Johnson Creek Watershed Characterization

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ENVIRONMENTAL SERVICES
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ACRONYMS AND ABBREVIATIONS

AC-FT	Acre-feet
ASA	American Sportfishing Association
BES	Bureau of Environmental Services
B-IBI	Benthic – Index of Biotic Integrity
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operations
CCSWCD	Clackamas County Soil & Water Conservation District
Cfs	Cubic Feet per Second
CIP	Capital Improvement Project
CSO	Combined Sewer Overflow
CWA	Clean Water Act
Dbh	Diameter at breast height
DEQ	Department of Environmental Quality
DO	Dissolved Oxygen
DDE	Breakdown component of pesticide DDT
DDD	Breakdown component of pesticide DDT
DDT	Pesticide (1,1,1-trichloro-2, 2-bis (*p*-chlorophenyl) ethane)
EDT	Ecosystem Diagnostic & Treatment
EMSWCD	East Multnomah Soil & Water Conservation District
EPA	Environmental Protection Agency
EPSC	Erosion Prevention and Sediment Control
EPT	Ephemeroptera, Plecoptera, and Tricotera
ESA	Endangered Species Act
ESRA	Environmentally Sensitive Restoration Area
ESU	Evolutionarily Significant Unit

FEMA	Federal Emergency Management Agency
FLIR	Forward Looking Infrared Radar
FWS	Fall, Winter, and Spring
GIS	Geographic Information System
IBI	Index of Biotic Integrity
JCCC	Johnson Creek Corridor Committee
JCJCCC	Johnson Creek Joint Culvert Crossing Committee
JCWC	Johnson Creek Watershed Council
JLA	Jeanne Lawson Associates, Inc.
LWD	Large Woody Debris
MS4	Municipal Separate Storm Sewer System
Msl	Mean Sea Level
NMFS	National Marine Fisheries Service (now NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Agency
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODFW	Oregon Department of Fish & Wildlife
ODOT	Oregon Department of Transportation
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
OWQI	Oregon Water Quality Index
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyls
PFC	Properly Functioning Condition
PoWER	Partnership for Willamette Ecosystem Restoration

RLIS	Regional Land Information System
RM	River Mile
4SOS	For the Sake Of the Salmon
SOWS	Save Our Wild Salmon
STEP	Salmon and Trout Enhancement Program
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
UGB	Urban Growth Boundary
UIC	Underground Injection Control
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
VGI	Vigil-Agrimis, Inc.
WES	Water Environment Services
WPA	Works Progress Administration
WPCF	Water Pollution Control Facility
WWTP	Wastewater Treatment Plant
WY	Water Year

WATERSHED CHARACTERIZATION

1. Introduction

Beginning in January 2003, Environmental Services participated in a process led by the Johnson Creek Watershed Council (JCWC) to develop a Watershed Action Plan (WAP) for Johnson Creek. The process outlined in the City of Portland *Framework for Integrated Management of Watershed and River Health* was used to develop the WAP.

The JCWC assembled a Technical Advisory Committee (TAC) to assist with the development of the Action Plan. The TAC included representatives from the Watershed Council, the Cities of Gresham, Milwaukie and Portland, Clackamas and Multnomah Counties, and the U.S. Geological Survey. JCWC completed the WAP in September 2003 (www.jcwc.org). The WAP includes an assessment of watershed conditions in Johnson Creek, which Environmental Services used as the basis for this watershed characterization.

This watershed characterization highlights and summarizes the most important and up-to-date information available for the basin. More detailed information on various elements and functions of the Johnson Creek Watershed can be obtained in the following key studies or reports: Johnson Creek Resources Management Plan (Johnson Creek Corridor Committee, 1995); Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon (Meross, 2000); Aquatic Inventory Project Physical Habitat Surveys (ODFW, 2000); the Johnson Creek Master Plan (City of Gresham, 2003); and the Johnson Creek Restoration Plan (Portland Bureau of Environmental Services (BES), 2001).

The Watershed Characterization identifies the key problems or factors limiting watershed health. The characterization also initiates discussion about sources of these problems and conditions and suggest opportunities that could lead to actions for protecting, restoring, and enhancing watershed functions.

It is important to note that while there is a focus and attention placed on fish and restoring conditions for their recovery and sustainability, they were selected as an indicator species for this watershed characterization. Improving conditions for both resident and anadromous fish species will improve overall watershed health, including water quality for human contact and conditions for other fish and wildlife species. In addition, flooding and factors that are contributing to flood conditions in the watershed are extremely important. Flooding elements are addressed in the characterization and through recommended projects that pertain to watershed functions. Restoring watershed functions will aid in reducing the frequency and magnitude of floods.

This characterization provides a general description of the watershed, highlights the human and built environmental conditions, and summarizes the current conditions and four main attributes of watershed and river health. These attributes are: 1) stream flow and hydrology; 2) physical habitats; 3) water quality; and 4) biological communities. The characterization concludes with a summary of the problems and opportunities, highlights the key functions and processes, outlines the major limiting factors, and focuses on specific reaches and sections of Johnson Creek which would most benefit from protection and restoration actions.

2. Watershed Description

2.1. General Location and Size

Located on the east side of the greater Portland Metropolitan region, 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 drainage basin encompasses approximately 34,000 acres or about 54 square miles.

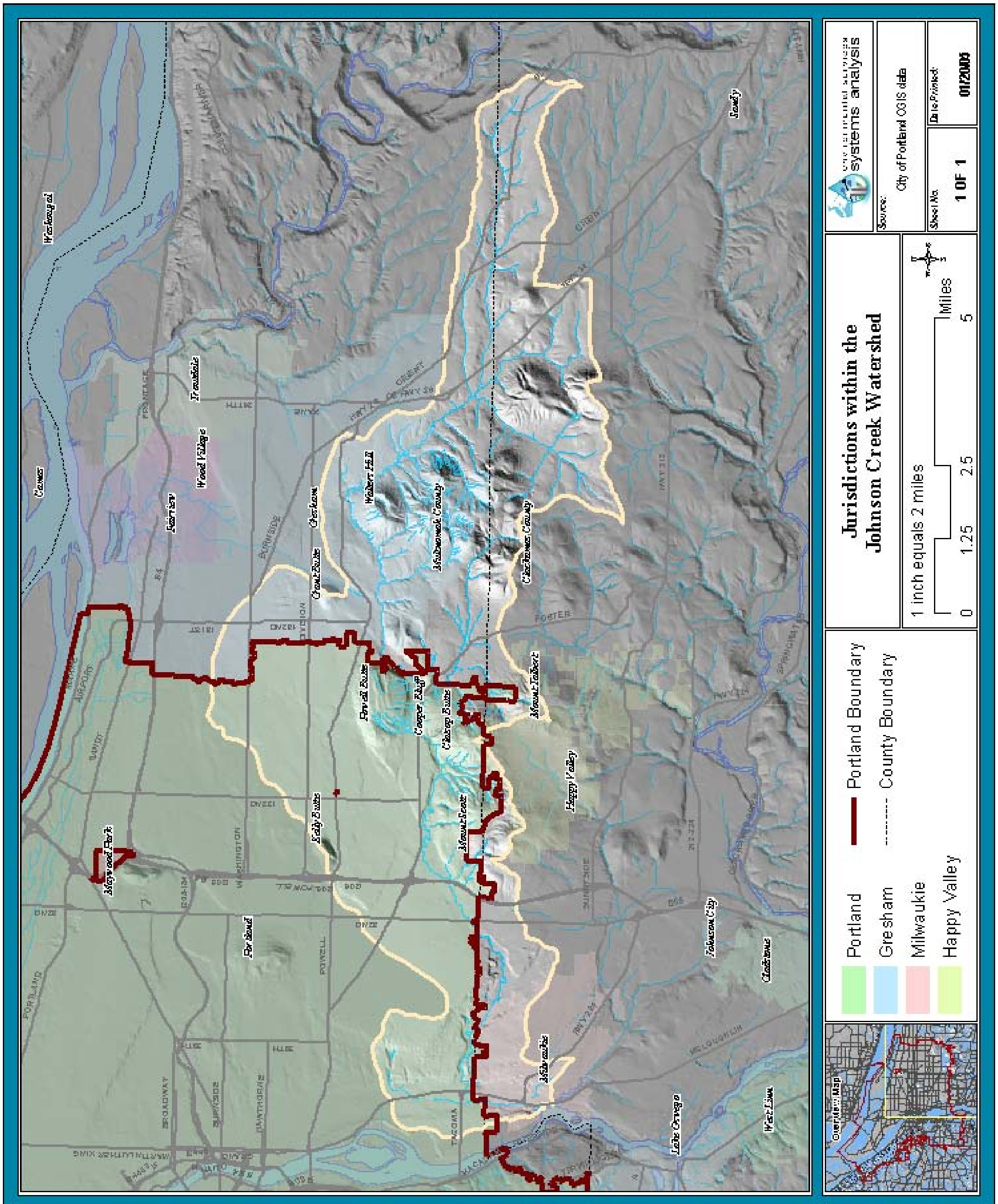
3. Jurisdictions and Sub-watersheds

The mostly urban watershed is contained within six local jurisdictional entities including Clackamas and Multnomah Counties, and the cities of Gresham, Happy Valley, Milwaukie, and Portland. Portland, Clackamas County (outside of Milwaukie and Happy Valley), and Gresham have the greatest portion of the watershed at 38 percent, 24 percent, and 23 percent respectively. The remainder of Multnomah County (outside of Portland and Gresham), Milwaukie, and Happy Valley has the least land acreage as a percentage respectively and are highlighted below (City of Portland BES GIS analysis, 2004). The general watershed location and jurisdictional boundaries are included in Figure 1.

Jurisdiction	Jurisdiction as percent of Watershed	Watershed as percent of Jurisdiction
Portland	38 %	14 %
Unincorporated Clackamas County	24 %	<1 %
Gresham	23 %	53 %
Unincorporated Multnomah County	11 %	1.2 %
Milwaukie	4 %	42 %
Happy Valley	0.1 %	19 %

The characterization of the Johnson Creek watershed is based on sub-watersheds and reach areas. The City of Portland ESA program's Ecosystem Diagnosis and Treatment (EDT) assessment of the watershed divided the basin into reaches defined as the main stem Johnson Creek (lower, middle, and upper); and the following major tributaries: Crystal Springs Creek; Kelley Creek; Butler Creek, Hogan Creek; Sunshine Creek, and Badger Creek (City of Portland ESA, 2002). Crystal Springs Creek, Kelley Creek, and Sunshine Creek are the largest tributaries in terms of flow contribution. Crystal Springs Creek is largely groundwater-fed and originates from springs on the north side of Johnson Creek. Numerous smaller tributaries also flow into Johnson Creek, such as Mitchell, Errol, Deardorf, Badger, and Spring (or Minthorne) Creek. Minthorn Creek discharges into Johnson Creek within the city of Milwaukie. Most of the tributaries are located south of Johnson Creek.

Figure 1. Jurisdictions within the Johnson Creek Watershed



4. Landscape Factors

4.1. Topography

Topography distinguishes the various landscape features of the watershed including the Boring Lava Domes and the floodplain. Elevations in the watershed generally range between 0 to 1,100 feet above mean sea level (msl). Slopes are highly variable and range generally between 1 to 25 percent. Mt. Scott and Powell Butte, which rise to approximately 1,000 feet, and have relatively moderate to steep slopes ranging from 10 to 30 percent. Gresham and Hogan Buttes have the highest slopes, with a few approaching or exceeding 50 percent.

The highest point in the watershed is in the Boring Lava Domes at approximately 1,100 feet above msl. The domes are of volcanic and erosional origin. Several of the hills reach an elevation of more than 1,080 ft. This is more than 800 feet higher than the terraces to the north and west. The Boring Lava Domes are divided into three main sections by their characteristically broad and gently rolling hills (Laenen, 1980).

The Kelso slope is a dissected northwestward-sloping surface west of the canyon of the Sandy River. It slopes from an altitude of approximately 1,000 feet near Sandy to around 400 feet east of Gresham. The ancestral Columbia and Willamette Rivers formed the east-side terraces. The terraces do not have a well-developed stream system in all areas and are underlain mostly by permeable sand and gravel. Although the precipitation is abundant, most of it percolates down to groundwater and leaves these areas by underflow (Laenen, 1980). Three isolated hills – Rocky Butte, Mount Taber, and Kelly Butte – rise about 200 to 400 feet above the surrounding terraces (Laenen, 1980). 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.

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.

4.2. Soils

Soils in the watershed are primarily either Multnomah and Latourell-Urban Land Complex (Type B hydrologic group) or Cascade Silt Loam (Type C hydrologic group). Type B soils are predominant (71 percent), followed by type C soils (21 percent). The Urban Land Complex classification refers to areas largely covered by impervious surfaces; these soils have been graded, cut and filled, or otherwise disturbed to the extent that their soil identification is not feasible. Soil erodibility varies throughout the watershed. The northwest part of the watershed mainly within Portland is characterized by Latourell soils, which have a medium-high risk of erosion. Maximum erosion for this type of soil is approximately 5 tons per year per acre. The potential for erosion is not a large threat however, due to the area being relatively flat and developed. Multnomah soils, which have a low-medium erosion factor, dominate in the northeast portion of the watershed. The southeast portion of the watershed is dominated by Cascade soils, which have a medium risk of erosion. Soils surrounding the Powell Butte and the Boring Lava Domes have an extremely high erodibility factor and are sensitive to ground disturbance.

The soils within the watershed also have varying ranges of permeability and water retaining capacity. In areas where soils are relatively undisturbed, permeability is moderate, and available water capacity is 4 to 12 inches per hour. The areas south of the 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 are only minimally capable of absorbing water through infiltration. Northern areas of the watershed are generally porous, with moderate to high permeability, and are suitable for infiltration type facilities.

5. Built Environment Conditions

5.1. History of Land Use Changes

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 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.

5.2. Existing Land Use

The land use varies from heavily developed urban areas in the lower and middle reaches of the Johnson Creek watershed (Cities of Portland, Milwaukie, and Gresham) to rural and agricultural in the upper watershed (Figure 2). Current land use (1999) in the basin reveals single-family residential and rural designations make up the largest acreage and percentages at approximately 15,000 acres or 45 percent and 11,000 acres or 33 percent respectively (Meross, 2000). Multi-family residential accounts for 9 percent, while industrial and commercial taken together make up 8 percent. Parks and open space account for the remaining 5 percent. In the agricultural rural 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 (Meross, 2000). There are currently 49 developed parks and recreational facilities within the Johnson Creek Watershed, totaling more than 1,000 acres (City of Portland BES, 2000). The Springwater Corridor Trail is a key recreational facility in the watershed. It extends more than 16 miles and occupies a former railroad right-of-way paralleling Johnson Creek for much of its length.

5.3. Existing Urbanization

The Johnson Creek Watershed is highly developed with over 50 percent of the watershed urbanized. Development consists primarily of buildings and structures, stormwater and sanitary systems, roadways, bridges, pipes, outfalls, and culverts. Metro estimated that approximately 38 percent of the tributaries were piped or relocated by development over the years (Meross, 2000). These drainage systems originated mainly in the northern portion of the watershed within Portland and a portion of Gresham. However, as noted earlier, the east side terraces do not have a well-developed stream in all areas and precipitation that falls on mostly permeable sand and gravel percolates to groundwater and leaves the area by underflow (Laenen, 1980).

5.4. Future Urbanization

Approximately 170,000 people currently reside within the Johnson Creek Watershed. To accommodate future population growth Metro approved an Urban Growth Boundary (UGB) expansion in 1997 including the 1500 acre area known as Pleasant Valley, which roughly corresponds to the Kelley Creek watershed. With this expansion, about 70 percent of the watershed's 34,000 total acres, or approximately 24,000 acres of the watershed, lie within the UGB (Meross 2000; City of Portland BES GIS Analysis 2004). In 2002, as the Pleasant Valley Concept planning process drew to a close, the Metro regional government expanded the urban growth boundary again. The bulk of the 2002 expansion area consists of more than 13,000 acres south and east of Gresham, including most of Sunshine Creek subwatershed and the headwaters of Kelley and Mitchell Creek (approximately 4000 acres) as well as approximately 3000 acres of the Johnson Creek Watershed known as the "Springwater Community Plan." The UGB and Expansion Areas are shown on Figure 3.

Comprehensive planning is required before these UGB expansion areas will be allowed to develop to urban densities, and is now underway. These areas contain some of 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.

