Figure 3-1
Willamette Watershed

- **Industrial Segment** (RM 6-12): The industrial segment extends from the St. Johns Bridge to the Steel Bridge and comprises the upstream portion of Portland's working harbor (Portland Harbor). The banks are almost completely filled and armored. The channel is dredged for shipping throughout the reach.

- **Downtown Segment** (RM 12-14): The downtown segment extends from the Steel Bridge to the Ross Island Bridge. The downtown seawall dominates the west bank. The east bank has been filled extensively, and Interstate 5 occupies most of the east side. This segment experiences significant barge traffic.

- **South Segment** (RM 14-17): The south segment extends from the Ross Island Bridge to Portland's urban services boundary south of the Sellwood Bridge. It is sometimes broken down into two segments: Ross Island and Sellwood. In the Ross Island reach, Holgate Slough and Oaks Bottom, along with the complex of forested islands, bottomlands, and river bluffs, provide Portland's most significant, albeit altered, remaining natural areas along the river.

Current Conditions

Before 1850, Portland's Willamette Watershed was an interconnected system of river channels, wetlands, riparian areas, and uplands. Today, the watershed is highly urbanized (except for the Forest Park subwatersheds), with an average impervious cover of 40 percent. Extensive development, urban activities, and structural changes to the river's banks and channel have diminished the watershed functions once provided by the natural environment, with negative effects on the hydrology, physical habitat, water quality, and biological communities in the watershed. The following conditions will have to be considered to determine the needs and best approaches for enhancing watershed health.

- The dams and reservoirs in the Willamette River Basin have altered the volume, timing, and velocities of the Willamette River's flows. Winter flood flows have been reduced, and summer low flows have been increased. Stream flow changes alter important ecological processes such as the interaction between the river and its floodplain.

- Channel deepening and straightening, bank hardening, vegetation removal, and increased impervious surfaces (both along tributary streams and in upland areas that drain to tributaries and the mainstem) have local-scale impacts on the Willamette's flows. Bank alterations and floodplain development prevent the river from overtopping its banks and connecting with its floodplain, thus reducing the attenuation of flood flows.

- With the exception of Forest Park, upland areas of the watershed have been heavily impacted by development. In Stephens Creek, high levels of imperviousness have likely increased wet season peak flows and decreased dry season base flows from historical conditions.

- Significant dredging, diking, and channeling of the mainstem Willamette have affected habitat. The mainstem has been narrowed and deepened, and off-channel habitat has been virtually eliminated and the floodplain has been degraded. Hardening of the river's banks precludes important naturally caused channel changes and minimizing the interaction between the river and riparian and floodplain vegetation. Habitat has been simplified, and large tracts of riparian vegetation have been cleared.

- Wetland losses, vegetation removal and increased impervious surfaces have altered the temporal and spatial patterns of groundwater inflows and groundwater inputs.

- Willamette River temperatures recorded in Portland and upstream regularly do not meet state standards during the summer.

- Progress has been made in reducing the amount of bacteria in the Lower Willamette River, but levels are still of concern. Portland's ongoing Combined Sewer Overflow (CSO) Program will ultimately result in even greater reductions in the bacteria entering the Willamette in Portland, and may reduce levels of copper and lead. Even after the CSO Program is complete, however, a large amount of stormwater, and the pollutants it carries, will continue to drain to the Willamette River via hundreds of private and dozens of municipal outfalls, creating the need for additional ongoing watershed management actions.

- Stormwater from streets and developed areas is a very significant—and difficult to manage—conveyor of pollution from countless diffuse sources.

- Many pollutants introduced into the water bind strongly to sediment. Because of the level of pollution in Lower Willamette River sediments, Portland Harbor was added to the federal Superfund cleanup list in December 2000. The pollutants of concern include elevated levels of DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals.

- Development has greatly reduced the biological integrity of the Willamette Watershed and the mainstem Willamette River within Portland. Some native fish species have become extinct, and introduced species currently occupy native species' habitat or compete with them for food, cover, and other habitat features. For example, local and upstream salmon populations have been greatly reduced from historical numbers, and some are listed as threatened under the federal Endangered Species Act.

Protection Opportunities

River Segments

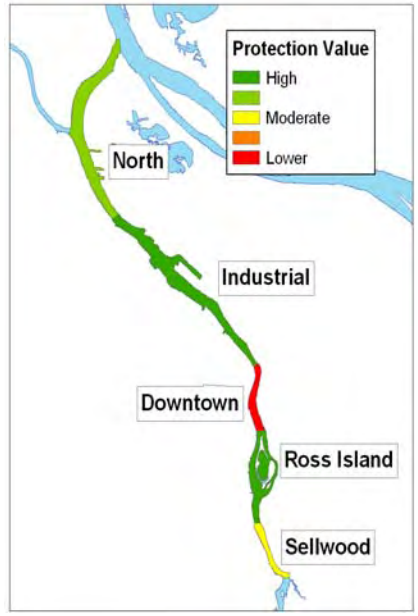
The north, industrial, and south (Ross Island) river segments of the watershed contain areas that provide habitat for migrating salmon and other fish and wildlife. These areas therefore have a high protection value, as summarized below and shown on Figure 3-2.

Figure 3-2
Willamette Watershed Protection Priorities

- The north segment between the St. Johns Bridge and the confluence with the Columbia River includes both remnant off-channel areas and relatively intact conditions on the west bank.

- In the industrial segment, the Swan Island lagoon and other terminal facilities provide areas for fish and wildlife to move out of the river's main current (off-channel habitat).

- In the south segment, Ross Island provides off-channel and shallow-water habitat, relatively intact streamside vegetation, and natural bank conditions. The adjacent wetlands at Oaks Bottom also provide watershed functions, including habitat, groundwater recharge, and stormwater retention.



Riparian and Terrestrial Opportunities

Forest Park and virtually all of Portland's riverside parks provide important watershed health benefits. Forest Park is the largest urban park in the nation, providing habitat for birds, black bear, bobcats, cougar, and elk. Powers Marine, Sellwood, Willamette, Oaks Bottom, Kelley Point Parks represent, to varying degrees, the Willamette Watershed's remaining natural riparian areas.

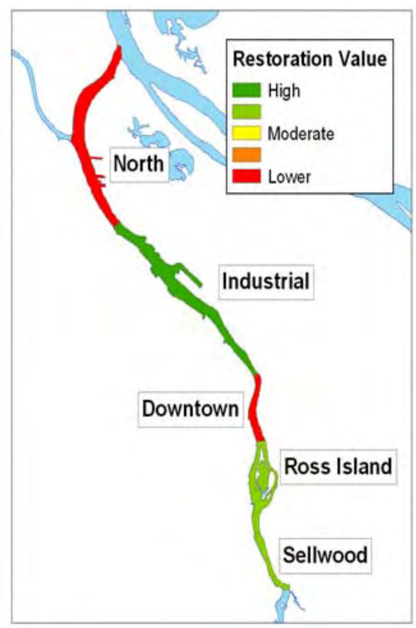
Although Stephens Creek has been affected by urbanization, its confluence with the Willamette just north of the Sellwood Bridge provides important off-channel habitat. The upper reaches of Balch, Saltzman, Doane, and Miller Creeks, along with several unnamed streams in Forest Park, are protected from intensive development by their location mostly within the park. While recreational use does cause some erosion, the water quality, hydrology, and habitat in these upper reaches contribute to watershed health. Several of these streams also support populations of cutthroat trout, sculpin, and other native fish. The lower reaches are conveyed in pipes and culverts across the industrialized floodplain terrace, blocking fish passage from the mainstem to upper reaches. Even if fish passage is not restored, however, the confluence areas of these streams could provide valuable watershed health benefits, including off-channel refuge areas for fish in the Willamette.

Metro's recently completed inventory of riparian and wildlife habitat resources estimates that more than 10,000 acres of land within the Willamette Watershed provide fish and wildlife habitat. This area is included in Metro's inventory of regionally significant resources. State land use planning Goal 5 requires analysis to determine if development should be limited to protect resources deemed significant by local jurisdictions and Metro. Currently, almost 7,600 acres of land in Portland's Willamette Watershed are within environmental overlay zones.

Restoration Opportunities

The City's initial analyses of the Willamette River and its banks have identified that the industrial and Ross Island segments have the greatest potential to provide watershed health benefits if restored (Figure 3-3). Limiting conditions currently include changes in hydrology (flow patterns), elevated summer water temperatures, bank armoring, loss of shallow-water habitat, high levels of bacteria, pollution in river sediments, and the presence of non-native fish species. Similar analyses of the upland portions of Portland's Willamette Watershed are underway. The purpose of these restoration efforts is to restore some watershed function within the limitations and competing interests of the urban setting, not to recreate historic conditions. This is a basin-wide effort with multiple entities implementing a wide variety of actions.

Figure 3-3
Willamette Watershed Restoration Priorities



Hydrology

Changes in flow patterns cannot be addressed solely or even predominantly through restoration actions in Portland, and must be coordinated with broader efforts throughout the entire Willamette Basin. In particular, opportunities exist to work with upstream jurisdictions and the U.S. Army Corps of Engineers to influence the way upstream flood control and hydropower dams are operated. Local actions to improve the Willamette River's connection to its current and historical floodplain will improve hydrologic conditions at the local and site-specific scale.

Habitat

Portland can significantly influence the condition of its river banks, as well as upland areas, through a variety of means, including purchases, incentives, zoning, regulations, restoration projects, and partnerships. The City also can establish new priorities for the land it owns along the Willamette River. In addition, Portland can work to increase the amount of shallow-water habitat, particularly in the protection areas identified above. Restoration actions have been included in the development of the Eastbank Esplanade and South Waterfront, and restoration plans have been developed for Ross Island and the Port of Portland's Toyota facility. These efforts serve as models for additional restoration actions.

Water Quality

Similar to hydrology, elevated summer water temperatures will require actions throughout the entire Willamette Basin, but Portland can play a significant role in the tributaries.

The City is addressing high bacteria levels by large investments in its sewer system to limit bacteria in the Willamette and in the tributaries draining to it (Columbia Slough, Johnson Creek, Tualatin River).

Local efforts in Portland can significantly (though not solely) address pollution. Pollution, particularly in sediments, will be addressed by the Portland Harbor Superfund Program and by stormwater management actions throughout the upland portions of Portland's Willamette Watershed and the tributary watersheds that drain to the Willamette. Addressing transportation-related pollution is an important aspect of improving water quality. Controlling the sources of pollution, including industrial and non-point sources, is the most cost-effective management approach for improving water quality.

Biological Communities

Non-native species probably will never be completely eliminated from the Willamette Watershed. However, their numbers and impact could be reduced by all the actions described above, which would provide conditions more favorable to native species and less favorable to non-native species.

Stormwater Management

Improving urban stormwater management to restore water quality and quantity is one of the most important restoration priorities for Portland's Willamette Watershed. Runoff from urban areas contains copper, lead, bacteria, and other pollutants. It also can contribute to high water temperatures. Stormwater runoff also causes combined sewer overflows that discharge untreated sewage into the Willamette. It will be especially critical to explore additional methods for controlling the sources of stormwater pollution and for treating and disposing of stormwater runoff from streets.

Revegetation

The City's Revegetation Program and ongoing support of street tree plantings provide benefits throughout the watershed, particularly for physical habitat and water quality. On the east side of the Willamette, particularly along the bluffs in the subwatersheds north of the Fremont Bridge, revegetation projects provide examples of active urban restoration with native plantings. A project to improve trail access to the river in the Mocks Bottom subwatershed near Swan Island complements the revegetation work already underway.

Combined Sewer Overflow Program

CSO Program work in the Willamette Watershed provides an opportunity to integrate the watershed approach into sewer facility planning.

Area and Neighborhood Plans

Development of the St. Johns/Lombard Plan and the Northwest District Plan provides opportunities to consider how proposed zoning and land use changes affect stormwater and to take measures to improve stormwater management and watershed health.

The Marquam Hills Nature Park in the Sheridan-Woods subwatershed provides water quality, hydrology, and habitat benefits. Planned development in the South Waterfront area is within this subwatershed. A creative stormwater swale and bank restoration project highlights innovative opportunities for stormwater and habitat improvements along the mainstem in a dense urban area. There will be additional opportunities for watershed improvements as part of the South Waterfront greenway development project and Oregon Health and Science University (OHSU) and other private development projects.

Section A: LANDSCAPE FACTORS

A-1: Topography

Significant topographic differences exist between the east and west sides of Portland's Willamette Watershed. The ground elevation of the east side is much flatter, generally ranging from about 30 feet to 300 feet above mean sea level (msl), with isolated hills of 800 to 1,000 feet scattered throughout. The most notable of the isolated hills is Mount Tabor in the easternmost area. Ground slope on the east side is typically less than three percent, except near and around the isolated hills, especially the Mount Tabor area.

The ground elevation of the west side is much more varied, with elevations ranging from 30 to 1,200 feet above msl. The West Hills dominate the landscape in the western half of the area, from the north to the south boundaries. The northern area is referred to as the Northwest Hills, and the southern area is called the Southwest Hills. The area along the Willamette River is much flatter, with elevations in the range of 30 to 100 feet above msl. Ground slope in the Northwest Hills ranges from 15 to 60 percent throughout. The slope decreases sharply to less than four percent in the industrial areas along the river. Slopes in the Southwest Hills can exceed 30 percent, decreasing to five to 20 percent in the lower elevations. Because of the topography and steep slopes, stormwater runoff on the west side (either directly or indirectly through the combined sewer system) travels faster than on the east side. This is partly responsible for the erosion and landslide problems that exist in the Northwest and Southwest Hills.

A-2: Soils

Most of the east side comprises soils of moderately high permeability. Soils on the west side are more diverse overall than on the east side, and vary by topographic areas. Soils in the higher topography in the western part are predominantly of moderately low permeability. Soils in the lower topography in the eastern part along the river are predominantly of moderately high permeability; the only variation is the occurrence of low-permeability soils just south of Multnomah Channel.

Section B: HUMAN INFLUENCES

B-1: Land Use

Portland's Willamette Watershed features a diverse mix of land uses. It is the most urbanized of Portland's watersheds, encompassing the Central City, large areas of commercial and industrial development, and residential and mixed-use neighborhoods. It also includes Forest Park, which comprises about 5,000 acres in northwest Portland and supports a diverse array of recreational resources that attract a multitude of local and regional recreational users.

Table 3-1 shows approximated current (1998) land uses by general zoning categories (as defined by the City of Portland Comprehensive Plan). The actual use of the land area may differ from the zoning category. Overall, the largest general zoning category currently is single-family residential, at about 33.5 percent of the total area. Single-family residential is also the largest category for the east side, at about 45 percent. On the west side (which includes Forest Park), the largest zoning category is public/open space, at about 38 percent. These percentages of zoning categories remain similar under planned future conditions. The largest increase is anticipated for the commercial zoning category on both sides of the watershed.

The watershed has an average impervious cover of 40 percent. The impervious coverage of the various subwatersheds (except for the Forest Park subwatersheds) ranges from 25 to 90 percent.

Table 3-1
Current (1998) Land Area for
General Zoning Categories in Portland's Willamette Watershed

Condition	ZONING CATEGORY AREA (Percentage)						
	Commercial	**Industrial**	**Multi-Family**	**Public/ Open Space**	**Rural**	**Single-Family**	**Other**
East Side Current (1998)	6.0	26.0	11.0	8.0	< 1.0	45.0	3.0
West Side Current (1998)	6.5	20.5	7.0	38.0	6.0	20.0	1.0
Total Willamette Current (1998)	6.0	23.5	9.5	22.0	3.0	33.5	2.0

B-2: Population

Table 3-2 shows current (1995) and forecasted (2015) population, households, and population densities in Portland's Willamette Watershed.

The area of greatest population density is located near West Burnside Street along the Interstate 405 freeway. This area has many multi-story apartment buildings. Most of the rest of the west side has a relatively low population density, since much of the area is part of the Central Business District or Forest Park, where housing is limited.

Overall, the east side has a much higher population and population density than the west side. Only the areas directly along the river on the east side have the lower population densities common to most of the west side. Areas with greater population density generally have more impervious area and less space available to manage stormwater onsite.

Table 3-2
Population, Households, and Population Densities for Portland's Willamette Watershed

	East Side	West Side	Total Watershed
Estimated Population			
Year 1995	168,400	52,800	221,200
Year 2015 (% change)	165,600 (- 0.1)	66,800 (26.5)	235,400 (6.4)
Estimated Households			
Year 1995	73,100	29,400	102,500
Year 2015 (% change)	80,800 (11.0)	41,900 (42.5)	122,700 (20.0)
Average Population Density			
Year 1995, persons/acre	8.9	3.2	6.3
Year 2015, persons/acre (% change)	8.9 (< 0.1)	4.1 (26.5)	6.8 (6.4)

B-3: Sanitary and Stormwater Infrastructure

Combined Sewer System

The combined sewer system conveys both sanitary sewage (wastewater) and stormwater in the same pipes. The combined system serves about half of Portland's Willamette Watershed (the older parts of the City) and conveys flows to the Columbia Boulevard Wastewater Treatment Plant (CBWTP) for treatment. Treated effluent is discharged into the Columbia River.

Although the combined system has adequate capacity for sanitary sewage, combined sewer overflows (CSOs) occur nearly every time it rains. Stormwater flows make up about 80 percent of CSO volume and cause the discharge of untreated sewage to the Willamette River through approximately 34 combined sewer outfalls. The CSOs contain bacteria and other pollutants.

Under an agreement reached with the Oregon Department of Environmental Quality (DEQ) in 1991, the City is working to control CSOs to the Willamette River. Some neighborhoods within the combined sewer area have been separated into sanitary and stormwater systems. Other projects involve reducing stormwater inflow, installing large sewers to capture the overflows, upgrading the CBWTP and pump stations, and implementing water quality treatment alternatives for separated stormwater flows. To date, over 40 percent of CSOs to the Willamette River have been controlled. When all projects are completed in 2011, at least 94 percent of CSOs to the Willamette River will be controlled.

Separated Sanitary System

The separated sanitary system (carries sanitary sewage only) serves the remaining half of the watershed (the newer areas of the City). Flow from these sewers is conveyed to the CBWTP.

Stormwater Facilities

The separated stormwater system includes both open conveyance (drainageways, drainage ditches, and swales) and closed systems (pipes, sumps, and culverts). Stormwater flow is discharged to the Willamette River through approximately 34 City outfalls. Some stormwater is filtered, typically through a retention system, but most flows are discharged untreated to the river. The majority of discharge from City stormwater outfalls is drainage from public streets and rights of ways. In general, pollution from these outfalls is what is associated with the transportation system—oil and grease, metals, PAHs, and sediments. Nutrients and some toxics from cleaners or horticultural products may also be discharged. Some runoff is from private property, especially lawns and driveways, that flow into the street. Numerous private stormwater outfalls from properties adjacent to the river and Port of Portland conveyance systems also discharge runoff into the river.

Approximately 2,720 sumps in the watershed dispose of stormwater under the ground surface.

B-4: Transportation Infrastructure

Of the Willamette Watershed's total area (44,000 acres) about 40 percent (17,668 acres) is impervious cover (streets, rooftops, and parking lots). Streets make up 9,200 acres, which is about 52 percent of the total impervious area and 21 percent of the total watershed area. The areas with the highest concentration of roads are clustered around the Central City: downtown, the Central Eastside Industrial District, and close-in residential areas on both the east and west sides of the Willamette River.

Parking lots add another 2,604 acres, bringing the proportion of transportation-related impervious area to 67 percent. The subwatersheds with the highest percentage of parking lot coverage are Swan Island and Rivergate, where the land uses are predominantly industrial shipping and distribution.

Sections C, D, E, and F describe the current conditions of Portland's Willamette Watershed related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvements in these conditions will indicate improvements in watershed health.

Section C: HYDROLOGY

The dams and reservoirs in the Willamette River Basin have altered the Willamette River's flows. Winter flood flows have been reduced, and summer low flows have been increased. For example, before dams were built in the Willamette Basin, flows in Portland every six to ten years were equal to or greater than the 1996 flood. These flow changes decrease river-floodplain interactions.

Portland-area urban activities such as channel deepening and straightening, bank hardening, removal of vegetation, and increases in impervious surfaces (both along tributary streams and in upland areas that drain to tributaries and the mainstem) have local-scale impacts on the

Willamette's flows. Bank alterations and floodplain development prevent the river from overtopping its banks and connecting with its floodplain.

The east side of the watershed has been almost completely urbanized. Nearly all the natural streams that once crossed the area have been buried in underground pipes and diverted into the sewer system. As a result, the east side streams drain to the river by way of a large number of stormwater and combined sewer outfalls.

The west side drains to the Willamette River by way of numerous natural creeks and piped stormwater outfalls in the northern area; combined and stormwater outfalls in the central area; and a combination of natural creeks and combined outfalls in the southern area. Almost all of the natural creeks flow through culverts or pipes for some distance before reaching the Willamette River. Expanded impervious areas resulting from urban development increase flows to the creeks; flows reach the creeks sooner and at higher velocities than they did with less (or no) impervious area. This degrades stream channels and significantly decreases the amount of water that infiltrates into the soil and recharges groundwater. Forest Park has low impervious area, so these impacts are minimal in Forest Park creeks.

Discharges to the river through stormwater and combined sewer outfalls peak after rainfall. However, they do not, even in aggregate, have a significant impact on the overall hydrology of the Willamette River. The river's flow ranges from about 5,000 cubic feet per second (cfs) in the summer to over 200,000 cfs during spring runoff; Portland's contribution to this flow is insignificant compared to flow from upstream.

Section D: PHYSICAL HABITAT

Historically, the Willamette River in the Portland area comprised an extensive and interconnected system of active channels, open slack waters, emergent wetlands, riparian forest, and adjacent upland forests. There was high habitat connection along the river and from the vegetated riverbanks to the upland forests. Vegetation types included bottomland forests in the low riparian areas and the forested wetlands (black cottonwood, Oregon ash, willow). Denser mixed conifer forests (Douglas fir, big leaf maple, western red cedar, western hemlock, grand fir, red alder) dominated the West Hills and were found in some parts of the east terrace. Both foothill savanna (Oregon white oak, Pacific madrone, Ponderosa pine, Douglas fir, red alder, big leaf maple) and meadow (grasses) were found on the east side.

Today, habitat in Portland's Willamette Watershed is heavily degraded compared to historical conditions:

- Upstream dams have altered seasonal flow patterns and greatly reduced peak flows. This has reduced the size and frequency of flooding, which is critical for maintaining habitats, including off-channel habitat for migrating salmonids.

- Channel straightening, filling, bank hardening, and dredging have greatly diminished floodplain functions for fish and wildlife throughout most of the watershed and have eliminated or degraded shallow water, riverine, off-channel, and wetland habitats.

- Channel complexity (variation in depth, channel meanders, side channels, banks, logs, rocks, gravel bars) once provided habitat for fish as well as for plants, insects, and other species on which fish depend. Channel complexity also provided fish with refuge from and during floods. Constriction of the riverbank by fill, docks, and seawalls has now caused the river channel to become deeper and more uniform. This has reduced the channel complexity, which is now rated as poor for both native and non-native fish habitat based on City of Portland analysis of changes over time in bank conditions, off-channel habitat, and bathymetry. Maintenance dredging to support commercial shipping and transportation activities also likely contributes to the lack of channel complexity.

- Most of the natural riparian areas on both sides of the river have been filled. The river's banks are now typically steep and composed primarily of bank stabilization and fill materials, such as sheet pile, riprap, seawall, and concrete fill. Remaining riparian vegetation is generally sparse to absent and frequently consists of non-native plants. The lack of riparian area and large wood contributes to the reduced complexity of the river channel and shoreline. Bank hardening and development make it difficult to restore trees and plants. Because of the scarcity of trees, few are available to fall into the river to provide habitat for fish and aquatic wildlife.

- In Portland, about 85 percent of the riparian features that provide shade and help reduce water temperature have been substantially altered. The loss of riparian area upstream of Portland may be a significant contributor to increased water temperature. The lack of riparian vegetation also decreases the filtering of pollutants and sediments from runoff and diminishes wildlife habitat.

- The lower reaches of the west side tributaries are conveyed in pipes and culverts across the industrialized floodplain terrace, blocking fish passage from the river to the upper reaches.

- Urbanization has substantially altered much of the historic upland habitat. The remaining habitat is fragmented and isolated. On the east side, fewer than 800 acres of natural vegetative area remain. On the west side, over 8,200 acres remain, primarily in undeveloped areas in the West Hills, Forest Park, and Balch Creek Watershed.

- Invasive, non-native species (including English ivy, reed canarygrass, and Himalayan blackberry) dominate in many areas. They threaten existing natural areas by reducing forest structure, diversity, and habitat value, and are very difficult to control.

Section E: WATER QUALITY

More than 150 years of development have degraded water quality throughout the Willamette River Basin. In Portland's Willamette Watershed, the river's water quality is fair to poor.

E-1: Fish Advisories

On November 20, 2001, the Oregon Health Division (now the Oregon Department of Human Services—Health Services) issued a health advisory concerning the consumption of all types of resident fish in the entire mainstem Willamette River. The advisory cited mercury, polychlorinated biphenyls (PCBs), organochlorine pesticides, and dioxins as pollutants found within edible fish tissue to the extent that the fish tissue presented a danger to the health of a human consumer. Because of this danger, the public was advised to consume Willamette fish in moderate amounts. Possible causes of the mercury contamination mentioned in the advisory were natural volcanic and mineral sources and manmade sources along the river. The advisory also postulated about the causes of the contamination by PCBs, organochlorine pesticides, and dioxins, mentioning widely distributed sources and human activity throughout the area.

E-2: 303(d) List and Total Maximum Daily Loads

The State Department of Environmental Quality (DEQ) placed the Lower Willamette River, including the reach in Portland, on the state's 303(d) list in 1998, with an update in 2002. The 303(d) list identifies water bodies that are "water quality limited" because they do not meet water quality standards for certain parameters. The Lower Willamette River does not meet standards for:

- Bacteria (fecal coliform)
- Mercury
- Pentachlorophenol
- Biological criteria (fish skeletal deformities)
- Aldrin and dieldrin
- DDT and DDE
- PCBs (polychlorinated biphenyls)
- PAHs (polycyclic aromatic hydrocarbons)
- Manganese
- Iron
- Temperature

DEQ has also identified lead and copper as potential water quality concerns and is evaluating whether they should be included on the 303(d) list.

DEQ establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the "assimilative capacity," which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. The water quality standards are established to protect the most sensitive beneficial uses of the river.

DEQ will release draft TMDLs for bacteria, mercury, and temperature for the Lower Willamette in 2004, with a public comment period to follow. All other Lower Willamette River TMDLs will be completed after June 30, 2007.

E-3: Water Quality in the Willamette Mainstem

Overview

Bacteria and temperature are primary water quality concerns in the Portland portion of the Willamette River. Concentrations of copper and lead may also be of concern. Trend analysis indicates that dissolved oxygen levels may be declining, but further analysis is required to confirm this trend. Few data exist for many of the 303(d) listed parameters (aldrin, DDT, dieldrin, manganese, mercury, pentachlorophenol, PAHs, PCBs).

In December 2000, Portland Harbor was designated as a federal Superfund site because contaminated sediments have been found in a six-mile stretch of the river, from the southern tip of Sauvie Island to Swan Island. The contaminants of concern include DDT, PCBs, PAHs, and heavy metals. A long-term program to clean up the harbor is underway, which will include an analysis of the water quality impacts of the sediment contamination.

Stormwater runoff from impervious urban areas contains a range of pollutants from residential, commercial, institutional, and industrial land uses. Transportation areas (roads and parking lots) can also be a source of pollutants such as metals, oil, and grease.

Sources upstream of Portland also impair the water quality of the Willamette mainstem. These include pollutants from industrial and stormwater discharges, discharges from wastewater treatment plants, and runoff from agricultural and other land uses.

Some water quality problems (especially temperature) and sediment problems (toxic constituents) impact many, if not all, fish species.

Bacteria (E. coli)

The purpose of the bacteria standard is to protect people from contact with and ingestion of pathogenic (harmful) bacteria, which can occur during recreational activities such as swimming and boating. Contact with these bacteria can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.
Current state standards for bacteria are measured in terms of *E. coli*.

The primary sources of bacteria in the Willamette River include CSOs, stormwater, and sediments. Monitoring has shown improving trends in levels of *E. coli* bacteria as a result of reduced CSOs. Monitoring has also shown that high bacteria concentrations exist upstream of Portland in the Lower Willamette. The sources of upstream bacteria are not known, but may include sewage treatment plants, agriculture, stormwater runoff, and pulp and paper operations. In addition, data have shown that the upstream sources may be related to wet weather.

Mercury

Mercury was listed on the Oregon 303(d) list in 1998 as a result of an Oregon Health Division fish advisory issued in 1997. Based on a DEQ document released March 15, 2004 titled *Willamette River Basin Total Maximum Daily Load Project - Preliminary Estimate of a Mercury Mass Balance for the Willamette River Basin*, the vast majority of the mercury sources (over 90% on an annual basis) are non-point source in nature, consisting of surface soil erosion and load to stormwater runoff from air deposition. The remainder are various point sources, including mines, public wastewater treatment plans, and industrial discharges.

Pentachlorophenol

Pentachlorophenol was listed on the Oregon 303(d) list in 1998 as a result of an Oregon Health Division alert for fishing and swimming in the area of the McCormick and Baxter Superfund site. There are known sources of pentachlorophenol in the heavily industrialized portion of the Willamette River.

Biological Criteria (fish skeletal deformities)

Biological criteria were listed on the Oregon 303(d) list in 1998 because of skeletal deformities found in juvenile northern pikeminnow collected at river mile 25.5. A recent report by Oregon State University scientists identifies parasites as the cause of the deformities.

Aldrin and Dieldrin

Aldrin and dieldrin were listed on the Oregon 303(d) list in 2002 as a result of an Oregon Health Division fish advisory issued in 2001. Monitoring by the U.S. Geological Survey (USGS) has shown that organic compound concentrations are generally highest during storm flows, particularly during the first storms of the fall. A 1999 USGS report cites increasing urbanization and agricultural development as causing fish and wildlife to be exposed to contaminants through runoff and atmospheric deposition. The report also mentions that chemicals used in industry and agriculture have been shown to cause reproductive abnormalities in bald eagles, river otters, and osprey in the Lower Columbia Basin. Organochlorines (such as aldrin, dieldrin, and DDT) and PAHs are suspected of causing negative health impacts in other species as well.

DDT and DDE

DDT and DDE were listed on the Oregon 303(d) list in 2002 as a result of an Oregon Health Division fish advisory issued in 2001 and year-round exceedances of water quality criteria. A 1993 Tetra-Tech study identified the main source of DDT in the river as resuspension of contaminated sediment. (The use of this pesticide was banned in 1972, but it persists in the environment.)

PCBs (polychlorinated biphenyls)

PCBs were listed on the Oregon 303(d) list in 2002 as a result of an Oregon Health Division fish advisory issued in 2001. Results of a 1997/1998 USGS study indicate that concentrations of PCBs at Portland are among the highest in the Lower Columbia Basin. Sources of PCBs include accidental spills, manufacturing activities, and disposal of products contaminated with PCBs from industrial equipment.

PAHs (polycyclic aromatic hydrocarbons)

PAHs were listed on the Oregon 303(d) list in 2002 because of year-round exceedances of water quality criteria. In a USGS study of organochlorine and polynuclear aromatic compounds in the Lower Columbia River, the Portland sampling location ranked in the top two sampling sites based on PAH concentrations. Sources include petroleum products and combusted materials.

Manganese

Manganese was listed on the Oregon 303(d) list in 2002 because of year-round exceedances of water quality criteria. Potential sources of manganese include natural occurrence, pesticides, fuel additives, food additives, automobile engine parts, power plants, industry, and mining.

Iron

Iron was listed on the Oregon 303(d) list in 2002 because of year-round exceedances of water quality criteria. Potential sources of iron exist in the heavily industrialized portion of the Willamette River.

Temperature

The Willamette River was placed on the Oregon 303(d) list for temperature in 1998 because it exceeds water quality standards in the summer. Stormwater runoff that absorbs heat from impervious surfaces and discharges directly to the river (rather than infiltrating into the ground) can elevate surface water temperatures. The lack of riparian vegetation and shading throughout the entire Willamette River Basin contributes to high water temperatures.

E-4: Water Quality in the West Side Tributaries

Water quality in Willamette River tributaries varies by area and proximity to land uses. Balch Creek and other creeks in southwest and northwest uplands have relatively good water quality in their upper reaches as they flow through forested areas and/or areas with little development. Some of these creeks, however, have exceeded water quality standards in some samples, particularly during storm events.