Figure 2. Land Use within the Johnson Creek Watershed

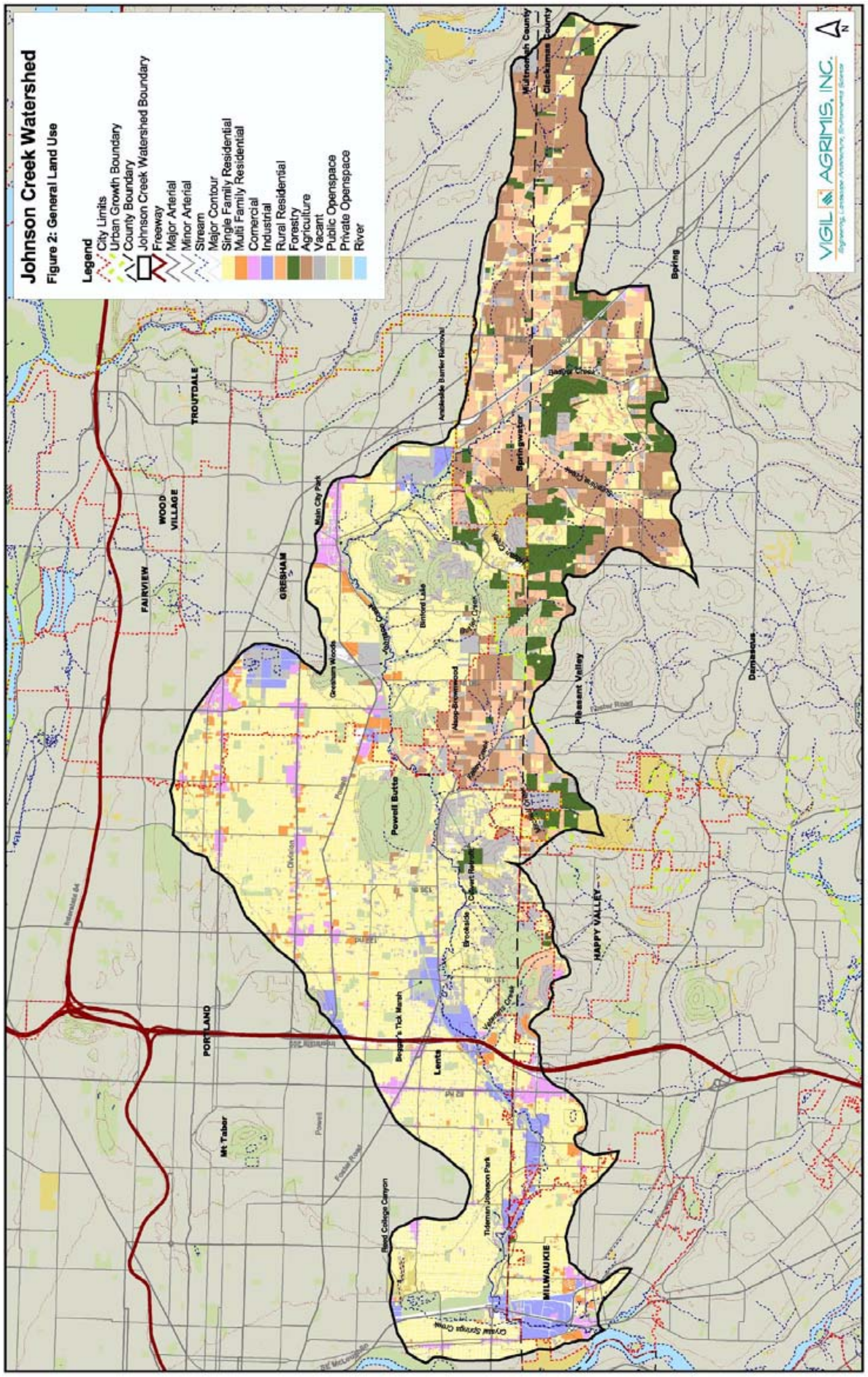
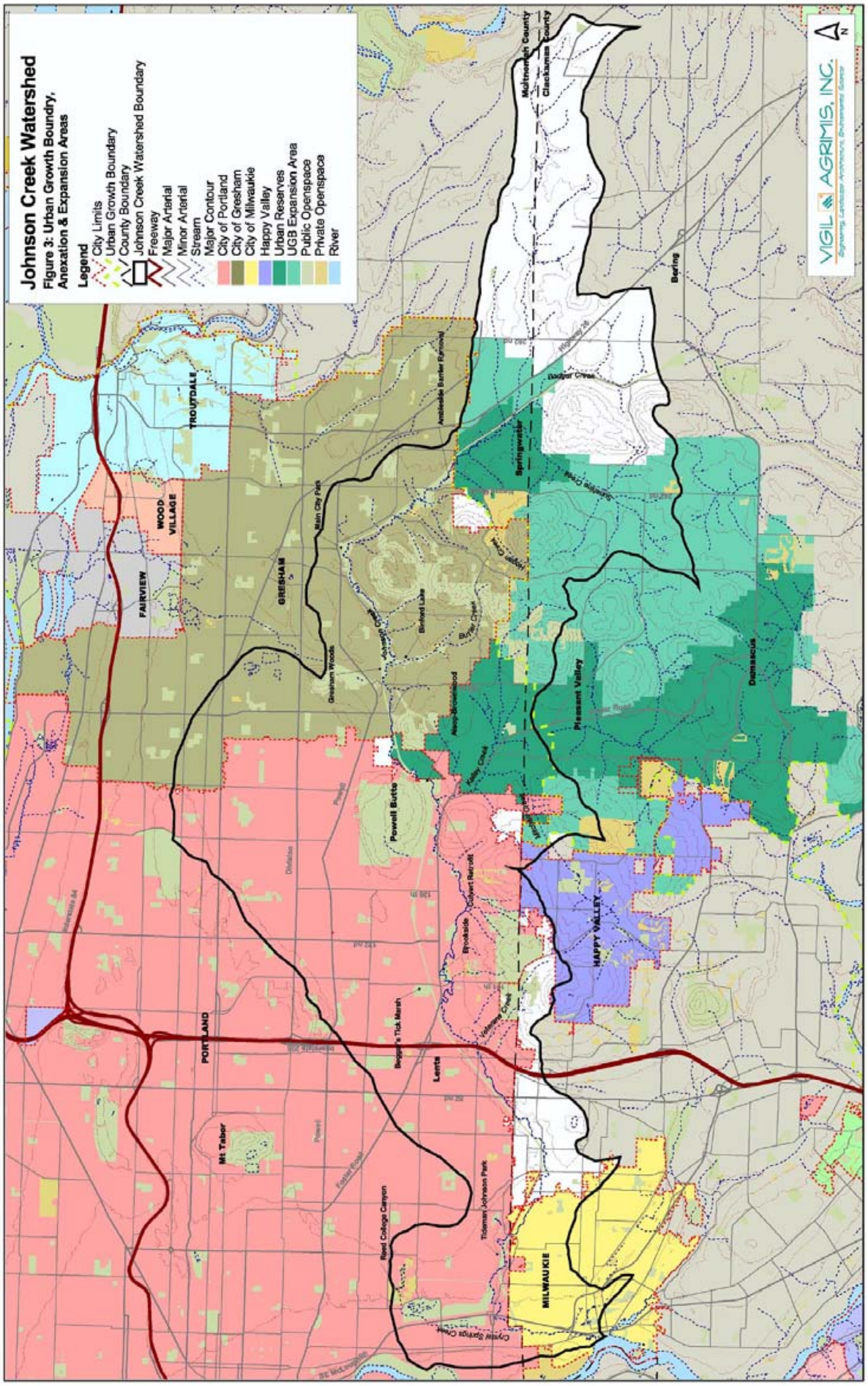


Figure 3. Urban Growth Boundary Annexation & Expansion Areas Map



5.5. Impervious Surfaces

Much of the existing development consists of impervious surfaces. Impervious surfaces as a percentage in the Johnson Creek watershed were estimated using BES's multispectral vegetation data analysis. Impervious area was approximated as the area of the watershed that is not vegetated. Using this methodology it is estimated that approximately 39 percent of the watershed as a whole is covered with impervious surfaces (BES, 2004).

It is difficult to compare the percent of the watershed that is impervious between jurisdictions because there is not a consistent GIS layer for building coverage for the whole watershed. In addition, zoning maps do not accurately reflect existing land uses in the upper watershed making it difficult to compare and estimate impervious area across the watershed based on zoning classes. Therefore, the most consistent comparison of impervious area by jurisdiction across the watershed is the area of the watershed that is not vegetated measured using BES's multispectral vegetation data. It is important to note that this is an estimate only and is an imperfect measurement because the area that is not vegetated may include pervious surfaces.

Jurisdiction Name	Area (acres)	Multispectral Imperviousness	Percent Impervious
Happy Valley	114.53	30.49	26.62%
Clackamas	9211.59	3174.36	34.46%
Milwaukie	1368.76	720.38	52.63%
Gresham	6303.70	2765.57	43.87%
Portland	13139.36	5547.08	42.22%
Multnomah	4391.94	1356.51	30.89%
Total	34529.87	13594.39	39.37%

The average impervious area for individual subwatersheds varies considerably. For instance, Crystal Springs is over 45 percent impervious while Kelley Creek is around 12 percent. Moreover, much of the impervious area, especially in Portland, is hydrologically disconnected from Johnson Creek and flows into combined sewers or sumps. Approximately 23 percent of the watershed in the Portland region drains to groundwater through stormwater sumps (BES, 2004). Approximately 8percent is directed to Portland's combined sewer system, and approximately 6percent is isolated areas with no discharge to the creek (Meross, 2000).

Percent effective impervious within the Johnson Creek watershed varies considerably; large areas in the middle and upper watershed areas have relatively low effective imperviousness that swamps out high percentages in the lower watershed. The net result is that overall, very little of the watershed actually exceeds the threshold of 10-15percent effective impervious (ESA, 2001). However, increased stormwater runoff from impervious areas throughout the watershed increases streamflow volume and velocities, downcutting and eroding stream habitat. Increased stormwater 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.

5.6. Stormwater and Sanitary Infrastructure

Combined Sewer System

The combined sewer system conveys both sanitary sewage and stormwater in the same pipes. Combined sewers serve the Sellwood, Eastmoreland, Westmoreland, and Woodstock neighborhoods of Portland contain 110,832 lineal feet of the city's combined sewer system within two basins- Lents 1 and Lents 2. There are no significant hydraulic problems in the Lents 1 basin; however, there are potential areas of basement flooding from saturated ground conditions and peak storm flows. Lents 2 has significant capacity problems that result in basement flooding. Problems are caused by undersized conveyances, flat slopes, and very long collection networks (Portland BES, 2000). The Portland Public Facilities Plan (Portland BES, 1999) identifies capital improvement program (CIP) projects for both of these basins to address basement flooding and combined sewer overflow (CSO) reduction.

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 mainly owned, operated and maintained by the Cities of Portland, Gresham, and Milwaukie. Parts of these systems are located within the floodway of Johnson Creek and several manholes are located within the stream channel. Sanitary sewerage within Portland (along with some combined flow) is conveyed by two pump stations within the watershed to the Columbia Boulevard Wastewater Treatment Plant. Sewage is conveyed through the watershed within Portland by 153,794 lineal feet of sewer pipe (Portland BES, 2000). In Gresham, sewage is piped through 470,721 feet of sewer pipe and pumped to the Gresham Wastewater Treatment Plant on the Columbia River. Sewage from development in the upper watershed east of the Gresham UGB is treated in onsite septic systems as there are no sewer extensions allowed outside of urban areas. There are also some onsite septic systems still used in certain areas of Milwaukie and Portland. Siting, development, and maintenance of onsite septic systems is regulated by DEQ, and the City of Portland Bureau of Development Services administers the program for Multnomah County. A new wastewater treatment plant (WWTP) is under construction near Mitchell Creek to replace a failing septic field in Happy Valley.

Stormwater Facilities

Drainage patterns in the lower portion or western end of the watershed were significantly altered by construction of a piped storm drainage system (Johnson Creek Corridor Committee, JCCC, 1995). Stormwater within the city of Portland is conveyed through approximately 38,832 lineal feet of storm drainage pipe. There are by 31 pollution reduction facilities within the watershed (Portland BES, 2000). Stormwater is then discharged into one of three main locations: the combined system, sumps, or directly into Johnson Creek. At the current time, there are no known estimates for the amount of untreated stormwater that enters Johnson Creek directly from stormwater outfalls. (See Data Needs in section 1.10.2.)

Stormwater pipes also convey stormwater within Gresham's portion of the watershed. Stormwater is conveyed through 384,282 feet of stormwater pipe. There are no combined sewer system pipes within Gresham's city limits.

The public stormwater system within the upper portion of the watershed (extends 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. In addition to surface water runoff, the ditch system carries water from farm field subsurface drainage systems to area creeks. The ditch system provides no water quality treatment other than in areas where ditch vegetation is maintained. For new developments, the rate of stormwater runoff from private property is required to be controlled to the pre-development rate under Multnomah County ordinances. The Oregon Department of Agriculture has jurisdiction over runoff from agricultural fields into the roadside ditch system.

The Oregon Department of Environmental Quality (DEQ) through the federal National Pollution Discharge Elimination System (NPDES) Permit Program regulates stormwater. As of March 2003, the following stormwater permits were issued by DEQ to permitted facilities that have discharges in or near Johnson Creek: 11 construction stormwater permits, 13 industrial stormwater permits, three combined animal feeding operations (CAFO that are administered by the Oregon Department of Agriculture including one dog, one mink, and one swine operation), and two industrial hydrocarbon cleanup related permits, and one domestic sewage drainfield (DEQ 2003). This does not include permits pending or those that have expired. Construction stormwater permits are for sites greater than 5 acres, although the threshold was lowered to sites greater than 1 acre in December 2002. The industrial permits allow precipitation to contact raw industrial materials and runoff into surface waters only if best management practices and controls are in place. Two of the industrial permits are for clean up of petroleum-contaminated soils at RM 10.8 and groundwater at RM 15.3. There is also an active permit for a Water Pollution Control Facility (WPCF), in this case a church, and domestic drainfield at RM 18.2. WPCF permits authorize discharge to groundwater, but not surface water.

In accordance with Clean Water Act (CWA) requirements, DEQ issued municipal NPDES permits to both Gresham and Portland and their co-permittees in 1995. These permits cover a five-year period and require the implementation of a stormwater management plan and submittal of annual reports. As of 2003, DEQ has received permit renewal packages from these jurisdictions but have opted to allow Gresham, Portland, and their co-permittees to continue functioning through an extension of their expired permits. Permit renewal will be completed by 2004.

Because the pervious soil north of Johnson Creek is appropriate for infiltration facilities, numerious sumps have been installed within the northern portion of the watershed. The sump or dry well area within the Portland portion of the watershed covers more than 8,000 acres and treats approximately 23 percent of the city's stormwater. There are roughly 2,400 Portland operated sumps in the watershed and an additional 53 operated by other jurisdictions (32 by the City of Gresham, 19 by Multnomah County, and 2 by the State of Oregon). These sumps receive runoff from a mix of commercial, residential, and transportation land uses. Both Gresham and Portland are implementing management programs for the new state and federally mandated Underground Injection Control (UIC) program. In addition, Multnomah County has implemented a UIC program within Gresham.

5.7. Transportation Infrastructure

The Johnson Creek Watershed includes an extensive network of streets, roads, and highways, including Interstate 205 and 11 major arterials. There are more than 50 bridges that cross the main stem of Johnson Creek. 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.

An estimate of total impervious surfaces from roadways throughout the watershed is presently not available. For a discussion of roadway culverts and fish passage barriers see Section 6.2.5 Culverts and Barriers.

5.8. Channelization

Beginning in 1933 depression-era public works agencies, primarily the Civil Works Administration and the Works Projects 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.

5.9. Water Rights

A number of water claims, permits, applications and certificates currently exist for the Johnson Creek Watershed. There are also unpermitted water withdrawals and some withdrawals 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 Johnson Creek is over-allocated during most summer months.

Adolfson Associates performed a cursory water rights information query from the Oregon Water Resources Department (OWRD) web site: http://stamp.wrd.state.or.us/apps/wr/wrinfo/wrinfo.php. Table 1 summarizes query results from the period 1900-2003 obtained for claims, permits, applications, or certificates currently listed for the Johnson Creek watershed:

Table 1. Water Rights including number of Claims, Permits, Applications, or Certificates within the Johnson Creek Drainage Basin

Number of Claims Permits, Applications, or Certificates	Characteristic	Type	Total flow (cfs) or volume (AC-FT)* for all claims, permits, applications, or certificates
32 Claims	Groundwater Registrations (GR)	Wells	15.17
65 Permits	Groundwater (G)	Wells	62.03
53 Permits	Surface water (S)	Surface Water including creeks, streams, or springs	31.51 (includes 12.0 cfs for Butler Cr. Reservoir and 6.0 cfs for Hessel Reservoir (Frank Schmidt Nursery)
3 Applications	Groundwater (G)	Wells	3.28
2 Applications	Instream Flow (IS)	Surface Water	15.0 cfs – Crystal Springs 25.0 cfs – Johnson Creek
4 Applications	Ponds (P)	Surface Water	5.60 AC-FT
23 Applications, Permits, or Certificates	Reservoirs (R)	Surface Water	110 AC-FT

* cfs = cubic feet per second; AC-FT = acre feet

Increasing baseflows throughout the Johnson Creek watershed will be important for restoring hydrology to a normal hydrograph and to obtain properly functioning conditions. More research will be required to: 1) locate illegal water diversions and withdrawals, 2) identify areas for irrigation improvement; 3) assess alternatives for off-line systems; 4) contact holders to assess opportunities for instream water rights purchase and dedication to instream use; and 5) review and comment on new water rights applications.

6. Watershed Conditions

The following provides an overview of existing environmental conditions in Johnson Creek, and evaluates watershed health by summarizing and presenting data available on a series of key indicators. The importance and justification for the selection of the indicators is described in the Internal and IST Review Draft *Framework for Integrated Management of Watershed and River Health* (City of Portland 2002).

This baseline is not intended to be a comprehensive summary of existing information on Johnson Creek. A number of reports provide excellent overviews of the large amount of information on environmental conditions and restoration efforts within the watershed (e.g., JCCC 1994; JCCC 1995; Meross 2000; BES 2001).

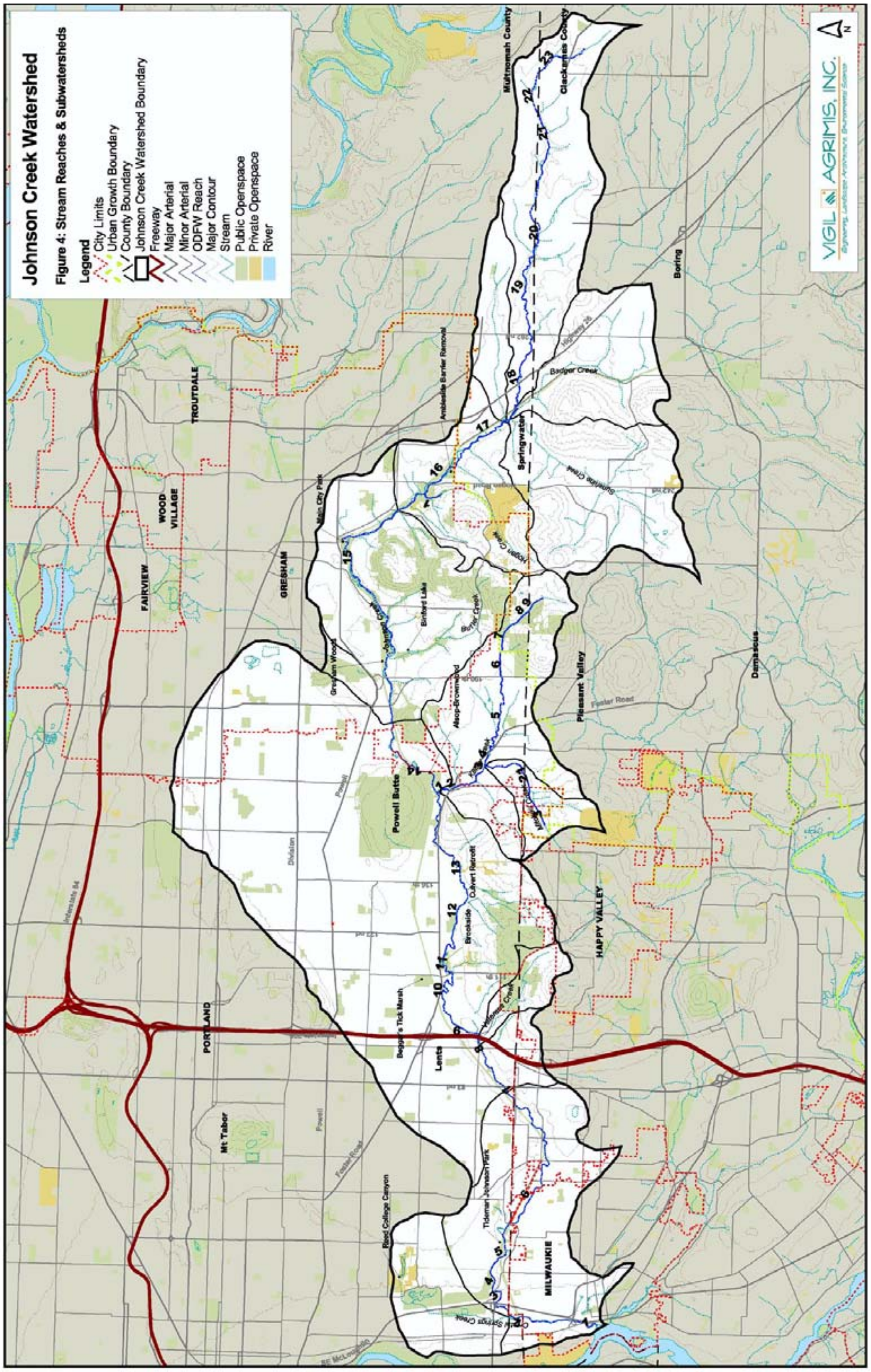
The 2000-2001 ODFW Aquatic Habitat Inventory Project separated Johnson Creek into 23 separate stream reaches. The City of Portland ESA program's EDT model grouped these reaches into three main areas – lower, middle, and upper Johnson Creek in a subsequent modeling project. Lower Johnson Creek consists of reaches 1-7; Middle Johnson Creek consists of reaches 8-15; and upper Johnson Creek consists of reaches 16-23. Table 2 highlights the stream reaches and their location (see also Figure 4).

The City of Portland ESA Program recently completed a summary of baseline environmental conditions in the Johnson Creek watershed. This document provides a brief narrative overview of existing conditions, and then evaluates a series of key indicators of watershed health by summarizing and presenting data available on each of the indicators (See Appendix A). This data served as background information and were inputs into theEDT model to assess protection and restoration opportunities in the Johnson Creek watershed (See Key Limiting Factors in Section 7.4).

Table 2. ODFW Stream Reaches

Number	Boundary Location
1	Willamette River confluence to Hwy. 224 overpass
2	Hwy. 224 to Crystal Springs tributary junction
3	Crystal Springs tributary junction to Old Tacoma bridge crossing
4	Old Tacoma bridge crossing to Tideman-Johnson rail and footbridges
5	Tideman-Johnson rail and footbridges to Johnson Cr. Blvd. bridge crossing
6	Johnson Cr. Blvd. bridge crossing to SE Linwood Ave. bridge crossing
7	SE Linwood Ave. bridge crossing to SE 82nd Ave. bridge crossing
8	SE 82nd Ave. bridge crossing to I-205 bridges
9	I-205 bridges to SE 106th bridge crossing
10	SE 106th bridge crossing to SE 110th Drive bridge crossing
11	SE 110th Drive bridge crossing to Brookside restoration site
12	Brookside Restoration site to SE 132nd bridge crossing
13	SE 132nd bridge crossing to Kelley Cr. tributary junction
14	Kelley Cr. tributary junction to SE 190th bridge crossing
15	SE 190th bridge crossing to Main City Park in Gresham
16	Main City Park in Gresham to Palmblad Road bridge crossing
17	Palmblad Road bridge crossing to Sunshine Cr. (known to locals as "McDonald Creek")
18	Sunshine Cr. or "McDonald Cr." to U.S. Hwy 26
19	US Hwy 26 to SE Stone Road crossing
20	SE Stone Road crossing to first tributary junction east of SE Orient Dr.
21	First tributary junction east of SE Orient Dr. to second tributary junction east of SE Altman Road
22	Second tributary junction east of SE Altman Road to last marked tributary junction on USGS topo map
23	Last marked tributary junction on USGS topo map to where creek disappears into a culvert draining cornfields.

Figure 4. Johnson Creek Subwatersheds and ODFW Stream Reaches



6.1. Flow and Hydrology

6.1.1. Gradient

Johnson Creek is a low gradient stream that drops approximately 700 feet over its 25-mile course. The average gradient along the mainstem is 0.5 percent. The steeper upper section with a gradient of 0.8 percent begins in the headwaters and extends down to about 5.5 miles to Regner Road in Gresham. The middle section is extremely flat and takes on a slough-like character with an average gradient of 0.4 percent (McConnaha, 2002). Beginning about at SE 82nd Avenue, Johnson Creek begins to cut its way down to the Willamette River with a correspondingly higher gradient than the middle section.

6.1.2. 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, nutrient exchange and organic input to the creek, and groundwater and wetland recharge. As discussed above, the channelization of Johnson Creek 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.

6.1.3. Flow

General hydrologic patterns in Johnson Creek are driven by rainfall and groundwater inflow. Peak flows normally occur in December, January, and February in response to abundant rainfall and high runoff as soils become saturated through the rainy season. Summer low flows in July, August and September reflect minimal groundwater contributions to streamflow throughout the watershed (Figure 5).

The U.S. Geological Survey (USGS, 2005) operates four gaging stations throughout the Johnson Creek watershed. In addition, the Oregon Department of Water Resources operates a gaging station in Crystal Springs Creek. A summary of these gaging stations is listed in Table 3.

Table 3. USGS Gaging Stations within the Johnson Creek Drainage Basin

USGS Gage Number/Location	River Mile	Drainage Area (mi.^{2})	Period of Record	Extremes for Period of Record *
14211400 Johnson Cr. at Regner Road (Gresham)	16.3	17.8	February 1998 to current year	Max.: 629 ft^3/s Feb. 27,28, 1999; gage=8.58 ft. Min.: 0.26 ft^3/s Sep. 27,28, 2000
14211499 Kelley Cr. at SE 159th Dr. (Portland)	At mouth	4.69	March 2000 to current year	Max.: 81 ft^3/s May 10, 2000, Mar. 27, gage=4.34 ft. Min.: 0.03 ft^3/s Sep. 27, 2000
14211500 Johnson Cr. at Sycamore, (Portland), Oregon	10.2	26.5	July 1940 to current year	Max.: 2,620 ft^3/s Dec. 22, 1964; gage=14.68 ft. and 2,350 ft^3/s Feb. 7, 1996; gage= 14.28 ft. Min.: 0.08 ft^3/s Aug. 21, 1966
14211546 Crystal Springs Creek at	At mouth	Not quantified	Periodic measurements	Average flows approx. 10-14 cfs prior to 1997 and 17-20 cfs 1997-1998. Higher

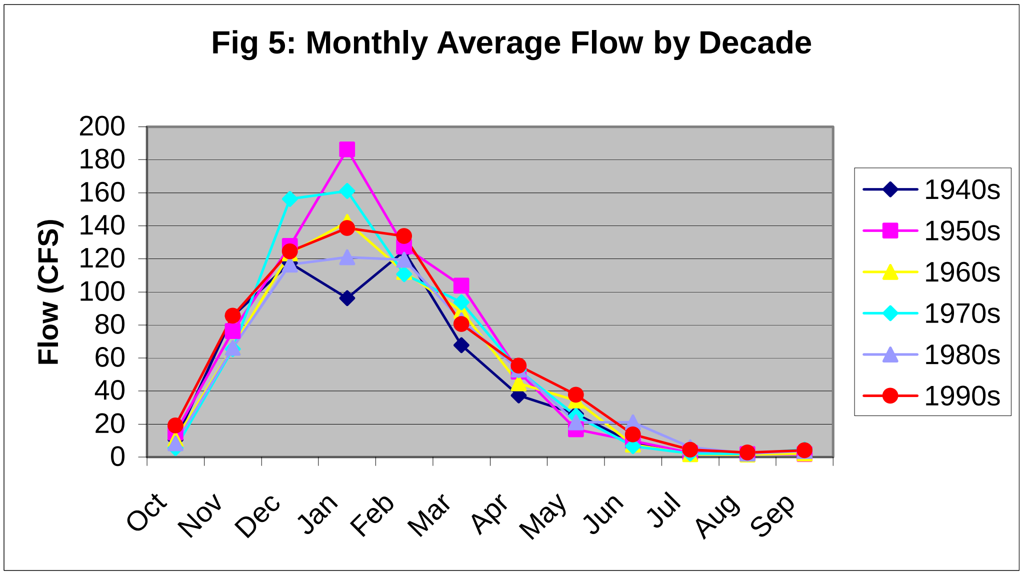
Clatsop St. (Portland)		because much of basin drains to City storm sewer	during late 1980's and 1998-2000	flows thought to be caused by higher than normal precipitation and subsequent elevated groundwater discharges (Adolfson, 2001).
14211550 Johnson Cr. at Milwaukie, Oregon	0.7	51.8	April 1989 to current year	Max.: 2,170 ft^3/s Feb. 8, 1996; gage=30.27 ft. Min.: 10 ft^3/s July 1, and 3-5, 1994

***** Does not include peak flows recorded during January 2003.

The Sycamore gage (River Mile 10.2/ ODFW Stream Reach 13) provides the longest period of record with which to evaluate changes in flow over time brought on by human activities and is often used in studies of flow and to calibrate hydrologic models for Johnson Creek. The long-term average streamflow at the Sycamore gageg is 54 cubic feet per second (cfs) (USGS, 2005 and McConnaha, 2002). Maximum flows usually are recorded in December or January. Minimum flows occur usually in August or September. Bankfull discharges at the Sycamore gage are around 867 cfs and occur about 3 times each year. Flood stage is reached at a flow of around 1,080-cfs, which occurs on average about 1.8 times each year. Major floods correspond to flows of 1,650 cfs, which has occurred about once every 3-4 years. The streamflow gage at Milport Road (Milwaukie) and its associated drainage area is almost twice as large as the drainage area of the Sycamore gage. Yet, the total annual runoff at the Milwaukie gage is only about 45 percent higher than runoff at the Sycamore gage. This supports the conclusion that the upper watershed (located upstream of the Sycamore gage) is contributing a much greater stream flow than is proportionate to its size (Portland ESA, 2000). This is likely due to the higher number of tributary systems entering Johnson Creek in the upper watershed as compared to the lower portion.

Various land uses, flow from piped streams, and stormwater runoff from impervious surfaces significantly affect flow patterns in the watershed. A 1984 study of the effects of development and resultant impervious surfaces on peak flows in Johnson Creek using 40 years of data from the Sycamore gage concluded that for a storm of a given size the peak flow under 1980's conditions was 30 percent greater than under 1940's conditions (Clement, 1984). However, a subsequent evaluation of the flow record for the Sycamore gage since 1940 indicates that the creek has become flashier; less precipitation is needed to create a peak event and the basin is responding with higher peaks to the same amount of precipitation. This study found a lack of increase in peak flows for the period of record as a whole (Clark 1999). In fact, peak flow frequency at the Sycamore streamflow gage shows no discernable upward trend over the last 60 years (See Figure 5). The discrepancy between the Clement and Clark studies may be because Clark's study uses a longer flow record than Clement, and the record includes a drought period and the introduction of sumps into the watershed, which divert flows subsurface (Clark, 1999). Regardless, it is clear that peak flows are flashier and increasing in frequency and may be increasing in amplitude. Together with channel confinement and floodplain disconnection (discussed above), this flashiness causes increased stream velocities and elevated water surface levels that increase erosion and flood damage along the creek.

Figure 5. Monthly Average Flow by Decade



Since much of the intensive rural and urban development upstream of the Sycamore gage occurred after the gage was installed, the gage data provides some indication that increased flashiness may be related to increased development. However, the range of variables (including soil type, slope, other geological factors, and watershed characteristics and conditions) makes it impossible to establish a direct cause and effect relationship. Peak flows also appear to be affected by alterations in the stream channel and floodplain, which change the way floodwater flows through Johnson Creek (Portland ESA, 2002).

6.1.4. Flooding

Johnson Creek has a long history of flooding. It has had at least seven major floods in the last 35 years. The worst flood on record occurred in 1964. It had a peak flow of 2,620 cubic feet per second at SE 158th Ave. Approximately 1,200 structures were flooded, most in the Lents area between SE 82nd and SE 122nd Ave. Significant flooding occurred again in February and November of 1996.

The Johnson Creek Restoration Plan

In June 2001 the City of Portland adopted by resolution the Johnson Creek Restoration Plan (JCRP). The goal of the JCRP is to rehabilitate the watershed's natural functions and ability to resolve flooding problems rather than relying on flood control structures to alleviate the problem. To achieve this goal the plan recommended restoration components that are compatible with natural watershed functions such as restoration of floodplains, riparian areas, wetlands, and instream habitat complexity. The key features of the plan are projects that will reconnect the creek with its historic floodplain to store floodwaters and provide off-channel opportunities for salmonids. The JCRP defined a targeted level of protection from more frequent and troublesome floods, such as the flooding that occurred several times during the 1994-1996 period. This target is termed the "nuisance flood" to indicate the desire to focus on flood events that occur repeatedly and cause nuisance or frequent damage.

The JCRP was based on the historical record of the Johnson Creek watershed, previous studies, hydraulic and hydrologic watershed modeling, the 1999/2000 ODFW Stream Habitat Surveys and field investigations. The model was used to identify reaches of the creek with high velocities, areas inundated by flooding events, and subbasins contributing high runoff rates, and to identify and simulate the effectiveness of various flood management strategies. The model showed that the three day rainfall depth is the strongest indicator of flooding events, including the maximum water surface level and flow volume and that short, intense rainfall bursts (1 hour) will not by themselves generate a nuisance flood event. In addition, a review of flood frequency impacts showed that managing for a 10-year flood will provide a level of protection that is cost-effective yet maximizes environmental benefits. Ultimately the nuisance flood was identified as the December 1977 flood, which is derived from an actual, historic three-day rainfall pattern and is a 10-year return period.

Flood Characteristics

The JCRP statistical analysis of USGS stream gage data, the City of Portland's rain gage data and data from the National Weather Service revealed that flood events in Johnson Creek occur only in the winter months when there has been sufficient rainfall to saturate the natural storage within the vegetation and soil. Flooding events primarily affect four areas within Portland: 1) Tideman-Johnson Park at SE 45th; 2) the area east of SE 82nd; 3) the Lents area, and 4) lower Powell Butte. The area most susceptible to flooding within Chackamas County is the Bell Station Area (between SE 45th and SE 82nd Ave). Due to its low gradient most flooding takes place in the middle section of the creek where floodwaters tend to spread out (McConnaha 2002). Lents is by far the largest area affected, flooding approximately 10-20 acres on average once every other year. Designated as a Flood Risk area by the City of Portland, this area has stricter development codes. Based on past history, the Lents area faces a high risk each winter that Johnson Creek will overflow its banks and flood nearby community roads and properties. Since 1941, there have been 37 out-of-bank flood events, 28 of which have resulted in property damage. Twenty-one of these events were considered "nuisance events" (a 10-year flood or less) (Lents Technical Memorandum, Portland BES, 2002). Frequently flooded areas in Lents include: 1) along Johnson Creek from 117th to 101st; 2) Foster Road between 111th and 101st; 3) Springwater Trail from 111th to Foster Road; and 4) Beggar's Tick Marsh associated marshlands.

Several of the largest flooding events in gage history for Johnson Creek occurred during the 1990s (Portland BES, 2000). BES mapped the footprint area for the February 1996 flood event BES (Figure 6) by tracing the inundation area from aerial photos. It is important to note that the aerial photos were taken 12 hours after the flood peak.. The JCRP review of historical flood maps indicate the following:

- Significant changes in flooding patterns in the Lents area have occurred over time due to channel improvements, development activities, and filling on properties;
- Many of the areas that flood frequently at this time are now publicly owned properties; and
- Due to the changes in Johnson Creek and the watershed, the extent and locations of flooding for a 5-year or 10-year flood are much different today than before 1980. The historical floods mapped prior to 1980 show a much different shape of floodplain compared with the pattern seen in the Lents area during the 1994-1996 period.

While most of the watershed and its tributaries are fed primarily by precipitation (average annual varies from 40 inches near the mouth to over 70 inches in the upper watershed and a watershed wide average of 53 inches), and surface water, some areas are controlled primarily by groundwater processes. Crystal Springs is the largest springs in the Portland Basin, with a total discharge of more than 5,000 gallons per minute (McFarland and Morgan, USGS, 1996). Crystal Springs Creek flooded during the summer of 1997 due to high ground water levels. It was the first recorded flooding and was attributed to three consecutive record precipitation years (Portland BES, 2000; Dames and Moore, 1998). Holgate Lake, formed by the local water table, is located near the intersection of Holgate Boulevard and Southeast 136th

Ave. The lake is located on private property. Elevated water levels in this area have caused flooding in the surrounding area, including damage to residences south and west of the lake. The latest episode of flooding occurred in the spring of 1999.