Bacteria, temperature, copper, and lead are water quality concerns in the west side tributaries. Other concerns include pH, total suspended solids, total phosphorus, and other metals (arsenic, cadmium, chromium, iron, mercury, and zinc). Water quality data for the west side tributaries are limited; further data are needed to confirm or remove any parameters currently considered to be of concern. In addition to the instream water quality of the tributaries, it is also important to consider the quality of stormwater discharges and combined sewer discharges from the west side tributaries to the Willamette River.

The large number of onsite sewage disposal systems in the northern part of the west side can potentially affect water quality in the tributary streams by contributing pollutants such as bacteria and nutrients (nitrogen, phosphorus). Many of these systems are aging and may not be receiving the maintenance necessary to prevent performance problems.

E-5: Water Quality in the East Side

Most east side tributaries are piped underground and receive stormwater runoff from high-density urban areas. This runoff is important to consider because it often enters the Willamette River through stormwater or combined sewer discharges. (Chapters 4 and 7 address water quality in the two main east side tributaries: Johnson Creek and the Columbia Slough.)

Section F: BIOLOGICAL COMMUNITIES

The fish and wildlife species that use the Lower Willamette River have changed significantly from historical conditions. Development has greatly reduced the biotic integrity of Portland's Willamette Watershed. Some sensitive species have become extinct. The introduction of non-native species, particularly warm-water fish, has increased competition for food and habitat for native species.

F-1: Fish

Willamette Mainstem

Both native and introduced species of both warm-water and cool-water fish inhabit the Lower Willamette River today. Common native species include sucker, reticulate sculpin, and various minnows including northern pikeminnow, and introduced species including smallmouth bass, black crappie, white crappie, and mosquito fish. Reticulate sculpin and redside shiner were the most predominant in Portland's streams. Lamprey eel is a species of concern.

The Willamette River in Portland is a gateway to the vast basin stretching southward. Likewise, the Columbia River at Portland impacts all the species that migrate inland. Thousands of anadromous salmonids, including steelhead, chinook salmon, and coho salmon, swim through Portland on their way to spawning beds upstream, and their offspring return as they travel out to the Pacific Ocean. Subyearling salmon are present in the Lower Willamette River year round, indicating that salmonids use the Lower Willamette for rearing.

Balch Creek

Balch Creek supports a healthy population of cutthroat trout that has been isolated in the creek by a culvert installed at Lower Macleay Park in the early 1920s. Upstream passage of adult fish is limited by steep gradients in Balch Creek and culverts draining into the creek.

Miller Creek

Coho salmon, steelhead, chinook, cutthroat trout, and lamprey have been identified in Miller Creek below the culvert at Marina Way. Cutthroat are found above the culvert. The culvert and adjacent railroad tracks just upstream limit the upstream migration of salmon and steelhead to an unknown degree. The limiting factors for fish habitat in Miller Creek are low surface flow levels and sparseness of pool habitat.

Stephens Creek

Coho salmon, steelhead, chinook, cutthroat trout, and lamprey have been identified in Stephens Creek at the mouth below the culvert. No fish have been identified above the culvert. The mouth of Stephens Creek, just downstream from the Sellwood Bridge, provides important habitat for endangered species as they migrate. Improving water quality in the creek will help maintain this habitat.

F-2: Wildlife

The east side of the Willamette Watershed is heavily urbanized and does not provide much urban wildlife habitat in most areas. The Oaks Bottom Wildlife Refuge is an important exception, supporting a diversity of wildlife. Key wildlife that resides at or visits Oaks Bottom includes waterfowl, wading birds (herons, egrets), bald eagles, amphibians, and beavers. Ross Island also provides habitat function similar to, and connected with, Oaks Bottom.

The West Hills (including Forest Park) have a high level of tree canopy and a low percentage of impervious area. Habitat connectivity for land, air, and waterborne wildlife is relatively good. As a result, the area supports 11 species of reptiles, 112 species of birds, and 62 species of mammals.

CHAPTER 4

Johnson Creek Watershed

INTRODUCTION

This chapter begins with a summary of current conditions in the Johnson Creek Watershed. The summary describes the watershed's current assets and problems, and identifies opportunities to protect and restore watershed health.

The following sections then provide more detailed information to support the summary. Section A presents landscape factors (topography and soils), and Section B discusses human influences (land use, population, and infrastructure) that affect watershed health. Sections C through F describe existing conditions related to each of Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities.

The summary is written to stand alone for readers who do not wish to read the entire chapter. For that reason, some repetition occurs between the summary and the sections that follow it.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health.

SUMMARY OF JOHNSON CREEK WATERSHED

Setting

Johnson Creek originates in Clackamas County east of Boring, Oregon, and flows westerly approximately 25 miles to its confluence with the Willamette River. The Johnson Creek Watershed encompasses approximately 34,000 acres, or about 54 square miles (Figure 4-1). The watershed intersects six local jurisdictions, as shown in Table 4-1.

Table 4-1
Johnson Creek Watershed Jurisdictions

Jurisdiction	Percentage of Watershed
City of Portland	40.0
Clackamas County (outside of Milwaukie and Happy Valley)	23.0
City of Gresham	22.0
Multnomah County (outside of Portland and Gresham)	10.9
City of Milwaukie	4.0
City of Happy Valley	0.1

The watershed is commonly divided into segments defined as the Johnson Creek mainstem (lower, middle, and upper) and the following major tributaries:

- Crystal Springs Creek
- Kelley Creek
- Butler Creek
- Hogan Creek
- Sunshine Creek
- Badger Creek

Crystal Springs Creek and Kelley Creek are the main tributaries to Johnson Creek and contribute the largest amount of flow to the mainstem compared with other tributaries. Crystal Springs Creek is fed mostly by groundwater and originates from springs on the north side of Johnson Creek. Numerous smaller tributaries also flow into Johnson Creek, such as Mitchell, Errol, Deardorf, and Wahoo Creeks. An estimated 38 percent of the historical tributaries in the watershed are now piped, sumped, or diverted to the combined sewer system.

The area of the watershed north of the Johnson Creek mainstem is typically flat, with large floodplain areas (particularly in Lents). These floodplains are thought to be a remnant of a series of large glacial floods that took place about 15,000 years ago. The topography south of the mainstem, where most of Johnson Creek's tributaries are located, is steep and varied.

Figure 4-1: Johnson Creek Watershed

INSERT MAP. INCLUDE LOCATION OF LOWER, MIDDLE, AND UPPER SEGMENTS.

Before urbanization, the Johnson Creek Watershed was a diverse area of upland and wetland forests with extensive vegetative growth. As pioneers settled along the banks of Johnson Creek, large ancient trees were cut and replaced with sawmills. Riparian vegetation was removed, and the wetlands along the lower segment of the creek were filled. The middle floodplains were cleared for farming to take advantage of the fertile soil deposited by frequent floods. By the 1920s, residential areas began to replace nurseries and farms, a trend that still continues. Today, the landscape varies from heavily developed urban areas in the lower and middle reaches (cities of Portland, Milwaukie, and Gresham) to rural and agricultural areas in the upper watershed (near Boring).

In 1903, the Springwater Division Line, which ran alongside much of Johnson Creek, was developed for rail service. In addition to passengers, the trains hauled farm produce to Portland markets. Many communities developed along the rail line, including Sellwood, Eastmoreland, Lents, and Pleasant Valley. To encourage weekend rail use, the rail corporation developed destination parks, such as Oaks Amusement Park, along the line. Passenger service was discontinued in 1958. By 1990, the City of Portland had purchased much of the rail corridor. In the following years, Metro purchased additional portions of the line. The historic rail corridor is now the 21-mile recreational Springwater Corridor Trail that runs through the heart of the watershed, almost entirely along the creek.

One of the most significant changes in the watershed occurred in the 1930s when the Works Progress Administration (WPA) attempted to control flooding by widening, deepening, and rock-lining the creek, creating a trapezoidal channel in 15 of the 25 stream miles. These actions disconnected the creek from its floodplain, degraded streambank conditions, and substantially altered Johnson Creek from its historical configuration. The actions did not, however, stop major flooding. Johnson Creek has exceeded its banks 37 times since 1942, and local residents have experienced at least seven floods causing major property damage in the last 35 years.

Current Conditions

Over the years, alterations to Johnson Creek have had long-lasting negative effects on hydrology, physical habitat, water quality, and biological communities in the watershed. The following conditions will have to be considered to determine the needs and best approaches for enhancing watershed health.

- Johnson Creek has been substantially altered due to channelization. The channelization has caused the creek to become more flashy (respond very quickly to rainstorms). It also eliminated riparian and inwater habitat. Channelization and filling the floodplain for development have disconnected the creek from its historic floodplain, which has prevented floodwaters from spreading out and slowing down. As a result, stream velocities have increased and are directed and concentrated into the main channel. This causes streambank erosion and impacts the channel bottom. Channelization and development have greatly reduced riparian vegetation throughout most of the watershed, decreasing shading and elevating water temperature. The loss of riparian areas also reduces the filtration of pollutants and sediments from runoff and diminishes wildlife habitat.

- Wood and other structural diversity within the creek are almost nonexistent as a result of high water velocities, a lack of source material within the riparian areas, and human removal of vegetation and large wood. In addition, disconnecting and filling the floodplain has eliminated off-channel habitat along the mainstem. These conditions result in low-quality, simplified habitat for fish and other aquatic organisms.

- In addition to the Johnson Creek mainstem, much of Crystal Springs Creek, a tributary, has been channelized, lacks healthy riparian buffers, and has degraded habitat. Similarly, much of the instream habitat in Kelley Creek, another tributary, is degraded. Artificial obstructions impair adult and juvenile migrations in Crystal Springs Creek, Kelley Creek, and other tributaries.

- Base flows in the Johnson Creek mainstem and some tributaries in the middle and upper watershed frequently do not meet minimum flow targets, particularly in spring and summer months, because of low groundwater inflow and impoundments for irrigation. This can contribute to reduced habitat and degraded conditions for aquatic species (e.g., higher stream temperatures, water quality problems, fish passage barriers).

- Major floods have occurred in the watershed about once every three to four years. Most flooding takes place in the middle section of the creek because of the low gradient. When the channelized banks are overtopped floodwaters tend to spread out.

- Impervious surfaces cover approximately 38 percent of the portion of the watershed that is within the City of Portland. Increased stormwater runoff from impervious areas throughout the watershed may increase streamflow volume and velocities, which in turn downcuts and erodes stream habitat. The runoff also carries pollutants from various land uses into the creek and elevates water temperatures. To address these impacts, strategies will be required to manage stormwater from impervious surfaces by retaining and infiltrating stormwater as close as possible to its point of origin.

- Water quality in Johnson Creek is rated as poor. Urbanization and agricultural land uses have produced the following water quality problems:

  - Failing septic systems and fecal matter from domestic animals, livestock, and birds contribute to high levels of harmful bacteria in the creek.

  - Elevated water temperatures are caused by low summer base flows, lack of riparian shade, and the impoundment of water in irrigation ponds in the upper watershed and in decorative ponds along the creek. Elevated water temperatures stress fish and aquatic communities.

  - Toxic pesticides that are now banned, but were once in widespread use, are bound up in sediments that erode off exposed soils and drain into Johnson Creek.

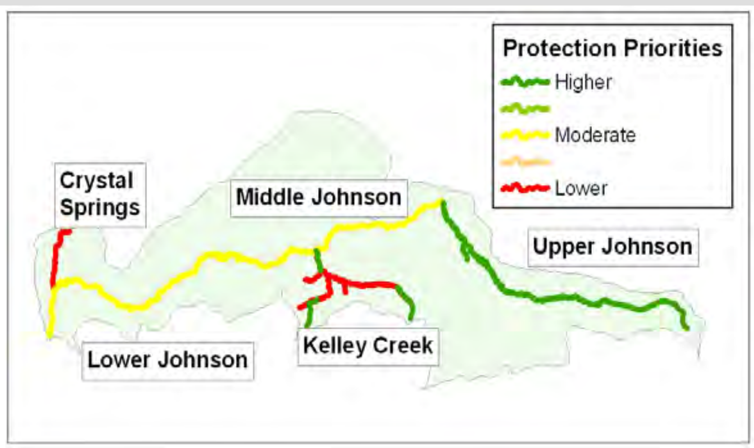
  - Excessive sediment is created by upland activities and by high streamflows that erode streambanks during winter months. The sediment smothers many areas of Johnson Creek, particularly the gravel beds that are critically important to salmon, steelhead, and other fish species and aquatic insects. Silt also reduces areas for macroinvertebrate production.

- The changes in hydrology, physical habitat, and water quality have had negative impacts on biological communities throughout the watershed. The diversity and populations of both upland and aquatic wildlife species have been significantly reduced. Salmon and trout were once plentiful in Johnson Creek, at one time supporting a small commercial fishery. Numbers declined dramatically as a result of the WPA channelization and urbanization. Today, the fish community in Johnson Creek includes non-native species tolerant of warm water and disturbed conditions. Native species present in the creek are redside shiners, reticulate sculpin, large scale suckers, and speckled dace. Adult salmonids, including coho salmon, chinook salmon, cutthroat trout, and steelhead, have been observed in recent years. Steelhead trout and chinook salmon are currently listed as threatened under the federal Endangered Species Act. The presence of salmonids indicates that Johnson Creek is capable of supporting salmon and trout populations, as well as other threatened aquatic species, but will require significant restoration work to support large numbers. Another factor that affects fish is the presence of culverts throughout the watershed that impair fish access to habitat. Although no culverts exist on the mainstem until high in the watershed, they are present on nearly all the tributaries to Johnson Creek.

Protection Opportunities

Remaining natural areas in the Johnson Creek Watershed provide important habitat benefits and therefore have a high protection value, as summarized below and shown on Figure 4-2.

Figure 4-2
Johnson Creek Watershed Protection Priorities



Upper Johnson Creek

Portions of upper Johnson Creek currently provide the most important functions in the watershed. Much of the capacity (the number of salmon a watershed can support) and nearly all of the productivity (the number of young salmon produced by each adult) depend on the section from Butler Creek to Hogan Creek, one of the most critical habitats in the watershed. Industrial development is currently planned for portions of this reach and for upstream reaches. Any degradation of this part of Johnson Creek would seriously threaten the watershed's remaining salmon populations.

Kelley and Mitchell Creeks

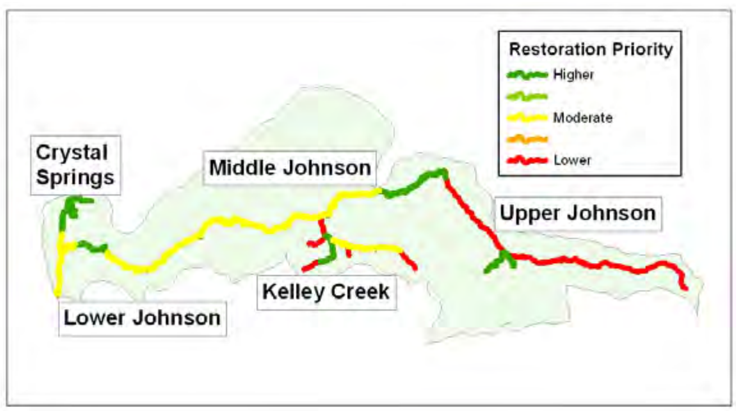
Fish surveys show that Kelley and Mitchell Creeks contain resident and potentially ocean-going trout populations. These tributaries to Johnson Creek currently have extremely valuable habitat diversity that provides fish and other species a variety of places to live. This habitat diversity is especially important in case landslides, spills, or other problems affect portions of a creek or stream. Kelley and Mitchell Creeks also contain high-quality remnant habitat for resident fish and wildlife and important water quality values for the entire watershed.

The Pleasant Valley Concept Plan calls for significant urban development in the Kelley Creek Watershed. Such development must be done with great care to protect a range of past and ongoing City actions, including projects to restore Kelley Creek's confluence with Johnson Creek, the 162nd and Foster culvert replacement, and others that have been and are currently being implemented.

Restoration Opportunities

In addition to the above protection areas, some currently degraded areas and attributes of the Johnson Creek Watershed could provide watershed benefits if restored, as summarized below and shown on Figure 4-3.

Figure 4-3
Johnson Creek Watershed Restoration Priorities



The middle and lower sections of Johnson Creek have the potential to provide the most significant watershed restoration benefits. In addition, restoring existing and potential refuge areas for fish and other species, and the reaches that connect these areas, would provide significant benefits. Restoration in Crystal Springs, Tideman Johnson Park, floodplains in the middle segment of the mainstem between SE 82nd and 112th, and the Gresham reaches of the Johnson Creek mainstem would likely provide the most watershed health benefits.

Hydrology

Through the Johnson Creek Willing Seller Program, the City acquires property in the Johnson Creek floodplain to restore wetlands and other natural features that store floodwater and manage flooding, as well as filter out pollutants and create fish and wildlife habitat. The Tideman Johnson, Lents, and Kelley Creek confluence areas are excellent locations to purchase property for these purposes.

Stormwater impacts across the upland portions of the watershed can be addressed by planting street trees, constructing green streets and ecoroofs, assessing and improving stormwater management regulations for new development, and retrofitting infrastructure. These actions would reduce peak winter flows, improve infiltration, and increase base summer flows.

Removing culverts in tributaries to Johnson Creek would allow flows to move more naturally from headwater areas to the mainstem without flooding.

Removing the WPA channel lining would provide the creek better access to its historic floodplain, allowing peak winter flows to spread out across a broader area designed to accept floodwaters and slowing the creek's velocity.

Habitat

Some Johnson Creek restoration projects are ready to implement, particularly Kelley Creek Meanders, Alsop Brownwood, and West and East Lents Restoration (includes the South of Foster and Springwater Wetland Complex restoration projects located around SE 111th).

The Johnson Creek floodplain in Gresham is adjacent to high-quality habitat in upper Johnson Creek. The large amount of floodplain in public ownership in the area makes it very well suited for restoration. The City of Gresham has been partnering with the Johnson Creek Watershed Council and the Portland Watershed Revegetation Program to restore riparian vegetation in the Gresham Woods area since 2001. The City of Gresham has also identified three project sites in this location for floodplain reconnection and wetland and riparian restoration.

Johnson Creek has a very limited amount of large wood in its main channel and tributaries, which is a significant limiting factor for salmon and trout. Adding large wood to the stream and ensuring that riparian areas are capable of growing trees that eventually can fall into the creek are important restoration opportunities.

Water Quality

Water temperatures in Johnson Creek consistently do not meet water quality standards, resulting primarily from a lack of trees in the riparian area to shade the stream. The duck pond in Crystal Springs Creek in Westmoreland Park is also a significant source of elevated temperatures in Crystal Springs Creek and Johnson Creek. Removing the duck pond would reduce temperature and bacteria levels, increase dissolved oxygen, and improve habitat in Crystal Springs Creek.

Decreasing the amount of sediment created by upland activities, and reducing high streamflows that erode streambanks would help protect gravel beds in middle Johnson Creek that are critically important to salmon, steelhead, other fish species, and aquatic insects.

Collaborating with the Johnson Creek Watershed Council and the U.S. Geological Survey to better evaluate threats posed by DDT, dieldrin, and other human-generated toxic pollutants would improve the understanding of how these toxic pollutants affect watershed health.

Information from instream surveys and on-the-ground observations suggests that the agricultural areas in the headwaters of Johnson Creek make a significant contribution to sediment, pollution, and habitat problems. Providing education and incentives for improved agricultural practices would help address these problems.

Actions throughout the Johnson Creek watershed, particularly in upland areas, would help address high summer water temperatures, excessive sediment, and toxic pollution.

Biological Communities

Pollution, altered flows, elevated water temperatures, and lack of habitat limit the number and diversity of benthic (bottom-dwelling) organisms and insects, reducing food sources for fish and wildlife. A lack of food is a key limiting factor for salmon in Johnson Creek. All of the restoration opportunities described above would contribute to improved biological communities in Johnson Creek.

Section A: LANDSCAPE FACTORS

A-1: Topography

Elevations in the watershed generally range between 0 and 1,100 feet above mean sea level (msl). Slopes are highly variable and generally range between 1 and 25 percent. The Boring Lava Domes are the highest point in the watershed at approximately 1,100 feet above msl. Mt. Scott and Powell Butte rise to approximately 1,000 feet above msl and have relatively moderate to steep slopes, ranging from 10 to 30 percent. Gresham and Hogan Buttes have the steepest slopes, with a few approaching or exceeding 50 percent. With the exception of the Powell Butte area, the terrain on the north side of Johnson Creek is less steep than the south side of the creek, which includes both Mt. Scott and the Boring Lava Domes.

A-2: Soils

The soils within the watershed vary in permeability and water-retaining capacity. In areas where soils are relatively undisturbed, permeability is moderate. The areas south of Johnson Creek and at the eastern end of the watershed consist mostly of clay soils that tend to have a high runoff potential and are incapable or only minimally capable of infiltrating water. Northern areas of the watershed are generally porous, with moderate to high permeability, and are suitable for infiltration-type facilities designed to help improve water quality.

Soils surrounding the Powell Butte and the Boring Lava Domes have an extremely high erosion factor and are sensitive to ground disturbance. These conditions may lead to greater erosion from development and construction activities.

Section B: HUMAN INFLUENCES

B-1: Land Use

The Johnson Creek Watershed is a relatively large and diverse watershed, with a variety of land uses (Table 4-2).

Table 4-2
Land Use in Johnson Creek Watershed (1999)

Land Use	Acreage (approx.)	Percentage of Watershed
Single-family residential	15,000	45
Rural	11,000	33
Multi-family residential	3,000	9
Industrial and commercial	2,700	8
Parks and open space	1,700	5

In the agricultural areas of the upper watershed, 50 percent of the land base is currently used for cultivated crops or pastures, and another 29 percent is used for tree and ornamental nurseries, greenhouses, or Christmas tree plantations.

There currently are 49 developed parks and recreational facilities within the Johnson Creek Watershed, totaling more than 1,000 acres. The Springwater Corridor Trail is a key recreational facility. It extends more than 21 miles and occupies a former railroad right-of-way that parallels Johnson Creek for much of its length.

Impervious surfaces cover approximately 38 percent of the area in the Portland portion of the Johnson Creek Watershed. The average impervious area for individual subwatersheds varies considerably, but overall is about 22 percent.

B-2: Population

Approximately 170,000 people currently reside within the Johnson Creek Watershed. To accommodate future population growth, the Portland metropolitan area's urban growth boundary (UGB) in the Johnson Creek Watershed has been expanded to include:

- Pleasant Valley—approximately 1,500 acres between Gresham and Portland, mostly within the Kelley Creek subwatershed of the Johnson Creek Watershed.
- Springwater—approximately 1,393 acres south and east of Gresham in the upper Johnson Creek area.
- Damascus study area—including most of the Sunshine Creek subwatershed and the headwater areas of Kelley and Mitchell Creeks.

With these expansions, about 27,900 acres of the Johnson Creek Watershed (82 percent) lie within the UGB.

Comprehensive planning is required before these UGB expansion areas will be allowed to develop to urban densities, and is now underway. These areas contain the highest quality remaining habitat in the watershed. Planning efforts will need to integrate urban development design with natural resource needs in order to protect these valuable habitat remnants and overall watershed health.

B-3: Sanitary and Stormwater Infrastructure

Combined Sewer System

The combined sewer system conveys both sanitary sewage (wastewater) and stormwater in the same pipes. Combined sewers serve Portland's Sellwood, Eastmoreland, Westmoreland, and Woodstock neighborhoods in the lower portion (western end) of the watershed (Figure 4-5). The Portland Public Facilities Plan identifies capital improvement program (CIP) projects for these areas to address basement flooding (caused by undersized pipes, flat slopes, and very long collection networks) and reduce combined sewer overflows (CSOs). Some collection pipes cross Johnson Creek. The pipe near Tideman Johnson park is exposed, posing a potential risk to the creek if it were to break. The pipe will be replaced or protected to prevent it from breaking or leaking.

Separated Sanitary System

Sanitary sewer systems within the watershed are owned, operated, and maintained primarily by the cities of Portland, Gresham, and Milwaukie. Parts of these systems are located within the floodway of Johnson Creek, and manholes are located within the stream channel. The collection pipes cross the creek several times. Replacing or maintaining these pipes must be done carefully to protect the stream from construction impacts.

In Portland, two pump stations convey sanitary sewage (along with some combined flow) to the Columbia Boulevard Wastewater Treatment Plant. In Gresham, sewage is conveyed to the Gresham Wastewater Treatment Plant on the Columbia River. Onsite septic systems treat sewage from development in the upper watershed east of the Gresham UGB because no sewer extensions are allowed outside of urban areas. Some onsite septic systems are also still being used in certain areas of Milwaukie and Portland. A new wastewater treatment plant is under construction in the Kelley Creek subwatershed to replace a failing septic field in Happy Valley.

Stormwater Facilities

Stormwater within the Portland portion of the watershed is conveyed through storm drainage pipes and treated by 31 pollution reduction facilities, although at the current time, there are no known estimates of the amount of untreated stormwater that enters Johnson Creek directly from stormwater outfalls. The stormwater then discharges into one of three main locations: the combined sewer system, sumps, or directly into Johnson Creek. The sumped area within the Portland portion of the watershed comprises more than 8,000 acres and treats approximately 23 percent of the City's stormwater.

Stormwater pipes also convey stormwater within Gresham's portion of the watershed. Because the pervious soil north of Johnson Creek is appropriate for infiltration facilities, 53 sumps have been installed within the northern portion of the watershed in Gresham. These sumps receive runoff from a mix of commercial, residential, and transportation land uses. No combined sewer system pipes are within Gresham's city limits.

The public stormwater system within the upper portion of the watershed (from the 2002 Gresham UGB east to the watershed boundary) consists of roadside ditches and culverts that convey runoff directly to Johnson Creek and its tributaries. This system provides no water quality treatment except in areas where ditch vegetation is maintained. For new developments, Multnomah County requires the rate of stormwater runoff from private property to be controlled to the estimated predevelopment rates. The Oregon Department of Agriculture has jurisdiction over runoff from agricultural fields into the roadside ditch system.

The Oregon Department of Environmental Quality (DEQ) issues stormwater permits to facilities that have discharges in or near Johnson Creek. The types of permits include construction, industrial, and animal-feeding operations.

There are no current estimates for the amount of stormwater that enters Johnson Creek from the direct stormwater outfalls.

B-4: Transportation Infrastructure

The Johnson Creek Watershed includes an extensive network of streets, roads, and highways, including Interstate 205 and 11 major arterials. SE Foster Road parallels Johnson and Kelley Creeks and encroaches on the riparian area and floodplain. In the Lents area, Foster Road regularly floods because it is located in the floodplain. In addition, numerous outfalls convey stormwater runoff from major arterials and residential streets directly into Johnson Creek, carrying pollution from road runoff and air particle deposits generated by traffic. Roadways convey significant nonpoint pollution to Johnson Creek, contributing solids (dirt, brake dust, tire dust); debris; nitrogen; oil and grease; bacteria; and heavy metals (copper, lead, zinc). Untreated stormwater from a 1.7-mile section of I-205 drains into Johnson Creek near SE 82nd Avenue. Numerous smaller outfalls along the creek drain large networks of residential streets. Many of these neighborhoods were built before stormwater treatment requirements were established in the City of Portland; as a result, much of the runoff is not treated before it enters the creek.

Sections C, D, E, and F describe the current conditions of the Johnson Creek Watershed related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvements in these conditions will indicate improvements in watershed health.

Section C: HYDROLOGY

C-1: Channelization

In the 1930s, the Works Progress Administration (WPA) channelized much of the two lower sections of Johnson Creek (15 of the total 25 miles of the creek) in an attempt to control flooding. At several locations along the stream, a new course was created and the stream channel was straightened, deepened, and widened. Dikes were constructed to contain and control the stream at high flow. Riparian vegetation was removed, and the dikes and streambed were armored with basalt rocks. The intent was to remove wood and vegetation to allow the creek to flow downstream as quickly as possible away from adjacent properties.

The channelization did not stop major flooding, but did substantially alter the creek from its historical configuration. These alterations have had long-lasting, negative effects on the physical habitat and hydrology of the watershed. Flows are now concentrated in the rock-lined channel, preventing lateral movement into the historic floodplain and increasing streamflow velocities. High winter velocities have almost entirely removed large wood and other diversity from the creek, eliminating refuge areas for salmonids. (Other reasons for the lack of large wood include the loss of trees within riparian areas and human removal of vegetation and wood.) The concentrated streamflow also increases scouring and degrades instream habitat.

Other WPA features that were constructed include a canal and waterfall above Tideman Johnson Park, a nearby fish ladder, an old Tacoma Street Bridge, and many other rock walls, stairways, and bridges. Ponds constructed along Johnson Creek and tributaries such as Crystal Springs Creek and Kelley Creek have had negative impacts on water flow and quality, as discussed in the following sections.

C-2: Floodplain

Floodplains provide room for dynamic channel movement, water storage areas, and off-channel wetlands, reducing downstream flooding. They also provide connection between habitat areas, safe refuge for fish, sediment transport and storage, and organic input to the creek. As discussed above, the channelization of Johnson Creek has reduced floodplain area and connectivity and eliminated many of the areas that once absorbed and conveyed floods through the watershed. In addition, significant development has occurred within the floodplain in many places throughout the watershed, further degrading the amount and quality of available floodplain.

C-3: Water Rights

A number of water claims, permits, applications, and certificates currently exist for various uses of Johnson Creek. There are also unpermitted water withdrawals, and some withdrawls may exceed permit conditions. Water diversions and withdrawals can reduce base flows, with negative impacts on water quality, especially in the summer. According to the Oregon Water Resources Department (WRD) Johnson Creek is over-allocated during most summer months. It may be possible to address summertime over-allocation if WRD were able to promulgate rules to encourage water conservation and better institutionalize water rights trading in smaller watersheds, such as Johnson Creek, where there is little market demand for water rights. In addition, significant savings may be achieved by enforcing existing rules on the amount and timing of withdrawals and on points of diversion and by taking away expired rights. However, there is a lack of state resources dedicated to enforcing existing rules.

C-4: Gradient

Johnson Creek is a low-gradient stream that drops approximately 700 feet over its 25-mile course. The steeper upper section begins in the headwaters and extends down about 5.5 miles to Regner Road in Gresham. The middle section is extremely flat. Beginning at about SE 82nd Avenue, Johnson Creek begins to cut its way down to the Willamette River, with a correspondingly higher gradient than the middle section. Stream gradient affects flooding potential, with the lowest-gradient areas such as Lents experiencing flooding most frequently.

C-5: Flooding

Johnson Creek reaches the top of its bank about three times each year. Flood stage is reached about twice each year. Major floods occur about once every three to four years. Most flooding takes place in the middle section of the creek because of the low gradient, and floodwaters tend to spread out when the channelized system is overtopped.

Flooding primarily affects four areas within the Portland are of the watershed:

- Tideman-Johnson Park at SE 45th
- The area west of SE 82nd
- The Lents area

- Lower Powell Butte around SE 145th

Lents is by far the largest area affected, flooding approximately 10 to 20 acres on average once every other year. Portland has designated Lents as a flood risk area, with stricter development codes than other parts of the City. Since 1941, 37 out-of-bank flood events have occurred, 28 of which have resulted in property damage. Twenty-one of these events were considered "nuisance events" (a 10-year flood or less). Frequently flooded areas in Lents include:

- Along Johnson Creek from SE 117th to 101st Avenues
- Foster Road between SE 111th and 101st Avenues
- Springwater Trail from Zenger Farm to Foster Road
- Beggar's Tick Marsh associated marshlands

While most of Johnson Creek and its tributaries are fed primarily by precipitation and surface water, some areas are influenced primarily by groundwater processes which are not well understood. Crystal Springs, the largest springs in the Portland basin, has a total discharge of more than 5,000 gallons per minute. Crystal Springs Creek flooded during the summer of 1997 because of high groundwater levels. It was the first recorded flooding and was attributed to three consecutive record-precipitation years. Holgate Lake, formed by a high water table, is located on private property near the intersection of SE Holgate Boulevard and 136th Avenue. Elevated water levels in that area have caused flooding in the surrounding area.

C-6: Flow

General hydrologic patterns in Johnson Creek are driven by rainfall and groundwater inflow. High flows normally occur in December, January, and February in response to abundant rainfall and high runoff as soils become saturated.

Various land uses, flow from piped streams, and stormwater runoff from impervious surfaces significantly affect flow patterns in the watershed. Data from a stream gage that measures flow in Johnson Creek indicate an increase in the "flashiness" of peak flows over the last 60 years; the amount of rainfall needed to produce a peak flow has decreased over time, and peak flows therefore occur more frequently. Together with channel confinement and floodplain disconnection (discussed above), this flashiness causes increased stream velocities and the associated impacts.