Figure 6. February 1996 Flood Inundation Area

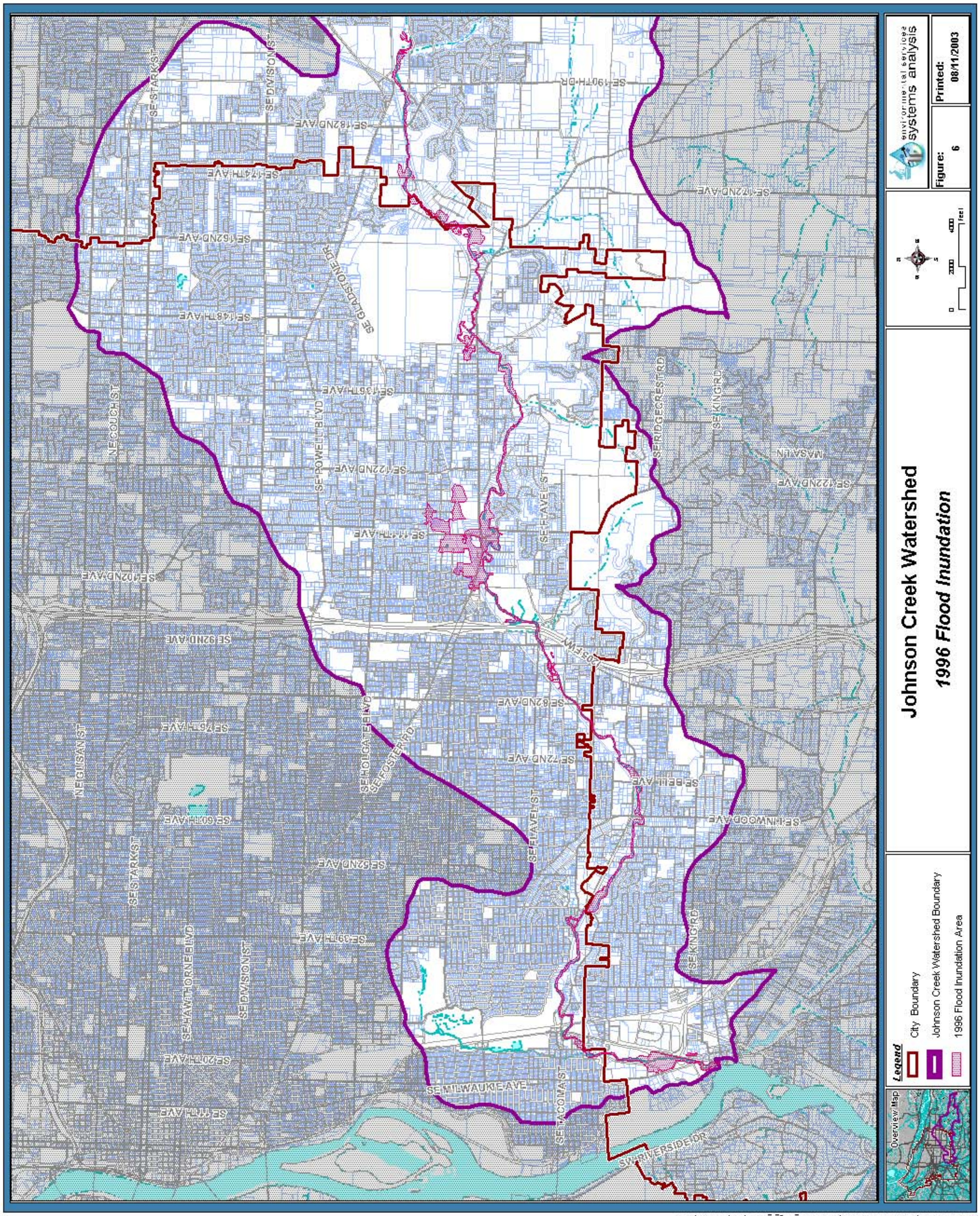
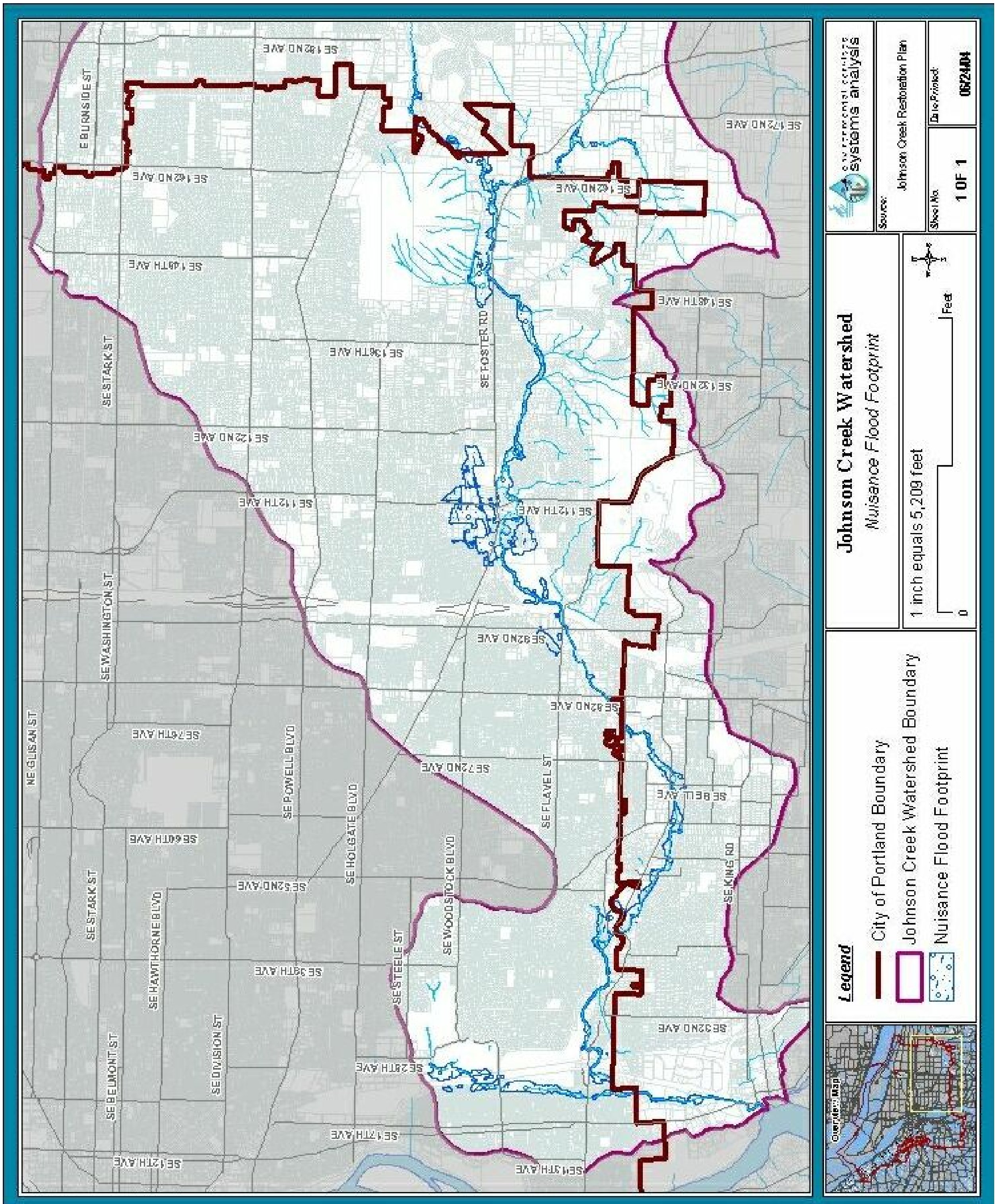


Figure 7. Nuisance Flood Footprint



6.1.5. Baseflows

Baseflow from springs and groundwater help to maintain summertime flows and water temperature and provide refuge areas for many aquatic species. Low base flows in the summer contribute to reduced habitat and degraded conditions for acquatic species. The Oregon Department of Fish and Wildlife (ODFW) has set minimum flow targets to protect salmonids in Johnson Creek. Johnson Creek suffers from a lack of base flows during the late spring/early summer through early fall season. In particular, flows in the middle and upper watershed frequently do not meet minimum flows 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.

During the 1995 and 1996 Water Years the USGS reported that Johnson Creek at Sycamore , had one of the lowest percent-base-flow components of streamflow (47 to 52 percent) compared to more than 50 other streamflow gaging stations throughout the Willamette basin. This may be attributed to rapid runoff from urban areas of the basin and lack of infiltration of precipitation into the groundwater system due to extensive impervious land cover (Lee and Risley, 2002).

Minimum instream flow targets are typically met below Crystal Springs, which provides consistent and abundant groundwater flows. Freshwater springs are major contributors to 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.

The Portland ESA Program assessed baseline conditions for flow and hydrology indicators in Johnson Creek (see Table 4). These indicators and their assessed base line condition compared to properly functioning conditions were incorporated into an Ecosystem Diagnosis & Treatment (EDT) Model. See Watershed Problems and Opportunities in Section 7 for discussion of this model and results of selected indicator attributes and their protection and restoration values. Additional baseline data graphs from the Portland ESA program are provided in Appendix E

Table 4. Flow and Hydrology Indicators within the Johnson Creek Watershed

Indicator	Baseline Condition	Key Function	Key Process or (Source)	Effect	Notes
Hydrograph	Not Properly Functioning	A stream's hydrograph characterizes the frequency, magnitude, and duration of flow. The hydrograph plays a key role in stream formation processes and characteristics.	An altered hydrograph can result from climate change and human development activities including a loss of vegetation in a watershed and increased impervious surfaces.	Altered hydrographs can result in stream scour and bank erosion. Altered hydrographs are also characteristic of changes in the magnitude, frequency, and duration of both peak and base flows.	*Peak Flow*: Statistical evaluation of flow since 1940 indicates that Johnson Creek has become "flashier" over time. While increases in absolute peak flows are not evident, the amount of rainfall needed to produce a peak flow had decreased over time (Clark, 1999). *Base Flow*: Low flow conditions in Johnson Creek may adversely impact salmonids: Flows in the middle and upper watershed frequently do not meet minimum flows, particularly in spring and summer months.
Impervious Surfaces	At Risk	The amount of effective impervious surface within a watershed has been generally shown to be negatively correlated with overall watershed health. Impervious surface reduces opportunities for stormwater infiltration. Collects pollutants.	Impervious surfaces include roads, buildings, parking lots, and other compacted surfaces that result from urbanization.	Impervious surfaces reduce groundwater recharge resulting in low summer flows. Increased stormwater runoff erodes banks and incises channels. Polluted runoff impairs aquatic organisms and reduces species richness and diversity. Water flows through system faster.	The City of Portland is in the process of obtaining estimates of impervious surfaces in the upper watershed. In the middle and lower watershed, smaller tributaries are at or above threshold values of 10-15 percent effective impervious area. The mainstem may have relatively low values when compared to other urban streams because of low levels of imperviousness in the upper watershed and diversion (CSO) of impervious areas in the most densely urbanized sections.
Hydrologic Sources	Not Properly Functioning	Springs, seeps, wetlands, floodplains supply water to streams. Provide cold water sources. Forests and uncompacted soils hold water and maintain streamflows.	Groundwater baseflow Springs, seeps in terraces and banks Off-channel wetlands Forests, intact topsoil	Loss of hydrologic sources results in low summer flows, higher stream temperatures, and water quality problems. Fish barriers	Thirty-eight percent of the former drainage network of the watershed has been artificially routed or diverted (piped, sumped, or diverted to the CSO), although only 8 percent of this flow has been piped away. Crystal Springs provides consistent and abundant inflows of groundwater, supplementing insufficient baseflows in the lower mainstem. Changes in groundwater dynamics through the rest of the watershed are unknown.
Floodplain Presence and	Not Properly Functioning	Floodplains allow interaction with the	Floodplains develop from an interaction of geology,	The lack of floodplains and connectivity	Due to channel alterations, the historical floodplain of Johnson Creek is minimally

Indicator	Baseline Condition	Key Function	Key Process or (Source)	Effect	Notes
Connectivity		stream channel, lateral channel movement, storage of floodwaters providing attenuation, and reduction in downstream flooding. Provide room for dynamic channel movement and water storage areas, and off-channel wetlands. Floodplains also provide habitat connectivity, refugia, sediment transport and storage, organic inputs and nutrient cycling.	hydrology, climate, and geomorphic processes.	concentrates water into the main channel, increasing scour and degrading instream habitat. Water flushes through system faster.	accessible or inaccessible through much of its length.

Source: Portland ESA Program and modified by Adolfson.

6.2. Physical Habitats within the Johnson Creek Watershed

The Johnson Creek watershed contains a mosaic of vegetation types, including agricultural lands, urban and suburban landscapes, upland forests, riparian woodlands, and wetlands. Vegetation moderates the effects of temperature, wind, and precipitation, stabilizes the soil, and slows run-off from storm events. Tree and shrub roots are important components of soil integrity. Urban areas are typically warmer, up to 20 degrees difference, than surrounding rural or undeveloped areas (Johnson and O'Neil, 2002). This is most likely to due to the sparse vegetation cover and a high amount of dark impervious surfaces that retain heat.

The composition and structure of vegetation strongly influences the abundance and diversity of wildlife species. In general, a complex habitat with multiple vegetation layers (i.e. herbaceous, shrub, and canopy layers) provides more niches than a simplified habitat, such as fallow field. Exotic plant species threaten to simplify and degrade native habitat. Modifications include a decrease in plant diversity and a reduction in insect prey. Evidence suggests that native plants support more insect species than exotic plants (Johnson and O'Neil, 2002). Vegetation provides many benefits to the watershed, including habitat, nutrients to streams, shade cover that helps keep stream temperatures cool, streambank and slope stabilization, moderation of hydrology, and sources of large woody debris to streams, which provides critical refuge for fish.

Because of extensive logging and clearing remnants of predevelopment vegetation are rare (Portland Bureau of Planning, 2001). About 57 percent of the watershed is currently vegetated (including grass, trees, blackberries and all other types of vegetation). The following is a summary of the various habitats (upland, wetland, riparian, and stream) that make up the Johnson Creek watershed and their baseline conditions.

6.2.1. Upland Habitat

The forest that historically covered the Johnson Creek watershed ridges and lowlands was mostly cleared in the early 1900s for agriculture, timber production, and urban uses. In the mid and late 20th century some areas such as the buttes and ridges in the south central and eastern part of the basin were left to regenerate into a second growth forest. Forest clearing of second growth has increased dramatically in recent years as housing development expanded from the lowlands onto the ridges and hillside slopes. (Portland Bureau of Planning, 1997).

The Johnson Creek watershed straddles the border between the Willamette Valley vegetation zone and the Western Hemlock zone (Franklin and Dyrness, 1988). The upland forest community exhibits characteristics common to both of these zones. The prominent occurrence of western red cedar and the presence of hemlock suggests that the forest is best characterized by the *Thuja plicata/Acer circinatum/Polystichum munitum* (red cedar/vine maple/sword fern) community of the Western Hemlock zone. The Willamette Valley *Pseudotsuga menziesii/Acer circinatum/ Polystichum munitum* (Douglas fir/vine maple/sword fern) community is similar though cedars are less common associates. Both of these communities frequently occur on north slopes such as those that make up the Boring Lava Domes and other buttes. The Boring Lava Domes area is more heavily forested than most of the watershed. The Lava Domes forest generally ranges from 40 to 100-year old second growth stands in a mid-successional stage referred to as *conifer topping hardwood*. Certain areas in the watershed, however, contain much older forest stands with tree diameters reaching five feet or more (Portland Bureau of Planning, 1997 and 1998b).

Upland forests in the watershed are typically comprised of a mixed conifer/deciduous forest with western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*) and Douglas fir (*Pseudotsuga menziesii*) frequently occurring as dominant tree species. Other occasional dominant trees include red alder (*Alnus rubra*), western hemlock (*Tsuga heterophylla*) and black cottonwood (*Populus trichocarpa*). Dominant shrubs in the forest community include vine maple (*Acer circinatum*), western hazel (*Corylus cornuta*), Indian plum (*Oemleria cerasiformis*) and snowberry (*Symphoricarpos albus*). Common herbaceous plants include western sword fern (*Polystichum munitum*), Oregon grape (*Mahonia sp.*), and fringecup (*Tellima grandiflora*).

Johnson Creek acts as a wildlife corridor for the passage of species not normally observed in large cities, including deer, coyote, bear, cougar, and many woodland and meadow birds. Pileated woodpeckers have been observed in the Boring Lava Domes forests (Portland Bureau of Planning, 1997).

6.2.2. Wetlands

Wetlands are areas that are inundated or saturated by surface or groundwater and support vegetation adapted for life in saturated soil conditions. Historically, floodplains in the Johnson Creek watershed were most likely similar to other 19th century watersheds, which consisted of seasonally inundated wetlands capable of naturally storing floodwaters. 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 acerage 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 in the basin of less than a tenth of an acre (Adolfson, 2000). Human-made wetlands include shallow drainage channels and excavated ponds of various sizes (Adolfson, 2000). Spring-fed wetlands are commonly associated with the numerous terraces found throughout the watershed but particularly along Crystal Springs Creek.

Forested wetlands within the Johnson Creek watershed are dominated by western red cedar (*Thuja plicata*), Oregon ash (*Fraxinus latifolia*), Pacific willow (*Salix lasiandra*), or red alder (*Alnus rubra*). Scrub-shrub wetlands within the watershed are dominated by Pacific willow, Piper's willow (*Salix hookeriana*), or hardhack (*Spiraea douglasii*). Emergent wetlands within the watershed are dominated by common cattail (*Typha latifolia*), colonial bentgrass (*Agrostis capillaris*), reed canarygrass (*Phalaris arundinaceae*), stinging nettle (*Urica dioica*), jewelweed (*Impatiens noli-tangere*), creeping spike-rush (*Eleocharis palustris*), common rush (*Juncus effusus*), or slough sedge (*Carex obnupta*). Wet meadows within the watershed were dominated by common rush, creeping spike-rush, dagger-leaved rush (*Juncus endifolius*), reed canarygrass, or meadow foxtail (*Alopecurus pratensis*) (Adolfson, 2000).

Several of the larger wetlands within the watershed contain intact native vegetation and have moderately mature, mid – to late successional vegetative communities. However, many of the wetlands in the watershed have non-native and invasive plant species that dominate most or all of the wetland (Adolfson, 2000).

Two major groups of wetlands exist within the watershed. The first group of wetlands are those associated directly with the hydrology of Johnson Creek and its tributaries. These wetlands tend to be located within the 100-year floodplain and often in very close proximity 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 sub-surface flows or groundwater (Adolfson, 2000).

The second major group of wetlands are small hydrologic systems in and of themselves that either drain into Johnson Creek directly or contribute to the creeks' annual flow through groundwater recharge. These wetlands are found in Errol Heights, Beggars Tick marsh area in Lents, and the Saddle area in Pleasant

Valley. These systems function more or less independently of Johnson Creek, and contain spring and seep-fed hydrology, which tends to create high quality aquatic ecosystem. The springs and wetland in Errol Heights, in particular, are directly connected to the hydrology of Johnson Creek, providing overland drainage directly to the creek (Adolfson, 2000).

Many wetlands in the basin 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 within the basin with dense breeding populations of amphibians, including red-legged frogs (Adolfson, 2000).

6.2.3. 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, contributes to increased stream flow, channel incision and streambank instability, increases erosion and sedimentation, removes nutrient sources, and reduces wildlife habitat.

Riparian zones cover a small portion of the general landscape in the Pacific Northwest (1-2%), but provide critical foraging, breeding, and resting habitat for a large percentage of species (>50%, Kauffman et al., 2001). Riparian areas with adequate vegetation diversity provide for a variety of food sources for aquatic species. Riparian widths will vary with topography, geology, and soils, and with the degree of development under current conditions. A minimum width of approximately 150 feet is necessary to ensure stream shading, inputs of wood, and invertebrate species necessary to aquatic species.

Current riparian areas are assessed by considering land within 300 feet of stream banks based on the area covering most riparian functions. In 2002, Metro completed an inventory of regionally significant riparian and wildlife habitat resources. The City of Portland Bureau of Planning is currently working on an update to the City's natural resource inventory

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 in the drainage basin are in smaller headwater creeks in the Boring Hills south of Powell Butte on either side of the Gresham/Portland urban services boundary (Portland Bureau of Planning, 2001). On the mainstem, Reaches 12 and 16 and parts of 13 and 14 have the largest forested riparian areas. The largest amount of intact riparian vegetation throughout the Johnson Creek drainage basin is found in the City of Gresham. In fact, the most extensive, intact, and highest quality riparian area is located upstream of Regner Road in Reach 16 (McConnaha 2002). The ODFW 2000 report noted the following comments concerning Reach 16:

> *Reach 16 is dominated by mixed coniferous and deciduous trees with a dbh of 50-90 cm, with few larger trees, and unlike the previous downstream reaches, this riparian zone exhibited favorable characteristics continually throughout the reach.*

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 and agricultural lands in the upper watershed have very little riparian vegetation.

Generally, existing riparian vegetation consists of areas dominated by blackberry or young native plants and lacks large mature trees. However, vegetation quality is improving as cities, other local agencies, and citizen groups have ramped up efforts to remove invasive and non-native plants and replant natives and as vegetation begins to grow and create more canopy closure (McConnaha, 2002).

Where healthy riparian forests exist, vegetation consist primarily of mixed forest with some coniferous forest and shrub areas. Vegetation includes Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), black cottonwood (*Populus balsamifera trichocarpa*), and red alder (*Alnus rubra*) as dominant tree species. Other common tree species include Oregon ash (*Fraxinus latifolia*), big-leaf maple (*Acer macrophyllum*), and Pacific willow (*Salix lasiandra*). Shrub habitats include Himalayan blackberry (*Rubus discolor*), red-osier dogwood (*Cornus sericea*), hardhack (*Spiraea douglasii*), red elderberry (*Sambucus racemosa*) and salmonberry (*Rubus spectabilis*).

Sensitive species known to occur in the riparian areas of Johnson Creek include three salamander species (long-toed, northwestern, and Columbia), two frog species, and one toad species. Painted turtles have been identified in the upper watershed (east of 162nd Avenue) (Adolfson, 2000).

The riparian findings of the ODFW assessments are summarized in table format in Appendix A.

6.2.4. Stream Habitat

Rivers, streams, sloughs, wetlands and drainage facilities are critical to hydrology and flow functions in watersheds. These above-ground and underground features provide for conveyance and storage within and between river, stream, and wetland systems. Wetlands, even those without any obvious surface connection to streams, contribute to watershed hydrology by storing and slowly releasing water into streams and groundwater. Underground aquifers also have a critical role in the hydrologic system. Headwater springs or drainages serve as the source of a stream network. Within any intact stream system and river network, headwater streams make up most of the total channel length. Therefore, such small streams offer the greatest opportunity for exchange between the water and the terrestrial environment. Maintaining functioning headwaters is important to maintaining functioning healthy streams, rivers, lakes and estuaries downstream and to providing natural flood control, recharging groundwater, trapping sediments and pollution from fertilizers, recycling nutrients, creating and maintaining biological diversity, and sustaining the biological productivity of downstream rivers, lakes, and estuaries (American Rivers and Sierra Club, 2003).

Instream habitat and channel complexity in the form of variation in depth, channel meanders, side channels, banks, logs, rocks, gravel bars, etc. provides habitat for fish as well as for plant, insect, and other species on which fish depend. Channel complexity also provides both velocity and predator refuge and spawning gravels. 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 through much of its length, flood flows cannot spread out and attenuate on the floodplain. Rather they are directed and concentrated into the main channel, increasing scour and degrading instream habitat for fish and other aquatic organisms. In addition, disconnection and fill in the floodplain has eliminated off channel habitat along the mainstem. With the exception of the Brookside constructed wetland, off-channel habitat is extremely rare (McConnaha, 2002).

The following is a summary of the 1999/2000 ODFW stream habitat survey. The instream habitat findings of the ODFW assessments are summarized in table format in Appendix A.

Johnson Creek has extremely low volumes of instream wood, particularly large wood necessary for pool formation. This results from the lack of large, mature riparian trees, removal of woody debris from the creek by citizens and officials from city agencies trying to prevent obstruction of flows downstream, and high winter flow velocities that remove large wood (McConnaha 2002).

There is a high percentage of hardened banks throughout the lower and middle sections of the mainstem while approximately 18 percent of the watershed has artificially hardened banks. 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. Crystal Springs, like most of the Johnson Creek watershed, has very little structure. In fact, Crystal Springs Creek has appreciably less structure than Johnson Creek even accounting for the WPA work in Johnson Creek. Many sections are totally lined by concrete and wood is almost non-existent.

In addition, there is a lack of refugia through many reaches, and high levels of channel incision and fine sediment. ODFW found Reach 16 to have the highest quality instream channel habitat structure with the following description:

> *Multiple channel units with good complexity occur upstream of Regner Road, and downstream of Hogan Road. The complexity at Hogan Road is very diverse, and has many large woody debris jams associated with deep pools and multiple channels. Reach 16 contains the greatest refuge potential that we found within the main stem survey. This is due to the presence of large woody debris, backwaters, deep pools, and shade cover. Reach 16 is the most natural and the least disturbed setting found on Johnson Creek in the 1999 survey.*

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 is an indication of the poor quality of instream habitat and is likely due to the deficiency of instream wood, a key element in breaking glides into pools and riffles. Existing pools and riffles are created not by woody debris but by existing geomorphic features that have evolved as energy is dispersed along the stream course (McConnaha, 2002).

The habitat of Johnson Creek's main tributaries is also compromised. Much of Crystal Springs Creek has been channelized, lacks healthy riparian buffers, and has degraded habitat. Habitat assessment of Kelley Creek reveals that there are a few small sections of higher quality habitat, while much of the creek is impacted or degraded. Most impacts are due to the lack of high quality riparian habitat and large quantity of stormwater draining to the creek as a result of tiling and other agricultural practices (ODFW 2000, BES 2001).

The Portland ESA Program assessed baseline conditions for habitat indicators in Johnson Creek (See Table 5). These indicators and their assessed base line condition compared to properly functioning conditions were incorporated into an Ecosystem Diagnosis & Treatment (EDT) Model. See Watershed Problems and Opportunities in Section 7 for discussion of this model and results of selected indicator attributes and their protection and restoration values.

6.2.5. Culverts and Barriers

During 2000-2001, a committee composed of jurisdictions within the watershed (known as the Johnson Creek Joint Culvert Crossing Committee) was formed to identify and inventory culverts within the Johnson Creek watershed and to make an assessment of their condition and fish passability. In addition to culverts, other instream passage structures such as bridges and potential obstructions such as dams, weirs, or exposed pipes within the public right-of-way were also inventoried. Six jurisdictions were involved including Multnomah and Clackamas Counties, Oregon Department of Transportation (ODOT), and the cities of Portland, Gresham, and Milwaukie. Results were fed into Geographical Information System (GIS) analysis and mapped by Portland (Prescott, 2001).

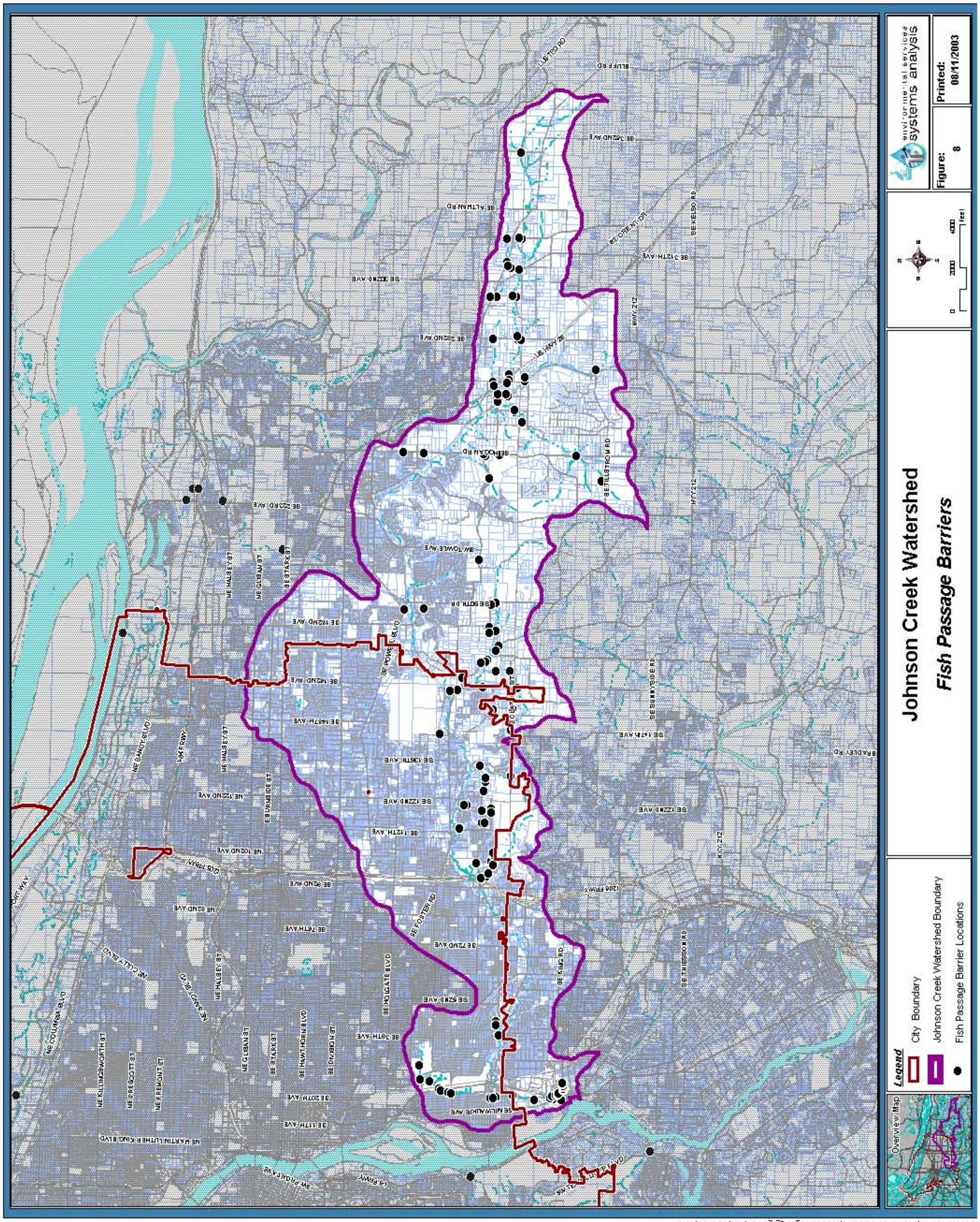
A total of 226 structures were inventoried watershed wide. Seventy-eight culverts were inventoried within Portland and a total of 38 structures were inventoried within Gresham. An assessment was made of each culvert of degree of blockage and various maintenance considerations. In addition, ratings were given for conditions such as distance to next culvert, instream and riparian habitat quality, fish presence, and downstream access (City of Portland ESA, 2002). Due to timing restrictions on federal grant fund programs and other constraints, the jurisdictions completed only the first phase of the inventory. Additional assessment will be required to finalize the culvert prioritization process. Both Clackamas and Multnomah Counties have ranked public right-of-way culverts within their jurisdictional boundaries. A summary of the public right-of-way culvert crossing inventory database is provided in the Action Plan in Appendix D. Culverts and other fish passage barriers on private lands have not been assessed. See Data Needs.

The assessment shows the following:

- 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 (see below).
- 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 passage barriers exist along Johnson Creek. Four instream structures within Johnson Creek have either recently been removed or plans are being finalized for removal. During 2000, Metro acquired property and removed a private instream dam on Johnson Creek above Hogan Road in Gresham. A 5 foot diameter sewer pipe that was originally 5 feet below the stream bed at Tideman Johnson Park is now exposed due to down cutting of the creek. In 2004, BES began finalizing plans to aggrade the stream and reinforce the pipe. Multnomah County also approved a permit to replace culverts in Johnson Creek mainstem above SE 282nd with an arched culvert/bridge (See Appendix D and I). Figure 8 presents a preliminary list of known fish barriers throughout the Johnson Creek watershed.

Figure 8. Passage Barriers in the Johnson Creek watershed.



6.2.6. Refugia

Refuge areas for fish consist of both chemical and thermal refugia. Refuge areas for fish are local areas where fish can escape chronic or episodic events such as high turbidity flow events during the winter or high water temperatures during the summer and early fall. Thermal refugia areas generally include groundwater springs, seeps, confluences of tributaries, and in some stream systems, localized areas of intact healthy riparian shaded areas.

DEQ obtained both field temperature data and the Forward Looking Infrared Radar (FLIR) imaging data during 2002. These surveys were conducted during a very low period (approximately 1 cfs). Preliminary results yielded no significant coldwater refugia areas. This was due in part to the low flow conditions and the limits of the FLIR capabilities (E-mail communication with Greg Geist, DEQ, 2003). See Figure 9 for a preliminary plot of Effective Shade by River Mile showing the current and potential conditions. This plot was produced by DEQ for development of the Draft Total Maximum Daily Load (TMDL).

No extensive survey of thermal refuges has been conducted in Johnson Creek. Salmonids and lamprey have been observed in the following areas:

• Lower Kelley Creek	Coho
• Lower Kelley Creek and possibly Lower Hogan Creek	Steelhead
• Crystal Springs Creek	Rainbow/Steelhead
• Lower and Upper Kelley, Johnson Creek Reach 16	Cutthroat Trout*
• Lower Crystal Springs Creek, Johnson Creek Reach 1 and 2, Reach 5	Coho spawners
• Johnson Creek Reach 1 and 2	Chinook
• Kelley Creek, Crystal Springs Creek, and Johnson Creek Reaches 4, 6, 8, 12, and 16	Lamprey

* Cutthroat Trout are likely in other areas of Johnson Creek and its tributaries.

Two of these tributaries with thermal refuge potential, Crystal Springs and Kelley Creek, fail to meet temperature standards during summer months. Temperture should be lower in both creeks, however, lack of shading causes high temperature in both and in particular instream ponds cause high water temperature in Crystal Springs. Errol Creek, located in Reach 5, provides significant potential for thermal refuge just upstream of Tideman Johnson. However, the creek is not accessable due to a number of instream barriers and road culverts and poor instream habitat.

Figure 9. Preliminary Draft Plot of Current and Potential Conditions for Effective Shade by River Mile in the Johnson Creek watershed

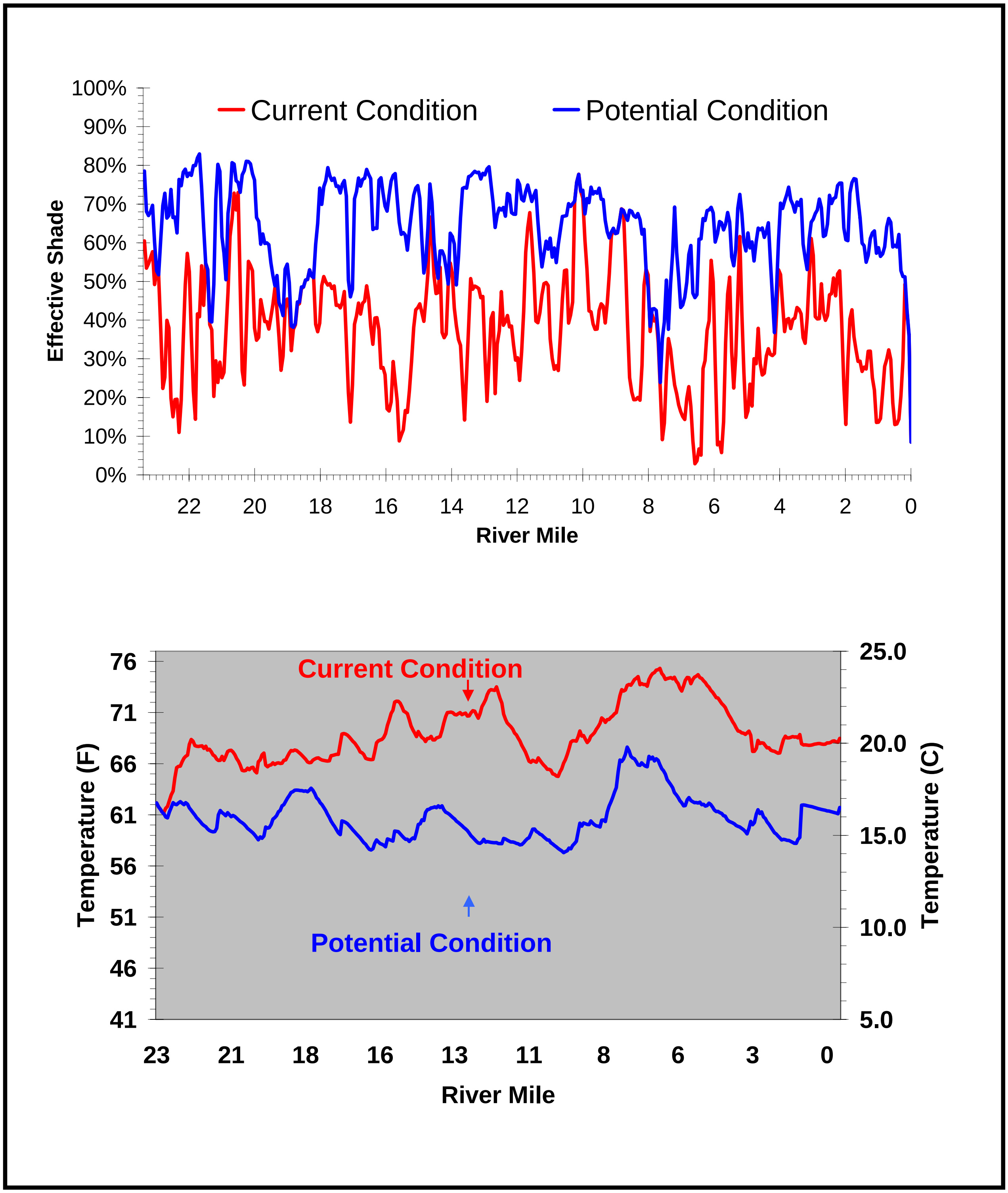


Table 5. Habitat Indicators in the Johnson Creek Watershed

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Floodplain Quality	Not Properly Functioning	High-quality floodplains provide diverse habitats for salmonids and other species	Geology, hydrology, climate, and geomorphic processes create floodplains	Loss of high quality floodplains reduces habitat complexity and off-channel habitat.	In many places throughout the watershed, development has occurred within the floodplain, degrading the amount and quality of floodplain available.
Riparian Integrity: Width; Composition; and Fragmentation	Not Properly Functioning	Riparian areas provide channel compensation and dynamics, structural complexity and habitat connectivity. Riparian integrity also contributes to shading and microclimate regulation, organic matter, temperature regulation, pollution and sediment control, bank stabilization, habitat for terrestrial species, and buffer from human activity	Riparian composition and width depends on disturbance regimes, soil, geology, and hydrology. Many riparian plants are adapted to fluctuating water levels. Important to have a variety of vegetation classes and ages to create microhabitats, refugia, and diversity. Provides a variety of nutrient inputs at different times of the year.	Narrow, non-native, and fragmented riparian areas result in higher summer temperatures, increased sediment and run-off, decreased colonization of native trees and shrubs, and reduced organic inputs.	*Width*: 34 percent of the watershed has little or no riparian vegetation present; an additional 32 percent has riparian vegetation less than 100 ft. wide. *Composition*: Important data gap. What little information exists on composition is being evaluated. *Fragmentation*: The riparian corridors within Johnson Creek are highly fragmented by frequent road crossings.
Bank Condition	Criteria not developed yet.	Stable banks contain streamflow and withstand erosive forces. Vegetation plays role in bank integrity, formation of streambanks and gravel bars and promotes development and maintenance of undercut banks.	Roots of riparian vegetation secure banks and facilitate bank building by trapping sediments.	Unstable banks erode easily degrading instream habitat. Armored banks prevent establishment of vegetation, simplify habitat, and prevent exchange with groundwater.	There are extensive amounts of WPA bank hardening throughout the lower and middle mainstem. Overall, approx. 18 percent of the watershed is artificially hardened. Crystal Springs has the highest percentage of hardened banks (50 percent).