The gage data indicate that increased flashiness is most likely related to the creek channelization and increased development. However, the range of variables (including soil type, slope, other geological factors, and watershed characteristics and conditions) make it difficult to understand and identify the cause-and-effect relationship clearly. Peak flows also appear to be affected by the alterations in the stream channel and floodplain, which change the way floodwater flows through Johnson Creek.

C-7: Base Flows

Low base flows (minimum streamflows) in the summer contribute to reduced habitat and degraded conditions for aquatic species (e.g., higher stream temperatures, water quality problems, fish passage barriers). The Oregon Department of Fish and Wildlife (ODFW) has set minimum flow targets to protect salmonids in Johnson Creek. Flows in the middle and upper watershed frequently do not meet those minimum flows, particularly in spring and summer months. Some of the tributaries dry up during the summer periods, and the velocity and volume of base flows in the mainstem of Johnson Creek decrease. Low summer base flows may be caused by water impoundments, withdrawals for irrigation, and lack of groundwater recharge.

Minimum instream flow targets are typically met below Crystal Springs, which provides consistent and abundant groundwater flows.

Freshwater springs are major contributors to the Crystal Springs Creek and Errol Creek tributaries. They also contribute significantly to base flows in lower Johnson Creek near Tideman Johnson Park and Minthorn Spring.

Increased base flows throughout the watershed would be required to help restore normal hydrology and attain properly functioning conditions.

C-8: Hydrology Summary

Table 4-3 compares current conditions for flow and hydrology in Johnson Creek with properly functioning watershed conditions.

Table 4-3
Comparison of Hydrology with Properly Functioning Conditions

Attribute	Compared to Properly Functioning Conditions
Hydrograph (frequency, magnitude, and duration of flow)	Not properly functioning
Impervious surfaces	At risk (see note)
Hydrologic sources (springs, seeps, groundwater, wetlands, floodplains)	Not properly functioning
Floodplain presence and connectivity	Not properly functioning
Note: Impervious surfaces are rated as “At Risk: and not “Not Properly Functioning” because much of the stormwater drains to sumps or the combined sewer system and not to Johnson Creek directly. ***Properly functioning*** *means the sustained presence of natural habitat-forming processes that are necessary for the long-term survival of the species through the full range of environmental variation.* ***At risk*** *means that conditions are susceptible to degradation or are showing a trend towards degradation.* ***Not properly functioning*** *means that one or more conditions are degraded to the point that they threaten the continued existence of a species.*	

Section D: PHYSICAL HABITAT

The Johnson Creek Watershed contains a mosaic of vegetation types, including agricultural lands, urban and suburban landscapes, upland forests, riparian woodlands, and wetlands. Because of extensive logging and clearing, remnants of predevelopment vegetation are rare. About 57 percent of the watershed is currently vegetated (including grass, trees, blackberries, and all other types of vegetation). The following discussion summarizes the four general habitats (upland, wetland, riparian, and instream) within the watershed.

D-1: Upland Habitat

The forest that historically covered the Johnson Creek watershed was mostly cleared in the early 1900s for agriculture, timber production, and urban uses. Forest clearing of second growth has dramatically increased in recent years as housing development has expanded from areas of low elevation up to the ridges and hillside slopes.

The Boring Lava Domes area is more heavily forested than most of the rest of the watershed. The forest generally ranges from 40- to 100-year-old second growth stands. Some other areas in the watershed, however, contain much older forest stands, with tree diameters reaching five feet or more.

D-2: Wetlands

Wetlands are areas that are inundated or saturated by surface or groundwater and support vegetation adapted for life in saturated soil conditions. Over time, development and associated changes to the landscape significantly impacted wetlands within the Johnson Creek Watershed. No accurate estimate exists of the total historic acreage of wetlands in the watershed, but there has been a substantial reduction in acreage since European settlement. The remaining wetlands are extremely diverse in nature and include forested, scrub-shrub, emergent, wet meadows, and open water (aquatic) vegetation types. They range in size from the 19-acre Beggars Tick marsh in the Lents area to numerous diminutive emergent wetlands of less than one-tenth acre. Human-made wetlands include shallow drainage channels and excavated ponds of various sizes. Spring-fed wetlands are commonly associated with the numerous terraces found throughout the watershed, but particularly along Crystal Springs Creek.

Several of the larger wetlands contain intact native vegetation and have moderately mature vegetative communities. However, non-native and invasive plant species now dominate most or all of many of the wetlands.

Two major groups of wetlands exist within the watershed. The first group comprises wetlands associated directly with the hydrology of Johnson Creek and its tributaries. These wetlands tend to be located within the 100-year floodplain and are often very close to the creek or tributary channels. They are often cut-off meanders from the creek, terraced wetlands, or lowlands that receive overland flows from the creek and are fed by shallow subsurface flows or groundwater.

The second major group of wetlands comprises small hydrologic systems located outside the 100-year floodplain. These wetlands are found in Errol Heights, the Beggars Tick marsh area in Lents, and the Saddle area in Pleasant Valley. These systems function more or less independently of Johnson Creek. They contain springs and seeps and tend to have high-quality aquatic ecosystems. These wetlands are connected to Johnson Creek through groundwater or small surface creeks.

Many wetlands in the watershed have good connectivity with undeveloped open space, upland habitats, and the Johnson Creek riparian corridor. Several significant areas of wildlife breeding and nesting are found in wetlands, with dense breeding populations of amphibians, including red-legged frogs.

D-3: Riparian Areas

Riparian habitats are water-dependent ecosystems characterized by rich and diverse groups of plant and animal species. They are the transitional ecosystem between terrestrial and aquatic ecosystems. They provide important habitat for water-dependent species and function as travel corridors along the watercourse for various wildlife species. The loss of riparian habitat decreases shading and elevates water temperature, reduces filtration of pollutants and sediments from runoff, and reduces wildlife habitat.

Channelization and development have greatly reduced riparian vegetation throughout most of the Johnson Creek Watershed. In most of the watershed, riparian vegetation is either narrow, minimal, or lacking. Thirty-four percent of the watershed has little or no riparian vegetation present, and an additional 32 percent has riparian vegetation less than 100 feet wide. The riparian corridors are also highly fragmented by frequent road crossings.

The most extensive vegetated riparian areas are in smaller headwater creeks in the Boring Hills south of Powell Butte on either side of the Gresham/Portland urban growth boundary. The largest amount of intact riparian vegetation throughout the watershed is in the City of Gresham. On the mainstem, the largest forested riparian areas are from the end of Brookside to Deardorff Road; the end of Main City Park to Palmblad Road; Deardorff Road to SE 159th; and SE 159th to SE 190$^{th.}$ The tributaries with the most heavily forested riparian areas are Mitchell, Badger, Sunshine, and Deardorf/Wahoo Creeks.

Crystal Springs and the lower reaches of Johnson Creek (near the Milwaukie/Portland boundary) have the least extensive riparian vegetation. The headwater streams flowing through rural agricultural lands in the upper watershed have very little riparian vegetation.

Generally, existing riparian vegetation consists of areas dominated by Himalayan blackberry (an invasive non-native species) or young native plants, and lacks large mature trees. However, vegetation quality is improving as cities, other local agencies, and citizen groups increase efforts to remove invasive and non-native plants and replant native vegetation to create more canopy and habitat.

D-4: Instream Habitat

The channelization of Johnson Creek has had a significant impact on the quality of instream physical habitat. Because the historical floodplain is disconnected or minimally connected to the creek along much of its length, flood flows cannot spread out on the floodplain. Instead, they are directed and concentrated into the main channel, increasing scour and degrading instream habitat for fish and other aquatic organisms. In addition, disconnecting and filling the floodplain for development has eliminated off-channel habitat along the mainstem. With the exception of the Brookside constructed wetland, off-channel habitat along the mainstem is extremely rare.

Johnson Creek has extremely low volumes of instream wood for habitat, particularly large wood necessary for pool formation. This results from a lack of large, mature riparian trees; human removal of large wood from the creek for to provide for flood storage; and high winter flow velocities that remove large wood.

Hardened banks occur throughout the lower and middle mainstem of Johnson Creek. Overall, approximately 18 percent of the watershed's banks are artificially hardened. Crystal Springs Creek has the highest percentage (50 percent) of hardened banks. Hardened banks prevent the establishment of vegetation, simplify habitat, and prevent exchange with groundwater. Bank hardening, channel straightening, and channel maintenance (e.g., removal of large wood) have also greatly reduced shoreline complexity, resulting in low-quality, simplified aquatic habitat.

High levels of fine sediments exist throughout the watershed. These sediments cover gravels and cobbles required for fish spawning, limit food production, and can affect behavior and cause stress in aquatic species. In addition, the Johnson Creek mainstem and Kelley Creek and its tributaries have inadequate levels of riffle gravels (shallow water flowing over gravel).

Pools that provide refuge for numerous fish and aquatic species are relatively abundant and well-dispersed throughout the watershed. Pool quality, however (as measured by pool depth and the number of complex pools) is fair or poor throughout much of the watershed.

Glides (stream areas with uniform flow and no surface turbulence or sediment deposition) are generally uncommon in natural, healthy creeks, but are widespread throughout Johnson Creek. This likely results from the deficiency of instream wood, a key element in breaking glides into pools and riffles.

The reach of Johnson Creek from Butler Creek to Hogan Creek in Gresham has the highest-quality instream channel habitat structure, with good complexity, large wood, backwaters, deep pools, and shade cover. It is the most natural and least disturbed setting found on Johnson Creek.

Much of Crystal Springs Creek has been channelized, lacks healthy riparian buffers, and has degraded habitat. Crystal Springs has less in-stream structure than Johnson Creek.

Much of Kelley Creek's instream habitat is degraded. Most impacts result from agricultural practices and urban development that disturb and expose soils to erosion; stormwater runoff; and lack of high-quality riparian habitat. A few small sections of Kelley Creek do, however, have relatively high-quality habitat.

These degraded instream habitat conditions have a number of negative impacts:

- Salmon and trout have few off-channel refuge areas where they can hide during high winter flows.
- Few places exist for salmon and trout rearing and spawning.
- Inadequate habitat exists for macroinvertebrates (aquatic insects such as stone flies, mayflies, and dragonfly nymphs that are the main food source for salmon, trout, and other aquatic organisms).
- Ongoing erosion problems throughout the watershed compromise high-quality habitat. Soil that washes into the creek can cover fish habitat, especially spawning gravels, and can contribute to water quality problems from contaminants attached to the soil particles.

Actions that could help address degraded instream habitat include:

- Removing channelization where possible and introducing new wood, through both the addition of large wood and the maturation of healthy riparian areas. This would help reconnect the floodplain and allow for more channel meandering, creating off-channel habitat. It would also slow water flow by adding roughness, channel structure, and riffles and pools.
- Investigating upland sediment sources and controlling them through appropriate best management practices.
- Restoring riparian areas to help stabilize eroding banks and provide the numerous other benefits of healthy riparian areas.
- Protecting remaining high-quality areas from degradation; supporting planning efforts to protect natural resources where urban development is occurring.
- Restoring areas with the potential to provide significant habitat.

D-5: Culverts and Barriers

In 2000-01, an inventory was conducted to identify and assess culverts, other instream passage structures such as bridges, and potential obstructions such as dams, weirs, and exposed pipes. A total of 226 structures were identified throughout the watershed, with the following results:

- No culverts exist on the mainstem of Johnson Creek until high in the upper reaches of the watershed.
- Apart from culverts, additional fish passage barriers exist along Johnson Creek (e.g., a dam and an exposed sewer pipe in Tideman Johnson Park). Four instream structures within

Johnson Creek have recently been removed. Removal plans for other structures are being finalized.

- Culverts are present on nearly all of the tributaries to Johnson Creek.

- Crystal Springs Creek, an area used by local and migratory Willamette salmonids, has a series of partially impassable culverts along its length.

- Kelley Creek and its tributaries have a number of impassable culverts and dams. The City of Portland recently removed a partial passage barrier by installing a new culvert at SE 162nd and Foster Road, providing fish access to lower Kelley Creek.

- Some of the least-developed Johnson Creek tributaries along the southern side of the middle section have culverts at their confluences with the mainstem.

Additional evaluation is needed to determine watershed and City priorities for addressing culverts and other fish passage barriers.

D-6: Thermal Refuge Areas

Refuge areas for fish are local areas where fish can escape chronic or episodic events such as high-turbidity flow events, high winter flows, or high water temperatures. Thermal refuge areas (cool water) generally include groundwater springs, seeps, confluences of tributaries, and, in some stream systems, localized areas of intact healthy riparian shaded areas.

No extensive survey of thermal refuges has been conducted in Johnson Creek. However, two key tributaries—Crystal Springs Creek and Kelley Creek—with the potential for thermal refuge do not meet temperature standards during summer months. Water temperatures in both of these creeks should be low because of high groundwater inflows. However, surface water temperatures are elevated by the lack of shading from riparian vegetation and by impoundments.

D-7: Habitat Summary

Table 4-4 compares habitat conditions in Johnson Creek with properly functioning conditions.

Section E: WATER QUALITY

E-1: Oregon Water Quality Index

The State Department of Environmental Quality (DEQ) developed the Oregon Water Quality Index (OWQI) as a general indication of water quality, based on several water quality parameters. DEQ has been monitoring Johnson Creek since 1990, and rates the creek's overall water quality as poor. The monitoring shows very high concentrations of nitrate nitrogen and high concentrations of total phosphates, fecal coliform bacteria, total solids, and biochemical oxygen demand. These conditions occur throughout the year.

E-2: 303(d) List and Total Daily Maximum Loads

DEQ placed Johnson Creek on the state's 303(d) list in 1998, with additional listings in 2002. The 303(d) list identifies water bodies that are "water quality limited" because they do not meet water quality standards for certain parameters. Johnson Creek does not meet standards for:

- Bacteria
- Summer temperature
- Toxics (DDT and dieldrin)
- PCBs (polychlorinated biphenyls)
- PAHs (polycyclic aromatic hydrocarbons)

Table 4-4
Comparison of Habitat with Properly Functioning Conditions

Attribute	Compared to Properly Functioning Conditions
Floodplain quality	Not properly functioning
Riparian integrity	Not properly functioning
Channel substrate (bottom)	Not properly functioning
Off-channel habitat	Not properly functioning
Large wood	Not properly functioning
Shoreline complexity	Not properly functioning
Fish passage/access	Not properly functioning
Thermal refuge	Not properly functioning
Depth refuge (pools)	At risk
Harassment (human disturbance from boats, lights, noise, etc.)	At risk

Properly functioning *means the sustained presence of natural habitat-forming processes that are necessary for the long-term survival of the species through the full range of environmental variation.*
At risk *means that conditions are susceptible to degradation or are showing a trend towards degradation.*
Not properly functioning *means that one or more conditions are degraded to the point that they threaten the continued existence of a species.*

DEQ establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the "assimilative capacity," which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. The water quality standards are established to protect the most sensitive beneficial uses for Johnson Creek. DEQ is currently establishing TMDLs for bacteria, temperature, and toxics for Johnson Creek.

Bacteria

The purpose of the bacteria standard is to protect people from contact with and ingestion of pathogenic (harmful) bacteria, which can occur during recreational activities such as swimming and boating. Contact with these bacteria can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.

Current state standards for bacteria are measured in terms of *E. coli*. Johnson Creek does not meet the standards throughout the watershed, during both winter storm events and dry summer periods. Bacteria concentrations are highest during high flows, most likely resulting from stormwater outfalls that discharge surface runoff from areas with high concentrations of animal wastes and from areas with leaking septic tanks or cesspools.

Summer Temperature

Water temperature has a large impact on the types of organisms found in a water body. Cool water is a basic requirement for native salmon, trout, some amphibians, and other cold-water aquatic species. Growth, reproduction, and survival are adversely affected when the water temperature is too warm. Temperature also plays a role in dissolved oxygen (DO) concentration. DO is important for fish survival. The colder the water, the greater amount of oxygen that can be dissolved in it.

Numerous investigations of water temperature in Johnson Creek have consistently indicated that summertime water temperatures do not meet state standards throughout the watershed. The elevated temperatures, with some potential contribution from elevated nutrients, result in DO concentrations that frequently drop below guidelines in the summer. These conditions limit salmon and trout productivity throughout the watershed.

The elevated temperatures are caused by low summer base flows, lack of riparian shade, and the impoundment of water in irrigation ponds in the upper watershed. Although Crystal Springs Creek is fed by cool groundwater springs, it has warmer summer and winter temperatures than Johnson Creek and is a source of high summer water temperatures in lower Johnson Creek. This may be attributed to solar warming in ponds along Crystal Springs Creek at Reed College, the Rhododendron Gardens, Eastmoreland Golf Course, and Westmoreland Park.

Water temperatures in Johnson Creek are highest between river miles 5 and 6.5 (approximately SE 60^{th} Avenue upstream to I-205). This may be a result of the low gradient, slow flow, and lack of shade.

One year of data shows that downstream areas have more total days with maximum temperature above 68˚ Fahrenheit (F) than upstream areas. Kelley Creek had the fewest days above 68˚ F. Temperatures of 72˚ to 75˚ F are fatal to salmonids, and temperatures of 68˚ F indicate that the creek is approaching fatal conditions.

Actions that could help address elevated water temperatures include reestablishing riparian buffers to help shade the creek, decreasing impoundments, increasing stormwater infiltration, and further investigating the sources of warming, such as instream ponds.

Toxics (DDT and Dieldrin)

An investigation by the U.S. Geological Survey (USGS) found high instream concentrations of DDT in Johnson Creek. Monitoring by the USGS, DEQ, and the City of Gresham reveals that both DDT and dieldrin do not meet state standards for chronic toxicity in Johnson Creek. This indicates that toxicity levels in the creek may contribute to the declining productivity of aquatic species. Additional investigations of DDT are planned to determine whether concentrations have changed over time and to evaluate the nature and sources of DDT throughout the watershed.

PCBs and PAHs

Limited data show the presence of PCBs and PAHs in Johnson Creek. Further study is needed to identify the nature and extent of these contaminants.

E-3: Other Water Quality Parameters

Eutrophication and Dissolved Oxygen

Eutrophication is a natural process where nutrients (such as nitrogen and phosphorus) and organic substances enter an aquatic ecosystem and increase biological productivity. As the nutrients and organic materials enter the system, microorganisms use oxygen to break them down; the amount of oxygen needed for this process is called biochemical oxygen demand (BOD). As BOD increases, the amount of dissolved oxygen (DO) remaining in the water decreases. Low DO is one of the limiting factors for cold-water fish, including salmonids. Fish use oxygen when it is transported across the gills by diffusion; this process relies on the difference in concentration of DO in the water versus the fish.

A number of studies show high levels of phosphorus and nitrogen at various locations in Johnson Creek. Agricultural runoff containing fertilizers is probably a major source of nitrogen and phosphorus, although further source identification is needed. Nitrate levels increase downstream, particularly where there is low flow; this is likely caused by accumulated fertilizer runoff and soil erosion. Failing septic systems may also be a source of nitrogen. Nitrate levels are also high in Crystal Springs Creek, likely a result of leaching from septic tanks, the historic use of cesspools in the recharge area, and input from the duck pond in Westmoreland Park.

The elevated nutrient levels, along with elevated water temperatures (discussed previously) cause DO levels to decrease in some sections of Johnson Creek. City of Portland monitoring shows that DO values in the middle section range from 5.5 to 9.8 mg/L, with a mean value of 7.84 mg/L. A number of these values do not meet state DO standards. These conditions limit salmon and trout productivity.

Sediment/Turbidity

Turbidity can be defined as murky water created by stirred-up sediment or suspended soil particles. High levels of sediment/turbidity can cover spawning gravels, impair fish feeding and respiration, diminish food sources, and decrease DO levels. Turbidity also abrades fish gills and skin, which may lead to infection.

Relatively high turbidity levels have been measured during both high and low flow conditions in Johnson Creek. They may be the result of bank erosion, roadside ditch erosion, runoff from construction activities, and runoff from agricultural and nursery operations. Turbidity levels are high in both the upper and lower portions of the watershed, indicating that the majority of sedimentation begins in the upper watershed. These conditions limit salmonid productivity.

Actions that could help address turbidity include further investigating sediment sources, reestablishing riparian buffers, controlling erosion control and enforcing erosion requirements, and using other best management practices to provide natural biofiltration.

Metals

Metals can have adverse impacts on aquatic species. DEQ classifies Johnson Creek as a waterbody of concern because of elevated levels of copper, chromium, and nickel in water and sediments. Copper and zinc levels are higher when flows are high, most likely a result of stormwater runoff into the creek. Generally, metal concentrations increase downstream. When flows are high, Johnson Creek may also contribute chromium, copper, mercury, and zinc to the Willamette River. Transportation is likely the most significant source of metals. Additional metal contamination may come from industrial sources.

E-4: Water Quality Summary

Table 4-5 compares water quality conditions in Johnson Creek with properly functioning watershed conditions.

Table 4-5
Comparison of Water Quality with Properly Functioning Conditions

Attribute	Compared to Properly Functioning Conditions
Temperature	Not properly functioning
Eutrophication	At risk
Toxic materials	Not properly functioning
Sediment	At risk

Properly functioning *means the sustained presence of natural habitat-forming processes that are necessary for the long-term survival of the species through the full range of environmental variation.*
At risk *means that conditions are susceptible to degradation or are showing a trend towards degradation.*
Not properly functioning *means that one or more conditions are degraded to the point that they threaten the continued existence of a species.*

Section F: BIOLOGICAL COMMUNITIES

F-1: Fish

Fish communities in Johnson Creek include non-native species tolerant of warm water and disturbed conditions. Native species present in the creek are redside shiners, reticulate sculpin, large scale suckers, and speckled dace. Johnson Creek historically had large salmon populations. Numbers declined dramatically once urbanization began and particularly after the channelization work was completed. Adult salmonids have been observed in recent years, however, including coho salmon, chinook salmon, cutthroat trout, and steelhead. Steelhead and chinook are listed as threatened under the federal Endangered Species Act.

A 2001-03 inventory of fish communities in eight Portland streams observed 1,626 native salmonids in Johnson Creek, 904 in Kelley Creek, and 868 in Crystal Springs Creek. Of the eight streams surveyed, Johnson Creek had the greatest number of families, including salmonids, lamprey, cottids, cyprinids, and centrarchids. Johnson Creek had both cutthroat trout and rainbow trout/steelhead. Coho salmon were found in the Johnson Creek mainstem, but not any tributaries. Lampreys were most abundant in Kelley Creek.

An index of biotic integrity (IBI) was calculated during the 2001 inventory to rank the biological integrity of Johnson Creek. Eight reaches were sampled. Mean 2001-03 IBI scores indicate that one reach was marginally impaired, whereas seven reaches were severely impaired. The low IBI scores can probably be attributed to fish barriers and environmental disturbances.

These surveys show that Johnson Creek supports salmon and trout populations and other aquatic species, but will require significant restoration work to support larger populations.

F-2: Benthic Macroinvertebrates

Benthic (bottom-dwelling) macroinvertebrates are an important source of food for fish and other aquatic life. A 1999 study found that benthic communities in Johnson Creek are degraded compared to reference creeks. Sedimentation and a lack of available habitat and food may cause the lack of macroinvertebrates.

F-3: Wildlife

Overall, the diversity of wildlife species in the watershed has been significantly reduced. Large mammals were once common, such as black bear, bobcat, cougar, wolf, fox, elk, and coyote. Black-tailed deer and coyotes are likely the only large mammals that can still commonly be found in or near the remaining forested areas. Birds are the most abundant wildlife forms living in the urban and rural areas.

Sensitive species known to occur in the riparian areas of Johnson Creek include Columbia torrent salamander, northern red-legged frog, and Western toad. Painted turtles have been identified in the upper watershed. Pileated woodpeckers have been observed in the Boring Lava Domes forests.

Urban growth and development have greatly diminished the wildlife habitat value of the watershed. Several important limiting factors include lack of structural diversity; narrow and degraded riparian corridor; lack of downed or standing dead wood; limited connection or linkage between riparian and upland habitats; fragmentation; disturbance; and encroachment of non-native vegetation such as Himalayan blackberry.

F-4: Inter-Species Interactions

Non-native species compete for survival with native species throughout the watershed. Changes to the watershed system can also increase the competitive advantages of some species; for example, habitat alterations can provide hiding places for predators, and increased temperatures provide competitive advantages to more temperature-tolerant species.

F-5: Biological Communities Summary

Table 4-6 compares biological communities in Johnson Creek with properly functioning conditions.

Table 4-6
Comparison of Biological Communities with Properly Functioning Conditions

Attribute	Compared to Properly Functioning Conditions
Instream communities	At risk
Salmonids	Not properly functioning
Inter-species interactions	At risk

Properly functioning *means the sustained presence of natural habitat-forming processes that are necessary for the long-term survival of the species through the full range of environmental variation.*
At risk *means that conditions are susceptible to degradation or are showing a trend towards degradation.*
Not properly functioning *means that one or more conditions are degraded to the point that they threaten the continued existence of a species.*

CHAPTER 5

Tryon Creek Watershed

INTRODUCTION

This chapter begins with a summary of current conditions in the Tryon Creek Watershed. The summary describes the watershed's current assets and problems, and identifies opportunities to protect and restore watershed health.

The following sections then provide more detailed information to support the summary. Section A presents landscape factors (topography and soils), and Section B discusses human influences (land use, population, and infrastructure) that affect watershed health. Sections C through F describe existing conditions related to each of Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities.

The summary is written to stand alone for readers who do not wish to read the entire chapter. For that reason, some repetition occurs between the summary and the sections that follow it.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health.

SUMMARY OF TRYON CREEK WATERSHED

Setting

The Tryon Creek Watershed in southwest Portland covers an area of approximately 4,142 acres, or 6 square miles (Figure 5-1). About 21 percent of the watershed (857 acres) is outside the City of Portland's boundary and within the jurisdictions of Multnomah County, Clackamas County, and the City of Lake Oswego. The watershed is bounded by the Fanno Creek Watershed to the west and north, Stephens Creek to the north, the Willamette River drainage basin to the east, and Lake Oswego to the south.

The Tryon Creek Watershed is divided into three subwatersheds: Tryon Creek, Arnold Creek, and Falling Creek. Arnold Creek and Falling Creek are Tryon Creek's two main tributaries. Other smaller tributaries flow into Tryon Creek both within and outside Portland's city limits.

The mainstem of Tryon Creek is about seven miles long from its headwaters near Multnomah Village (just north of Interstate 5 and Highway 99) to its confluence with the Willamette River in Lake Oswego at the Highway 43 crossing. Tryon Creek flows in a northwesterly to southeasterly direction from its headwaters to its confluence with the Willamette River.

Current Conditions

Development has greatly altered the watershed's historic conditions. Extensive logging occurred between 1880 and 1920. Today, land use in the upper watershed (above SW Boones Ferry Road) is characterized by significant residential development. The changes that have occurred over the years have had negative effects on the watershed's hydrology, physical habitat, water quality, and biological communities, including salmonid fish species such as steelhead and trout. Watershed health in the upper watershed is much more impaired than in the lower watershed (below Boones Ferry Road), which contains the 455-acre Tryon Creek State Natural Area. The following conditions will have to be considered to determine the needs and best approaches for enhancing watershed health.

- The Tryon Creek Watershed is characterized by steep slopes and soils that are generally slow to infiltrate rainfall. In addition, impervious surfaces cover an average 26 percent of the watershed. These natural and development-related watershed characteristics cause relatively high stormwater volumes and velocities to flow into the stream channels during storm events, causing a fast rise in streamflow ("flashiness"). This has severe impacts on the stream system, including streambank instability and undercutting, landslides and erosion, instream sedimentation, loss of riparian vegetation, and channel incision (downcutting through erosion of streambed materials).

Figure 5-1
Tryon Creek Watershed

Measures to help reduce flashiness include reducing impervious surface area, controlling stormwater onsite as much as possible, and replanting native vegetation.

- Residential land use, impervious surfaces, and road crossings have severed the creek from its floodplain. This means that the creek cannot overflow into surrounding flat riparian areas to create habitat, deposit nutrients, and accommodate and attenuate high streamflows. This contributes to increased streamflows and velocities and the associated impacts. Floodplains can be restored by restricting development in remaining floodplain areas and near streams; acquiring and restoring properties in the floodplain; and improving channel structure to increase water overflow to the floodplain.

- Instream habitat conditions range from optimal (in only a few areas) to marginal. The highest-quality instream habitat is within Tryon Creek State Natural Area. Most of the marginal habitat is within the more heavily urbanized upper watershed. Stream complexity (defined by the presence of features such as wood, beaver dams, side channels, and riffles) and habitat quality have been greatly reduced by significant stream channel alteration and straightening, downcutting of the streambed by fast-moving water, lack of instream wood, lack of floodplain connectivity, underground piping of tributaries, and bank erosion. Impassable or partly passable culverts limit salmon access and affect watershed processes through much of the watershed. Preserving remaining good instream habitat and restoring areas by replacing culverts, daylighting streams, and providing instream structure would improve instream habitat.

- Riparian integrity is largely intact throughout much of the lower watershed. In the upper watershed, however, development has fragmented and altered riparian areas. The loss of riparian vegetation decreases shading and elevates stream temperature, reduces filtration of pollutants and sediments from runoff, and reduces wildlife habitat. In addition, removal of native riparian vegetation reduces the input of wood to the creek, which is important for aquatic species. Measures to address the loss of riparian habitat include preserving those areas that do remain and replanting other areas with native trees and shrubs.

- The Oregon Water Quality Index (OWQI) rates the overall water quality for Tryon Creek as poor. The degraded water quality has negative impacts on aquatic habitat and species. Water quality concerns include:

    - Stream temperatures do not meet state standard in the summer. The elevated temperatures are likely caused by very low streamflows during the summer months, warmer air temperature resulting from urban heat island effects, reduced riparian vegetation (and consequent lack of stream shading), and stormwater runoff from impervious surfaces exposed to sunlight.

    - Bacteria levels sometimes do not meet standards. Potential bacteria sources include both human sources (illegal sanitary connections and dumping to storm drains and failing septic systems) non-human sources (birds, dogs, cats, raccoons, and other animals).

- Tryon Creek experiences elevated levels of suspended sediments and nutrients (phosphorous and nitrogen), especially during storm events. Sediment smothers fish spawning beds and transports a variety of pollutants, such as oil, grease, metals and pesticides. Excess nutrients can contribute to low dissolved oxygen levels in the creek, which is harmful to fish. Sedimentation may result from vegetation removal, landslides, and erosion caused by increased stormwater runoff. Excess nutrients are probably associated with sediments and with runoff from landscaped residential areas.

- Stormwater carries pollutants from upland land uses, including residential areas and transportation corridors such as Interstate 5, Barbur Boulevard, and Terwilliger Boulevard.

Possible measures to address water quality problems include reducing pavement and other impervious surfaces to reduce stormwater runoff; tree planting and revegetation programs; erosion control; water quality swales; and working with citizens to identify new ways to reduce pollutants at the source.

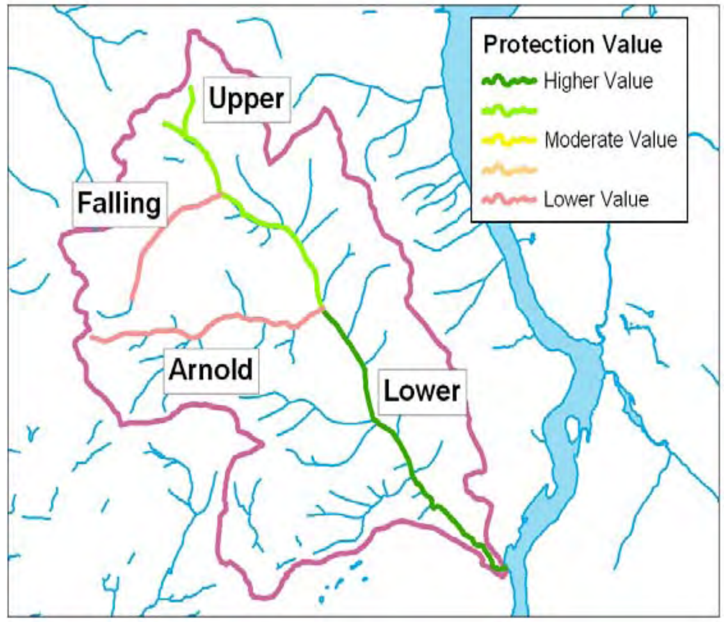
- The health of the watershed's biological communities has been greatly reduced from historical conditions. The watershed now supports only small populations of resident and anadromous coho salmon; chinook salmon at the mouth of the creek below the Marine Drive culvert; and steelhead and cutthroat above the culvert. Chinook and steelhead are listed as threatened under the federal Endangered Species Act. As discussed above, these populations are jeopardized by degraded habitat and water quality, and are highly vulnerable to existing and continued urban development and other disturbances. Addressing flow, habitat, and water quality issues will also address the needs of fish and wildlife.

- Many native wildlife species have disappeared or have been greatly reduced in number. Introduced or nuisance species compete with native species for food and habitat. Remaining natural areas provide habitat for many smaller, more adaptive mammal species, over 60 species of birds, and a number of amphibian and reptile species.

Protection Opportunities

Some areas in the watershed provide important habitat benefits, as summarized below and shown on Figure 5-2. Damage to these areas would create significant harm to watershed health; for this reason, they have a high protection value. Local actions can maintain and enhance most of the beneficial features of these areas.

Figure 5-2
Tryon Creek Watershed Protection Priorities



Lower Tryon Creek (below Boones Ferry Road)

Lower Tryon Creek (which includes Tryon Creek State Natural Area) provides important habitat for migrating and spawning salmon and other fish and wildlife. It retains more intact streamside vegetation and complex, winding river channel area than other parts of the creek. Important habitat features that benefit fish include riffle gravels (shallow water flowing over gravel), deep pools, beaver ponds, and access to intermittent and perennial tributaries.

Trees and shrubs in this area are at an age and size that will provide good sources of wood in the creek in the very near future. The existing tree and shrub canopy helps prevent stream temperatures from reaching lethal and unhealthy levels for fish and indirectly helps ensure enough dissolved oxygen in the creek to support fish and other aquatic species. Native fish that use this portion of Tryon Creek year-round include cutthroat and steelhead.

Upper Tryon Creek (above Boones Ferry Road)

Upper Tryon Creek contains areas important to watershed health, particularly Marshall Park, which is adjacent to the creek. Streamside conditions in the park are healthier than in many other parts of upper Tryon Creek. In addition, the reach of upper Tryon Creek just above Boones Ferry Road has intact streamside trees and other vegetation and relatively healthy streambank conditions.

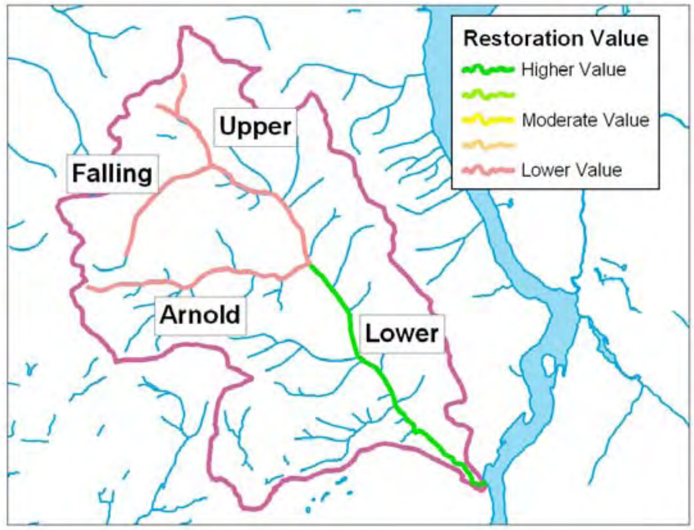
Arnold Creek

Arnold Creek's water quality provides benefits for both that creek and the Tryon Creek mainstem. The Arnold Creek drainage is entirely single-family residential; creeks that drain this land use generally have better water quality than creeks that drain commercial or transportation use lands.

Restoration Opportunities

In addition to the above protection areas, some currently degraded areas and attributes of the Tryon Creek Watershed could provide watershed benefits if restored, as summarized below and shown on Figure 5-3.

Figure 5-3
Tryon Creek Watershed Restoration Priorities



Hydrology

Increased peak flows following storm events have caused deep incisions and erosion in the Tryon Creek channel above Boones Ferry Road. The incisions often prevent the creek from accessing its historic floodplain, which contributes to increased flows and velocities within the creek. Reductions in the amount of pavement and other impervious surfaces in the watershed, if accompanied by tree planting and revegetation programs, would help reduce the volume and rate of stormwater entering the creek. Removing or improving culverts and other crossings that currently block fish passage and alter the volume and timing of instream flows would help restore the health of the watershed.

In addition to the year-round flowing creeks, numerous intermittent (seasonal) streams, seeps, and springs throughout the watershed provide important hydrologic and habitat functions. These streams are most recognizable during the winter season when water is present or flowing in them. Protection and restoration of intermittent streams, seeps, and springs throughout the watershed, particularly in the upland areas, is important to improve overall stream hydrologic and flow functions and to reduce or prevent localized flooding.

Habitat

Improving conditions at the Highway 43 culvert (the first culvert on the mainstem of Tryon Creek, near its mouth) and at the Boones Ferry Road culvert to allow fish access would provide critical habitat to native steelhead, coho, cutthroat, and perhaps chinook (in the lower reaches).

Arnold Creek has good instream habitat within its lower section, but fine sediments, bank erosion, and channel incision have degraded the creek's upper sections. Arnold Creek also is highly segmented by culverts from road and driveway crossings. Falling Creek has poor to marginal instream habitat, with a lack of instream cover, poor bank and streamside structure, and excessive fine sediments. Restoration actions could be designed to address these problems. Invasive non-native plant and animal species are evident throughout Arnold and Falling Creeks. These species compete with native species, resulting in diminished habitat quality. Removal of non-native plants and revegetation with native plants would help restore these areas.

Water Quality

Excessive sediment occurs throughout the watershed. Sediment is transported in stormwater from upland sources. It is also created by storm-driven peak flows that scour streambanks.

Sediment smothers fish spawning beds and is linked to a variety of toxic pollutants, such as oil, grease, metals, and pesticides. Addressing the sediment challenge will require a variety of stormwater and other upland management actions. Those actions would be most effective if aimed at reducing sediment-laden runoff and the excessive peak flows that scour streambanks. Tree planting and revegetation programs, water quality swales, and reductions in pavement and other impervious surfaces in the watershed are likely to be effective techniques for reducing sedimentation.

Planting trees and reducing impervious area would help address elevated summer water temperatures.

Biological Communities

Addressing the flow, habitat, and water quality issues discussed above would also address the needs of fish and wildlife in the Tryon Creek Watershed. Creating and investing in strategies to address invasive plant species is a high-priority restoration action. Additional research on insects and benthic (bottom-dwelling) organisms would help frame additional management priorities.

Stormwater Management

The heavily urban sections of the upper Tryon Creek Watershed and the Interstate 5, Barbur Boulevard, and Terwilliger Boulevard transportation corridors are likely the largest potential sources of ongoing stormwater-related watershed health problems. Implementing source control and stormwater treatment actions, such as green streets, treatment swales, and stormwater detention, along these corridors would likely produce the greatest watershed health benefits.

Section A: LANDSCAPE FACTORS

A-1: Topography

The elevation in the Tryon Creek Watershed varies from near mean sea level (msl) to 970 feet above msl. The lowest point in the watershed, about 10 feet above msl, is the confluence of Tryon Creek with the Willamette River; the highest point is at the top of Mt. Sylvania. In addition to Mt. Sylvania, Portland's West Hills are a prominent topographic feature in the watershed.

Approximately 60 to 75 percent of the slopes within the watershed exceed a 30 percent grade. Some slopes exceed a 50 percent grade. Steep slopes increase stormwater runoff rates, which can increase erosion and sediment in stormwater, scour streambanks, and deposit sediments in downstream channels. The *Southwest Hills Resource Protection Plan* classifies slopes in excess of 30 percent grade as generally having severe landslide potential.

A-2: Soils

Most of the soils in the watershed are classified as Type C (sandy clay loam). Soils with this classification have a slow infiltration rate. Isolated pockets of Type D (clay loam) soils, which are even slower to drain, also exist. Low soil permeability affects the watershed's hydrology because it limits water absorption and interflow. This increases stormwater runoff peak flows and decreases base flows in the stream system. The low permeability also limits the function of onsite stormwater and septic systems.

Soils in the watershed typically have a dense subsurface layer. This layer contributes to slope instability and erosion by limiting the rooting depth of plants to 30 to 48 inches and by serving as a failure plane (a hard surface that stays undisturbed after softer materials above it move because of erosion or landslides).

Soils in the upper watershed are classified as Urban Land, reflecting the urban nature and amount of impervious surfaces in that area.

Section B: HUMAN INFLUENCES

B-1: Land Use

Single-family residential development is currently the major land use in the watershed (55 percent) and is likely to remain so in the future (Table 5-1). Commercial land use comprises a small portion of the watershed (3 percent) and is generally located along major transportation corridors, such as SW Barbur Boulevard and Interstate 5.

Parks and open space total 592 acres, about 14 percent of the watershed, and predominate in the lower portions of the watershed. Major parks include Tryon Creek State Natural Area (455 acres, mostly within Portland) and Marshall Park (24 acres). Tryon Creek State Natural Area provides recreation opportunities with hiking, biking, and horse trails. City parks and open areas and public schools also provide passive and active recreation.

Impervious surfaces cover an average of 26 percent of the watershed. The amount of impervious cover varies among the subwatersheds, and is concentrated along major transportation corridors. Based on Metro's 2040 plan, future mapped impervious area is expected to increase by only two percent. In small tributary areas of the watershed, increased development associated with zoning changes would have a noticeable impact on the tributaries, where the relative increase in stormwater peak flows would be the greatest.

Table 5-1
Land Use Zoning Distribution within the Tryon Creek Watershed

Land Use Category	Current (1998)		Future (2015)	
	Area (acres)	Percentage	Area (acres)	Percentage
Commercial	127	3%	89	2%
Multi-family Residential	185	5%	208	5%
Parks/Open Space	592	14%	593	14%
Single-family Residential	2,289	55%	2,303	56%
Outside City Boundary	857	21%	857	21%
Insufficient Data	92	2%	92	2%
Total	**4,142**		**4,142**	

B-2: Population

The population (2002) of the Tryon Creek Watershed within Portland's city limits is 18,168. The population density for most of the watershed is six to 12 people per acre.

B-3: Sanitary and Stormwater Infrastructure

Sanitary System

The Tryon Creek Watershed is served by a separated sanitary sewer system. Three primary sewer pipelines convey flows to the Tryon Creek Wastewater Treatment Plant. Private septic systems serve about 90 structures in the watershed.

Stormwater System

The Tryon Creek stormwater system consists of storm drainpipes, 45 miles of open drainageways, and 11 detention basins. There are 18 culverts on Tryon Creek and its tributaries. This system conveys stormwater to the Willamette River.

B-4: Transportation Infrastructure

The major transportation corridors in the Tryon Creek Watershed are Interstate 5, SW Barbur Boulevard, Boones Ferry Road, Taylors Ferry Road, and Terwilliger Boulevard. Surface streets are distributed throughout the upper and southwestern portions of the watershed.

Sections C, D, E, and F describe the current conditions of the Tryon Creek Watershed related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvements in these conditions will indicate improvements in watershed health.

Section C: HYDROLOGY

Tryon Creek is a perennial stream, located in Portland's West Hills. The stream system has several culverts at road crossings and steep slopes. The are an estimated 45 stream miles in the watershed.

The Tryon Creek Watershed is characterized by steep slopes, significant impervious area, and soils that are slow to infiltrate rainfall. These characteristics make the creek "flashy," which means it responds very rapidly to rainstorms. The increased runoff from impervious surfaces in the upper watershed results in higher velocities in stream channels and a fast rise in streamflow during storm events. This weakens bank stability, resulting in streambank erosion and loss of riparian vegetation. Severe local damage has occurred, including undercutting of streambanks, landslides, and exposed sewer pipes.

Streambank erosion potential along Tryon Creek ranges from moderate to high or very high. Monitoring has shown that more than 70 percent of the bank area is potentially a chronic source of sediment. The moderate and high bank erosion potential is most influenced by very steep banks (greater than 80 degrees) caused by stream incision (deepening of the streambed through erosion) and by marginal surface protection of channel banks.

An analysis of stormwater pipe capacity found that many pipes throughout the watershed are currently undersized to handle some storm events. As the watershed develops further, the ability of stormwater pipes and culverts to handle storm events designated as the City's basic level of service (conveyance of the 10-year storm) will be affected.

The major flood event of February 1996 caused severe landslide, streambank, and streambed damage in Tryon Creek and its tributaries, but did not cause any significant flooding or property damage in the watershed. The effects of flooding in the watershed will likely remain similar in the future, causing damage to the stream system but no significant flooding of properties. Property damage resulting from excessive rainfall could occur in the form of landslides on steep and unstable slopes and along stream channels.

Section D: PHYSICAL HABITAT

D-1: Vegetation

Where vegetation has not been altered by human activities, the Tryon Creek Watershed is mostly wooded. Nearly 37 percent of the watershed is a mix of forested areas, with closed canopy forest (33 percent) dominating the landscape.

Many forested areas in the watershed, including Tryon Creek State Natural Area, are adversely affected by non-native invasive plants such as English ivy, Himalayan blackberry, holly, garlic mustard, and western clematis. These species compete with native species, resulting in diminished habitat quality.

D-2: Floodplain Area

Floodplain interaction is the process where streams overflow into surrounding flat riparian areas; this creates habitat, deposits nutrients, and accommodates high streamflows. The inability of a creek to access its historic floodplain contributes to increased streamflows and velocities and associated impacts.

Steep slopes and stream gradients limit floodplain interaction throughout much of the watershed. Stream reaches with the lowest gradients and largest (and most integral) floodplains are located in Tryon Creek State Natural Area and are protected from near-stream urban development.

D-3: Wetlands

No wetlands have been delineated in the Tryon Creek Watershed. In general, the steep gradient of Tryon Creek and its tributaries and the steep/hilly terrain of the watershed do not allow for the formation of well-functioning wetlands. Most of the “wetland” type areas are in stream corridor areas, mainly within Tryon Creek State Natural Area.

D-4: Riparian Corridor

Riparian vegetation is important for a stream system because it helps provide bank stability, nutrients, and large wood. It also provides shade and reduces stream exposure to sunlight, keeping water temperatures cool. Degraded riparian conditions contribute to increased streamflow and channel incision, streambank instability, erosion and sedimentation, and high water temperatures.

Riparian integrity is largely intact throughout much of the lower portion of the watershed, with the exception of the Willamette River and Tryon Creek confluence. Riparian widths are greater than 250 feet. Well-established, second-growth forest dominates the landscape and is of sufficient age to provide long-term sources of wood. With the exception of key culverts and road crossings, the riparian corridor is continuous and not fragmented. Upper Tryon Creek has marginal riparian condition because residential development is a dominant landscape feature along the streambank.

D-5: Instream Habitat

Instream habitat conditions range from optimal (in only a few areas) to marginal. The highest-quality instream habitat is within Tryon Creek State Natural Area in the lower watershed. Most of the marginal habitat is within the more heavily urbanized upper watershed. Stream complexity (defined by the presence of features such as wood, beaver dams, side channels, and riffles) and habitat quality have been greatly reduced by significant straightening of stream channels, downcutting of the streambed by fast-moving water, lack of wood, lack of floodplain connectivity, underground piping of tributaries, and bank erosion. Sedimentation throughout the watershed is an ongoing problem. In addition, some culverts are impassable by fish.

Culverts and Fish Passage

Culverts, which convey streams under roads and other urban development, have disconnected streams throughout the watershed. Many of these culverts are wholly or partly impassable for fish, confining resident fish populations to certain stream reaches and barring anadromous fish from many portions of the watershed.

As residential development encroaches on the stream corridor in the upper portions of Tryon Creek, stream connectivity is becoming more compromised by new street crossings and culverts.

Pools

Pools provide salmon rearing habitat and refuge, especially during high flows. In general, pool area and pool depth in the watershed are considered marginal to desirable. Pool area is best in the lower and middle reaches.

Refuge

Stream refuges provide food, temperature stability, and protection for salmonids. Tryon Creek is naturally confined, and side channels were probably never a significant landscape feature. Currently, off-channel refuges are primarily associated with tributaries. Landscaping practices, road crossings, and residential development have had significant negative impacts on near-stream habitat structure in the upper watershed, and have altered the volume and timing of flows downstream. As a result, there is a lack of instream structure (e.g., wood) in nearly all reaches of the watershed, and instream refuge is generally minimal throughout all of Tryon Creek.

Spawning and Rearing Habitat

Eroding banks contribute sand, silt, and organic matter into the stream channel. These sediments settle to the stream bottom and cover spawning habitat throughout the creek. For example, Tryon Creek State Natural Area has some of the best habitat in the watershed, but much of the riffle gravels are covered with sediments.

Section E: WATER QUALITY

E-1: Oregon Water Quality Index

The Oregon Department of Environmental Quality (DEQ) developed the Oregon Water Quality Index (OWQI) as a general indication of water quality. The overall OWQI for Tryon Creek is poor. However, the score is higher than the scores of other local urban streams, such as Fanno Creek and its tributaries. The major reasons for the low overall score include elevated nutrients (total phosphorus, nitrate, and ammonia nitrogen), total solids, and bacteria.

E-2: 303(d) List and Total Maximum Daily Loads

DEQ maintains a state 303(d) list that identifies water bodies that are “water quality limited” because they do not meet water quality standards for certain parameters. DEQ then establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the “assimilative capacity,” which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. The water quality standards are established to protect the most sensitive of the water body’s beneficial uses.

Tryon Creek is on the 303(d) list for temperature. DEQ is expected to establish a TMDL for temperature in the Tryon Creek Watershed in 2004.

Temperature

Water temperature has a large impact on the types of organisms found in a water body. Cool water is a basic requirement for native salmon, trout, some amphibians, and other cold-water aquatic species. Growth, reproduction, and survival are adversely affected when the water temperature is too warm. Temperature also plays a role in dissolved oxygen concentration; the colder the water, the greater amount of oxygen that can be dissolved in it.

Tryon Creek is on the 303(d) list as water quality limited for temperature because it frequently does not meet the temperature standard for the protection of salmonid fish rearing and anadromous fish passage during the summer. In addition, Tryon Creek exceeds the temperature standard for the protection of salmonid spawning, incubation, and fry emergence during May and June.

High stream temperatures are likely caused by low streamflows, lack of riparian vegetation and stream shading, high air temperature that heats up stream temperature, and stormwater runoff from impervious surfaces exposed to sunlight.

E-3: Other State Water Quality Standards

Dissolved Oxygen

Dissolved oxygen (DO) is important for cold-water fish, including salmonids. Fish use oxygen when it is transported across the gill by diffusion; this process relies on the difference in concentration of DO in the water versus the fish.

Monitoring shows that Tryon Creek meets state DO standards except occasionally between May and June. The lower DO concentrations during this period appear to be the result of elevated instream temperatures.

Bacteria

The purpose of the bacteria standard is to protect people from contact with and ingestion of pathogenic bacteria, which can occur during recreational activities such as swimming and boating. Contact with these bacteria can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.

Current state standards for bacteria are measured in terms of *E. coli*. Tryon Creek sometimes does not meet standards, primarily during periods of precipitation and increased streamflows. Potential sources of *E. coli* bacteria in Tryon Creek include both human sources (illegal sanitary connections or dumping into storm drains and failing septic systems) and non-human sources (birds, dogs, cats, raccoons, and other animals).

Toxics

Very limited water quality data are available for toxics in Tryon Creek and its tributaries. Available data are limited to six metals sampled three times in 1999 and early 2000 at Boones Ferry Road. All samples met both acute and chronic water quality criteria, except for a single sample that did not meet the chronic criterion for copper.

Sediments and Nutrients

Other water quality concerns in Tryon Creek include sediments and nutrients, especially during storm events. Increased sedimentation may result from development and associated removal of vegetation, landslides onto roadways and into watercourses, and streambed and streambank erosion caused by increased stormwater runoff. Excess nutrients are probably associated with sediments and with runoff from landscaped residential areas.

Section F: BIOLOGICAL COMMUNITIES

F-1: Fish

As discussed in Section D-5, fish habitat is limited compared with historic conditions. The watershed now supports only small populations of coho salmon; chinook salmon at the mouth of the creek below the Highway 43 culvert; and steelhead and cutthroat above the culvert. Chinook and steelhead are listed as threatened, while coho salmon are listed as proposed, under the federal Endangered Species Act.

The following conditions were observed in 2002:

- Coho were present in the lower reach below Highway 43 of Tryon Creek, but were not observed in any other stream segment. Notably, they were observed during all three sample seasons (spring, summer, and fall), indicating they may use (and/or rear in) this stream reach year-round.

- Chinook were present in the lower reach of Tryon Creek and were observed in summer and fall, but not spring.

- Steelhead were present in the lower and middle portion of Tryon Creek, indicating that anadromous steelhead pass above the State Street culvert and/or a resident rainbow trout population persists throughout the Tryon Creek subwatershed. Steelhead were also observed in spring, summer and fall, indicating they may be present year-round.

- Cutthroat were observed in every reach of Tryon Creek and during every sampled season, indicating they are present year-round and persist throughout the Tryon Creek subwatershed.

- No salmonids have been observed in Arnold or Falling Creek.

F-2: Benthic Macroinvertebrates

Benthic macroinvertebrates (bottom-dwelling aquatic insects, such as stoneflies , mayflies, and dragonfly nymphs) are the base of the food chain and therefore support higher organisms. To date, information on benthic macroinvertebrates in Tryon Creek and its tributaries is limited to observations by fish biologists as part of their work to assess fish and fish habitat. These observations have consistently pointed to the absence of aquatic insects.

F-3: Wildlife

The Tryon Creek Watershed provides shelter to several wildlife species, most of them nocturnal. The green space of the West Hills and the forested refuge of Tryon Creek State Natural Area are the primary habitat areas for these species. The most common mammals are bats, beavers, black-tail deer, chipmunks, coyotes, flying squirrels, mice, moles, opossums, rabbits, raccoons, red foxes, shrews, skunks, and squirrels.

More than 60 species of birds reside within the watershed for at least a portion of the year. Birds are attracted to the variety of habitats found within the watershed’s evergreen forests, deciduous woods, stream corridors, fringes of open fields, and numerous backyard birdhouses.

The watershed also supports a number of amphibians and reptiles, including frogs, salamanders, snakes, toads, and turtles.

CHAPTER 6
Fanno Creek Watershed

INTRODUCTION

This chapter begins with a summary of current conditions in the Fanno Creek Watershed. The summary describes the watershed's current assets and problems, and identifies opportunities to protect and restore watershed health.

The following sections then provide more detailed information to support the summary. Section A presents landscape factors (topography and soils), and Section B discusses human influences (land use, population, and infrastructure) that affect watershed health. Sections C through F describe existing conditions related to each of Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities.

The summary is written to stand alone for readers who do not wish to read the entire chapter. For that reason, some repetition occurs between the summary and the sections that follow it.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health.

SUMMARY OF FANNO CREEK WATERSHED

Setting

Fanno Creek flows in a southwesterly direction to the Tualatin River, which then flows east to the Willamette River. The Fanno Creek Watershed covers an area of approximately 20,259 acres, or 32 square miles. Approximately 4,529 acres are within the City of Portland (Figure 6-1). The remaining watershed area is mainly within the jurisdiction of Washington County.

The Fanno Creek Watershed is divided into eight subwatersheds:

- Fanno Creek mainstem – includes Ivey and Columbia Creeks
- Pendleton Creek
- Vermont Creek
- Woods Creek
- North Ash Creek
- South Ash Creek
- Red Rock Creek
- Sylvan Creek

Current Conditions

Development has greatly altered the watershed's historic conditions. Today, over 80 percent of the watershed within the City of Portland is in single-family residential land use. The changes that have occurred over the years have had negative effects on the hydrology, physical habitat, water quality, and biological communities in the watershed. The following conditions will have to be considered to determine the needs and best approaches for enhancing watershed health.

The Fanno Creek Watershed is generally characterized by steep slopes, steep stream gradients, and soils that are slow to infiltrate rainfall. In addition, impervious surfaces cover about 33 percent of the watershed. These natural and development-related watershed characteristics cause relatively high stormwater volumes and velocities to flow into the stream channels during storm events, causing a fast rise in streamflow ("flashiness"). This has severe impacts on the stream system, including bank instability, downcutting of the channel bottom, erosion and sedimentation, and loss of riparian vegetation. In addition, stormwater carries pollutants from upland areas. These conditions degrade water quality and impair aquatic habitat. Possible measures to reduce stormwater impacts include reducing impervious surface area; controlling stormwater onsite as much as possible; maintaining existing riparian corridors and open spaces that detain and treat stormwater; and adding vegetation in existing developments.

Figure 6-1
Fanno Creek Watershed

- The mainstem Fanno Creek floodplain area has been disturbed, cleared of vegetation, filled, and topped with impervious surfaces. This has reduced historical floodplain interactions, preventing the creek from overflowing into surrounding flat riparian areas to create habitat, deposit nutrients, and accommodate and attenuate high streamflows. Loss and alteration of floodplain area can result in more frequent flooding, property damage, loss of habitat and off-channel refuges for fish, and loss of habitat for birds and animals. Floodplains also serve important water quality functions. Where possible, floodplains can be restored by reconnecting streams with upland areas, regrading streambanks, and installing instream structures that raise water levels so the water goes over the streambanks and floods the floodplain areas.

- Watershed development and streamside disturbance have reduced riparian vegetation along many sections of Fanno Creek and its tributaries. The loss of riparian areas decreases shading and elevates stream temperature, reduces filtration of pollutants and sediments from runoff, and reduces wildlife habitat. In addition, the loss of riparian vegetation reduces the input of wood to the creek, which is important for aquatic species. Some relatively wide, connected, and vegetated riparian corridors remain in portions of the upper Fanno Creek mainstem, Woods Creek, and Vermont Creek. Measures to address the loss of riparian habitat include preserving those areas that do remain and replanting other areas with native trees and shrubs.

- The Oregon Water Quality Index rates overall water quality from very poor (Vermont Creek, Cedar Mill Creek) to poor (Fanno Creek, Woods Creek). The degraded water quality has negative impacts on aquatic habitat and species. Water quality concerns include:

  - During a typical year, Fanno Creek does not meet the state standard for water temperature in the summer. Water temperature is influenced by the lack of riparian vegetation and consequent lack of shade the vegetation provides. High stream temperatures can also be caused by stormwater runoff coming from impervious surfaces exposed to sunlight.

  - High bacteria levels are likely caused by both human sources (sanitary sewer overflows, illegal sanitary connections and dumping to storm drains, and failing septic systems) and non-human sources (birds, dogs, cats, raccoons, and other animals).

  - Low dissolved oxygen (DO) levels occur, caused by a combination of increased water temperature and the decay of organic matter in the stream.

  - High levels of phosphorus are caused by natural phosphorus leaching into the creek from the ground, fertilizers carried in stormwater, and eroding upland soils that contain phosphorus. Possible measures to address water quality problems include constructing additional pollution reduction facilities, improving the operation and maintenance of sanitary and stormwater infrastructure, managing erosion and replacing vegetation on construction sites, reducing stormwater runoff, revegetating riparian areas, and working with citizens to identify new ways to reduce pollutants at the source.

- Invasive non-native vegetation, such as Himalayan blackberry and English ivy, has crowded out native plants in many areas. Continuing to remove non-native vegetation and replant with native vegetation can help address this problem.

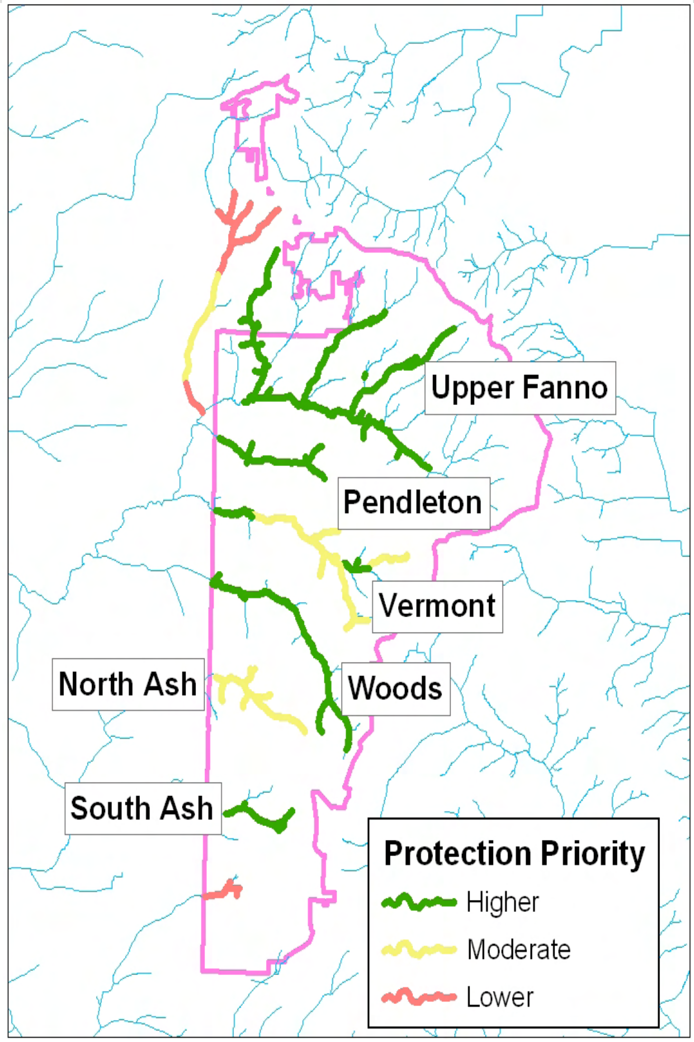
- Instream habitat quality in Fanno Creek, Vermont Creek, and Woods Creek is rated as extremely impaired or threatened, primarily because of the adverse effects of excessive fine sediment resulting from eroding streambanks throughout the watershed. Sediments are settling to the stream bottom and covering critical spawning and rearing habitat. There is a lack of large wood and/or rock to provide refuge, temperature stability, and protection for salmonids. The abundance of deep pools and lack of connecting riffle-type habitat (shallow water flowing over gravel) between the deep pools indicate a lack of habitat complexity that may severely limit the number of fish that can survive in Fanno Creek. Culverts, which convey streams under roads and other urban developments, are common throughout the watershed. Many of these culverts are impassible or semi-passable for fish, limiting salmon access and affecting flows and other stream processes throughout much of the watershed. Possible measures to address these impacts include stabilizing stream channels to reduce erosion and help prevent degradation of critical fish spawning habitat, improving instream structure to provide refuge and rearing habitat for fish, replacing or retrofitting culverts, and preserving and protecting remaining instream habitat critical for spawning and rearing.

- The health of Fanno Creek's biological communities has been greatly reduced from historical conditions. The wildlife species most commonly observed are those that can tolerate a wide variety of habitat and the disturbance usually associated with residential and commercial development. Many native species of fish and aquatic insects are at risk, and many introduced or nuisance species compete with native species for food and habitat. The abundance of salmonids has been greatly reduced from historical numbers. Small populations of coho salmon, steelhead, and cutthroat trout are present in Fanno Creek and its tributaries. As discussed above, however, their survival is jeopardized by fish passage barriers (culverts), lack of refuge areas, sedimentation of critical spawning and rearing habitat, and degraded water quality. Chinook and steelhead are listed as threatened under the federal Endangered Species Act.

Protection Opportunities

Upland areas in the Fanno Creek Watershed, including the tributaries that drain to Fanno Creek from the north, currently provide the most significant watershed health benefits and therefore have a high protection value, as summarized below and shown on Figure 6-2.

Figure 6-2
Fanno Creek Watershed Protection Priorities



Upper Fanno Creek

Development has affected stream connectivity the least (i.e., fewer culverts or pipes in the stream) in upper Fanno Creek from above the Beaverton SW Highway and Scholls Ferry Road interchange to the Shattuck Road road-crossing culvert. Columbia Creek and another small tributary near Shattuck Road enter Fanno Creek in this reach and likely provide critical off-channel habitat during high storm flows, and cool-water areas in the summer. This reach also contains the best spawning and rearing habitats (riffles with gravel and cobble, with relatively low amounts of fine sediment). In addition, these habitats likely sustain much of the benthic (bottom-dwelling) macroinvertebrate production in the upper creek. (Macroinvertebrates are aquatic insects such as stone flies, mayflies, and dragonfly nymphs that are food sources for many aquatic species, including salmonids.) Undercut banks and pools containing fallen trees provide the predominant forms of instream structure in this reach. Deep, complex pools (and a beaver pond) and undercut banks immediately upstream of this area (between SW Shattuck Road and SW 45th Avenue) provide critical habitat for fish during winter's intense rains.