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Channel Substrate: Fine and Coarse Sediments	Not Properly Functioning	Salmonids require a balance of substrate types to complete their life cycle. Availability and size can impact viability of aquatic species.	Channel substrate is influenced by geology, hydrology, geomorphic processes and input from upstream reaches. A mix of gravel and rubble size can affect invertebrates.	Excess fines imbed and cover gravels/cobbles required for spawning and limit food production. Fine sediments can affect behavior and cause stress in aquatic species.	*Fines*: Twenty percent of the riffles throughout the watershed have percent fines > 11; riffles in Church (100 percent), Mitchell (66 percent), and Clatsop (61 percent) – all tributaries to Kelley Cr. frequently exceed that benchmark. *Coarse*: The Johnson Cr. mainstem and Kelley Cr. and its tributaries have inadequate levels of riffle gravels.
Depth Refugia	At Risk	Pools with varying depths provide refuge from high-flow areas and niches for numerous species. Pools also are important for channel composition and dynamics and contribute to structural complexity.	Pools are created from streamflow diversions such as logs or debris.	Low numbers and quality of pools may negatively affect the life cycle of salmonids and other fish and aquatic species.	Pools are relatively abundant and well dispersed throughout the watershed. Pool quality, however, as measured by residual pool depth and the number of complex pools is fair or poor throughout much of the watershed.
Off-Channel Habitat	Not Properly Functioning	Off-channel habitats provide connections to streams and interaction with the floodplain. Provides rearing, feeding, and spawning habitat for many aquatic species. Off-channel habitat also provides important refugia from disturbances such as high flows and sediment loading.	Off-channel habitat is created from lateral channel movement and overflows during flooding events.	Lack of off-channel habitat results in larger, downstream flood peaks, reduces refugia, and simplifies in-stream habitat.	Side channels, alcoves, and backwater areas are present in some reaches of Johnson Cr., but extensive bank hardening and channel alterations have greatly reduced the number, quality, and accessibility of off-channel habitats. Crystal Springs and Kelley Cr. provide much of the remaining off-channel habitat.

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Large Wood (LW)	Not Properly Functioning	LW influences channel dynamics by diverting flow, creating channel roughness, and stabilizing banks. LW also retains smaller debris and promotes the formation and maintenance of side channels, pools, and lower velocities. LW provides habitat and refugia for salmon and invertebrates.	LW enters the stream from adjacent riparian areas and modifies the channel resulting in pools, riffles, low velocity areas, and side channels	Lack of LW simplifies channel habitat and reduces fish refugia required for rearing or feeding.	Wood volume is extremely low throughout Johnson Cr.
Shoreline Complexity	Not Properly Functioning	Complex shorelines provide microhabitats for aquatic organisms including off-channel habitat. May provide important feeding and resting areas.	Shoreline complexity arises through natural stream meander and development of off-channel habitat following flooding events. Also includes large tree roots, and live trees and shrubs.	Lack of shoreline complexity results in low-quality, simplified aquatic habitat.	WPA and other bank hardening channel straightening, and channel maintenance (e.g., removal of large wood) have greatly reduced shoreline complexity.
Harassment (e.g., boat traffic; lights; and noise)	At Risk	The level of harassment is negatively correlated with habitat for many wildlife species.	Harassment within riparian and stream zones results from intense development and uninformed or insensitive human activity	Many aquatic and terrestrial organisms are sensitive to human disturbance. Results include decreased species richness and diversity and polluted habitat from trash / boat fuel.	Commercial, industrial, residential, and recreational uses are located close to the stream in many reaches.
Fish Passage / Access	Not Properly Functioning	Free-flowing, passable streams support larger salmonid populations and healthier resident populations. Access to all parts of the watershed can be critical for certain species during portions of their life cycle.	Culverts and other fish passage barriers arise from road and driveway crossings, dams, utilities, diversion structures, and other development.	Barriers may completely or partially block fish passage to high quality habitat to the detriment of the population. Culverts concentrate stream flow causing erosion or scour. Barriers may impact different life stages.	Some of the highest quality habitats within the watershed (Kelley Cr. upper Crystal Springs, and southern tributaries) have one or more culverts that limit access.

Source: Portland ESA Program and modified by Adolfson.

6.3. Water Quality

Numerous water quality studies have been conducted throughout the Johnson Creek watershed. Unfortunately, many were conducted with objectives other than characterizing the entire Johnson Creek watershed. Sampling programs were designed to provide site-specific water quality data related to a capital improvement project or were of limited duration. As a result, there is no recent summary characterizing the water quality throughout the entire watershed. A brief summary is provided from recent data collected by local jurisdictions as well as efforts related to DEQ's development of the Total Maximum Daily Load (TMDL) and recent data collected by the USGS.

6.3.1. Water Quality Monitoring

Oregon Water Quality Index

DEQ developed the Oregon Water Quality Index (OWQI) as a general indication of water quality based on several water quality parameters including temperature, dissolved oxygen (percent saturation and concentration), biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogen, total phosphorus, and fecal coliform bacteria. OWQI scores range from 10 (worst case) to 100 (ideal water quality). Table 6 summarizes the minimal seasonal average OWQI results for the Lower Willamette Basin during the 1994-2003 Water Years. OWQI scores that are less than 60 are considered very poor; 60-79 poor; 80-84 fair; 85-89 good; and 90-100 excellent. The OWQI scores reveal that Johnson Creek has the lowest minimal seasonal average out of the 14 sites sampled, has very poor water quality, and is showing no trend in water quality changes (water quality is neither improving nor degrading further) (Mrazik, 2004). See DEQ web site at http://www.deq.state.or.us/lab/wqm/OWQISummary03.pdf.

Table 6. Seasonal Average Oregon Water Quality Index (OWQI) Results for the Lower Willamette Basin (WY 1994-2003)

Site	River Mile	Minimal Seasonal Average	Category	Trend	Magnitude
Beaverton Creek at Cornelius Pass Road	0.3	53	vp	Inc.	+10.0
Clackamas River at High Rocks	1.2	91	e	Inc.	+2.5
Clackamas River at McIver Park	22.6	95	e	NT	
Clackamas River at Memaloose Road	35.7	92	e	NT	
Columbia Slough at Landfill Road	2.6	37	vp	Inc	+14.7
Fanno Creek at Bonita Road	2.3	62	p	NT	
Johnson Creek at SE 17th Avenue	**0.2**	**29**	**vp**	**NT**	
Swan Island Channel midpoint	0.5	80	f	Inc.	+3.3
Tualatin River at Boones Ferry Road	8.6	59	vp	NT	
Tualatin River at Elsner Road	8.6	59	vp	NT	
Tualatin River at HWY 210	26.9	65	p	NT	
Tualatin River at Rood Bridge	39.0	76	P	Inc.	+3.3
Willamette River at Hawthorne Bridge	13.2	82	F	Inc.	+4.8
Willamette River at SP&S RR Bridge	7.0	79	p	NT	

WY = Water Year (October-September)
Category Key: **e**: Excellent; **g**: Good; **f**: Fair; **p**: Poor; **vp**: Very Poor.
Trend Key: **Dec**.: Significant Decrease; **Inc**.: Significant Increase; **NT**: No significant Trend.

Baseline Ambient Monitoring

The City of Portland monitors Johnson Creek in response to a number of programs and projects. Portland has monitored ambient conditions along Johnson Creek main stem and two tributaries (Crystal Springs and Kelley Creek) since 1996 (5 locations from 1996-2000, 8 locations since 2000). Generally, the monthly grab samples revealed fair dissolved oxygen concentrations, and high temperatures and *E. coli* bacteria levels, as referenced above. Selected water quality results from 1998-2002 during the summer season (July through October) are presented in a table in Appendix C.

City of Gresham Storm Event Sampling and Monthly Monitoring

The City of Gresham has conducted water quality sampling programs at various locations in Johnson Creek since the early 1990's. During Permit Year 6 of their NPDES Permit, Gresham sampled four locations within Johnson Creek during 2000–2001 at the upstream and approximate downstream jurisdictional boundaries and two intermediate locations near Main City Park. Both routine monthly and storm event monitoring were conducted. Most pollutants are washed off land surfaces and discharged to waterbodies during storm runoff events. Storm event monitoring can provide opportunities to identify nonpoint pollution sources and loadings. Table 7 summarizes mean values from monitoring Johnson Creek at Palmblad Road (upstream jurisdictional boundary) during four storm events in 2000-2001.

Table 7. Storm Event Sampling Results in Johnson Creek at Palmblad Road (Gresham)

Water Quality Parameter	Maximum value	Mean value (four storms)
Turbidity	544 ntu	399 ntu
Total Suspended Solids	491 mg/L	199 mg/L
Total Phosphorus	930 ug/L	492 ug/L
E.coli bacteria	5,900 cfu/100mL	2,525 cfu/100mL

ntu = nephelometric turbidity unit
mg/L = milligrams per liter
ug/L = micrograms per liter
cfu = colony forming unit

Results from the above storm events reveal extremely poor water quality conditions as compared to "natural" conditions and state and federal standards and recommended guidelines. In fact, the mean values in Table 7 exceed state water quality standards or EPA guidelines ranging from 2.4 to 6.2 times more (EPA, 1999, and 1986; OAR, 1992). The maximum value for E.coli bacteria listed in Table 7 (5,900 cfu/100mL) is more than 14 times the state water quality standard of 406. Also, the desired phosphorus goal for the prevention of plant nuisances in streams is 100 µg/L (EPA, 1986). Finally, in a study downstream from the discharge of a rock quarry where inert suspended solids were increased to 80 mg/L, the density of macroinvertebrates decreased by 60 percent while in areas of sediment accumulation, benthic macroinvertebrate populations also decreased by 60 percent regardless of the suspended solids concentration (Gammon, 1970).

6.3.2. 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) listing includes the entire stream, from the mouth to headwaters. 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)

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 temperature, bacteria, and toxics for Johnson Creek.

Temperature

Johnson Creek was placed on the 303(d) list for temperature, although data collected was obtained during a drought year. Temperature was de-listed during 2002, however, due to numerous data results showing temperature problems throughout the watershed, DEQ is currently moving forward with development of a Total Maximum Daily Load (TMDL) for temperature (Geist, 2003).

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. The colder the water, the greater amount of oxygen that can be dissolved in it. DO is important for fish survival.

The numerous investigations of temperature in Johnson Creek over the years have consistently indicated that summer water temperatures do not meet state standards throughout the watershed. Elevated temperatures, with some potential contribution from elevated nutrients, result in dissolved oxygen concentrations that frequently drop below guidelines in the summer. These conditions limit salmon and trout productivity throughout the watershed. Elevated temperatures are caused by low summer base flows, lack of riparian shade, and impoundment of water in ponds.

While there is not a long-term temperature record for Johnson Creek the USGS has collected temperature records from 6 stations since 1998 (3 along mainstem, 2 in Crystal Springs, and 1 in Kelley Creek). The existing data provides a good understanding of seasonal temperature patterns and dynamics. From an analysis of one year of data it appears that there are more total days with maximum temperature above 20 degrees Celsius when moving downstream. Kelley Creek had the fewest days above 20 degrees Celsius. Twenty degrees Celsius represents a threshold in the EDT model where thermal temperatures are approaching fatal condition for salmon and trout (McConnaha, 2002).

The City of Portland's Ambient Monitoring Program found that over a 4-year period, mean maximum summertime temperatures in Johnson Creek exceeded state standards (See City of Portland Ambient Monitoring Results summary table in the Action Plan in Appendix C.) For the Willamette Basin, where salmonid fish rearing is a designated beneficial use, this standard is 17.8 degrees C. Data collected by BES as well as DEQ indicate that water temperatures in Johnson Creek peak between River Miles 5 and 6.5 – approximately 60th Avenue upstream to I-205 (Geist, 2003).

Although Crystal Springs Creek is fed by cool groundwater springs it has warmer summer and wintertime 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 the creek located at Reed College, the Rhododendron Gardens, Eastmoreland Golf Course and Westmoreland Park (McConnaha 2002).

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.

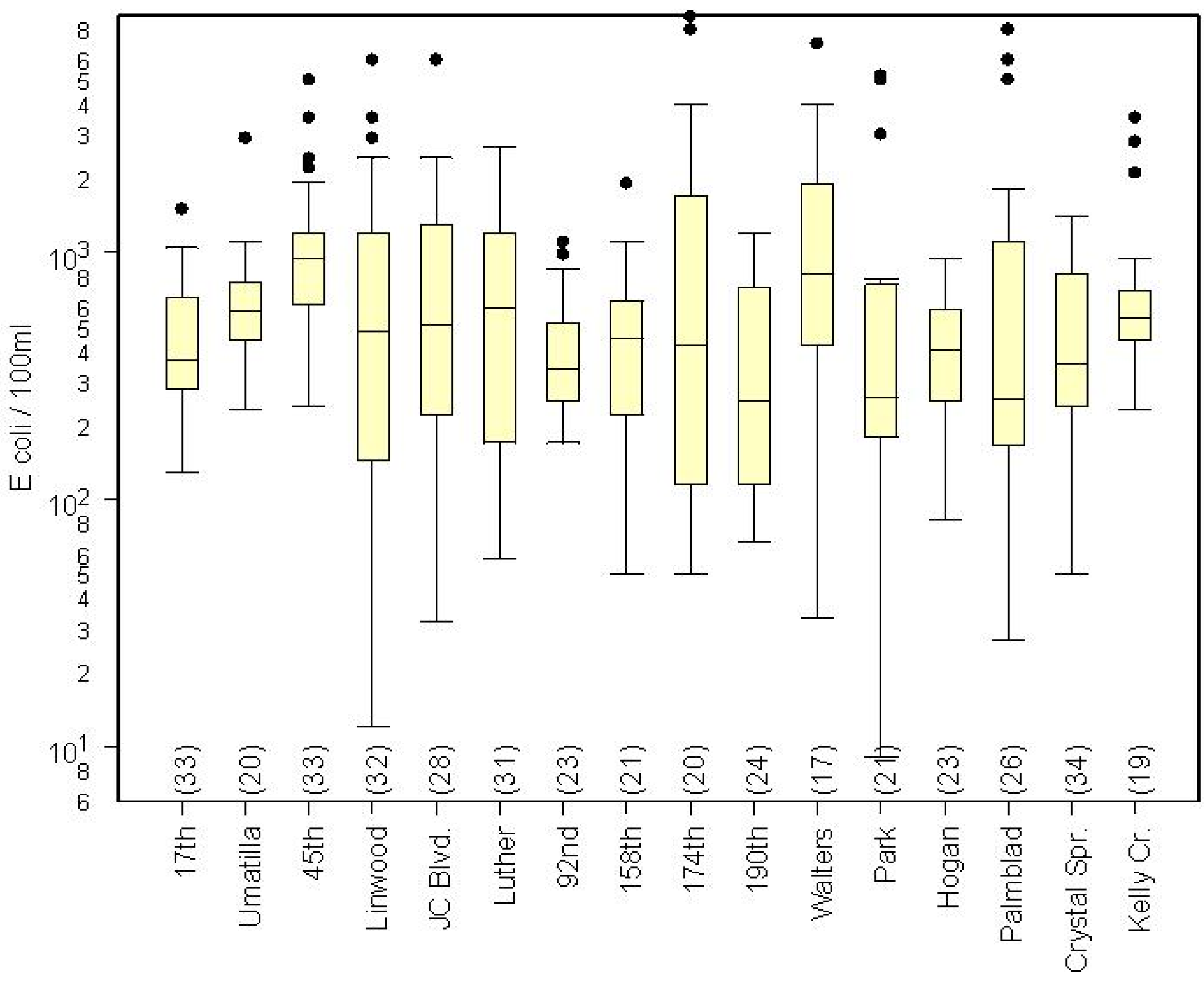
Several studies found that bacteria concentrations in Johnson Creek exceed state water quality criteria. Concentrations are highest during high flows, most likely a result of stormwater outfalls discharging surface runoff from areas with leaking septic tanks or cesspools or areas with high concentrations of animal wastes.

Routine monitoring by both Portland and Gresham reveal *E. coli* bacteria levels that exceed state water quality standards throughout the Johnson Creek watershed. These standards include a 30-day log mean of 126 *E. coli* organisms per 100 mL, based on a minimum of five samples, and no single sample shall exceed 406 *E. coli* organisms per 100 mL. The City of Portland's Ambient Monitoring Program sampling revealed geometric mean values for *E. coli* bacteria ranged from a low of 44 to a high of 1,894 colonies/100mL with a mean of 553 colonies/100mL (See City of Portland Ambient Monitoring Results summary table in the Action Plan in Appendix C). These exceedances occur both during winter storm events as well as during the dry summer periods.

From 1998 through 2001, Clackamas County Water Environment Services (WES) collected bacteria samples at three locations between 92nd and 45th Avenue in Johnson Creek. Results reveal relatively high *E. coli* values. Geometric means ranged between 321 and 1,423 and fecal coliform bacteria geometric mean values ranged between 741 to 1,093 organisms/100mL.

Figure 10 summarizes E. coli bacteria data throughout the Johnson Creek watershed. Results reveal exceedances of state standards throughout the drainage basin.

Figure 10. E. coli bacteria levels throughout the Johnson Creek watershed



Toxics

DDT was identified as a problem based on the results of a USGS investigation (Edwards 1994), which found high instream concentrations. In addition, the USGS is working on a toxics monitoring report from data collected during 2002. Additional investigations of DDT are planned to determine whether DDT concentrations have changed over time, and to provide further evaluation of the nature and sources of DDT concentrations throughout the watershed.

During May 2000, and August 2001, the City of Gresham obtained sediment samples within Johnson Creek. Table 8 summarizes selected toxics results from these sampling sessions.