North Ash Creek and Upper Woods Creek

North Ash Creek and about half of the upper part of Woods Creek provide riffle habitat with gravels, cobbles, and low amounts of fine sediment. The other half of Woods Creek's bed is smothered with fine sediments, but still contains important pool areas. Given the degraded nature of Fanno Creek, this area has high protection value despite the sediment problem.

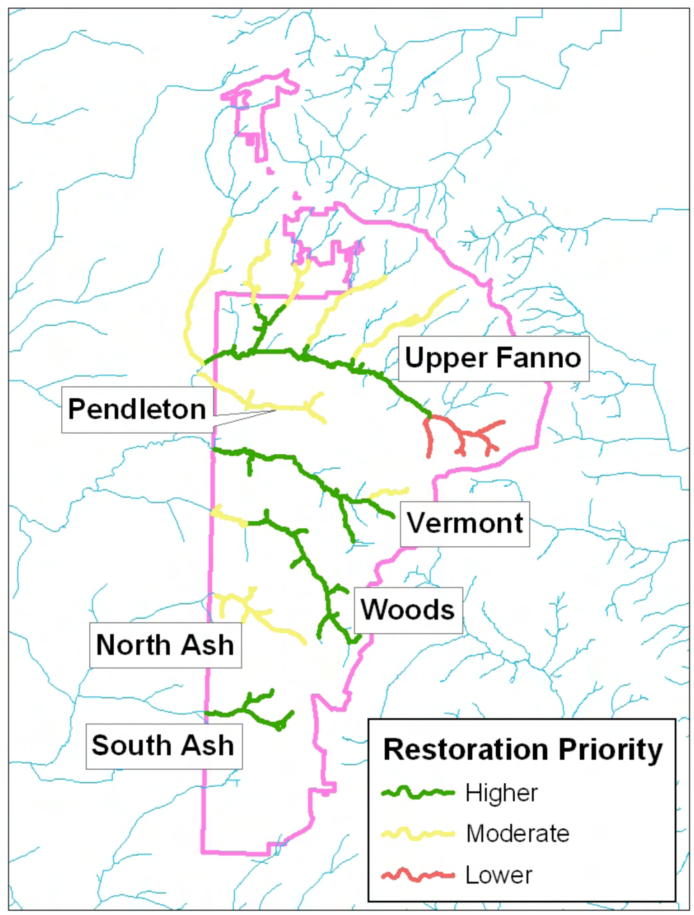
South Ash Creek

South Ash Creek provides important pool habitat. Although pool area is low in quantity, gravels and sands are moderately high in quality, and the amount of fine sediment is low. Additionally, the pools are deep, providing important areas for fish to hide. The pools contain downed trees and boulders that also provide important cover and shelter.

Restoration Opportunities

In addition to the above protection areas, some currently degraded areas and attributes of the Fanno Creek Watershed could provide watershed benefits if restored, as summarized below and shown on Figure 6-3.

Figure 6-3
Fanno Creek Watershed Restoration Priorities



Hydrology

In addition to the year-round flowing creeks, numerous intermittent (seasonal) streams, seeps, and springs throughout the watershed provide important hydrologic and habitat functions. These streams are most recognizable during the winter season when water is present or flowing in them. Protection and restoration of intermittent streams, seeps, and springs throughout the watershed, particularly in the upland areas, is important to improve overall stream hydrologic and flow functions and to reduce or prevent localized flooding.

Habitat

In the Upper Fanno mainstem and its northern tributaries, reclaiming stream connectivity at the SW Beaverton-Hillsdale Highway and Scholls Ferry Road intersection would provide additional habitat for anadromous salmon, as well as resident trout. Areas above these roadways contain spawning and rearing habitat; improved access to this habitat would significantly improve fish productivity. Adding boulders, large downed trees, overhanging vegetation, and channel complexity (side channels, backwater pools, deep pools, and undercut banks) in this section would improve channel roughness and help the creek withstand high scouring flows. In addition, increased channel complexity would provide refuge to fish during winter storm flows and cover from predators.

Repairing this section’s actively eroding streambank and enhancing habitat quality in the short term would prevent further streamside erosion and infusion of sediment into the creek.

Water Quality

Improving tree canopy and stormwater management would help address bacteria and high summer temperature problems. Repairing actively eroding banks and enhancing habitat quality would prevent further streamside erosion and infusion of sediments into the creek.

Biological Communities

Reclaiming high-quality riffle habitat is critical for improving fish productivity throughout mainstem Fanno Creek and its tributaries. Reclaiming stream connectivity in Vermont, Woods, Ash, and Sylvan Creeks would provide additional habitat to resident fish. These tributaries may provide additional spawning and rearing areas and off-channel habitat for fish living in mainstem Fanno Creek; improved access into these areas could therefore substantively improve fish productivity.

Stormwater Management

Maintaining existing riparian corridors, increasing canopy cover and diversity, and maintaining open spaces within the entire corridor and remnant floodplain are possible means to reduce or eliminate the stormwater-related problems in Fanno Creek and its tributaries.

Section A: LANDSCAPE FACTORS

A-1: Topography

The topography of Fanno Creek is highly variable, with elevations ranging from around 15 feet above mean sea level (msl) to 1,070 feet above msl above Council Crest in Portland's West Hills. Steep slopes are prevalent throughout the watershed. Steep slopes increase stormwater runoff rates, which can increase erosion and sediment in stormwater, scour streambanks, and deposit sediments in downstream channels.

A-2: Soils

Most of the soils in the watershed are classified as Type C (sandy clay loam). Soils with this classification have a slow infiltration rate, which can increase stormwater runoff. Isolated pockets of Type D (clay loam) soils, which are even slower to drain, also exist. The low permeability of the soils limits the function of onsite stormwater and septic systems. Low soil permeability also affects watershed hydrology because limited soil absorption and interflow result in higher runoff peaks and lower base flows.

Soil erodibility in the watershed is moderate or high relative to other soils of western Oregon. Phosphorus availability is high in contrast to other regional soils.

Soils in the developed parts of the watershed are classified as Urban Land, reflecting the urban nature and amount of impervious surfaces in those areas.

Section B: HUMAN INFLUENCES

B-1: Land Use

The predominant land use in the watershed is single-family residential, which comprises over 80 percent of the watershed's area (Table 6-1). Land zoned for commercial and multi-family residential land uses, comprising four percent and eight percent of the watershed respectively, is generally concentrated along or near major transportation routes, such as SW Beaverton-Hillsdale Highway and Capital Highway. Interstate 5 is another major transportation corridor in the watershed.

The upper reaches of the Fanno Creek mainstem are primarily steep and forested ravines in private ownership.

Parks and open space, totaling over 260 acres and comprising 6 percent of the watershed, are distributed throughout. Major parks include Gabriel Park and Woods Memorial Park. Other City parks include April Hill Park and Albert Kelley Park. Metro (the regional planning agency) also maintains some open spaces. Generally, environmental overlay zones protect park areas along streams.

Impervious surfaces cover about 33 percent of the watershed. However, impervious cover varies among the subwatersheds. For example, impervious surfaces cover only about 26 percent of the

Sylvan Creek and Pendleton Creek subwatersheds, but nearly 40 percent of the South Ash Creek subwatershed. Much of the impervious surface cover is concentrated along major transportation corridors, such as SW Beaverton-Hillsdale Highway and Interstate 5.

Table 6-1
Land Use Zoning Distribution within the Fanno Creek Watershed
(within Portland's City Limits)

Land Use Category	Current (1998)		Future (2015)	
	Area (acres)	*Percentage*	*Area (acres)*	*Percentage*
Commercial	173	4	114	3
Multi-family Residential	353	8	410	9
Parks/Open Space	261	6	262	6
Single-family Residential	3,741	82	3742	82
Insufficient Data	1	0	1	0
Total	**4,529**		**4,529**	

B-2: Population

The population of the Fanno Creek Watershed within Portland's city limits is about 28,000, based on the 2000 U.S. census.

B-3: Sanitary and Stormwater Infrastructure

Sanitary System

The sanitary sewer system within the watershed is 99 percent separated. Gravity sewer pipelines convey flows to the recently constructed Fanno Creek Pump Station. From there, flows are routed to either the Columbia Boulevard Wastewater Treatment Plant or Tryon Creek Wastewater Treatment Plant.

The Metzger sanitary sewer basin is located in the southwest corner of the watershed. Collectors convey flow west to Clean Water Services' Durham Wastewater Treatment Plant.

The sanitary system in the watershed is constructed almost entirely of concrete pipes with an average age of 50 years. The system has extremely high infiltration and inflow (I&I) rates, a condition where groundwater seeps into the sanitary pipes through loose joints and cracks. This can cause the sanitary pipes to reach capacity during storm events, resulting in localized flooding and/or sewer backups. The City of Portland has initiated a project to evaluate I&I conditions in the watershed and determine ways to address them.

Stormwater System

The stormwater system for the Fanno Creek mainstem includes storm drainpipes and approximately 200 culverts. In addition, approximately 27 miles of small open drainageways, mostly straight and confined within steep banks, are distributed throughout the watershed. Thirteen stormwater detention facilities and one sedimentation box are currently in operation.

In addition to the culverts along the Fanno Creek mainstem, there are 15 major stormwater culverts along Vermont Creek, 12 along Woods Creek, 13 along Pendleton Creek, and 13 along North Ash Creek.

B-4: Transportation Infrastructure

The major transportation corridors in the watershed are Interstate 5, SW Beaverton Hillsdale Highway, and SW Capital Highway.

Sections C, D, E, and F describe the current conditions of the Fanno Creek Watershed related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvements in these conditions will indicate improvements in watershed health.

Section C: HYDROLOGY

The Fanno Creek Watershed is characterized by fairly steep slopes and stream gradients, significant impervious area (resulting in the loss of many small creeks, seeps, and springs), and soils that are slow to infiltrate rainfall. These characteristics make the creek "flashy," which means it responds very rapidly to rainstorms. The increased runoff from impervious surfaces results in higher velocities in stream channels and a fast rise in streamflow during storm events. This weakens bank stability, resulting in erosion and loss of riparian vegetation. Channelization (straightening of the creek channel) of many reaches of Fanno Creek and its tributaries, such as the reach adjacent to SW Beaverton-Hillsdale Highway, places greater erosive force on areas immediately downstream. This causes a much higher velocity than would have occurred given the natural meandering pattern of the creek. Confinement of the creek in channels also causes downcutting of the streambed, resulting in deepened narrow channels and sediment loss from undercut banks.

A survey was conducted in 1998 to identify actively eroding streambanks and determine the components that contribute to erosion potential and affect streambank stability. Based on the survey results, three variables influence the stability of Fanno Creek: steep bank angles (greater than 60 percent), moderate to poor surface protection provided by vegetation, and moderate root density. Of 44 sampled sites, the survey found 25 sites with low bank erosion potential and 19 with moderate to high erosion potential. Three quarters of the 19 sites with moderate to high erosion potential were on the southern banks adjacent to SW Beaverton-Hillsdale Highway. A separate evaluation of channel condition found that a high proportion of streambanks (36 to 61 percent) are actively eroding, indicating bank instability and high potential for erosion during storm flows.

In areas of low to moderate stream gradient, the combination of erosive processes and lack of streambank vegetation results in excessive deposits of sediment in the stream channel. This in turn degrades water quality and impairs instream aquatic habitat.

All City culverts are designed to convey a 10-year storm event. Modeling to simulate stormwater runoff routes in the Fanno Creek Watershed has revealed that a number of culverts have capacity problems during 25-year storm events. This can lead to surcharging (water backing up behind a culvert). These culverts include:

- Four culverts in the Fanno Creek mainstem conveyance system, located in three areas toward the bottom of the watershed. Culverts toward the upper end of the watershed generally appear to have sufficient capacity.
- Three culverts on Columbia Creek, a tributary of Fanno Creek.
- Several culverts on other tributaries.

It is important to note that this does not necessarily mean these culverts compromise safety, floodplain regulations, environmental considerations, or property rights. This is because in many cases there is sufficient area to accommodate the short-term flooding.

A major flood event occurred in the Portland metropolitan area in February 1996. It caused severe landslide, streambank, and streambed damage to Fanno Creek and its tributaries, but did not cause any significant flooding or property damage in the watershed. The effects of flooding in the watershed will likely remain the same in the future.

Section D: PHYSICAL HABITAT

D-1: Vegetation

Overall, the Fanno Creek Watershed contains numerous introduced ornamental trees, shrubs, and groundcovers. Some of these, such as Himalayan blackberry and English ivy, are invasive non-native species that have crowded out native plants in many areas. Most of the introduced vegetation species do not provide good habitat and food sources for birds and wildlife. Invasive species also do not provide good groundcover, which is essential for erosion control and protection of soils, slopes, and stream corridors.

In the remaining forested areas in the watershed, vegetation is a mix of native and non-native species.

D-2: Wetlands

The only unique habitat type or feature in the Fanno Creek Watershed is wetland habitat, observed in Fanno Creek (three areas), Vermont Creek (three areas), Woods Creek (eight areas), and along the lower Columbia Creek tributary. Generally, scrub-shrub and wetland forests are thought to provide breeding and/or foraging habitat for over 200 wildlife species. Herbaceous wetlands are believed to provide breeding habitat for approximately 70 species and foraging for 178 wildlife species. Many of these species live in the Fanno Creek Watershed. Wetlands also provide important water detention and filtering functions.

D-3: Floodplain Area

The Fanno Creek mainstem floodplain area has been disturbed, cleared of vegetation, filled, and covered with impervious surfaces. This has reduced floodplain interaction, the process by which streams overflow into surrounding flat riparian areas to create habitat, deposit nutrients, and accommodate high streamflows. The Fanno Creek mainstem is more confined than its key tributaries, particularly Ash Creek and Woods Creek. Within the mainstem, stream reaches from Patton Creek upstream to Kelly Creek at SW 39th Drive are believed to provide the greatest existing floodplain functions.

D-4: Riparian Corridor

Urban development throughout the watershed has converted riparian areas of mixed conifer and deciduous trees to landscapes dominated by second-growth deciduous trees, shrubs, and grasses. Parking lots, streets, lawns, homes, and commercial buildings are prominent land features. The loss of mature forests and the conversion of forest floor to impervious surfaces have changed Fanno Creek's hydrology. Greater surface runoff and degraded riparian and streambank vegetation have resulted in increased (and flashy) streamflow and channel incision. Streambanks are steep, unstable, and actively eroding. Under these conditions, the cycle of erosion severely hinders the establishment of vegetation.

Along mainstem Fanno Creek, riparian condition is best in upper reaches where canopy cover is highest and continuous and larger trees are present. Nearly all tributaries provide more tree canopy cover, a wider riparian corridor, and more representative native species composition than anywhere along upper mainstem Fanno Creek. Woods Creek (middle and upper) has the best riparian condition.

When riparian cover is present, it provides shade and reduces stream exposure to sunlight. Lack of shading is a major cause of high stream temperatures (see Section E-2 below). A 2001 habitat survey measured percent of stream shading in the Fanno Creek Watershed, as summarized in Table 6-2. Percentages indicate the portion of each creek with shade cover exceeding 90 percent. For example, 67 percent of Fanno Creek mainstem is at least 90 percent covered by shade. Shade of 90 percent and above is an important measure of stream channel protection from direct sunlight and of potential instream water temperature; the more shaded the creek, the cooler the instream water.

Table 6-2: Stream Shading—Fanno Creek Watershed

Creek Name	Portion of Creek Exceeding 90% Shade
Fanno Creek Mainstem	67
Woods	56
Vermont	47
North Ash	57
South Ash	37

D-5: Instream Habitat

Instream habitat quality in Fanno Creek, Vermont Creek, and Woods Creek is rated as extremely impaired or threatened, primarily because of the adverse effects of excessive fine sediment. The eroding streambanks throughout the watershed are adding significant amounts of sand, silt, and organic matter into the water channel. Channel complexity and habitat quality have also been greatly reduced by significant channelization, downcutting, lack of wood, lack of floodplain connectivity, and underground piping of tributaries, particularly in the upper watershed.

The abundance of deep pools and lack of connecting riffle-type habitat between the deep pools indicate a lack of habitat complexity that may severely limit the number of fish that can survive in Fanno Creek. Sediments settle to the stream bottom and cover critical spawning habitat, particularly in the slow-moving reach of Fanno Creek mainstem between SW Scholls Ferry Road and Shattuck Road, where riffles comprise 37 percent of the habitat and provide important spawning areas. The Fanno Creek mainstem between SW Shattuck Road and 45^{th} Avenue provides critical rearing habitat in the form of deep, complex pools and good riffle habitat.

Refuges

Stream refuges provide food, temperature stability, and protection for salmonids. The primary refuges in mainstem Fanno Creek are the tributary confluences, undercut banks, boulders, side channels, and small amounts of large wood. Stream refuge is relatively absent in most of upper Fanno Creek. Portions of Fanno Creek between SW Shattuck Road and 45th Avenue are believed to provide the best refuge areas.

Culverts and Fish Passage

Culverts are common throughout the watershed and can hinder or completely prevent fish passage, depending upon a number of factors, including culvert diameter, length, and flow rate.

Upper Fanno Creek is highly disconnected from lower and middle Fanno Creek (and the Tualatin River Basin) because of the Beaverton-Hillsdale Shopping Center. The creek here is piped for roughly 600 feet and is impassable for fish under most conditions. This culvert cuts off lower and middle Fanno Creek from upper Fanno Creek. Resident fish may be sequestered to the upper basin, and anadromous fish may not be able to access upper basin habitats. Additionally, culverts at SW Shattuck Road, SW 45^{th} Avenue, and SW 39^{th} Drive may impact resident fish passage. Generally, most resident fish probably have a limited home range (unless they opportunistically migrate downstream during high streamflows) because of the numerous roadway culverts.

D-6: Habitat Values

Field studies conducted in 1996 provided detailed information about the status of existing stream and riparian resources within the City's portion of the Fanno Creek mainstem, Vermont Creek, and Woods Creek subwatersheds. Based on the field data, the following habitat values were assigned:

- Fanno Creek mainstem: Riparian and wildlife habitat value is rated between low and moderate. Only one segment near SW Bertha Boulevard and 27th Avenue was rated as having high value.

- Vermont Creek: The quality of wildlife habitat varies from high to moderate in the upper portions of the creek to moderate to low in the lower portions.

- Woods Creek: Wildlife habitat in Woods Creek was the best of all the tributaries, with 78 percent classified as high quality.

Section E: WATER QUALITY

E-1: Oregon Water Quality Index

The Oregon Department of Environmental Quality (DEQ) developed the Oregon Water Quality Index (OWQI) as a general indicator of water quality. Overall water quality in the Fanno system ranges from very poor (Vermont Creek, Cedar Mill Creek) to poor (Fanno Creek, Woods Creek). High levels of bacteria, total phosphorus, and total solids are the major reason for the poor quality. a seasonal basis, the results show slightly lower OWQI values during the summer

E-2: 303(d) List and Total Maximum Daily Loads

The State Department of Environmental Quality (DEQ) maintains a state 303(d) list that identifies water bodies that are "water quality limited" because they do not meet water quality standards for certain parameters. DEQ then establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the "assimilative capacity," which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. The water quality standards are established to protect the most sensitive of the water body's beneficial uses.

In 2001, DEQ revised the TMDL for phosphorus and established new TMDLs for temperature, bacteria, and dissolved oxygen in the Tualatin River. These TMDLs apply to the mainstem and all tributaries of the Tualatin River, and therefore affect Fanno Creek and its tributaries.

Temperature

Water temperature has a large impact on the types of organisms found in a water body. Cool water is a basic requirement for native salmon, trout, some amphibians, and other cold-water aquatic species. Growth, reproduction, and survival are adversely affected when the water temperature is too warm. Temperature also plays a role in dissolved oxygen concentration; the colder the water, the greater amount of oxygen that can be dissolved in it.

During a typical year, Fanno Creek does not meet the state standard for water temperature during the summer months. Water temperatures increase gradually in a downstream direction in the mainstem upper Fanno Creek.

Stream temperature is influenced by the disturbance and removal of riparian vegetation, which reduces stream shading and exposes streams to higher levels of solar radiation. Another source of heat is stormwater runoff from impervious surfaces exposed to sunlight.

Bacteria

The purpose of the bacteria standard is to protect people from contact with and ingestion of pathogenic bacteria, which can occur during recreational activities. Contact with these bacteria can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.

Current state standards for bacteria area measured in terms of *E. coli*.

The bacteria TMDL is set for two categories: discharges from the municipal separate storm sewer system (called waste load allocations, or WLAs), and runoff and other discharges (called load allocations, or LAs). Monitoring results show frequent exceedances of the LAs for *E. coli* bacteria, with summertime bacteria levels significantly higher than winter levels. The monitored *E. coli* concentrations were well below the WLA.

Potential sources of *E. coli* bacteria in Fanno Creek include both human sources (sanitary sewer overflows, illegal sanitary connections and dumping to storm drains, and failing septic systems) and non-human sources (birds, dogs, cats, raccoons, and other animals).

Dissolved Oxygen

Dissolved oxygen (DO) is important for cold-water fish, including salmonids. Fish use oxygen when it is transported across the gill by diffusion; this process relies on the difference in concentration of DO in the water versus the fish.

Fanno Creek and several of its tributaries do not meet the DO standard, mostly from May to October. Low DO concentrations are caused by a combination of increased water temperature and the decay of organic matter in the stream. In addition, DO concentrations can be influenced by total suspended solids (TSS), which can indicate high organic nutrient loads. As the nutrients and organic materials enter the system, microorganisms use oxygen to break them down, which reduces the amount of DO remaining in the water.

Phosphorus

Phosphorus is a nutrient that promotes algal growth. The decomposition of excessive algae can lower DO levels, which can affect fish populations. Natural phosphorus leaches into Fanno

Creek from the ground and is also added to the environment by fertilizers. Additionally, phosphorus in area soils can reach streams in stormwater runoff, increasing TSS and phosphorus levels in the streams.

Monitoring results show that total phosphorus loadings from various measured land uses (open space, residential, multifamily, commercial, highways) range from one to almost three times the waste load allocation established in the TMDL for phosphorus. Analyses show there is a significantly decreasing trend for total phosphorus, which is important for achieving compliance with the TMDL.

Section F: BIOLOGICAL COMMUNITIES

F-1: Fish

Although large numbers of salmonids are not observed in Fanno Creek, individuals have been observed in the past five reproductive cycles during all or parts of their freshwater life stage. Fish surveys show that salmonids occupy upper Fanno Creek year-round.

- Steelhead (winter-run) are assumed to inhabit a significant portion of lower Fanno Creek (85 percent of the mainstem habitat). Steelhead are listed as a threatened species under the federal Endangered Species Act.

- Coho salmon are assumed to inhabit the greater portion of mainstem Fanno Creek below the Beaverton Hillsdale shopping center. Lower Columbia River coho salmon were listed on the state ESA in July 1999, and are a candidate for listing on the federal ESA.

- Cutthroat trout have been observed throughout mainstem Fanno Creek. They were observed in middle and upper Fanno Creek year-round. In upper Fanno Creek, abundance was highest in the winter and lowest in the fall.

- Unidentified trout (steelhead and/or cutthroat) were observed in Ash Creek during 2001 habitat surveys.

The City of Portland sampled fish populations in 1993 and found several native fish species including reticulate sculpin, redside shiner, and peamouth present in the upper reaches.

Section D-5 discusses instream habitat conditions that affect fish survival.

F-2: Benthic Macroinvertebrates

Benthic organisms are low in diversity and abundance in Fanno Creek because of a lack of suitable stream bottom (particularly cobble and gravel-size particles) and the preponderance of silt. This may significantly impair the system’s ability to support salmonids and other cold water species.

F-3: Wildlife

The wildlife species most commonly observed in the Fanno Creek Watershed are those that can tolerate a wide variety of habitats and the disturbance usually associated with residential and commercial development. Amphibians that may be present include the northwestern salamander, long-toed salamander, ensatina, Pacific chorus frog, and others. Garter snakes are common. At least 100 bird species are thought to use the watershed. Mammals typical of the watershed include raccoons, opossums, skunks, muskrats, and fox squirrels. Several species of mice, shrews, moles, and voles also occur. Continued urban development threatens to further fragment and degrade the remaining habitat these species rely upon.

CHAPTER 7
Columbia Slough Watershed

INTRODUCTION

This chapter begins with a summary of current conditions in the Columbia Slough Watershed. The summary describes the watershed's current assets and problems, and identifies opportunities to protect and restore watershed health.

The following sections then provide more detailed information to support the summary. Section A presents landscape factors (topography and soils), and Section B discusses human influences (land use, population, and infrastructure) that affect watershed health. Sections C through F describe existing conditions related to each of Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities.

The summary is written to stand alone for readers who do not wish to read the entire chapter. For that reason, some repetition occurs between the summary and the sections that follow it.

Fish, specifically threatened salmonid species, are used extensively throughout this report as indicators of watershed health. Human activities throughout the landscape affect the water and watershed. If native salmonids are thriving, this indicates the overall watershed is thriving. If not, the watershed is in poor condition. Using fish as indicators does not mean they are the sole purpose of watershed restoration efforts. Rather, the condition of fish helps guide where to look for sources of problems and for opportunities to improve watershed health.

SUMMARY OF COLUMBIA SLOUGH WATERSHED

Setting

The Columbia Slough Watershed drains approximately 32,700 acres of land, or 51 square miles (Figure 7-1). Portland's city limits end at approximately NE 185th Avenue on the east, but the watershed also includes Fairview Lake and Fairview Creek, and portions of Troutdale, Fairview, Gresham, Maywood Park, Wood Village, and Multnomah County are within the watershed.

The watershed once contained a system of side channels, lakes, and wetlands that covered the floodplain of the Columbia River between the mouths of the Willamette and Sandy Rivers. High water, known as freshets, seasonally inundated the floodplain, cutting new channels and depositing sediment. Native Americans used these waterways and the uplands for fishing, hunting, and gathering food.

Over the years, the watershed and waterway have been drastically altered to accommodate industry and agriculture. Beginning in 1918, levees were built to keep out Columbia River flows and provide flood protection. Wetlands and side channels were drained and filled to allow for development. The waterway was channelized, and dozens of streams were filled or diverted to underground pipes. This resulted in a massive loss of habitat, flood storage capacity, and ability to filter sediments and pollutants.

Today, the Columbia Slough comprises a 19-mile main channel that parallels the Columbia River, as well as approximately 30 miles of secondary waterways. It is a highly managed system, with piped surface water, dikes and levees, and a system of pumps that provide watershed drainage and flood control. The watershed continues to serve industrial uses, but is also home to commercial enterprises and thousands of Portland residents.

Current Conditions

The Columbia Slough has suffered from severe water quality problems and contaminated sediments. Conditions are improving, however, and measures are being taken to reduce pollution and improve natural resources. Industrial discharges have been regulated; over 99 percent of combined sewer overflows have been controlled; miles of streambank have been revegetated; and environmental education is offered at public and private schools in the watershed. Many more people are beginning to see the Slough as an urban amenity, with hiking and biking trails, a regional environmental education center, and several access points where boaters can put canoes and kayaks in the water and enjoy wilderness in the City. Developers are also beginning to view the Slough as an amenity. Some new buildings have been constructed to face the Slough instead of turning their back on it. One new award-winning industrial building in the watershed meets the country's most stringent environmental standards.

Figure 7-1: Columbia Slough Watershed

There is still much work to do to restore even some of the natural resource functions the Slough once had, however. Continuing urban growth and development, past and current land uses, and management of the Slough system for multiple purposes have all had significant impacts on the watershed. The following conditions will have to be considered to determine the needs and best approaches for enhancing watershed health.

- The Slough watershed's flat topography, altered hydrology, tidal influences, and highly managed system result in slow water movement. Sluggish water forms ponds behind culverts and levees. These physical conditions contribute to water temperatures that are too high to support cold-water fish, and allow excessive growth of algae and macrophytes (water vegetation). Nutrients that enter the Slough from groundwater and surface water runoff feed the algae and macrophytes. Macrophytes slow water flow, which increases temperature even more. Algal growth negatively impacts dissolved oxygen and pH levels in the water. These water quality problems have adverse effects on fish and other aquatic species. Measures that can be taken to improve water quality conditions include changing culverts to bridges to allow water flow, and planting trees to shade the water. Multnomah Drainage District No. 1 removes 90 to 100 tons of macrophytes from pump station screens each fall after the macrophytes die off. Harvesting macrophytes from the Slough channel during the summer to allow water flow has not yet been attempted, but could be another measure to improve water quality.

- The densely developed watershed comprises about 54 percent impervious surfaces, such as roads, parking lots, sidewalks, and rooftops. This large impervious area has significantly increased stormwater runoff volume and peak flows, causing the Slough to evolve into a "flashy" urban stream. A surge of stormwater runoff now enters the Slough within hours of rainfall, instead of over the course of days as would occur in undeveloped conditions, with potential negative impacts on aquatic habitat. Stormwater runoff also carries pollutants from urban land uses into the Slough. The transportation system, which includes many miles of major highways, is a significant source of pollutants such as metals, oil, and grease. The pollutants carried in stormwater attach to sediment particles and accumulate in the Slough's sediments. The contaminated sediments pose risks to human health and wildlife. To reduce the amount of stormwater and associated pollution entering the Slough, stormwater should be managed as close to its source as possible. This should be attempted first by removing impervious areas and using vegetation to mitigate impervious areas. Using bioswales and constructed wetlands to filter stormwater before it enters the Slough should be attempted second. Since vehicles are the main source of pollution in stormwater, methods to reduce vehicle use, such as carpooling and increased use of public transit, can also be used.

- Chlorinated compounds such as PCBs and pesticides (DDT and chlordane), which have been banned for many years, are still found in the Slough's sediments and in fish tissue samples. Contamination in fish pose a risk to human health. Some contaminated sites contain elevated levels of heavy metals, especially lead and chromium, which may adversely affect benthic organisms and wildlife. Sediment in the Marx-Whitaker Slough, between NE 112th and 128th Avenues, contains persistent pesticides that are toxic to benthic organisms. Studies have shown that the most cost-effective way to deal with the contaminated sediments is to leave them in place and let them degrade naturally over time, while preventing further deposition and re-contamination. As a result, the City's discussions with the Oregon Department of Environmental Quality (DEQ) have shifted emphasis from strictly cleanup to pollution source control and watershed health actions.

- In the fall and occasionally in winter, high BOD loadings result in low dissolved oxygen concentrations that limit the ability of fish and benthic organisms to survive and thrive in the Slough.

- Urban development within the riparian (streamside) corridor has resulted in extensive removal of riparian vegetation and negative impacts to water quality. The riparian area is generally narrow and degraded. Impacts to water quality include decreased shading, leading to elevated water temperature and algal and macrophyte growth; decreased ability to filter pollutants and sediments from runoff; and loss of wildlife habitat. The primary method to reduce these impacts is to revegetate the Slough's banks with native trees and shrubs. On private property, this could be done through partnerships with land owners. On public property, it could be done through partnerships with the agencies that own the land. Public agencies could also purchase, restore, and protect the most important areas.

- The levee system and associated water control structures and water management practices have eliminated historic flooding in the watershed. Current flood control measures do not allow for the flushing of sediments, nutrients, and pollutants with seasonal freshets. The best ways to deal with pollutants in the water or sediment is through source control and pollution prevention. These take several forms, but the primary methods are education for businesses, industries, and property owners and enforcement of existing regulations.

- Habitat areas such as open water, tree/thicket cover, and marsh/wetlands have been greatly reduced in the last 60 years. The remaining habitats are highly disturbed. The loss of habitat is detrimental to a large number of bird, mammal, fish, reptile, and amphibian species that use the watershed at various points in their life cycle. To provide more high-quality habitat, existing habitat areas can be restored and protected through voluntary means or regulations.

- Many non-native invasive species flourish in the watershed and threaten to out-compete native species. Himalayan blackberry and reed canarygrass have taken over many riparian areas. Some sections of the riparian area have been replanted with native vegetation, but these areas need continuing maintenance to make sure the invasive species do not return. Upland areas contain little native forest and include primarily fragmented habitat areas such as city parks and street tree canopy that offer limited habitat value for native wildlife populations and lack of safe corridors for travel.

- There is limited habitat for salmonids because of the simplified channel, lack of wood and off-channel habitat, stream bottom structure composed of fine sand and silt, slow flows, elevated water temperatures, pollutant levels, and impeded fish passage. Salmonid use is confined to the tidally influenced Lower Slough because of barriers to upstream passage. Benthic macroinvertebrates production is low, which limits available food resources for other aquatic and terrestrial species. The Lower Slough provides off-channel refuge habitat for salmonids in the Lower Willamette River.

- Culverts in the middle and upper slough impound water which then provides ideal conditions for algal and macrophyte growth. The culverts also hinder stream connectivity resulting in limited mobility for aquatic and terrestrial species.

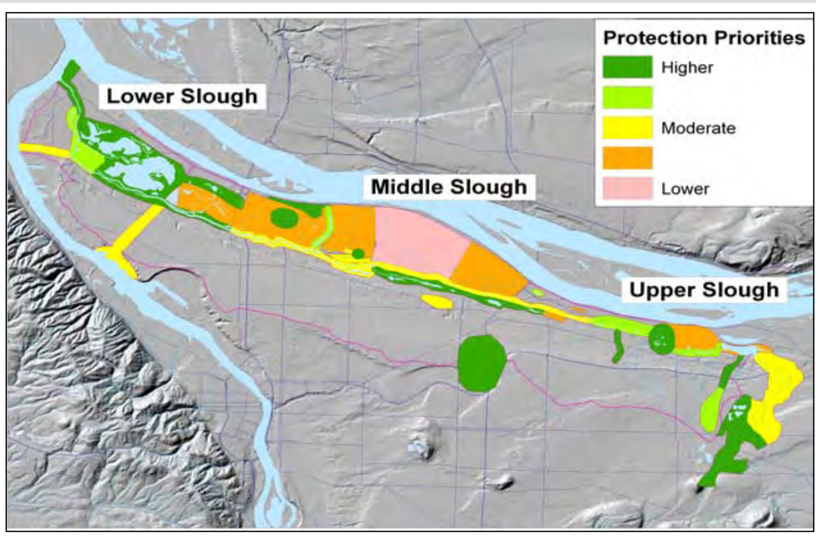
- Despite the many hydrologic changes and pollutant contributions, the Columbia Slough Watershed is still home to wildlife. Species diversity remains high, but numbers are reduced. Over 170 species of birds have been identified. Smith and Bybee Wetlands Natural Area provide valuable wetland and floodplain habitat. The Big Four Corners core habitat area provide valuable upland and wetland habitat.

- The City's backup drinking well field is located in the Middle and Upper Slough watershed. The well field has special designation, and different regulations govern how stormwater is handled in this area. Deep injection of untreated stormwater is not allowed, so onsite stormwater management focuses on surface infiltration that provides some treatment. For new development, stormwater planters, surface bioswales, and ecoroofs are common management techniques. Because old Multnomah County sump systems, which have no pretreatment, exist in this area, spill control is a priority.

Protection Opportunities

Two core habitat areas in the Columbia Slough Watershed—Smith and Bybee Wetlands Natural Area in the Lower Slough and Big Four Corners in the Upper Slough—currently provide important watershed health benefits. These and other areas that provide significant benefits have a high protection value, as summarized below and shown on Figure 7-2.

Figure 7-2
Columbia Slough Watershed Protection Priorities



Lower Slough

The off-channel habitat from the mouth of the Lower Slough to Simpson Cove, including Smith and Bybee Wetlands Natural Area, is very valuable for migrating salmon. It represents one of the last remaining areas of its kind near the confluence of the Columbia and Willamette Rivers.

Smith and Bybee Wetlands Natural Area and the Peninsula Drainage Canal in the Lower

Slough provide habitat for painted turtles, western pond turtles, red-legged frogs, and great blue herons.

Middle Slough

The Subaru Wetlands provide valuable habitat for wetland species. Prison Pond meets water temperature standards year-round. Macroinvertebrates (aquatic insects such as stone flies, mayflies, and dragonfly nymphs that are food sources for many aquatic species, including salmonids) sensitive to watershed degradation have been found here, documenting the site's relative health.

Upper Slough

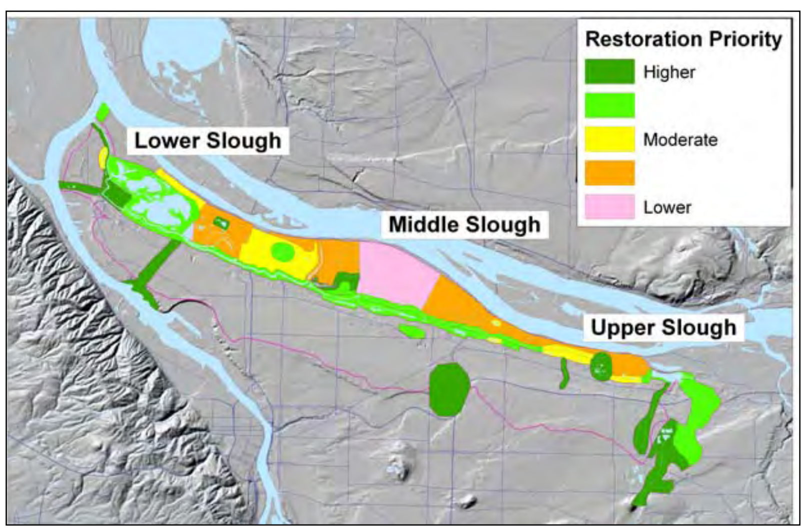
Big Four Corners and Fairview Creek wetland complexes provide valuable habitat for wetland species.

Wilkes Creek and Alice Springs in the Upper Slough meet water temperature standards year-round. Macroinvertebrates that are sensitive to watershed degradation have been found at these sites, documenting the sites' relative health. Although it is not possible for ocean-going salmon to use these streams, resident salmon species could benefit from the streams' habitat.

Restoration Opportunities

In addition to the above protection areas, some currently degraded areas and attributes of the Columbia Slough Watershed could provide watershed benefits if restored, as summarized below and shown on Figure 7-3.

Figure 7-3
Columbia Slough Watershed Restoration Priorities



Restoration potential lies in restoring riparian canopy and managing hydrology within the existing channel to mimic conditions that are more natural. In the Lower Slough, opportunities include the lower reach near its confluence with the Willamette River, the Bonneville Ponds area, and Smith and Bybee Wetlands Natural Area. The Peninsula Crossing Trail and the Bonneville Ponds wildlife corridor offer high restoration potential because they connect the Willamette River and Columbia Slough systems.

Hydrology

Increasing stormwater infiltration throughout the watershed would increase groundwater flows, resulting in cooler water throughout the Slough system. Expanding upon the relatively intact tree canopy on Rocky Butte is one potentially valuable opportunity. Working with local drainage districts on management actions that more closely mimic historic flows is also a possibility. Replacing 13 culverts on the southern arm of the Middle Slough with bridges would improve hydrologic conditions favorable to watershed health.

Habitat

The mainstem Slough provides a thin ribbon of connectivity between the upper and lower sections of the watershed. Removing the culverts on the southern arm of the Middle Slough would allow the creation of emergent wetlands and improve terrestrial and aquatic habitat connectivity. The Subaru Ponds wetlands add additional habitat restoration potential to the Middle Slough.

In the Upper Slough, the Salish Ponds, Big Four Corners, and Wilkes Creek areas present the most valuable potential habitat restoration opportunities. The St. Johns Landfill is an excellent candidate for open meadow habitat restoration. It has value because it is adjacent to the Slough and Smith and Bybee Wetlands Natural Area.

Creation of emergent wetland benches within the Lower Slough would provide new instream habitat.

In summer, the water in the slough near Heron Lakes Golf Course and the Portland International Raceway recedes, exposing extensive mudflats. With the addition of emergent wetland plants and other habitat structures, this area could provide additional watershed health benefits.

Water levels in the Kenton Cove Peninsula area become shallow and mudflats emerge each year. The area immediately to the north along the south wall of the levee is devoid of vegetation, except grasses. Improving the vegetation at this site would provide habitat benefits.

The south riparian edge of the Lower Slough between North Denver and NE Martin Luther King Boulevard is a blackberry-covered levee. At low water levels, concrete rubble and other fill emerge. The blackberries could be removed and the rubble capped with clean fill to support native vegetation.

Creating wetland benches and placing large wood in the Lower Slough from the Willamette River confluence to approximately North Portland Road would improve and increase salmon habitat. Habitat enhancement potential also exists in the Blind Slough, Wapato Wetlands, and Ramsey Lake Wetlands areas.

Water Quality

Improving hydrology and habitat will also improve water quality. Improved groundwater recharge, continued pollution source control, and revegetation projects will help limit additional water quality problems. The recent completion of the City's Combined Sewer Overflow (CSO) Program in the Slough has made a significant contribution to improved water quality.

Biological Communities

Improving hydrology, habitat, and water quality will also improve the Columbia Slough's biological communities. In addition, developing management strategies to address invasive, non-native aquatic species such as Asian shrimp, carp, and invasive aquatic and terrestrial plants would provide watershed health benefits.

Stormwater Management

Although many of the upland areas are not highlighted on Figure 7-3, protection and restoration of the upland areas would benefit the parts of the Slough to which they drain. For areas that drain to the Slough, restoration potential lies in addressing both the water quality and quantity of stormwater runoff.

Section A: LANDSCAPE FACTORS

A-1: Topography

The topography of the Columbia Slough Watershed is generally flat near the Columbia River, with elevations ranging from 5 to 50 feet above mean sea level (msl). The gradient, or slope, of the Slough waterway is nearly flat (an approximately one-inch drop per linear mile). As a result, the Slough can flow in both directions, depending on the tide and operation of the pumps and levees. The flat topography means the slough flows very slowly which impacts water quality. Elevation rises in the upland area south of the Slough (from Columbia Boulevard to the Alameda Ridge) to a maximum of approximately 600 feet above msl.

A-2: Soils

Soils in the low-lying area of the watershed north of Columbia Boulevard are generally poorly drained. Large areas of the soils have been filled, drained, cut, or otherwise disturbed by urban development. During wet weather from December to July, the water table tends to be high, within 12 inches of the surface. In relatively undisturbed areas, permeability is moderate to moderately slow.

Soils in the area south of Columbia Boulevard and west of roughly NE 18th Avenue are well drained. In over half of this area, urban development has disturbed the soil. Soils in the area of the watershed south of Columbia Boulevard and east of NE 18th Avenue are also well drained, and urban development has disturbed most of the area. In relatively undisturbed areas, permeability is moderate.

The areas in and around Portland International Airport (PDX) and Rivergate (at the far west end of the watershed) have been filled with dredge spoils from the Columbia River. The soils consist of a surface layer of sand over a sandy subsoil to an average depth of 60 inches or more. In some areas, the layer of sandy soil may be more than 20 feet thick. The permeability of these soils is very high.

Section B: HUMAN INFLUENCES

B-1: Land Use

The Columbia Slough Watershed includes virtually every type of land use: residential neighborhoods, commercial and industrial development, agriculture, PDX, interstate highways, railroad corridors, 54 schools, and large open spaces. Table 7-1 shows current and projected land uses in the watershed. In general:

- The watershed has major air, water, rail, and truck transportation routes.
- The portion of the watershed north of Columbia Boulevard is predominantly industrial and commercial. PDX is located in this area. Land for industrial uses is also preserved in the Columbia South Shore area between NE 82nd and NE 185th Avenues north of Sandy Boulevard.

- The area south of Columbia Boulevard is predominantly residential, with commercial areas along major arterial streets.

- The eastern portion of the watershed has agricultural areas that are quickly developing into commercial/industrial areas.

- About 54 percent of the watershed comprises impervious surfaces, such as roads, parking lots, and rooftops.

Table 7-1
Land Use in the Columbia Slough Watershed

Zoning Category	Current (2001)		Future (2040)	
	Acreage	Percent	Acreage	Percent
Commercial	772	2	5,272	14
Industrial	6,911	18	9,997	26
Residential	8,944	24	12,013	32
Vacant	8,788	23	0	0
Parks/Open Space	4,920	13	5,517	15
Rural	53	1	0	0
Agricultural	434	1	0	0
No data available	6,919	18	4,942	13
Total Acreage	**37,741**	**100**	**37,741**	**100**

The watershed has significant recreational amenities. The waterway provides excellent canoeing and kayaking, with seven canoe and kayak launch sites. Hiking and biking facilities include segments of the 40-Mile Loop Trail, the Peninsula Crossing Trail, Lewis and Clark Greenway Heritage Trail, I-205 bike path, and a paved bike path along much of Marine Drive. Other recreational sites include Smith and Bybee Wetland Natural Area, the Children's Arboretum, six golf courses, and Whitaker Ponds Learning Center. Much of the watershed provides excellent bird-watching opportunities.

B-2: Population

Based on the U.S. census, the Columbia Slough Watershed has a population of 230,069 and 87,781 households. The most densely populated area in the watershed is south of Columbia Boulevard between I-205 and I-5. The commercial/industrial area north of Columbia Boulevard and the Rivergate area have the lowest residential densities.

About 3,900 businesses and 57,000 jobs are located in the watershed, significantly contributing to the region's economic prosperity.

B-3: Sanitary and Stormwater Infrastructure

The following discussion addresses infrastructure within the Portland portion of the watershed.

Combined Sewer System

The City's combined sewer system conveys both sanitary sewage and stormwater in the same pipes. In the Columbia Slough Watershed, the combined sewer area comprises approximately 5,500 acres located west of NE 42nd Avenue.

Combined sewer overflows (CSO) occur during rain events when the capacity of the pipes is exceeded and combined sewage and stormwater discharges into the Slough. The City of Portland has controlled over 99 percent of CSOs to the Slough as of December 2000. Before this date, 13 combined sewer outfalls discharged up to 1.2 billion gallons of combined sewage annually into the Lower Slough. The Columbia Slough Consolidation Conduit (known as the Big Pipe) now collects and transports combined sewage to the Columbia Boulevard Wastewater Treatment Plant (CBWTP). Other measures implemented to reduce CSOs include sumps, downspout disconnection, and sewer separations.

Separated Sanitary System

The separated sanitary system conveys sanitary sewage to the CBWTP. Because the northern portion of the watershed is relatively flat, 61 sanitary pump stations are required to convey the flows.

Unsewered Areas

The area east of NE 42nd Avenue was predominantly unsewered in the past, using individual septic and cesspool systems for sanitary waste disposal. This resulted in increased nitrogen going into the Columbia Slough via groundwater, with potential impacts to human and wildlife health and safety and ongoing water quality impacts. Major portions of the unsewered area were eliminated in the 1990s with the construction of the Mid-County Sewer Project. However, pockets of unsewered areas still exist.

Stormwater Facilities

Separated stormwater systems include both open channels (drainageways, swales, water quality facilities, and constructed wetlands) and closed systems (pipes, culverts, and sumps). The watershed contains 57 permitted City stormwater outfalls, as well as 139 permitted private outfalls. In addition, there are many other private outfalls that are not required to have permits.

B-4: Transportation Infrastructure

The Columbia Slough Watershed includes an extensive network of streets, roads, and highways. The primary impacts of roadways include increased stormwater runoff volume resulting from the imperviousness, increased stormwater pollution, and air particle deposits generated by traffic.

Roadways are one of the leading sources of nonpoint source pollution to the Slough waterway, contributing solids (dirt, brake dust, tire dust), debris, nitrogen, oil and grease, bacteria, and heavy metals (copper, lead, zinc).

PDX, owned and operated by the Port of Portland, is both a civil airport and military airport (Portland Air National Guard Base). Airport infrastructure includes large amounts of impervious surface that increase stormwater runoff volume and pollutant levels. In addition to solids, de-icing agents were a major pollutant at PDX in the past. The Port completed the final infrastructure needed to manage these agents in 2002.

The Union Pacific Railroad and Burlington Northern Santa Fe Railway operate in the watershed. Little information exists about the impacts of railroads on water quality. However, railroads typically use creosote ties, which contribute pollution to waterways. Engine oils and fuel can also be transported to the waterway via stormwater runoff. Spilled freight can contribute pollutants as well.

Sections C, D, E, and F describe the current conditions of the Columbia Slough Watershed related to Portland's four watershed health goals: hydrology, physical habitat, water quality, and biological communities. Improvements in these conditions will indicate improvements in watershed health.

Section C: HYDROLOGY

C-1: Overview

The hydrology of the Columbia Slough Watershed has changed drastically from its historical condition. The Columbia Slough was once the floodplain of the Columbia River, but the levee system has greatly changed the historic floodplain and reduced the area available to floodwaters. Floodplain development has resulted in an extensively managed surface water system that includes levees, pumps, and other water control structures. Pumps control flow in the Middle and Upper Slough. The levee on which Marine Drive is located has totally blocked the direct connection between the Slough and the Columbia River.

Today, the remaining major surface water features include the Slough's main channel and secondary waterways, Fairview Creek, Fairview Lake, Smith and Bybee Wetland Natural Area, Mays Lake, Force Lake, Prison Pond, and Whitaker Ponds. Upland development has eliminated all but four small surface streams: Osborn, Wilkes, No Name Creek, and Alice Springs.

The current hydrology is complex, and the highly managed nature of the Columbia Slough significantly affects flow. Based on hydraulic characteristics, the Slough watershed is divided into five sections:

- **Fairview Creek** originates in a wetland complex at the base of Grant Butte, near SE 181st and Powell Boulevard. Fairview Creek and its tributaries flow into Fairview Lake.

- **Fairview Lake** is bordered by 223rd Avenue on the east, Interlachen Lane on the north, and Fairview Lake Way on the west. It receives water from Fairview Creek, Osborn Creek, and

No Name Creek. Fairview Lake flows into the Upper Slough through a culvert/weir system on the west side of the lake.

- The **Upper Slough** starts at Fairview Lake on the east and flows west to the mid-dike levee at NE 142nd Avenue. It receives water from Wilkes Creek, stormwater outfalls, natural springs, groundwater, and overland flow from the south.

- The **Middle Slough** extends from the NE 142nd Avenue levee to the Pen2 levee near NE 18th Avenue. It includes a substantial southern-arm complex of sloughs and lakes, including Buffalo Slough, Whitaker Slough, Johnson Lake, Mays Lake, Whitaker Ponds, and Prison Pond. The Middle Slough receives water from the Upper Slough, stormwater outfalls, natural springs, overland flow from the south, and groundwater. Pumps are used to move water from the Upper and Middle Sloughs to the Columbia River or the Lower Slough.

- The **Lower Slough** starts at the Pen 2 levee and extends approximately 8.5 miles to the Willamette River. It contains the watershed area that is subject to flooding because it is unprotected by levees. Water flow and levels in the Lower Slough are affected primarily by the Columbia River and Willamette River stages and the ocean tides, as well as by pumping. Flow direction varies with the tide. During incoming tides, Willamette River water travels up the Lower Slough to approximately Denver Avenue. The easterly flow induced by rising tidal changes complicates the discharge of water from the Lower Slough to the Willamette River.

  The Lower Slough includes Smith and Bybee Wetland Natural Area, a complex of nearly 2,000 acres that is the largest urban wetland in the United States.   A water control structure regulates the lakes' levels and controls water flow to the Lower Slough.

Groundwater from shallow aquifers provides significant inputs to the Upper and Middle Slough, as well as some input to the Lower Slough and nearby lakes and wetlands. The City of Portland's Columbia South Shore Well Field, located in the Upper Slough area, supplements the City's primary water supply from the Bull Run Watershed. The well field has 24 production wells that draw on the deeper aquifers in the Columbia Slough system. Pumping of the well field is likely to have only a small effect on groundwater influx to the Slough because the connection between the shallow and deeper aquifers is weak.

Three drainage districts provide flood control and drainage services to the approximately 11,208 acres (18 square miles) of floodplain area in the watershed:

- **Multnomah Drainage District No. 1 (MCDD)** is the largest of the districts, containing 8,832 acres (14 square miles) in the Middle Slough and Upper Slough areas. MCDD is responsible for managing flow in the Upper and Middle Columbia Slough and maintaining the Upper and Middle Slough waterways and tributary drainageways.

- **Peninsula Drainage District No. 2** contains 1,475 acres (2 square miles).

- **Peninsula Drainage District No. 1** contains 901 acres (1 square mile).

The drainage districts manage the upper half of the Slough system for multiple purposes, including providing flood control storage capacity, maintaining wetland conditions in mitigation wetlands in compliance with regulatory requirements, and maintaining water levels for recreational uses. They manage water levels for water quality when it does not interfere with flood control.

Historically, freshets would occur in spring, and water levels would gradually lower throughout the summer. In addition, the entire Columbia Slough was tidally influenced. Current water level management results in conditions that are the opposite of these historic conditions. During the summer months, usually between June and mid-October, MCDD keeps the Upper Slough water level relatively high to provide irrigation for water rights and to maintain mitigated wetlands that also hold water rights. In addition, Fairview Lake levels are allowed to rise to allow summer recreational use. Middle Slough summer water levels are typically maintained slightly lower than the Upper Slough levels. In winter months, water levels are lowered to provide flood control storage capacity. The Columbia Slough also experiences altered flow resulting from the direct effect of Columbia and Willamette River dams; the Lower Columbia and Willamette Rivers experience low flows from September through March and high flows during May through July.

C-2: Effects of Development on Hydrology

The large amount of impervious surfaces (54 percent) in the watershed has significantly increased stormwater runoff volume and peak flows, causing the Columbia Slough to evolve into a “flashy” urban stream. This means that a surge of stormwater runoff now enters the Slough within hours of rainfall, instead of over the course of days as would occur in undeveloped conditions. This has potential negative impacts on aquatic habitat. In addition, land use changes that remove riparian tree cover reduce shading of the Slough and lead to increased water temperature. Impervious surfaces also decrease stormwater infiltration into the soil and groundwater; the reduced groundwater input to surface water may affect low and summer flows.

Most undeveloped land in the eastern portion of the watershed is currently zoned industrial. As development occurs and impervious area increases, stormwater volume and associated pollution may also increase.

C-3: Effects of Hydrology on Water Quality

The development of the watershed and associated hydrologic changes over time have caused many of the Slough’s current water quality problems, including water temperature, dissolved oxygen levels, pH levels, and algal growth (see Section E: Water Quality). The levee system and associated water control structures and water management practices have eliminated historic flooding in the watershed. Current flood control measures do not allow for the flushing of sediments, nutrients, and pollutants with season freshets.

In addition, dams and water management practices have dramatically altered the hydraulic regimen of the Columbia River and Willamette River systems and consequently affected the Slough's hydraulic character. High water levels and long water residence times resulting from in-channel flow constrictions exacerbate water quality problems. Groundwater going into the

Slough has relatively high nutrient levels, while stormwater carries heavy metals to the waterway.

C-4: Interaction of Hydrology and Algae/Macrophytes

Algae are simple plants that contain chlorophyll and lack roots, stems, and leaves. Macrophytes are rooted and non-rooted aquatic plants that grow either as emergent plants in shallow water or saturated soil, or as submerged plants where there is sufficient light.

The thick algal mats that float on top of the water are a direct result of the Slough's hydrology and water quality conditions. The very slow water movement allows the water to heat up, creating ideal conditions for algal blooms. Excessive nutrients in the Slough feed the algae.

A strategy to reduce algal growth in the Upper Slough was field tested in 1995. Groundwater was used to increase the velocity of water flow in the Slough and decrease water residence time. The increased flows did reduce the algal growth. However, the reduced algal growth enabled sunlight to penetrate deeper into the water column, allowing dormant macrophyte seed to flourish. With clearer water, the macrophytes quickly established themselves in the Middle Slough. Today, they clog the main channel from NE 122nd Avenue to NE 18th Avenue from about mid-May until they die off at the end of September. They raise water levels and decrease water flow and velocities through the Middle Slough as water piles up behind the plants. MCDD removes approximately 90 to 100 tons of macrophtyes from pump station trash racks each year. (See Section E: Water Quality, for additional information.)

In addition to the 1995 field test, other flow augmentation strategies have been investigated to increase flow rate, decrease algal growth, and dilute pollutant concentrations. Studies showed, however, that these strategies require large capital investment and produce limited benefits.

Section D: PHYSICAL HABITAT

D-1: Overview

Historically, the Columbia Slough was thickly forested along the shores and low-lying areas. It contained expanses of wetland prairie and oak savannah. Over the years, the watershed and waterway have been drastically altered, and habitat areas such as open water, tree/thicket cover, and marsh/wetlands have been greatly reduced. The remaining habitats are highly disturbed and are primarily found along and adjacent to the riparian areas. Habitat areas away from the waterway and from riparian areas are often fragmented and do not have adequate corridors for wildlife to move safely between them. The success of non-native plant species has caused an overall decline in habitat quality, and non-native wildlife species that are extremely adaptive to degraded habitats often out-compete more sensitive native species. This will remain one of the most important priorities in the restoration of urban habitats in the next century.

Overall, the loss and fragmentation of habitat has been detrimental to a large number of bird, mammal, fish, reptile, and amphibian species that use the watershed at various points in their life cycle. Yet, a number of high-quality habitat pockets and large natural areas still remain and support a rich diversity of wildlife, although in reduced numbers. Although the habitats are greatly altered from historic conditions, the Columbia Slough continues to provide an 18-mile-long riparian corridor and extensive wetland areas in a region where streams and wetlands have been heavily impacted by agriculture and urbanization during the last century.

The following conditions exist today:

- Native vegetation such as willow, black cottonwood, Oregon ash, Douglas hawthorn, sedges, and rushes are scattered throughout the watershed. Populations of wapato and Columbia sedge are less common, found only in a few places.

- In most areas, the riparian corridor is a continuous but narrow strip of native black cottonwood and Oregon ash adjacent to the Slough channel. Some riparian areas are maintained as primary levees, requiring the removal of all trees and shrubs. Much of the riparian area contains buildings and other paved surfaces.

- As urbanization increases in the watershed and natural habitats are affected, non-native species proliferate, adapting to the urban environment and out-competing native species. Non-native species such as reed canarygrass and purple loosestrife dominate many of the watershed's wetland habitats, and Himalayan blackberry often dominates the riparian forest understory.

- The fragmentation of the riparian corridor, combined with numerous dangerous road crossings, inhibit safe travel for terrestrial wildlife along the Columbia Slough.

- A number of areas within the watershed provide islands of high-quality habitat:
  - Lower Slough
    - Heron Rookery
    - Kelley Point Park
    - Peninsula Drainage Canal
    - Rivergate mitigation sites and Ramsey Lake Wetlands
    - Smith and Bybee Wetlands Natural Area
    - Vanport Wetlands
    - Delta Park and Heron Lakes Golf Course
    - Bridgeton Slough
    - Brandwein Wetlands
  - Middle Slough
    - Slough channel through the Sunderland neighborhood
    - Broadmoor Golf Course Wetlands (Subaru Wetlands)
    - Whitaker Ponds
    - Prison Pond
  - Upper Slough
    - Big Four Corners area
    - Fairview Creek wetland complex
    - Wilkes Creek
    - Alice Springs

The following text summarizes watershed conditions by habitat type.

D-2: In-Channel Habitat

Alteration of the hydrologic cycle has greatly changed the Columbia Slough's in-channel habitat, with adverse impacts on the biological communities. In-channel habitat is basically marginal to poor throughout the entire system. Salmonid use is limited to the tidally influenced Lower Slough because the levee and pump station at NE 18th Avenue prevent upstream fish passage. The Lower Slough provides prime off-channel refuge habitat for salmonids. It represents one of the last remaining areas of its kind near the confluence of the Columbia and Willamette Rivers.

Stormwater discharges, chemical contaminants, industrial pollutants, and decades of sewage discharges (now controlled by over 99 percent) have also had adverse effects on in-channel habitat and associated biological communities.

Fairview Creek and Osborn Creek in the upper watershed have higher gradients and higher-velocity water than the Columbia Slough and provide instream habitat complexity in the form of pools and riffles (shallow water flowing over gravel). These tributaries of the Columbia Slough provide suitable habitat for resident cutthroat trout, which have been found in both creeks.

Barriers and Culverts

Numerous fish passage barriers exist on the Columbia Slough's main channel and side channels. The largest barriers are the large levees that were constructed for flood control. These levees prevent fish from entering the Middle and Upper Slough. They are located at:

- Peninsula Drainage District No. 2 levee at NE 18th Avenue, which separates the Lower Slough from the Middle Slough and has a large pump station.
- Mid-dike levee at NE 142nd Avenue, which separates the Middle Slough from the Upper Slough.
- Marine Drive levee at NE 178th Avenue, which separates the Upper Slough from the Columbia River and has a large pump station.

Many culverts cross the main channel and the south arm of the Middle and Upper Slough. Some have been replaced with larger culverts that allow better water flow, and one has been replaced with a bridge. Several more will be replaced with bridges in 2004. Bridges allow more natural, less constricted water flow. Bridges also provide habitat connectivity for aquatic and terrestrial wildlife, and access for water-based recreation and stewardship activities such as volunteer monitoring.

D-3: Riparian Habitat

Riparian habitats are water-dependent ecosystems characterized by rich and diverse groups of plant and animal species. They are the transitional ecosystem between terrestrial and aquatic ecosystems, provide important habitat for water-dependent species, and also function as travel corridors along the watercourse for various wildlife species.

The riparian fringe has the richest wildlife species diversity in the Columbia Slough Watershed. However, urbanization, fragmentation, and non-native species have reduced the habitat value of the riparian ecosystem. The majority of the natural riparian corridor is very narrow and contains buildings and paved spaces. The remaining riparian habitat is dominated by a native canopy of black cottonwood, Oregon ash, and willow species, and an understory of native red osier dogwood and snowberry and non-native Himalayan blackberry and reed canarygrass. A few stands of Oregon white oak are also found. The fragmentation of the riparian corridor, combined with numerous dangerous road crossings, inhibit safe travel for terrestrial wildlife along the Columbia Slough.

Several miles of riparian areas within the watershed are devoid of trees, while several more along the Slough are maintained as primary levees, requiring the removal of all trees and shrubs. Until the mid 1990s, additional bank areas were cleared to allow the drainage district to maintain the Columbia Slough channel with large machinery.

D-4: Wetlands Habitat

Wetlands are areas that are inundated or saturated by surface water or groundwater and support vegetation adapted for life in saturated soil conditions. Most of the wetlands in the Columbia Slough Watershed are relics of the once-extensive complex of lakes, channels, marshes, and forested wetlands found in the historic floodplain. A small portion are newly constructed mitigation or water quality treatment wetlands. Beginning in 1918, levees were built, and much of the original wetland complex began to be filled, dredged, channelized, isolated, and/or degraded by agricultural and urban practices. The hydrologic changes have created a favorable environment for invasive non-native species, such as reed canarygrass and purple loosestrife, to become the dominant plant species in the wetlands. This contributes to an overall decline in wetland conditions.

Several of the wetlands in the Columbia Slough are isolated and lack a connection to other wetland, riparian, or upland habitat areas. The lack of adjacent upland habitat also reduces species use because the majority of wetland species use upland habitat for critical stages of their life cycle. The remnant wetlands in the watershed, however, provide important habitat, water quality, and water quantity functions. Connecting and restoring remaining wetlands with uplands or with the Slough would increase their habitat value for many wildlife species.

D-5: Upland Habitat

The upland area of the watershed, located primarily south of Columbia Boulevard, is predominantly urbanized, with commercial and residential development that provides little habitat value. The small portions of upland habitat with native vegetation are isolated remnants or recently planted revegetation sites. The large upland open spaces that occur are developed parks, golf courses, agricultural land, undeveloped industrially zoned lands, and the St. Johns Landfill. These areas have a low diversity of plant species and contain a high proportion of non-native species. Diversifying existing upland areas by planting native plants in developed parks and increasing the native habitat on golf courses could help enhance these areas for wildlife. The St. Johns Landfill represents an opportunity to create and protect upland meadow habitat.
In addition, wildlife corridors that allow travel among upland areas, wetlands, or the Slough need to be addressed.

D-6: Unique Habitats

Smith and Bybee Wetlands Natural Area and Big Four Corners provide significant habitat areas within the watershed.

Smith and Bybee Wetlands Natural Area

Smith and Bybee Wetlands Natural Area is the largest and most diverse habitat in the Columbia Slough Watershed. The 2,000-acre publicly owned wildlife area is a complex system of two shallow lakes, abundant wetlands, five miles of riparian area along the Slough, and over 200 acres of upland meadow (St. Johns Landfill). Most dominant habitat types found in the Columbia Slough Watershed are represented. A large stand of Oregon ash is on the south side of Bybee Lake, along the North Slough, with some trees over 100 years old. Invasive non-native species also occur, including reed canarygrass, teasel, deadly nightshade, thistles, and purple loosestrife. The wildlife area hosts large populations of wintering waterfowl, great blue herons, nesting habitat for neo-tropical songbirds, and nesting Savannah sparrows on the St. Johns Landfill. A dam has hydrologically cut off Smith and Bybee Wetlands from the Slough for over 20 years. A new water control structure replaced the dam in November 2003. The new structure enables flexible management of water levels, enables Metro personnel to replicate the historic hydrology of the lakes, and provides a fish ladder for passage. Smith and Bybee Wetlands will now provide over 1,000 acres of refuge habitat, and juvenile salmonids will be able to find refuge in the lakes during high winter flows.