Table 8. Sediment sample results in Johnson Creek

Sample Date	Sample Site	4,4' DDD	4,4' DDE	4,4' DDT	Alpha-Chlordan	Chlor dane	PCB 1016	PCB 1221	PCI 123	PBI 124	PCI 124	PCI 125	PCI 126	Dieldri	Toxaphen
Detection Limit		13.4	13.4	13.4	13.4	300	67	67	67	67	67	67	67	13.4	400
05/30/00	JCI1	13.4	13.4	22.1	13.4	300	67	67	67	67	67	67	67	13.4	400
05/30/00	JCI2	14.8	29.7	15.4	13.4	300	67	67	67	67	67	67	67	13.4	400
08/28/01	JCI1	33.5	33.5	33.5	33.5	750	67	134	67	67	67	67	67	33.5	1000
08/28/01	JC12	89.4	60.7	89.4	89.4	2000	179	358	179	179	179	179	179	89.4	2670

Note: units are ug/Kg
JCI1 = Johnson Creek at 174th (downstream jurisdictional boundary)
JCI2 = Johnson Creek at Palmblad Road (upstream jurisdictional boundary)

Oregon does not currently have freshwater sediment standards. DEQ utilizes guidelines contained in the November 1998 Dredged Material Evaluation Framework-Lower Columbia River Management Area for evaluating freshwater sediments. This document uses a tiered evaluation process in a sequential manner for evaluating the suitability of dredged material for unconfined aquatic disposal. Table 9 presents dry weight interpretive guidelines for selected chemicals including a screening level, bioaccumulation level, and maximum level. A screening level (SL) value is listed that identifies chemical concentrations at or below which there is no reason-to-believe that dredged material disposal would result in unacceptable adverse effects due to toxicity measured by sediment bioassays. These screening values were developed for the marine environment. Freshwater values are under development. A second, higher Maximum Level (ML) is identified for each chemical above which there is reason-to-believe that the material would likely fail the standard suite of biological tests and thus be unacceptable for unconfined aquatic disposal. A third chemical screen, the bioaccumulation trigger (BT) has been determined for some chemicals of concern. This may be an important factor in determining sediment suitability for sediments at or above the ML. Bioaccumulation is defined as the accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material. Although not directly applicable to Johnson Creek sediments, it provides a comparative summary for the relative concentrations of sediment results obtained in Table 8.

Table 9. Sediment guidelines – Dredged Material Evaluation Framework

Pesticides	Screening Level	Bioaccumulation Level	Maximum Level
Total DDT (sum of 4,4' – DDD, 4,4'-DDE, and 4,4' – DDT)	6.9*	50	69
alpha-Chlordane	10	37	---
Dieldrin	10	37	---
Total PCBs	130	38**	3,100

* Concentrations are ug/kg
** This value is normalized to total organic carbon, and is expressed in mg/kg (TOC normalized).

City of Gresham sediment sampling results from May 2000 and August 2001 in Johnson Creek at Palmblad Road reveals that sediment samples for Dieldrin, alpha-Chlordane, and PCBs exceed both the screening and bioaccumulation levels. DDT also exceeds the maximum level guideline at this location. Additional sediment samples should be obtained to confirm these results and to isolate source areas.

In addition, water column samples were obtained in Johnson Creek for the following priority pollutants: DDT, Dieldrin, PAH, PCB and Chlordane. Water quality standards for selected priority pollutants are shown in Table 10 below and were obtained from Table 20 in –Water Quality Criteria Summary in Oregon Administrative Rules (OAR) Chapter 340, Division 41 – DEQ.

Table 10. Priority Pollutants and 303(d) listings in Johnson Creek

Compound Name or Class	Priority Pollutant	Carcinogen	303(d) List Date	Data Results to Support Listing	Fresh Acute Criteria* (ug/L)	Fresh Chronic Criteria * (ug/L)
DDT	Yes	Yes	1998	.001 ug/L – 0.1 ug/L	1.1	0.001
Dieldrin	Yes	Yes	1998	0.007 ug/L – 0.021 ug/L	2.5	0.0019
PAH	Yes	Yes	2002	0.0423 ug/L		
PCB	Yes	Yes	2002	0.02002 ug/L	2.0	0.014
Chlordane	Yes	Yes	Not listed	0.0016 ug/L	2.4	0.0043

ug = micrograms or one millionth of a gram (10^{-6})
ng = nanograms or one billionth of a gram (10^{-9})
pg = picograms or one trillionth of a gram (10^{-12})
* For protection of Aquatic Life
** For protection of Human Health

The above priority pollutants and associated supporting data results obtained by the USGS, DEQ, and other public agencies reveals that DDT, Dieldrin, and PCBs are exceeding state standards for chronic toxicity in Johnson Creek. Additional monitoring will be required to identify and control sources of toxic contamination in the watershed.

PCBs and PAHs

Limited data show the presence of PCBs and PAHs in Johnson Creek. The 303(d) listing was based on a 1999 USGS study (McCarthy and Gale 1999) that found concentrations of PCBs and PAHs more than 1000 times the state criterion. However, this study was based on one sample. Further study is needed to identify the nature and extent of these contaminants.

6.3.3. Other Water Quality Parameters

Eutrophication and Dissolved Oxygen (DO)

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 (McConnaha 2002).

A 2002 study of the sources and hydrologic pathways of nutrients in an urbanizing landscape and their relative nutrient contributions to Johnson Creek revealed that Total Phosphorus (TP) concentrations did not vary significantly between urban and non-urban areas for the entire study period or during the wet season. This is thought to be the result of the continuous input of particulate P that is an unreactive form and transported by surface runoff from both urban and agricultural areas within the watershed (Heathwaite and Johnes, 1996). Other sampling results of this study found that surface and near-stream shallow groundwater have significantly higher phosphorus concentrations within urban areas, while stream water and near-stream groundwater nitrogen concentrations were higher in non-urban areas. Johnson Creek surface water had almost twice as much N than near-stream groundwater. These results indicate that Johnson Creek receives significant input of N to the stream from surface sources. Significantly higher stream water N levels were correlated with non-urban landuse areas, while elevated levels of P were highly correlated with urban land use.

A number of these values do not meet the state standard of 11.0 mg/l for spawning periods and 8.0 mg/L all the rest of the time. (See City of Portland Ambient Monitoring Results summary and DEQ Dissolved Oxygen and Intergravel D.O. Criteria DEQ Table 21 in Appendix C.)

Sediment and 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 were measured during both high and low flow conditions, and are most likely a result of bank erosion, roadside ditch erosion, runoff from construction activities, and runoff from agricultural and nursery operations. Turbidity levels are high in the upper portions of the watershed, indicating that sedimentation begins in the upper watershed.

Metals

Metals can have adverse impacts on acquatic 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 runoff into the creek. Generally, metal concentrations increase downstream. When flows are high Johnson Creek may also contribute chromium, copper, mercury and zinc in the Willamette River (McConnaha 2002). Transportation is likely the most significant source of metals. Additional metal contamination may come from industrial sources.

Table 11. Water Quality Indicators in the Johnson Creek Watershed

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Temperature	Not Properly Functioning	Temperature is related to shading and microclimate functions, and amount of impervious surface. Temperature affects the amount of dissolved oxygen in a stream and, in turn, fish physiology and health. Salmonids require cold water (less than 17 degrees Celsius)	Temperature can be influenced by air temperature, cold water inputs such as seeps and springs, groundwater interactions, stormwater runoff, canopy cover, solar heating, and channel width-to-depth ratios. In addition, the orientation (such as east to west) of a stream can have significant effect on temperature regimes. High temperatures result from inputs of warm stormwater and a loss of riparian vegetation, which moderates stream microclimates.	Warm water temperatures impair native fish health by increasing their susceptibility to disease and parasites. Warm water also has a direct effect on the amount of dissolved oxygen it can contain. Warm water can act as a barrier and have a significant effect on reproduction success. Negatively affects productivity and activities of aquatic species.	Temperatures throughout Johnson Cr. exceed water quality standards during the summer months. Temperatures begin to exceed the spawning and incubation standard in April, although data is lacking to determine whether eggs and fry are still present within the gravel during this period. Temperatures at the mouth of Johnson Cr. are consistently higher than temperatures in the middle and upper watershed.
Thermal Refugia	Not Properly Functioning	Tributary streams and confluences, springs, seeps, and other groundwater inputs provide refuge areas for salmonids.	Development, barriers, groundwater usage, and climate changes can impact thermal refuge areas.	Lack of thermal refuge areas can have a significant impact on fish and aquatic species during critical times of their life cycles.	No extensive survey of thermal refugia has been conducted in Johnson Cr. However, two key tributaries within Johnson Cr. – Crystal Springs and Kelley Cr. fail to meet temperature standards during summer months. Crystal Springs has large inputs of 55°F groundwater and yet exceeds temperature standards.
Eutrophication: (Nutrients, D.O., and Chlorophyll a)	At Risk	Nutrients and chlorophyll provide energy requirements to living organisms. High eutrophication associated with sediment and nutrient loading is negatively correlated with fish and aquatic habitat functions.	Sources of eutrophication include erosion, and other human activities on the landscape including residential, commercial, agriculture, and others.	Low D.O. can cause stress and lethal impacts. High nutrient loads can contribute to excessive aquatic vegetation densities and large diurnal changes in D.O. levels. High Chlorophyll a concentrations can lead to visibility problems.	Nutrient concentrations exceed federal guidelines (Edwards, 1992; Reininga, 1994). D.O. concentrations frequently drop below 8.0 mg/L in summer; approximately thirty percent of the measurements throughout Johnson Cr. in August are below this value. Low dissolved oxygen concentrations are likely due to a combination of elevated temperatures and nutrient loading.

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Toxic Materials	At Risk	Toxic materials have negative correlation with fish and wildlife health.	Sources of toxic pollutants include agricultural, municipal, and industrial wastewaters, stormwater runoff, and chemical spills. Toxic chemicals bind to sediments, are ingested by aquatic organisms or are washed and deposited downstream.	Toxics can cause lethal or sub lethal effects in aquatic organisms. Sub lethal effects include impaired reproduction. Bioaccumulation of pollutants in fish can negatively impact human health and piscivorous birds. Toxins can become a chemical barrier for aquatic species.	Johnson Cr. is on the 303(d) list for DDT and Dieldrin. Instream DDT concentrations measured in a USGS study are among the highest measured in the region (Edwards 1994). Concentrations of PCBs and PAHs have also been recently observed exceeding state water quality standards, and are proposed for 303(d) listing.
Sediment	At Risk	Normal sediment inputs replenish scoured areas and contribute to bank creation.	Sediments originate from the landscape from overland flow / stormwater runoff or upstream. Sediments also originate normally from stream channels and from excessive high flows and erosion of streambed and banks.	High levels of sediment (or turbidity) can impair feeding and respiration and limit, impact, or destroy food resources. Turbidity abrades fish gills and skin leading to infection.	Fines in certain portions of Johnson Cr. are presently at levels that seriously limit fish food production or embed spawning areas.

Source: Portland ESA Program and modified by Adolfson Associates

6.4. Biological Communities

6.4.1. Fish

Fish communities in Johnson Creek include both native and non-native species. Native species present are predominantly those tolerant of warm water and disturbed conditions. These include redside shiners, reticulate sculpin, large scale suckers, and speckled dace (McConnaha, 2002, JCCC, 1995). Johnson Creek historically had large salmon populations. Numbers declined dramatically once urbanization began and particularly after the channelization work was completed (McConnaha, 2002). As part of the Lower Columbia River Evolutionary Significant Unit, steelhead and Chinook are listed as threatened in Johnson Creek under the Endangered Species Act. However, adult salmonids have been observed in recent years, including: coho salmon, Chinook salmon, cutthroat trout, and steelhead (ODFW unpublished data, as cited in Portland BES, 2000).

The 1995 Johnson Creek Resources Management Plan summarized the different salmonid life stages and species use in Johnson Creek. Winter-run adult steelhead return to spawn in Johnson Creek from mid-November through May. Two separate runs appear to peak in January-February and again in April-May. Eggs or salmon fry can be present in the gravel from December to July. Juvenile steelhead can remain in Johnson Creek for one to two years before migrating as smolts to salt water. Steelhead are likely to use the mainstem and tributaries (JCCC, 1995).

Historically, coho salmon were observed in the lower reaches of Johnson Creek and Crystal Springs Creek from late September through early November. Eggs or coho fry could be within Johnson Creek gravels between October and March. Fry attempt to establish territories and remain in streams as juveniles for one to two years before smolts migrate to salt water (JCCC, 1995).

Chinook salmon probably enter Johnson Creek to spawn during mid-September through October. Fry emerge from gravels in January or February. Unlike steelhead or coho salmon, Chinook only spend a few weeks near spawning grounds before migrating to salt water, and are usually out of the freshwater systems by June (JCCC, 1995).

Coastal subspecies of cutthroat trout are also present in Johnson Creek. This coastal subspecies has both sea-run and resident forms. No current documentation of the sea-run form exists. Data from 1992 and 1993 indicated that cutthroat trout were present in low numbers throughout the mainstem of Johnson Creek, but were more abundant in many of the smaller headwater tributaries (JCCC, 1995). Coastal cutthroat trout spawn from late December through February, and most fry emerge from the gravel by mid-April. This can vary depending on the spawning period and water temperature. Resident forms of coastal cutthroat trout typically remain in, or relatively close to their natal streams. Juvenile sea-run coastal cutthroat trout often spend a year in the small headwater streams and then move downstream into larger streams for the remainder of their freshwater residency. They can live in these larger stream systems for a period of two to nine years, but typically spend three years in freshwater before migrating to the ocean.

Clyde Brummel, a local resident, with the assistance of the Sellwood-Moreland Improvement League (SMILE), maintained a small hatchery (hatch box) on Crystal Springs Creek from 1981 to 2001. From 1981 to 1993, an average of 15,000 coho and steelhead eggs were incubated in the hatch box then released as fry in the winter into upper Crystal Springs Creek to rear for approximately one year. Egg numbers dropped to 1,000 to 5,000 after 1993. From 1991 to 1997, a hatch box was maintained on lower Johnson Creek (RM 2.5) by a private landowner, Steve Johnson. An average of 15,000 to 20,000 coho and steelhead eggs were hatched from this box and released as fry in Lower Johnson Creek. ODFW supplied fertilized eggs for both hatch boxes through the Salmon and Trout Enhancement Program

(STEP). In 1994, ODFW released substantial numbers of hatchery-reared juvenile fall Chinook salmon as part of an effort to support restoration. A “put and take” rainbow trout fishery was also maintained through spring stockings of hatchery-reared catchable rainbow trout downstream of S.E. 82nd Avenue. The fishery programs ended in 1997 with the ESA listings (Caldwell, 2003, Ellis, 1994, JCCC, 1995, Portland Bureau of Planning, 1991).

Recent information on fish in the Johnson Creek watershed comes from several surveys, fish kill reports and occasional observations made by volunteers, residents and agency personnel. The City of Portland in 1992 and ODFW in 1993 conducted surveys of the fish community (JCCC, 1995). From Summer 2001 to Spring 2003, ODFW and the City of Portland’s Endangered Species Act program inventoried fish communities within Johnson Creek to determine salmonid presence, life history and habitat usage throughout the watershed (Tinus et al, 2003). Fish surveys were conducted in eight Portland streams including Crystal Springs, Johnson, and Kelley. Study results from the first year of the survey showed that native fish were observed in Johnson Creek (1,626), Kelley Creek (904), and Crystal Springs Creek (868). A total of 131 non-native fish were collected and identified, all from the lowest reach of each stream (Tinus et al, 2003).

Results indicate the following:

- Cutthroat trout and were found throughout Johnson Creek and in Kelley Creek and Crystal Springs. The largest numbers of cutthroat trout were observed in Kelley Creek with winter abundance more that twice as high as in Johnson Creek.
- Rainbow/ Steelhead trout were found throughout Johnson Creek in low numbers and it is unknown whether they were year-long residents.
- Coho and Chinook salmon juveniles from the Willamette River appear to use the lower reaches of Johnson Creek for rearing and overwintering. Johnson Creek is a potential producer of coho although the study did not find a viable population. Chinook juveniles were found in the lower reaches of Crystal Springs.
- The presence of Pacific lamprey macropthalmia suggests adult Pacific lamprey spawn in Johnson Creek.

Appendix D summarizes the estimated number of salmonids per 100-m of selected reach sampled during the summer 2001 through spring 2003 surveys.

An index of biotic integrity (IBI) was calculated for eight sampled reaches during the study for both the extensive summer sampling and intensive seasonal sampling. An IBI is a scoring criteria used to rank a stream based on current biological integrity (Hughes et al. 1998 in Tinus et al, 2003). The IBI is useful for assessing the effects of humans on entire fish assemblages. Mean 2001-03 IBI scores indicate that one reach was marginally impaired, whereas seven reaches were severely impaired. Low IBI scores can probably be attributed to barriers and environmental disturbances. The study concludes that due to environmental disturbances in Johnson Creek, restoration efforts should be concentrated in middle reaches, which are deep, lack cover, and are channelized by WPA tiling (Tinus et al, 2003).

6.4.2. Benthic Macroinvertebrates

Benthic macroinvertebrates are an important source of food for fish and other aquatic organisms. During 1999, Portland State University (Pan, et. al, 2001) conducted a pilot bioassessment study of urban streams including Johnson for the City of Portland BES. The main objective of this study was to assess the spatial variation of biota in two urban streams (Johnson and Tryon Creek) and two adjacent rural ecosystems

(Clear Creek and Deep Creek). A total of 65 sites were sampled for physical, chemical, and biological parameters during late August through early September 1999. Of 65 sites, 30 were in Johnson Creek, 25 of which were on the main stem. Sites were sampled monthly for diatoms, macroinvertebrates, and water chemistry. The results of the study found that benthic communities are degraded in comparison to regional reference creeks within the same ecoregion (Hoy, 2001; Pan et al. 2001). Specifically in Johnson Creek the results indicated marginal conditions for physical habitat, macroinvertebrates and lack of a quality food base .

As expected, macroinvertebrate assemblages were significantly different between the urban and rural streams. Of 22 metrics, 14 were significantly different. Species diversity and total number of sensitive taxa (Mayfly, Caddisfly and Stonefly), which generally indicate the degree of stream health were significantly lower in the urban streams than those in the rural streams. Results also reveal that both macroinvertebrates and diatom assemblages were significantly different between urban and rural streams and that richness metrics were consistently different between urban and rural streams for two years. Water quality variables such as conductivity, ortho-phosphate, and NO_3+NO_2 were greater and more variable at the urban than the rural site throughout the year.

The scores indicated that overall physical habitat conditions in Johnson Creek were marginal. Of the generally sensitive taxa found in Johnson Creek most were pollution tolerant species indicating marginal conditions for sensitive macroinvertebrates and the lack of a quality food base within Johnson Creek (Hoy, 2001; Pan et al. 2001).

The Portland ESA Program assessed baseline conditions for biological indicators in Johnson Creek (Table 13). These indicators and their assessed base line condition compared to properly functioning conditions were incorporated into an Ecosystem Diagnosis & Treatment (EDT) Model. See Section 7.4.1 for discussion of this model and results of selected indicator attributes and their protection and restoration values.