Big Four Corners Area

The Big Four Corners area lies between NE 158th and 185th Avenues in the Upper Slough watershed. The approximately 300-acre area comprises vacant and developed industrial land, agricultural land, natural and mitigation wetlands, and natural vegetation along riparian and upland areas. It contains significant natural resource values, including habitat for raptors, woodpeckers, and neo-tropical migratory songbirds. Mitigation wetlands and stormwater treatment facilities are located in this area, and wetland restoration is occurring along the Slough. Ownership includes both public and private property, and current environmental zones provide some level of protection for much of the area. To fully protect this large, high-quality area, the lands would need to be purchased and set aside for habitat.

Section E: WATER QUALITY

The water quality of the Columbia Slough is important for both public and ecosystem health. People use the Slough for recreation, including canoeing and fishing, and wildlife use it for habitat and food. Although water quality has been monitored since 1971, Portland’s Bureau of Environmental Services (BES) began extensive monitoring in 1994 to attempt to define and track conditions. BES continues to collect water quality data at multiple sampling sites.

E-1: 303(d) List and Total Daily Maximum Loads

The Oregon Department of Environmental Quality (DEQ) has placed the Columbia Slough on the state’s 303(d) list. The 303(d) list identifies water bodies that are “water quality limited” because they do not meet water quality standards for certain parameters.

The Columbia Slough does not meet standards for:

- Bacteria
- Temperature
- Eutrophication (phosphorus, chlorophyll *a*, pH)
- Dissolved oxygen
- Toxics (DDT/DDE, dieldrin, dioxin, PCBs and lead)

DEQ establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the "assimilative capacity," which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. In 1998, DEQ established TMDLs for all 303(d) listed parameters in the Columbia Slough, except temperature. DEQ is currently establishing a TMDL for temperature.

Total suspended solids (TSS) is also a parameter of interest in the Columbia Slough. Although no water quality standards or TMDLs have been established for TSS, this parameter is discussed in this report because it is related to how toxics are managed.

Bacteria

The purpose of the bacteria standard is to protect people from contact with and ingestion of human pathogens, which can occur during recreational activities such as swimming and boating. Contact with these pathogens can cause skin and respiratory ailments and gastroenteritis. Bacteria is also a general, indirect indicator of the presence of sanitary sewage in the environment and therefore the presence of pathogenic organisms such as viruses.

Current state standards for bacteria are measured in terms of *E. coli*. The Columbia Slough usually meets bacteria standards; overall, five percent of samples do not meet the standards.

CSOs were historically the largest source of bacteria in the Lower Slough. The City's CSO Program has controlled the discharge of over 99 percent of CSOs as of December 2000, and bacteria levels have been greatly reduced. Potential remaining sources of bacteria in the Slough include wildlife and pet feces, bacteria in urban stormwater, illicit discharges, Portland Meadows, sewage pump station leaks or overflows, and leaking cesspools and septic systems. Controlling bacteria at the source is possible for some sites. Where the sources of bacteria are more diffuse, treating stormwater before it enters the Slough is one control method.

Temperature

Cool water is a basic requirement for native salmon, trout, some amphibians, and other cold-water aquatic species. The State of Oregon classifies the Columbia Slough as a cold-water fishery.

The Columbia Slough does not meet state temperature standards in the summer months. Some sampling sites periodically do not meet standards in spring and fall, as well. The Slough consistently meets temperature standards in winter. The Middle Slough tends to be slightly cooler than the Upper Slough and Lower Slough, most likely because cool groundwater flows into this section.

A number of factors contribute to elevated water temperatures. The banks of the Slough lack vegetation, reducing shading that could help keep water temperatures cool. High culvert elevations cause impoundments that increase water residence time. The Slough is a low gradient and shallow system which increases the residence time of water in the Slough. Extensive development has changed the hydrologic cycle, reducing aquifer recharge and therefore decreasing cool groundwater inflow during the summer months. Water temperatures in the lower Slough are also impacted by Willamette and Columbia River tides which increase residence time. Revegetating the Slough's banks and replacing culverts with bridges would provide temperature benefits.

Eutrophication

Eutrophication is a natural process by which nutrients and organic substances enter an aquatic ecosystem and increase biological productivity. Human activities can greatly accelerate eutrophication by increasing the rate and amount of nutrients and organic substances that enter the water. The main problem with eutrophication is algal and macrophyte growth, which results in wide variations in pH during spring, summer, and fall. These variations make it hard for aquatic species to survive. The Columbia Slough does not meet pH standards, especially in spring, summer, and fall.

Sources of nutrients include groundwater (wastes from previously unsewered areas of mid-Multnomah County were discharged directly to groundwater that flowed toward the Slough) and stormwater runoff, which can contain nutrients from uses such as fertilizers. Additional sources of nutrients include agricultural runoff and sewage discharges from pump station overflows or leaks. Controlling these sources by prevention or treatment will alleviate the water quality problems associated with eutrophication.

Dissolved Oxygen

Dissolved oxygen (DO) is very important for fish, including salmonids, and benthic (bottom-dwelling) organisms. Fish consume oxygen when it is transported across the gills by diffusion; this process relies on the difference in concentration of DO in the water versus in the fish.

DO levels in the Columbia Slough are high in summer because macrophytes and algae add ("pump") oxygen into the system. In fall and winter, the Slough does not meet standards for minimum DO levels. This is partly because the algae and macrophytes die off, decreasing the pump of oxygen. The die-off also increases biological oxygen demand (BOD), which is the amount of oxygen microorganisms need to break down organic waste. Increased BOD decreases the amount of DO remaining in the water. Harvesting algae and macrophytes in the fall could reduce BOD and increase DO levels.

Lead

Lead is the most soluble of the metals associated with urban pollution and has occasionally been found in water samples from the Columbia Slough. Dissolved lead is of concern because when consumed by humans, it can have adverse impacts on the body, including impacts to the nervous system and kidney damage. Water containing dissolved lead could be consumed during water contact recreation such as swimming or boating. Dissolved lead also has negative impacts on fish and wildlife.

Two standards for lead apply to the Columbia Slough: one for total lead and one for dissolved lead. The Environmental Protection Agency (EPA) recommends using dissolved lead because it is the most biologically available. The Columbia Slough usually meets the dissolved lead standard; less than one percent of samples do not meet the standard. The Slough sometimes does not meet the standard for total lead. Transportation is one of the largest contributors of lead because stormwater runoff from streets, parking lots, and driveways transports lead, along with other pollutants, to the Slough.

Toxic Compounds

Monitoring does not reveal toxic compounds (DDT/DDE, dieldrin, dioxin, PCBs) in the water column. Toxic compounds are found in sediments, however, and are discussed in Section E-2.

Total Suspended Solids (TSS)

Total suspended solids (TSS) —fine soil particles that are suspended in the water column—pose a water quality problem for multiple reasons:

- Organics (such as PCBs, dieldrin, DDT, DDE, and dioxin) and metals that are toxic to aquatic life bind to soil particles.
- Suspended solids cause turbidity and siltation that cause breathing problems in fish and limit the ability of macroinvertebrates to find food.
- Suspended solids reduce dissolved oxygen (microorganisms use oxygen to break down the organic matter associated with the soil) and decrease sunlight availability to aquatic life.

Although no standards have been established for TSS, DEQ has identified a benchmark for TSS discharge in stormwater to the Columbia Slough. The Lower and Upper Sloughs do not meet the TSS benchmark, while the Middle Slough usually does.

Sources of TSS include sediments transported in stormwater from streets, parking lots, driveways, agriculture runoff, and construction activities.

Table 7-2 summarizes water quality in the Upper, Middle, and Lower Sloughs.

Table 7-2
Water Quality in the Columbia Slough by Reach

	Upper Slough	Middle Slough	Lower Slough
Bacteria	In general, meets water quality standards.	Main arm has overall low levels. Whitaker Slough generally does not meet standards.	Main source (CSOs) virtually eliminated since winter 2000, but some recent water quality samples still do not meet standards.
Temperature	Does not meet the standard primarily during summer months.	Has moderate temperature compared with Upper and Lower Sloughs. Does not meet the standard primarily during summer months.	Warmer overall than Upper and Middle Sloughs. Does not meet the standard primarily during summer months.
pH	Does not meet the upper limit in spring and summer. Occasionally does not meet the lower limit in fall and winter.	Occasionally does not meet the upper limit in spring and summer. Occasionally does not meet the lower limit in fall and winter.	Consistently does not meet the upper limit in spring and summer. Occasionally does not meet the lower limit.
Dissolved oxygen (DO)	Does not meet standards in fall and winter.	Does not meet standards in fall and winter.	Does not meet standards in fall and winter.
Lead	Generally meets the standard for dissolved lead. Usually does not meet the standard for total load.	Generally meets the standard for dissolved lead. Occasionally does not meet the standard for total load.	Generally meets the standard for dissolved lead. Usually does not meet the standard for total load.
Total suspended solids (TSS)	Does not meet the benchmark.	Occasionally does not meet the benchmark.	Does not meet the benchmark.

E-2: Sediments

Sediments are soil particles, sand, clay, or other substances that settle to the bottom of a water body. They come from many sources, including natural weathering of rocks, erosion, stormwater runoff, and vegetative debris. Chemicals tend to attach to sediments. Synthetic chemicals (such as heavy metals and toxic organic compounds) are of particular concern because they may leave the sediment particles, dissolve in water, and are eventually accumulated by biological organisms. Over time, some of these chemicals move up the food chain from plants to insects to fish. In the process, they progressively increase in concentration in the tissues of the organisms, and may be harmful. Other chemicals, such as heavy metals, may have a more direct effect on the environment through their toxicity to benthic organisms.

A 1989 BES study indicated elevated levels of heavy metals and some toxic organic compounds in the Columbia Slough. Fish sampling in 1993 found high levels of PCBs and pesticides (such as DDT and dieldrin) in the fish tissues of five fish caught at one location near the St. Johns Landfill. This finding of toxic organic compounds in fish raised much concern about the people of immigrant communities who frequently fish from the Slough as subsistence anglers. In September 1993, the Oregon Health Division (now the Oregon Department of Human Services—Health Services) issued a health advisory about eating carp from the Slough.

The City of Portland and DEQ entered into a consent order agreement in late 1993 to conduct a remedial investigation and feasibility study (RI/FS) of sediment contamination along 31 miles of the Columbia Slough waterway, including all connected side channels. The RI/FS identified 34 sites (called Priority A and B sites) that required additional in-depth investigation. It also found that fish caught in the Columbia Slough contain chemicals that pose cancer risks to humans that eat them. The primary chemicals of concern are PCBs and chlorinated pesticides.

Additional studies were conducted on the Priority A and B sites in the Middle and Upper Slough to identify the nature and extent of sediment contamination and consider cleanup methods.

BES is currently in negotiations with DEQ about next steps. Studies have shown that the most cost-effective way to deal with the contaminated sediments is to leave them in place and let them degrade naturally over time, while preventing further contamination. As a result, the City's discussions with DEQ have shifted emphasis from strictly cleanup to pollution source control and watershed health actions.

Section F: BIOLOGICAL COMMUNITIES

Predevelopment species in the Willamette Valley region included 54 mammal species, 24 reptile and amphibian species, 25 to 30 fish species, and over 150 breeding bird species. Most of these species still exist as breeding species in the Willamette Valley today, except for the grizzly bear, gray wolf, California condor, Lewis's woodpecker, yellow-billed cuckoo, and black-crowned night heron. Although habitats have been negatively impacted and wildlife numbers have decreased, the biodiversity in the Columbia Slough Watershed is unique and valuable and warrants continued preservation and restoration.

F-1: Fish

A 1988 survey of the mainstem portions of the Lower, Middle, and Upper Sloughs recorded 17 game fish species (e.g., bass, crappie, bluegill, and salmon) and non-game species (e.g., stickleback, sculpin, and sucker). The study found that limited habitat exists for salmonids because of stream bottom structure, slow flows, elevated water temperatures, pollutant levels, minimal large wood and protective cover, and impeded fish passage. Salmonid use is confined to the tidally influenced Lower Slough because the levee at NE 18th Avenue is a barrier to upstream passage.

Recent surveys by the City of Portland Endangered Species Program and Ducks Unlimited found a total of 26 species in the Lower Slough, and that rearing juvenile chinook and coho salmon use the Lower Slough in fall, winter, and spring. Summer surveys in 2003 did not reveal the presence of salmonids. Spawning has not been documented and is unlikely because of a lack of suitable spawning habitat. In addition to juvenile chinook, coho, and unidentified salmonids, the survey found an additional 17 species of fish, shrimp, and crawfish. These surveys have shown that the area from the mouth of the Columbia Slough to Simpson Cove (river mile 6.5) in the Lower Slough provides prime off-channel refuge habitat for salmonids. It represents one of the last remaining areas of its kind near the confluence of the Columbia and Willamette Rivers.

Fairview Creek and Osborn Creek in the upper watershed contain the last known remaining populations of resident cutthroat trout in the watershed. These streams have greater elevation change than the Slough and provide more suitable habitat in the form of riffles and pools for cutthroat trout. These areas should be restored and protected.

As the watershed continues to develop, impervious surfaces, stormwater runoff, and the pollutants carried in runoff will continue to negatively impact the Slough system and degrade instream habitat for salmonids. Eliminating sources of pollution and/or treating stormwater will help alleviate this problem. Additionally, enhancing instream complexity with large wood, channel meanders, emergent wetland benches, and enhanced off-channel habitat will provide higher-quality habitat for juvenile salmonids using the Lower Slough as refuge.

F-2: Benthic Macroinvertebrates

A review of Columbia Slough macroinvertebrate surveys since 1989 shows that the highest diversity of macroinvertebrates is found in association with aquatic vegetation, such as elodea and coontail, that inhabits the Slough. Fewer macroinvertebrates are found in the benthic environment because it tends to be very light and unconsolidated, contains some toxic pollutants from historic discharges, and can have very low DO levels.

F-3: Wildlife

The Columbia Slough Watershed serves as a travel corridor along the Lower Columbia River, as well as along the Pacific Flyway and other migratory bird pathways. More than a dozen species of ducks, geese, and swans winter in the area, and neo-tropical migrant shorebirds and songbirds stop over in spring and fall and nest in summer. Several great blue heron rookeries are present in black cottonwood groves along the Slough. In 2003, a bald eagle pair began nesting in the watershed. In 2002, it was estimated that the watershed hosted over 160 migratory, breeding, and wintering species of birds throughout the year.

The mainstem and secondary channels and lakes are home to American beaver, muskrat, northern river otter, and non-native nutria. Several amphibian species, painted turtles, and western pond turtles inhabit the mainstem and secondary channels.

Coyote, black-tailed deer, and red fox live in the upland and riparian habitats.
Invasive wildlife species in the watershed include the house sparrow, European starling, rock pigeon, nutria, and bullfrogs.

CHAPTER 8
Lower Columbia River Watershed

INTRODUCTION

In this report, the Lower Columbia River Watershed refers to the section of the Columbia River that is within the City of Portland and the land area that drains directly to the Columbia River. Because the bulk of the Columbia River's bank in Portland is a levee managed by the U.S. Army Corps of Engineers, the City of Portland has put a higher priority on developing information and analyses for the other watersheds in the City. This chapter provides a brief overview of existing conditions. The City intends to do more research and evaluation in conjunction with future watershed plan updates .

Section A: OVERVIEW

Land uses within the Lower Columbia River Watershed are urban/industrial, residential, and rural/agricultural. Many of the region's heaviest industrial users are present in the Lower Columbia Watershed. Land uses upstream of Portland include timber production, grazing, irrigated and dryland agricultural, and a variety of urban uses.

The Lower Columbia River Watershed has been heavily urbanized and industrialized in the vicinity of Portland for decades and has had many problems from both point source and non-point source pollution. The south bank of the Columbia River in Portland is moderately urbanized. The banks are a mixture of steep natural cobble, sandbanks, and riprap. Riparian vegetation is generally sparse to absent and consists mostly of invasive plants and shrubs.

Hayden Island is located in the Columbia River. The eastern half of the island has commercial and high-density residential land uses. The western half is currently undeveloped and provides excellent habitat in many areas, although some wetlands are highly disturbed. West Hayden Island is within Multnomah County, but Portland plans to annex this portion of the island, where the Port of Portland will develop shipping terminals.

Section B: HYDROLOGY

The Columbia River Basin's storage reservoir/hydropower system has altered the river's natural flow regime, which has affected water temperature and river/floodplain interactions. Seasonal patterns of flow have been markedly changed by development: winter flood flows have been reduced and summer low flows have been increased. Portland-area urban activities have had local-scale impacts on flow; bank alterations and floodplain development preclude flow access to the historic floodplain.

Section C: HABITAT

Significant dredging, diking, and channelization of the mainstem Columbia has occurred in the Portland area, narrowing and deepening the mainstem. Off-channel habitat (side channels, oxbow lakes, and marshes) has been diked, filled, and eliminated in a large portion of the metropolitan area. The river's steep, riprapped shorelines have reduced expansion of riparian areas, decreased the deposit of large wood into the river through natural processes, and minimized the interaction between the river and riparian and floodplain vegetation. Large tracts of riparian vegetation have been cleared, and remaining habitat has been simplified. Silt and sand dominate the river bottom.

Section D: WATER QUALITY

The Oregon Department of Environmental Quality (DEQ) has placed the Columbia River on the state's 303(d) list. The 303(d) list identifies water bodies that are "water quality limited" because they do not meet water quality standards for certain parameters. The Columbia River does not meet standards for temperature, arsenic, PAHs (polycyclic aromatic hydrocarbons), DDE, and PCBs (polychlorinated biphenyls). DDE and PCBs are found in fish tissue; the other parameters are found in the water column.

DEQ establishes total maximum daily loads (TMDLs) for 303(d) listed parameters. TMDLs identify the "assimilative capacity," which is the maximum amount of the parameter the water body can assimilate without violating the water quality standard. DEQ has established TMDLs for dioxin and total dissolved gas for the Columbia River.

Section E: BIOLOGICAL COMMUNITIES

The biological communities of the Columbia River are greatly reduced from historical conditions. Many native species of fish and aquatic insects have gone extinct (e.g. yellow-billed cuckoo, California condor), and many introduced species currently compete with native species for food and habitat. Salmon populations locally and upstream have been greatly reduced from historical numbers. Salmon hatcheries also have affected native fish populations. Species such as river otters and bald eagles have suffered negative effects from toxic compounds in the river's food chain.

Appendix O
Inventory of Existing Programs and Activities in the Lower Willamette Subbasin*

Within the Lower Willamette Subbasin area, there are many programs and activities related to protecting and improving watershed health. These programs serve a variety of functions and encompass public and private partnerships, inventories, manuals, regulations, and individual projects for the subbasin's land, streams, and Willamette River reaches.

This appendix summarizes existing programs and activities which currently, or could potentially, help to achieve subbasin biological health objectives. The existing programs and activities are presented below in six categories:

- Fish and Wildlife Habitat Protection and Restoration Activities
- Watershed and River Corridor Planning and Assessment Activities
- Natural Resources and Land Management Activities
- Stormwater and Wastewater Management Activities
- Vegetation and Landscape Management Activities
- Coordination, Review, and Outreach Activities

The general purpose and background of each program or activity is summarized. The programs and activities are then related to the various limiting factors or working hypotheses. Finally, the programs and activities are then evaluated for management gaps between actions needed and actions taken to achieve the working hypotheses.

Summary Descriptions of Existing Programs and Activities

Fish and Wildlife Habitat Protection and Restoration Activities

Willamette Restoration Initiative (WRI). Established by the governor of Oregon in response to recommendations from the Governor's Willamette River Task Force, the WRI is an ongoing project that seeks to coordinate a unified regional approach to managing watershed health within the Willamette Basin. Through the WRI, the Willamette Restoration Strategy was developed for improving fish and wildlife habitat, and enhancing water quality and managing floodplains in the Willamette Basin, within the context of human habitation and projected population growth. The Willamette Restoration Strategy was developed by a diverse stakeholder advisory group, and offers four key recommendations and 27 critical actions that are necessary to restore the health of the Willamette Basin. WRI developed the Willamette Subbasin Summary (2001) as part of the Northwest Power Planning Council's (NPPC) subbasin planning initiative. The Willamette Subbasin Summary provides a detailed description of the watershed (geomorphology, climate, hydrology, land use, etc.), a comprehensive assessment of fish and wildlife resources, a review of existing and past efforts to improve watershed health, a summary of the current management, and recommended projects to improve watershed health.

Oregon Plan for Salmon and Watersheds Implementation Team (Governor's Office). Governor John Kitzhaber unveiled his Oregon Plan for coastal salmon recovery in August 1996. This plan and a subsequent steelhead supplement and Executive Order in January 1999 committed state agencies to enforce environmental laws, coordinate activities for protecting listed salmonids, and provide technical assistance to local conservation activities. The plan's stated goal is "to restore salmon to a level at which they can once again be part of people's lives." The Oregon Plan identified how private interests could work through local watershed councils, identified restoration activities on forestlands to be completed by forest industries, and identified water quality planning opportunities at a basin level. The City of Portland, which is a member of the Oregon Plan Implementation Team, is committed to embracing the goals and approaches in the Oregon Plan.

Oregon Restoration and Enhancement Program (Oregon Department of Fish and Wildlife). The Oregon Fisheries Restoration and Enhancement Act of 1989 allows the Department of Fish and Wildlife to undertake a comprehensive program to restore state-owned fish hatcheries, enhance natural fish production, expand hatchery production, and provide additional public access to fishing waters. Any public or private non-profit organization may request funds to implement a wide range of fish restoration or enhancement projects. The enhancement program focuses on projects to increase fish production (either hatchery or natural production), increase recreational or commercial opportunities or access to the fish resources, or improve fish management capabilities.

Endangered Species Act (ESA) Program (City of Portland Bureau of Planning). The City of Portland ESA Program was established in 1998 in response to federal listings of several salmon species. The ESA Program provides technical assistance to all City bureaus to assure actions and programs are in compliance with requirements of ESA. The ESA Program has assisted in the completion of watershed assessments for Johnson, Tryon/Fanno, and Willamette watersheds, and in the development and selection of natural resource protection, restoration and mitigation actions within these watersheds. Partnerships have been developed with the National Marine Fisheries Service, US Fish and Wildlife Service, Corps of Engineers, Oregon Department of Fish and Wildlife, and Division of State Lands and others. The program's aim is to go beyond the minimum standards set by the ESA (that is, to avoid take) to help the City of Portland achieve its goal of assisting with the recovery of native fish and wildlife. In addition, the program acts to empower, engage and motivate the community and City government to act strategically and proactively so that the greatest overall community, economic and environmental benefits are achieved.

Willamette River Habitat Restoration and Enhancement Projects (City of Portland Bureau of Environmental Services). The City of Portland is working to improve fish and wildlife habitats in the urban area. These projects include, for example, improving fish access to off-channel habitat at Oaks Bottom and Smith and Bybee lakes for resting and rearing of juvenile fish migrating in both the Willamette and Columbia rivers. The City of Portland is restoring portions of the Willamette River streambank as part of the redevelopment of the South Waterfront District and is implementing a number of revegetation projects along with Willamette. Bioengineered bank treatments have been incorporated into a variety of riverfront parks and redevelopment, including the East Bank Esplanade, the Riverplace Development and South Waterfront Park.

Water Resources Development Act (WRDA) Project (U.S. Army Corps of Engineers, City of Portland). The City is the local sponsor of the U.S. Army Corps of Engineers (Corps) Lower Willamette River Ecosystem Restoration WRDA project to help formulate and implement restoration projects that will meet the City's River Renaissance's "Clean and Healthy River" vision. The objective of the feasibility study is to develop a publicly-supported plan for ecosystem restoration actions throughout the Lower Willamette River. This project is intended to leverage federal funds to assist in riparian and in-water habitat restoration. Phase 1, expected to last about 6 months, will focus primarily on developing evaluation criteria and selecting restoration opportunities on the Willamette mainstem within the City of Portland boundaries. Phase 2 will include an evaluation of the feasibility of the selected restoration projects. Additional restoration projects outside of the City boundaries on the mainstem and projects on the tributaries to the Lower Willamette also may be considered in Phase 2.

Lower Willamette River Fish Research (City of Portland ESA Program, Oregon Department of Fish and Wildlife). The City's Endangered Species Act Program partnered with the Oregon Department of Fish and Wildlife in 2000 to conduct a 4-year study in the lower Willamette River to evaluate the habitat functions that bank treatments and near-shore developments provide for salmonids. Information is being collected on the types of bank treatments and near-shore developments that are preferred, how they are distributed in the lower Willamette, and the specific features that distinguish them from other areas. The results will provide the City of Portland with information that will be useful when more certainty is desired regarding planning, permitting and enforcement actions. The work also will help define properly functioning conditions in this reach of the river. The City also is working with the Oregon Department of Fish and Wildlife, Ducks Unlimited and others to conduct fish research in the area's tributary streams. All of Portland's watersheds are being sampled seasonally to determine when fish are present.

Johnson Creek Restoration Plan (City of Portland Bureau of Environmental Services). The City of Portland and the Johnson Creek Watershed Council developed a plan to restore habitat, improve flows and reduce flooding in Johnson Creek. The plan, which is aimed at managing floods, includes more than 60 activities that will restore corridor function. An action plan that is based in part on City analyses will help inform City and private protection and restoration priorities.

Assessment of City of Portland Activities for Potential to Affect Steelhead (City of Portland). The City of Portland commissioned this assessment in 1998 to determine whether City activities have the potential to affect steelhead and steelhead habitat. Activities assessed include planning, permitting, inspection and enforcement; water delivery; stormwater and wastewater management; structure and road construction and maintenance; environmental enhancement; and emergency response. The assessment also evaluated Endangered Species Act compliance approaches and potential conservation strategies for Portland-area watercourses used by steelhead and other salmonids.

ESA Section 7 Streamlining Agreement (City of Portland ESA Program). In October 2002, the City entered into a federal ESA Section 7 streamlining agreement with the National Marine Fisheries Service in the National Oceanic and Atmospheric Administration (NOAA Fisheries), the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service (USFWS). This agreement establishes a cooperative process for streamlining ESA Section 7 consultations among the four parties to the agreement for City projects that require federal permit approval or funding. Benefits of the agreement include increased coordination for review, analysis and documentation of City projects, programs and activities so that they proceed in a timely manner while meeting federal agency and City goals for ensuring ESA compliance and assisting in the conservation of listed species.

Fish-Friendly Maintenance Practices Manual (City of Portland Bureau of Environmental Services, City of Portland ESA Program). The City of Portland's Maintenance Bureau, in conjunction with the Endangered Species Act Program, developed a manual of fish-friendly maintenance practices. The manual was the basis for a City application to NOAA Fisheries for an ESA Section 4(d) take limitation program, to help ensure that City road maintenance activities do not harm listed species.

Salmon Safe Certification for Portland Parks (City of Portland Bureau of Parks and Recreation). The City is working with the independent, third-party environmental certification organization called Salmon Safe to seek certification of City parks management as "fish-friendly". Certification criteria have been developed and are being applied to a variety of Portland parks. Improvements in park management identified through the certification process will be addressed on an ongoing basis. Portland is the first city to undergo a third-party certification of its parks.

Watershed and River Corridor Planning and Assessment Activities

Total Maximum Daily Load (TMDL) Development (Oregon Department of Environmental Quality). The state is required by the Federal Clean Water Act (Section 303(d)) to periodically publish a list of water quality limited streams and rivers. The current 303(d) list includes Johnson Creek, Tryon Creek, Fanno Creek, the Columbia Slough, and the Willamette River. Inclusion on the 303(d) list is the first step in setting Total Maximum Daily Loads (TMDLs) that limit the amount of pollutants that can be discharged to the waterway. EPA has approved TMDLs for Fanno Creek and the Columbia Slough. DEQ must develop draft TMDLs for Johnson Creek, Tryon Creek, and the Willamette River by the end of 2003. Bacteria, mercury, and temperature are being modeled and analyzed in preparation for allocation, TMDL setting, Water Quality Management Plan development, and public review. The City of Portland is developing comprehensive watershed plans for these basins to meet TMDLs and other regulatory requirements.

Watershed Restoration Projects and Watershed Councils Support (Oregon Watershed Enhancement Board). OWEB administers State Lottery proceeds to fund watershed restoration projects and support watershed councils. OWEB will collaborate with the federal government as it implements its mission to promote and implement programs to restore, maintain, and enhance watersheds in Oregon, and to protect the economic and social well-being of the state and its citizens. OWEB considers grant applications for watershed restoration, enhancement, assessment, monitoring, education, outreach, land acquisition, watershed council support, technical assistance, and a new small grants program.

River Renaissance (City of Portland Bureau of Planning). River Renaissance is a partnership of City bureaus and agencies working toward the revitalization of the Willamette River. This comprehensive and integrative approach is intended to align City efforts, build strong public and private partners, leverage resources for implementation, and involve the public in a long term strategy for river management. It recognizes that the City needs to involve many partners in order to make the vision a reality, and that this will take time. The River Renaissance vision is a "call to action" to (1) assure a clean and healthy river, (2) maintain and enhance our prosperous working harbor, (3) embrace the river as Portland's front yard, (4) create vibrant waterfront districts and neighborhoods, and (5) promote partnerships, leadership, and education.

Watershed Planning and Analysis (City of Portland Bureau of Environmental Services). The City performs watershed planning and analysis for Portland's urban watersheds, including the Columbia Slough, Fanno, Tryon, and Johnson Creeks, and the Willamette River. The watershed planning process includes formulation of watershed health goals and objectives, assessment and characterization of watershed conditions, and identification of recommended actions. Each Planning Group coordinates closely with other City programs to integrate regulatory compliance, Clean River Plan, and River Renaissance goals into the watershed planning process. Watershed plans provide a comprehensive approach to address multiple objectives including: water quality and in-stream flow improvement, fish and wildlife habitat enhancement, protection of public health and responding to environmental regulations. Actions may include implementation measures such as restoration projects or administrative approaches such as policy and code changes and the integration of watershed protection and restoration efforts into other City programs.

Willamette River Greenway Plan (City of Portland Bureau of Planning). The Bureau of Planning is updating the Willamette River Greenway Plan, last revised in 1987, to better address new environmental mandates and improve implementation strategies, including zoning code. This multi-objective plan will help implement Portland's River Renaissance Plan and Statewide Planning Goal 15 objectives. Goal 15's purpose is to protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of lands along Portland's rivers.

Healthy Portland Streams Project (City of Portland Bureau of Planning). The Healthy Portland Streams project is an important part of the City's comprehensive River Renaissance effort. This project is designed to update the City's policies, natural resources inventories and tools for protecting wildlife habitat, streams and the streamside functions of Johnson, Tryon and Fanno creeks, the Columbia Slough and the West Hills watersheds. Through the project, the City is evaluating and recommending both voluntary and regulatory measures, including changes to Portland's Comprehensive Plan goals, policies and codes. The project is intended to help protect existing high-quality natural resources, prevent erosion, landslides, and water quality degradation, manage floods, and conserve natural spaces for wildlife, fish, and people to enjoy. The project also will advance the City's compliance with the ESA, the CWA and Title 3 of Metro's *Urban Growth Management Function Plan.*

Clean River Plan (City of Portland Bureau of Environmental Services). The Clean River Plan serves as an over-arching, guiding document for all of the programs and responsibilities of BES. The Plan sets forth a comprehensive approach to catching and treating stormwater before it enters the sewer system or reaches a receiving stream. The Clean River Plan was designed as a major supplement to the Combined Sewer Overflow (CSO) Abatement Program to more effectively and efficiently address sewer overflows and bacterial pollution, as well as overall watershed health and stewardship. It uses a variety of innovative techniques to reduce stormwater runoff, reduce pollutant levels, restore floodplains, and foster environmental education, and stewardship. Of the ten actions offered by the Clean River Plan, eight specifically address stormwater impacts on watershed health, and the other two focus on sewer system improvements to protect receiving waters.

Portland Harbor Superfund Program (U.S. Environmental Protection Agency, Oregon Department of Environmental Quality, Lower Willamette Group). The Portland Harbor Superfund Site is a heavily industrialized stretch of the Lower Willamette River from Swan Island to the southern tip of Sauvie Island. Contaminants found in sediments included metals, pesticides, herbicides, PCBs and petroleum products. EPA is responsible for cleanup decisions. EPA and DEQ have entered into an agreement, with EPA taking the lead for river work and DEQ taking the lead for upland cleanup and controlling sources of contamination to river sediments. Determination of responsible parties, identification of sources, characterization of contaminant distribution and impacts, and evaluation of clean-up options are currently underway. Also as part of Superfund, the federal and state natural resource agencies and Tribes will determine natural resource damages (NRD). A NRD claim seeks compensation for losses to the public resulting from the injury to publicly-owned or managed resources. The Lower Willamette Group (LWG), a subset of businesses and public agencies (including the City of Portland) that may have responsibility for contamination in the site, is working with EPA and DEQ to conduct the investigation of the Harbor.

Upper Tryon Creek Corridor Assessment (City of Portland Bureau of Environmental Services). The Bureau of Environmental Services completed the Upper Tryon Creek Corridor Assessment in 1998 as part of the City's Public Facilities Plan. The corridor assessment analyzes stream corridors in Upper Tryon Creek Watershed and identifies high-priority areas for restorations. The report also contains an assessment of the hydrologic and hydraulic conditions in the watershed. Some actions recommended in this report have been implemented. This report also provided critical technical support to the Planning Bureau's Southwest Community Plan project.

Natural Resources and Land Management Activities

Metro Title 3 Project (Metro). The goal of this project is to identify strategies for managing corridors in the Portland Metro region to protect fish and wildlife habitat. Title 3 of Metro's *Urban Growth Management Functional Plan* regulations focus on water quality and flood management standards. Title 3, Section 5, identifies the need to protect regional resources for fish and wildlife. Metro, with some input from the City of Portland, is developing a regional program to conserve, protect, and restore fish and wildlife habitat.

Metro Natural Resources <u>Planning</u> (Metro). Metro's Natural Resource Planning Division works to create regional policy directives for the conservation and enhancement of parks, natural areas, water quality, and fish and wildlife habitat. The 2040 Growth Concept explains the planning policies adopted in 1995 that will allow the metropolitan area to manage growth, make improvements to facilities and infrastructure, and protect natural resources. The Urban Growth Management Functional Plan was adopted by the Metro Council in 1996 to help the region meet goals in the 2040 Growth Concept. The Fish and Wildlife Habitat Protection Plan provides ways to develop an effective, fair and efficient approach to protecting fish and wildlife. The Water Quality and Floodplain Protection Plan provides region-wide protection measures for water quality and floodplain management. The Greenspaces Master Plan update identifies a cooperative regional system of parks, natural areas, greenways and trails. The 1995 Greenspace bond measure marked a major first step. It provided $135.6 million to purchase 8,000 acres of ecologically significant habitat and trail linkages throughout the region. The Livable Streets Program explains how street systems can be designed to reduce stormwater runoff and impacts from stream crossings.

Open Spaces Acquisition Program (Metro). Metro's Natural Resource Planning Division purchases natural areas, trails and greenways to be held for future use as parks, trails, and fish and wildlife habitat. Metro is acquiring property in 14 regional natural areas and six regional trails and greenway projects. In addition, a "local share" portion of the bond monies is funding more than 100 local park projects, located in almost every city, county and park district in the region. As of March 3, 2003, Metro has acquired more than 7,880 acres of land for regional natural areas and regional trails and greenways, in 243 separate property transactions. These properties protect more than 62 miles of stream and river frontage.

Preservation and Restoration of Natural Areas (City of Portland Bureau of Environmental Services, City of Portland Bureau of Planning). The protection of natural areas is important in helping the City meet its goals regarding benefits to both wildlife and aquatic organisms. The City has proposed an expansion of its environmental overlay zone designations. Environmental overlay zones are elements within the zoning code that protect waterways and upland natural resource areas and prevent, limit or require certain design standards for development in their vicinity. The City also has purchased properties during the last few years—including riparian areas—for purposes of flood storage, natural parks and resource protection and restoration.

Columbia and Willamette River Natural Resource Inventories (City of Portland Bureau of Environmental Services). Preliminary habitat inventories for both the Willamette and Columbia rivers have been completed. The inventories identified data gaps that the City of Portland is now attempting to fill and were instrumental in the development of high-priority protection and restoration actions.

Natural Resources Inventories and Management Plans (City of Portland Bureau of Environmental Services). The City has compiled and adopted eight natural resources inventories and management plans, including for the Johnson Creek Basin, Columbia Corridor, Balch Creek, Northwest Hills, Southwest Hills, East Buttes, Fanno Creek and tributaries Protection Plan, Skyline West, and Forest Park. These plans provide a regulatory overlay that helps ensure protection of important natural features and functions. The plans provide a legislative mechanism for adopting changes to the City's natural resource policies.

Natural Resource Program (City of Portland Bureau of Parks And Recreation). Created in 1988, the Natural Resource (NR) Program manages over 7,000 acres of natural areas and trails across 30 sites, as well as management of approximately 35 miles of the 40 Mile Loop and the Willamette Greenway Recreational Trail System, and management of 183 acre Hoyt Arboretum. The Program's mission is to protect and restore natural resource values in Portland parks, and contribute to the natural resource quality of a larger, connected system of greenspaces. The Program plans to design and implement a science-based Ecosystem Management Program to manage natural area sites as interrelated systems rather than as separate sites, and to involve the community in the protection and management of natural area sites and natural resource systems.

Ross Island Lands Transfer (City of Portland, Ross Island Sand & Gravel Company). Ross Island Sand and Gravel and the City are negotiating the transfer of Ross Island to the City. The island presents a tremendous opportunity for habitat restoration and long-term research on the costs and benefits of various restoration measures.

Johnson Creek Culvert Replacements (Cities of Portland, Gresham, and Milwaukie; Multnomah County; Clackamas County). The Cities of Portland, Gresham, and Milwaukie are working with Multnomah County and Clackamas County to coordinate the replacement of culverts throughout the Johnson Creek watershed. The jurisdictions are developing a unified prioritization scheme to identify the culvert replacements that provide the maximum benefit for salmonids. The City of Portland also worked with Metro and state and federal resource agencies to remove a culvert that blocks access to high-quality steelhead habitat in Kelly Creek, a tributary to Johnson Creek, and is working with the U.S. Army Corps of Engineers to remove culverts in Crystal Springs, a tributary to Johnson Creek.

Transportation System Planning (City of Portland Department of Transportation). The Planning Program's major responsibilities are the Transportation System Plan (TSP), major regional transportation planning projects and the development of transportation capital projects in Portland. Plans include recommendations for transportation and design improvements, and establish a blueprint for public and private development. Chapter 3 of the TSP describes Portland's 20-year list of major transportation system improvements, including general location and timing, responsible agency, and approximate cost. These projects include streetscape improvements, which may provide opportunities to improve watershed health.

Stormwater and Wastewater Management Activities

National Pollution Discharge Elimination System (NPDES) Stormwater Permits (City of Portland, Port of Portland, and Multnomah County). The City of Portland, Port of Portland, and Multnomah County are co-permittees of an NPDES (National Pollution Discharge Elimination System) Municipal Stormwater Permit. The NPDES permit and annual reports describe activities undertaken by the co-permittees that consist of stormwater management programs to reduce pollutant discharges "to the maximum extent practicable" from their respective municipal stormwater systems. The permit was first issued in September 1995. In February 2000, the copermittees submitted an NPDES permit renewal to DEQ. The application is still under review by DEQ, to be followed by a 30-day public comment period. While the review continues, the City and its co-permittees are working under an administrative extension of the existing permit and implementing revised BMPs identified in the February 2000 submittal.

Combined Sewer Overflow (CSO) Abatement Program (City of Portland Bureau of Environmental Services). Portland has passed the halfway mark of a 20-year program to reduce combined sewer overflows (CSOs) to the Columbia Slough and Willamette River. The CSO Program involves 100 individual projects including the construction of storm-water separation systems, constructed wetlands, wet-weather treatment plants, and infiltration sumps for storm-water disposal, and large-diameter interceptor pipelines and tunnels. The Columbia Boulevard Wastewater Treatment Plant will be expanded with more treatment capacity and new odor control facilities to handle the additional volume of CSOs. An important step in reducing CSOs is getting stormwater out of the combined sewers. Installing street sumps, disconnecting residential downspouts, diverting underground streams, and building separate sewers for stormwater are all strategies the City is using to reduce the amount of stormwater that contributes to CSOs.

Stormwater Management Manual (City of Portland Bureau of Environmental Services). Stormwater management is a key element in maintaining and enhancing environmental conditions within Portland. The City of Portland has developed a comprehensive stormwater management manual to provide design professionals with specific requirements for reducing the impacts of stormwater runoff and pollution resulting from new development and redevelopment within Portland. The manual's requirements apply to all development, whether public or private. The City and NOAA Fisheries are working together to develop an ESA Section 4(d) take limitation proposal based on the *Stormwater Management Manual* (City of Portland 2000).

Structural Controls (City of Portland Bureau of Environmental Services). The City has created or retrofitted a number of stormwater management facilities to reduce stormwater quantity and improve the quality of stormwater runoff. The City offers incentives and assistance for projects that control stormwater runoff from commercial and industrial properties. This includes disconnection of downspouts, replacement of pavement with porous materials and the use of vegetated swales, planters or other landscape features that assist stormwater management.

Sustainable Stormwater Program (City of Portland Bureau of Environmental Services). The City is implementing this program to promote innovative strategies and techniques for an integrated, ecosystem-based approach to development and stormwater management. The goal of the program is to affect and change stormwater management and site development practices on the ground. Elements of the program include education and outreach, policy development, technical assistance, demonstration projects and incentive funding. The program promotes sustainable onsite stormwater management measures such as eco-roofs, infiltration planters, street and parking lot vegetated swales and other natural system based approaches. These projects assist the City in reducing the volume of stormwater entering the combined system and filtering out stormwater pollutants.

Industrial Stormwater Program (City of Portland Bureau of Environmental Services). The Industrial Stormwater Program addresses discharges to the City's sanitary and storm sewer systems from industrial and commercial properties. The City administers industrial stormwater permits for those facilities that are located within the City of Portland. These permits require development of a Stormwater Pollution Control Plan (SWPCP) and twice yearly monitoring of stormwater runoff from the facility. The SWPCP must identify Best Management Practices (BMPs) to minimize the amount of pollutants in the stormwater runoff. The City reviews the SWPCPs and inspects facilities Stormwater Inspection Forms to ensure compliance with the plan and permit conditions. The Program also evaluates non-stormwater discharges to the storm sewer system, including uncontaminated pumped ground water, non-contact cooling water, and illicit discharges, among others.

Environmental Systems Program (City of Portland Bureau of Maintenance, City of Portland Bureau of Environmental Services). This program is charged with maintaining the surface storm drainage system within the City of Portland. The Clean Water Act of 1972 established the City's responsibility for the quality of the outflow from the City's sewer and drainage systems. In order to comply with the regulations and guidelines set forth by a variety of federal, state and local agencies, a comprehensive program to manage the storm water drainage system and roadside vegetation has been developed. The program is responsible for cleaning and inspecting the sewer system, repairing and reconstructing damaged, broken or deteriorated sewers, maintenance of drainages and ditches, and conversion of roadside ditches into infiltration shoulders.

Stormwater Advisory Committee (City of Portland, Bureau of Environmental Services). The current Stormwater Advisory Committee (SAC) was appointed in September 2000 to guide City compliance with federal clean water regulations. SAC's three major advisory topic areas are new development/redevelopment (implementation and evaluation of the City's Stormwater Management Manual, or SWMM), existing development, and transportation-related development.

Wastewater Treatment Plants (City of Portland Bureau of Environmental Services). The Columbia Boulevard Wastewater Treatment Plant operates every day, around the clock. Dozens of pump stations and hundreds of miles of sewer lines are part of the system that brings wastewater to the facility. The Tryon Creek Wastewater Treatment Plant, a second wastewater treatment plant south of Portland, is also monitored at the Columbia Boulevard facility. The Columbia Boulevard Plant has a two-phase treatment process. After disinfection, the water flows into the Columbia River. Biosolids are used as a soil supplement on dry pasture land.

Illicit Discharge Control Program (City of Portland Bureau of Environmental Services). The City of Portland has developed an illicit discharge elimination program to prevent, search for, detect and control illicit discharges to the City's stormwater systems and surface waters. The program includes identification and tracking of public and private outfalls, verification of commercial and industrial connections to the City storm system, monitoring to detect non-permitted discharges and evaluation of non-stormwater discharges to the storm system. The City also maintains a Spill Protection and Citizen Response (SPCR) Team to reduce the frequency and impact of spills and inappropriate discharges to the combined sewer system and the storm system.

Industrial Pretreatment Program (City of Portland Bureau of Environmental Services). The Industrial Pretreatment Program manages industrial discharges to the sanitary sewer system by identifying and regulating sources of water pollution from discharges of point sources (outfalls) and non-point sources (street run-off). Pretreatment reduces the amount of pollutants and neutralizes wastewater to meet federal and local discharge requirements. Permits are issued to industries based on their wastewater characteristics or amount of discharge. The permits require industries to monitor for pollutants of concern and to comply with reporting schedules, along with general conditions listed in the permit. any industrial/commercial activity with spill potential is required to prepare Accidental Spill Prevention Plans (ASPPs).

Spill Protection and Citizen Response Section (City of Portland Fire Bureau, City of Portland Bureau of Environmental Services). The City of Portland Fire Bureau Hazardous Materials Response Team is a certified Oregon State Regional Hazardous Materials Response Team. BES maintains regular communication with the Fire Bureau regarding hazardous materials procedures and techniques that may have an impact on water quality. BES also maintains a 24 hour Spill Response "Duty Desk" to receive spill reports. The City responds in particular to spills that threatens the City's storm or sanitary sewer systems. In the case of spills from auto accidents and small spills of gasoline, oil, diesel, and similar pollutants the Bureau of Maintenance will respond to clean up the spill. Containment or other controls may be imposed if appropriate.

Underground Injection Control (UIC) Program (Oregon Department of Environmental Quality, City of Portland Bureau of Environmental Services). The Oregon Department of Environmental Quality (DEQ) UIC program manages injection of fluids into the ground in order to protect groundwater for beneficial uses such as drinking water. The City of Portland Bureau of Environmental Services uses an Underground Injection System to dispose of stormwater below the surface of the ground in east Portland. The City submitted a system wide assessment that included an estimation of land use and activities in areas drained by sumps, evaluation of groundwater elevations across the city, and BMPs for source control and operations and maintenance. The City is currently seeking a final permit from DEQ to operate the UICs.

Vegetation and Landscape Management Activities

Erosion Control Program (City of Portland Bureau of Environmental Services, City of Portland Bureau of Maintenance). In response to ESA listings, the City assembled a citywide team to expand and improve on the City's erosion control program, which works to reduce erosion and its impacts on fish and their habitat. This effort produced new erosion control regulations as well as an erosion control manual. The manual provides guidelines that require all sites of ground disturbance to comply with a "no visible or measurable" sediment discharge standard. There also are enhanced controls for large, sloped and sensitive development sites. Erosion, sediment and pollutant control plans are required for all sites needing a City permit.

Integrated Pest Management Program (City of Portland Bureau of Parks and Recreation). Portions of Portland Parks and Recreation's Integrated Pest Management Program have been acknowledged by NOAA Fisheries as protective of listed salmon under ESA Section 4(d). Other City bureaus also follow the program to ensure effective and environmentally sound pest management. The City is working with NOAA Fisheries and a variety of environmental and other organizations to continue its ongoing efforts to refine, improve and expand its integrated pest management practices.

Watershed Revegetation Program (City of Portland Bureau of Environmental Services, City of Portland Bureau of Parks and Recreation). Through the Watershed Revegetation Program, the City is working to restore native habitat and improve water quality throughout Portland area watersheds. Partnerships are formed with public and private landowners to restore degraded stream bank, wetland, and upland areas. This restoration work improves water quality by controlling erosion, reducing stormwater pollution, aiding in long-term salmon recovery, and enhancing wildlife habitat. The Program is currently working the Parks Bureau to improve fish and wildlife habitats in the urban area. Example projects include improving fish access to offchannel habitat at Oaks Bottom and Smith and Bybee Lakes for resting and rearing of juvenile fish migrating in both the Willamette and Columbia Rivers. The City is restoring portions of the stream bank along Willamette Park and is participating in the updating of a comprehensive restoration plan for Ross Island.

Urban Forestry Program (City of Portland Bureau of Parks And Recreation). In 1972 the City of Portland adopted an ordinance to protect and preserve trees located along city streets and other public areas. The ordinance created the Urban Forestry Program to manage and care for public trees, but requires property owners to maintain trees located on adjoining street right-of-ways. The Urban Forestry Program maintains and manages Portland's urban forest. The primary responsibility is to manage the 140,000 publicly owned trees in parks, along streets and around public buildings.

Parking Lot Landscaping (City of Portland Bureau of Planning, City of Portland Bureau of Environmental Services). The Planning Bureau, Bureau of Environmental Services and Endangered Species Act Program developed new parking lot landscaping requirements designed to reduce water quality and stormwater impacts.

Coordination, Review, and Outreach Activities

Metro ESA Coordinators Group (Various Local Governments). The Metro ESA Coordinators Group is made up of natural resource and planning staff representing many of the 23 government jurisdictions within the boundary of the Portland area's regional government, Metro. The group meets monthly to share information and provide a single forum for federal and other natural resource staffs to provide briefings and answer questions related to the Endangered Species Act and plans for species protection and recovery in the region.

Willamette Urban Watershed Network (Various Entities). The Willamette Urban Watershed Network (WUW-Net) is a group of environmental professionals who have volunteered to work toward watershed health and salmon recovery in the urban areas of the Willamette River Basin. The purpose of the WUW-Net is to promote collaboration among local, state and federal agencies to help solve watershed and species problems related to urbanization. An important focus of this effort is addressing Endangered Species Act compliance and species recovery needs in the urban setting. WUW-Net provides a unique forum for the City of Portland to share information and collaborate on basinwide issues.

Oregon Subbasin Planning Coordination Group (Various State, Federal and Tribal Agencies). This group is made up of key state, federal and tribal agencies responsible for managing fish, wildlife and other natural resources. The group is responsible for organizing and managing the state of Oregon's work related to the Northwest Power Planning Council's subbasin planning process. The group also manages a team of state technical experts who support local planners.

Pacific Northwest Ecosystem Research Consortium (PNERC). PNERC is an interdisciplinary research group made up of scientists from Oregon's state universities, the EPA, private research consultants, and others (Pacific Northwest Ecosystem Research Consortium 2002). The consortium's goals are to understand the ecological consequences of societal decisions in the Pacific Northwest, develop transferable tools to support management of ecosystems at multiple spatial scales, and strengthen linkages between ecosystem research activities and ecosystem management applications in the Pacific Northwest. Specific objectives are to characterize ecosystem condition and change, identify and understand critical processes, and evaluate outcomes (including modeling alternative future scenarios and potential consequences of these alternatives to humans and the environment).

Environmental Review (City of Portland Bureau of Environmental Services). Since 1989, the City has used environmental overlay zoning to protect more than 19,000 acres of environmentally sensitive areas in Portland. The environmental overlay zones regulate the way development can take place. Specifically, Environmental protection zones (p-zone) provide the highest level of protection; this zone includes a regional network of urban natural areas and stream corridors. The environmental conservation zone (c-zone) is less restrictive than the p-zone, allowing limited urban development. For example, the c-zone limits the amount of land area that may be disturbed during development, limits the number of trees that may be removed, and establishes minimum setbacks from streams, lakes, wetlands, and other water bodies.

Site Development Review Process (City of Portland). The City is undertaking a comprehensive review of all aspects of the administration and enforcement of the City's environmentally related programs. Receiving particular attention in this project are the programs concerning erosion control, stormwater management, trees and landscaping standards, subsurface drainage and the enforcement of site-related conditions and standards from the Zoning Code and Land Use Reviews. The purpose of this review is to ensure the effective administration and enforcement of development regulations that affect the environment. The review will result in recommendations for both substantive and administrative modifications and improvements. Primary areas that will be addressed include code consolidation, regulatory coordination, clarification of responsibilities and procedures, modifications to fee structures and revenue distribution, staff training and expertise, the handling of complaints, and enforcement tools.

Development Standards Review (City of Portland Bureau of Environmental Services). All building permit applications and public works improvements are routed to BES for review of storm and sanitary disposal issues. Reviews relate to Title Codes 17 and 21. Development standards have been put in place to comply with the City's NPDES MS4 permit and the City's policies pertaining to a sustainable environment and the recovery of threatened or endangered species. The City of Portland's Stormwater Management Manual (City of Portland 2000), for example, requires specific measures to reduce the impacts of stormwater runoff and pollution resulting from new development and redevelopment within the city.

Building Code Review (City of Portland Bureau of Development Services). All building permit applications are routed to the Portland Bureau of Development Services for review of building code issues. Reviews relate to Title Codes 10, and 24 to 29. BDS review applications for building design standards and erosion control practices. Erosion, sediment and pollutant control plans are required for all sites needing a City permit. In response to ESA listings, the City assembled a citywide team to expand and improve on the City's erosion control program, which works to reduce erosion and its impacts on fish and their habitat. This effort produced new erosion control regulations as well as a revised erosion control handbook. The City of Portland's Erosion Control Manual (City of Portland 2000) provides guidelines that require all sites of ground disturbance to comply with a "no visible or measurable" sediment discharge standard. There also are enhanced controls for large, sloped and sensitive development sites.

Community Watershed Stewardship Program (City of Portland Bureau of Environmental Services, Portland State University, Americorps, Friends of Trees, SOLV, Others). The City has joined with Portland State University, Americorps, local watershed councils, neighborhood associations, Friends of Trees, SOLV and the community to raise awareness of watershed health City-wide. BES offers education and restoration grants, educational workshops (e.g., Naturescaping for Clean Rivers), restoration project technical assistance, and informational resources. Watershed stewardship grants provide up to $5,000 to citizens and organizations to encourage watershed protection and enhancement at the local level. Grant money can be used for supplies, materials, equipment, room rentals, feasibility studies or technical assistance.

Watershed Health Public Education and Outreach (City of Portland Bureau of Environmental Services). The City of Portland offers a variety of public education programs about watershed health. Examples include classroom and field studies on water chemistry, macroinvertebrate identification and stormwater issues and solutions. Educators offer canoe and jetboat tours to groups that have taken on a significant stewardship project. The City's education programs also provide community service projects and curriculum resources. The City has recently worked with students at Oak's Bottom for restoration and education, marked permanent messages on storm drains, and conducted tours of innovative stormwater sites.

Public Education and Outreach about Stormwater (City of Portland Bureau of Environmental Services). The City of Portland offers a variety of public education programs about stormwater. Examples include free education programs to schools and community groups and technical assistance and partnerships with businesses and industry groups. The City's education programs also provide community service projects, stewardship grants and curriculum resources.

Office of Sustainable Development (OSD). The City of Portland created the OSD to provide leadership and create policies and programs to promote environmental, social and economic health in Portland and to encourage sustainable development to protect our environment and economy for future generations. OSD integrates efforts related to energy efficiency, renewable resources, waste reduction and recycling, green buildings and sustainable practices and education.

Relationship of Existing Programs and Activities to the Working Hypotheses

The relationship of existing programs and activities described above to the working hypotheses are summarized in Table O-1 for fish and wildlife habitat protection and restoration activities, Table O-2 for watershed and river corridor planning and assessment activities, Table O-3 for natural resources and land management activities, Table O-4 for stormwater and wastewater management activities, Table O-5 for vegetation and landscape management activities, and Table O-6 for coordination, review, and outreach activities. The tables indicate a relationship between existing activities and hypotheses at four different levels of detail using the following letter symbols:

- P – *Planning* level. This level indicates the activity is directed at the hypothesis at a planning level only. As such, the activity indicates or suggests a plan to address factors related to the hypothesis, but does not assess or describe any specific characteristics related to the hypothesis, does not assess or recommend any particular solutions, and does not take any actions directed at the hypothesis or related factors.
- C – *Characterization* level. This level indicates the activity has provided data or information that describes and characterizes factors or conditions related to the hypothesis. However, at this level, the activity does not assess or recommend any particular solutions, and does not take any specific actions directed at the hypothesis or related factors. An example would include a specific study that has helped to identify and describe a specific hypothesis or related factors (e.g., a fish sampling study that has determined limited off-channel habitats to be preferred refuge areas for juvenile salmonids).
- S – *Solutions* level. This level indicates the activity has provided information that characterizes factors or conditions related to the hypothesis, and offers or recommends solutions to address the hypothesis or related factors. However, it does not take, or to-date has not resulted in any specific actions directed at the hypothesis or related factors.
- A – *Actions* level. This level indicates the activity has resulted in specific action (or actions) directed at the hypothesis or related factors. An example would include a specific habitat enhancement project that addresses a specific hypothesis or related factors (e.g., riparian plantings that have increased streamside shading and thereby decreased summer temperatures).

A blank indicates no relationship is explicitly made or assumed.

TABLE O-1
Hypotheses and Strategies Addressed by Existing Fish and Wildlife Habitat Protection and Restoration Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
Willamette Restoration Initiative	S	C	S	S	S	S	C	C	S	S	S	S	S	S	S	A	A
Oregon Plan for Salmon and Watersheds Implementation Team	S		S	S	S	S			S	S	S	S	S	S	S	A	A
Oregon Restoration and Enhancement Program			P	P	P	P	P	P	P	P	P	P				P	P
Endangered Species Act (ESA) Program	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	A	A
Willamette River Habitat Restoration and Enhancement Projects			S	A	S	A	A	A	S	A		S	A	S		A	A
Water Resources Development Act (WRDA) Project			P	P	P	P	P	P	P	P	P	P	P	P		P	A
Lower Willamette River Fish Research	C		C	C	C	C	C	C	C	C		C	C	C		A	A
Johnson Creek Restoration Plan	A	A	S	A	S	A	A	A	S	A	S	S	S	S		A	A
Assessment of City of Portland Activities for Potential to Affect Steelhead	C	C	C	C	C	C	C	C	C	C	C	C	C		C	A	C
ESA Section 7 Streamlining Agreement	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A
Fish-Friendly Maintenance Practices Manual	S	S		S			S	S		S	S	S	S			A	A
Salmon Safe Certification for Portland Parks	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

TABLE O-2

Hypotheses and Strategies Addressed by Existing Watershed and River Corridor Planning and Assessment Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
Total Maximum Daily Load (TMDL) Development												C	C			A	A
Watershed Restoration Projects and Watershed Councils Support	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	A
River Renaissance																A	A
Watershed Planning and Analysis	C	C	C	C	C	C	C	C	C	C	C	C	C	C		A	A
Riverside Plan	C	C				C	C	C		C		C	C			A	A
Healthy Portland Streams Project	C	C	C	C	C	C	C	C	C	C	C	C				A	A
Clean River Plan		S		S			S	S		S	S		S			A	A
Portland Harbor Superfund Program													C			A	A
Upper Tryon Creek Corridor Assessment	C	C		C			C	C			C					A	A

TABLE O-3
Hypotheses and Strategies Addressed by Existing Natural Resources and Land Management Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
Metro Title 3 Project				A			A	A		A	A	A	A			A	A
Metro Natural Resources Planning	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	A
Open Spaces Acquisition Program			A	A	A	A	A	A	A	A		A				A	A
Preservation and Restoration of Natural Areas			A	A	A	A	A	A	A	A		A				A	A
Columbia and Willamette River Natural Resource Inventories				C		C	C			C						A	A
Natural Resources Inventories and Management Plans			S	S	S	S	S	S	S	S	S	S	S	S		A	A
Natural Resource Program	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	A
Ross Island Lands Transfer				S		S	S		S	S						A	A
Johnson Creek Culvert Replacements		A	A					A		A						A	A
Transportation System Planning		P											P			A	A

TABLE O-4
Hypotheses and Strategies Addressed by Existing Stormwater and Wastewater Management Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
National Pollution Discharge Elimination System (NPDES) Stormwater Permits		S									S	S	S			A	A
Combined Sewer Overflow (CSO) Abatement Program		A											A			A	A
Stormwater Management Manual		S									S		S			A	A
Structural Controls	A	A								A	A		A			A	A
Sustainable Stormwater Program	P	P								P	P	P	P			A	A
Industrial Stormwater Program													A			A	A
Environmental Systems Program	A	A								A	A		A			A	A
Stormwater Advisory Committee	P	P								P	P	P	P				
Wastewater Treatment Plants													A			A	A
Illicit Discharge Control Program													A			A	A
Industrial Pretreatment Program													A			A	A
Spill Protection and Citizen Response Section													A			A	A
Underground Injection Control (UIC) Program	A	A											A			A	A

TABLE O-5
Hypotheses and Strategies Addressed by Existing Vegetation and Landscape Management Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
Erosion Control Program							S	S		S	S		S			A	A
Integrated Pest Management Program													A			A	A
Watershed Revegetation Program				A			A	A		A		A	A			A	A
Urban Forestry Program				A			A	A		A		A	A			A	A
Parking Lot Landscaping		S											S			A	A

TABLE O-6
Hypotheses and Strategies Addressed by Existing Coordination, Review, and Outreach Activities in the Lower Willamette River Subbasin.

Existing Programs and Activities	Hypotheses/Strategies																
	Flow		Habitat								Water Quality			Biota		Other	
	Increase summer flows	Decrease peak flows	Improve stream connectivity	Increase large wood	Increase channel length and complexity	Increase off-channel habitat	Increase bank vegetation	Increase bank stability	Increase deep pools	Increase riparian and floodplain function	Balance sediment input/output	Decrease summer temperature	Control sources of contaminants	Increase macroinvertebrates	Increase stream nutrients (via carcass placement)	Public education	Regional coordination
Metro ESA Coordinators Group																A	A
Willamette Urban Watershed Network.																A	A
Oregon Subbasin Planning Coordination Group																A	A
Pacific Northwest Ecosystem Research Consortium																A	A
Environmental Review																A	A
Site Development Review Process																A	A
Development Standards Review																A	A
Building Code Review																A	A
Community Watershed Stewardship Program																A	A
Watershed Health Public Education and Outreach																A	A
Public Education and Outreach about Stormwater																A	A
Office of Sustainable Development																A	A

Management Gaps Between Actions Needed and Actions Taken

The relationship of existing programs and activities to the working hypotheses as summarized in the tables above suggest several findings between actions needed and actions taken to date. These findings are as follows:

- Public education and regional coordination actions are the most comprehensive and widespread actions taken to date. Most of the programs and activities involve some degree of stakeholder or public outreach, and coordination with stakeholders and regulatory agencies. While these actions do not directly address the hypothesis or its related factors, these actions are nonetheless essential precursor steps to gaining the support for implementing such actions when the time comes (such as a specific habitat enhancement project).
- Of the 15 working hypotheses, the hypothesis aimed at controlling sources of urban-related chemical contamination has received the most emphasis relative to actions taken to date. Of the various programs and activities described in this appendix, 13 have resulted in actions that help to address this hypothesis or related factors. Many of these actions result from several existing stormwater and wastewater management programs and activities (Table O4).
- The several existing stormwater management activities also have resulted in actions that help to address the hypothesis or related factors related to decreasing peak flows. In addition, notable natural flood control and culvert replacement actions have been taken in the Johnson Creek watershed to decrease peak flows.
- Several activities have resulted in actions that help to address the five hypothesis related to increasing riparian vegetation and function (including associated bank stability, LWD recruitment potential, and enhancing shade to decrease summer temperatures). For example, many habitat restoration or enhancement projects undertaken to date by Metro (e.g., *Open Spaces Acquisition Program, Preservation and Restoration of Natural Areas)* and the City of Portland (e.g., *Willamette River Habitat Restoration and Enhancement Projects, Watershed Revegetation Program, Johnson Creek Restoration Plan)* have directly targeted protection and enhancement of riparian areas.
- Several programs or activities have recommended solutions, but little actions have been taken to date with regard to the six hypotheses aimed at increasing deep pool and off-channel habitat, improving stream connectivity and channel length/complexity, increasing summer baseflows, and balancing sediment input/outputs. These hypotheses relate to key habitat features known to be of high importance to salmonids, but that involve complex environmental factors and functions that can be demanding to address with actions, particularly in the urban setting. The activities that have resulted in actions to date have been few in number and localized. However, the existing significant efforts to characterize and offer solutions to these key habitat needs (e.g., *Lower Willamette River Fish Research, Watershed Planning and Analysis, Ross Island Lands Transfer, Preservation and Restoration of Natural Areas)* bodes well for more future actions related to these key habitat needs.

There are few recommended solutions and no specific actions to-date with regard to the two hypotheses aimed at increasing macroinvertebrates and stream nutrients (via salmon carcass replacement).

Macroinvertebrate characterization work has been done in the lower Willamette River and several tributaries that could support further development of potential solutions and actions.

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