6.4.3. Wildlife

Currently, no large or exhaustive database of information exists on wildlife resources and their habitats throughout the watershed. 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 (JCCC, 1995). A cougar sighting was recently reported. However, Black-tailed deer and coyotes are likely the only large mammals still commonly found in or near the remaining forested areas. Birds are the most abundant wildlife forms living in urban and rural areas within the watershed and Pileated woodpeckers have been observed in the Boring Lava Domes forest (Portland Bureau of Planning, 1997).

Sensitive species known to reside in the riparian areas of Johnson Creek include three salamander species (long-toed, northwestern, and Columbia), two frog species, and one toad species. Painted turtles have been identified in the upper watershed (east of 162nd Street). Other sensitive species have been sited in the following specific areas: 1) 162nd and Kelley Creek (salamanders); 2) 182nd and Springwater Corridor, opposite Fairview Creek headwater wetlands area (great horned owls, red-legged frogs, hawks, and coyotes); and 3) Powell Butte (Tall bugbane, listed as a sensitive species on the ODFW state sensitive species list) (Portland BES, 2000).

The wildlife habitat value of the Johnson Creek watershed is greatly diminished due to urban growth and development. Many different factors influence and generally reduce these values. Several important limiting factors listed the 1995 Johnson Creek Resources Management Plan include: lack of structural diversity; narrow and degraded riparian corridor; lack of dead wood, standing or snags, or down wood;

limited connection or linkage between riparian and upland habitats; fragmentation, disturbance; and encroachment of non-native vegetation.

Table 12. Biological Indicators in the Johnson Creek Watershed

Indicator	Baseline Condition	Key Function	Key Process	Effect	Notes
Instream Communities	At Risk	Benthic and aquatic invertebrate, and other instream communities support higher orders of wildlife species and are widely used as indicators of stream health and condition. Many fish species rely on benthic organisms as a food source	Highly sensitive to pollutants, temperature, and flow changes.		Biotic integrity of Johnson Cr. is degraded. Many native fish species have been extirpated or greatly reduced, and many introduced or nuisance species currently occupy their habitat. Benthic communities in Johnson Cr. are significantly degraded in comparison to local reference streams (Hoy 2001; Pan et. al., 2001; and Walker, 2001).
Salmonids	Not Properly Functioning	Salmonids are important in stream ecosystems because they are often the largest species in the community and at the top of the food chain in the aquatic system.	The physical stream habitat, geographic location, and evolutionary history of the species determine the numbers and species composition of fish in a given stream.		The cumulative impacts of the factors listed above threaten salmonid survival and salmonid populations locally and upstream and have been greatly reduced from historical numbers.
Interspecific Interactions	At Risk	Non-native species compete with native species. Changes to the watershed system can increase the competitive advantages of some native species as well.	Non-native species may be directly introduced, such as certain game fish, or may be escaped species.		Competition with and predation by introduced and native species has been increased by 1) introductions of non-native species; 2) habitat alterations that provide hiding places for predators; and 3) increased temperature regime which provides competitive advantages to more tolerant species.

Source: City of Portland ESA Program

7. Watershed Problems and Opportunities

7.1. Overview

A focus for watershed management efforts in urban areas is to protect the remaining high quality habitats first (e.g., opportunities), and then restore the rest in a prioritized approach (e.g., problems or challenges). Opportunities are watershed conditions or features that are currently in healthy, and close to properly functioning condition and that are considered key to sustaining important watershed functions. Problems or challenges are watershed conditions or features that are not properly functioning or that contribute to impairment of watershed health. The City of Portland Framework for Integrated Management of Watershed Health suggests that restoration of these conditions will result in significant benefits for indicator species that depend on those conditions (Portland ESA 2002). Problems and opportunities are determined by analyzing existing conditions and comparing them to reference conditions. The following discussion highlights the analyses used to identify problems and opportunities, define them, and describe where they are located in the watershed.

Fixing problems and restoring functioning conditions within the watershed requires an assessment of "limiting factors"- factors or processes that limit watrershed health. Problems are local (can be addressed where the problem is found) or watershed-wide (must be addressed on a much larger scale). In addition, solutions will vary in scale and in length of time necessary to achieve results. For example, much of Johnson Creek is devoid of large woody debris (LWD). LWD plays an important function in providing habitat and diversity to the channel, aids in pool formation, and provides structure for other aquatic insects. LWD can be locally placed and anchored into targeted site-specific locations where it is missing, but for long-term sustainability, wood recruitment is the key process involved in maintaining future wood deposition. Revegetation of the riparian corridor involves all of the upstream contributing watershed area, time to attain a suitable growth size, and time for trees to decay and eventually fall into the creek. This is a long-term restoration action given the growth rates of trees.

This section begins with a list of the most outstanding data gaps followed by a discussion that summarizes the areas of risk to watershed health in terms of human activities, urbanization, and other foreseeable threats. An examination of significant results from an Ecosystem Diagnosis and Treatment (EDT) model output follows that will assist in focusing restoration actions and protection activities. Key functions and limiting factors are highlighted for each of five major sections of the watershed including: 1) Lower Johnson Creek; 2) Middle Johnson Creek; 3) Upper Johnson Creek; 4) Crystal Springs Creek; and 5) Kelley Creek.

7.2. Data Needs

Although a wealth of information is available for many functional elements of the Johnson Creek watershed there are a few areas where data is missing or inadequate. These information gaps include:

- Identification of areas contributing to sedimentation in the creek;
- Specific WPA locations and condition;
- Toxics sampling and analysis (sediment and fish tissue);
- Bacteria identification and tracing;
- Fish usage areas and locations of refugia areas;
- Outfall discharge characterization;

- Upper watershed tributary instream habitat conditions;
- Fish barriers on private lands;
- Vegetation classes;
- Pollutant sources and loadings;
- Upland habitat and wildlife resources;
- Cutthroat trout EDT Model results;
- Water rights information.

7.3. Assessment of Risks

Watersheds face a multitude of risks. These include risks from human population growth and associated activities as well as natural and anthropogenic climatic changes. Risks from human activities generally include development practices, agricultural and industrial land practices, vegetation removal, and changes to the landscape including filling of wetlands, drainage course alterations, the addition of impervious surfaces and resultant increase in stormwater runoff, debris and refuse, and point and nonpoint pollution loadings. Natural and human-induced climate changes can alter watershed hydrology through increased flooding or droughts.

Urbanization of watersheds continues to be one of the leading causes of degradation. Impacts to riparian areas and the increase of impervious surfaces including sidewalks, driveways, rooftops, and roadways contribute to significant hydrologic alterations. Removal of vegetation can lead to increased runoff, sediment loading and sedimentation. As a result, stream hydrology can be altered for both high flows where flooding can become more frequent and severe and where baseflows can be reduced earlier and remain problematic longer during the dry season.

In addition, agricultural uses can significantly contribute to water quality problems. Removal of riparian vegetation, streambank erosion, and instream water diversions can result in excessive sedimentation and increases in water temperatures. Other foreseeable threats to watershed health in Johnson Creek include continued urban growth and development pressures in agricultural areas and associated increases in stormwater runoff and potential for erosion, especially in areas like Pleasant Valley, Springwater, and Damascus Other threats to both urban and rural areas include inadequate or poorly enforced erosion prevention and sediment control policies and programs and introduction of new nonnative invasive species..

The City of Portland has identified linkages between indicators of human influences and their impacts on Riverine-Riparian indicators for use in measuring watershed health. These indicators and linkages are summarized in Table 14.

Table 13. Linkages between the Indicators of Human Influences and Activities and their impacts on the Riverine-Riparian Indicators

Indicators of Human Influences and Activities	Riverine – Riparian Indicator Categories			
	Streamflow and Hydrology	Physical Habitat	Water Quality	Biological Communities
Land Use	X	X	X	X
Impervious Surfaces	X	X	X	X
Dam Impacts	X	X	X	X
Water Withdrawals	X	X	X	X
Drainage Network	X	X	X	X
Channel Alterations	X	X	X	X
Vegetation Removal and Wetland Destruction	X	X	X	X
Outfall Discharges	X	X	X	X
Spills and Illicit Discharges	X	X	X	X
Erosion		X	X	X
Exotic Species		X		X
Harrassment				X

Source: City of Portland Internal and IST Review Draft - A Summary of the Framework for Integrated Management of Watershed and River Health. 2002.

7.4. Key Limiting Factors (Problems)

7.4.1. Ecosystem Diagnosis and Treatment (EDT) Modeling

EDT, or Ecosystem Diagnosis and Treatment, was developed by Mobrand Biometrics, Inc. to provide a practical, science-based approach for developing and implementing watershed plans. It is a salmonid life history based procedure for rating the quality, quantity, and diversity of stream habitat. The model uses a probe or indicator species, such as coho or Chinook salmon, to identify the most significant problems in a stream and to identify reaches for protection and restoration. The methodology includes a conceptual framework for decision-making and a set of modeling tools with which to organize environmental information and rate the habitat elements with regard to the indicator species. In effect, EDT describes how the fish would rate conditions in a stream based on our scientific understanding of their needs. The value of EDT is that it can identify the potential for a stream under a set of conditions such as those that occur now or those that might occur in the future. The result is a scientifically based assessment of conditions and a prioritization of restoration needs (www.edthome.org).

EDT assesses habitat conditions along a scale ranging from extremely degraded reference conditions to restored reference conditions. Reference conditions are necessary to provide a standard for comparing the relative value of existing conditions as well as different restoration alternatives. The result is a scientifically based assessment of conditions and a prioritization of restoration needs. Because each segment, or stream reach, is rated individually, we can systematically examine conditions along a stream from the perspective of the fish. In this way, we locate areas where conditions are particularly good or bad and identify what needs to be fixed. In particular, EDT identifies the "*restoration potential*" and the "*protection value*" of each reach. This helps us prioritize actions and focus them on areas with identified problems and where the potential for benefit is highest (www.edthome.org).

The model uses rating curves to relate habitat conditions to life stage survival and capacity. These life stages are then linked to form life history trajectories (or the path of a salmonid through space or a chosen migratory course). Because habitat is described by reach and month, many potential trajectories can be formed. All successful trajectories are combined to form an overall estimate of capacity and productivity at a population level. The range of successful trajectories is a measure of life history diversity.

Each reach of a stream has a certain *capacity* or number of fish that can be supported for each life stage depending on the quantity of key habitat; a certain number of fish can spawn in the riffles while the pools can support a number of juveniles. Quantity of habitat is thus measured as *capacity*. Overall survival is measured as the number of adult fish that return for each fish that spawns. This is termed *productivity* and is a measure of habitat quality. Each pool or riffle has a quality that affects the survival of a life stage in that habitat. (www.edthome.org)

The model provides the flexibility to incorporate the effects of up to 45 specific variables or attributes that affect fish survival. Functional relationships between conditions and rates are described in a series of rule curves derived from an extensive review of the scientific literature. Effects of specific habitat conditions are used to scale stage-specific survival rates between normal ranges reported from empirical data (www.edthome.org).

EDT represents the state of the art in salmon habitat-fish modeling. It is in wide spread application for salmon recovery planning efforts throughout the Pacific Northwest. The following strengths and weaknesses of EDT are listed in the Lower Columbia Fish Recovery Subbasin Plan: Proposed Analytical Framework (The JD White Company, Inc. and SP Cramer & Associates, 2003):

Strengths of EDT

- Data input structure provides a systematic means of describing basin-wide habitat conditions, qualifying the quality of the input data, and identifying reach-specific limiting factors based on a comprehensive review of the state of salmon knowledge.
- Extensive documentation of underlying relationships and assumptions is available.
- Detailed representation of stream habitat conditions and effects of habitat on fish provides flexibility in representing factors of concern and projecting fish benefits of specific changes.
- Sender-based approach to estimating survival rates protects against unrealistic estimates of population productivity and capacity.
- Estimates of population response to habitat changes are robust even where specific inputs are uncertain.
- One of the few realistic alternatives for inferring historic, current, and future fish population characteristics where empirical estimates based on fish data are not available.
- Provides a means for estimating fish sensitivity to departures from Properly Functioning Conditions.
- Life cycle approach at the core of EDT facilities linkage with life cycle-based population viability approach for integrated analysis.

Weaknesses of EDT

- Highly mechanistic nature requires extensive data that is often unavailable.
- Model complexity can obscure transparency in underlying assumptions, which has led to characterization as a *black box.*
- Complex interactions of habitat effects on fish can bias projected fish response to change where habitat inputs are unrealistic.
- Incomplete inputs can produce very specific results that are difficult to corroborate without independent data.
- Does not provide explicit estimates of uncertainty in results based on input assumptions.
- Model accessibility is limited by system requirements and specialized expertise.
- Description of equilibrium population conditions does not allow for consideration of risk assessments based on random variables such as ocean conditions.
- Not developed for detailed evaluations of mainstem, estuary, and ocean limiting factors.

Much of the EDT modeling performed to date by the City of Portland has focused on coho salmon. Preliminary results for steelhead were recently completed. Additional work will continue including EDT analysis of other salmonid species, assessment of sources, and project effectiveness. The EDT analysis indicated that in a restored condition, Johnson Creek would probably operate differently than it does today. Many more successful population trajectories (as characterized within the EDT model) would begin from the lower sections of the creek. Also, a portion of the trajectories starting in upper reaches of Johnson Creek would rear in the middle sections, which would provide abundant habitat for juvenile rearing.

EDT Model for Johnson Creek

There is not a systematic account of historic conditions and few historic studies for Johnson Creek that can be used as a basis for reference conditions. In addition, urbanization of the watershed has brought on fundamental changes, many of which are likely permanent, such as filling in small streams and the WPA channelization of the creek. It is unrealistic to restore the historic configuration of the creek given the scale of changes that have taken place in the watershed. As a result the point of comparison in the EDT model is a restored reference condition or “normative condition”. The normative condition is the biologically sustainable conditions for a stream within its existing social-economic context. The normative reference condition for Johnson Creek was developed by decreasing anthropogenic constraints relative to current conditions for the following environmental quality attributes:

Hydrology

- Flow- diel variation
- Flow- change in interannual variability in high flows
- Flow- intra-annual flow pattern
- Flow- change in interannual variability in low flows

Water Quality

- Temperature- daily maximum (by month)
- Temperature- spatial variation
- Dissolved oxygen

- Metals/ pollutants- in sediment
- Metals- in water column
- Nutrient enrichment
- Turbidity

Instream Habitat

- Bed scour
- Confinement- Artificial (channelization)
- Embeddedness
- Fine sediment
- Riparian Function
- Wood
- Biologic Communities
- Benthos diversity and production
- Fish community richness
- Fish pathogens
- Fish species introductions
- Harassment
- Hatchery fish outplants
- Predation risk
- Salmon carcasses (McConnaha, 2003, 2004)

The EDT model results identified the top ranking habitat attributes (limiting factors) affecting coho when set to the reference or normative condition. Changes in the abundance of coho are measured by the capacity or quantity of available habitat and by the productivity or quality of habitat. In EDT capacity is assessed by the quantity of key habitat. Key habitat quantity is determined by the amount of different stream unit types in each reach (McConnaha, 2003). All three main stem segments and all tributaries have a limited amount of key habitat capacity, particularly Lower Johnson, Crystal Springs and Errol Creek. Productivity in the three main stem segments and tributaries is affected by channel stability, chemical pollutants, interspecies competition, flow, food, habitat diversity, harassment, obstructions, oxygen, pathogens, predation, sediment load, temperature and water withdrawals. The following section summarizes the key functions and processes that are associated with these attributes.

Key Habitat Quantity is a measurement of the percent of a reach by stream unit types (riffles, pools, glides). It determines the quantity of habitat available for the various life stages. Because much of Johnson Creek is narrower and straighter than reference conditions and because of the high percentage of glide habitat, key habitat quantity is a limiting factor in much of the main stem and tributaries.

Habitat diversity is a primary limiting factor in Johnson Creek resulting from channelization and confinement due to the WPA works and the lack of large woody debris. Actions that can improve this condition include: a) wherever possible, remove the WPA walls should be prioritized; b) introduce large woody debris through both new, anchored wood and through maturation of a healthy riparian area; and c) restore the riparian area wherever possible.

Lack of Channel Stability or Simplified channel structure is caused by a lack of streamside complexity and a lack of microhabitats. Channels that are allowed to meander form off-channel complex habitats. Large wood and boulders promote shifts in flow changes and velocity currents that help support channel structure and roughness and riffle-pool sequences. Actions that can improve this condition include: a) Remove WPA lining; and b) add large wood.

Degraded banks are not able to contain flows and withstand erosive forces. Vegetation and especially root systems play a key role in the integrity of stream banks.

Degraded riparian areas are not able to promote channel compensation and integrity. Healthy riparian areas provide structure and complex habitats and connectivity to uplands. Disturbance regimes can result in changes to vegetative classes.

EDT Model results also reveal the importance of restoring **floodplain connectivity**. Particular emphasis should be placed on supporting the following Portland projects in Middle Johnson Creek: Kelley Creek Meanders, Alsop Brownwood, West Lents Restoration, East Lents Restoration including south of Foster and Springwater Wetland Complex Restoration projects. Lower Johnson Creek projects including Tideman Johnson/Errol Heights Restoration, Bell Station Flood Mitigation, and the Westmoreland Park Restoration project should also be a high priority (Middaugh and Prescott ESA, 2002).

Excessive sedimentation and **high summer water temperatures** limit production of coho salmon throughout Johnson Creek. Therefore, sediment and water temperature sources should be investigated and riparian buffers should be established to complete shading and provide natural biofiltration. Actions that can improve this condition include: a) identify and control local and upstream sediment sources; b) restore riparian areas to help cool water temperatures; c) remove WPA lining to form low flow channel; d) improve potential cool water sources such as Crystal Springs.

Lack of food in the Johnson Creek watershed is a function of the lack of habitat (overhanging vegetation and substrate structure) for aquatic species such as benthic macroinvertebrates. Additionally, high flow disturbances and poor water quality conditions including excessive sedimentation are contributing to a lack of food sources and availability.

Low **flows** in the summer and high flows in the winter present a significant limiting factor in Johnson Creek. Actions that can improve this condition include: a) removing WPA lining to form low flow channel; and b) improving management of summertime water withdrawals.

Recent information on pesticides and other **toxics** that were not incorporated into the EDT Model indicate that water quality may be of greater importance, especially during storm runoff events and the potential for both chronic and acute toxicity levels for aquatic organisms throughout the watershed. Actions that can improve this condition include: a) identify and control local and upstream sources.

Both animal and human wastes cause high fecal coliform and E. coli bacteria levels. A wide variety of animals utilize habitats throughout the Johnson Creek watershed - both native (wildlife) and domestic (pets and livestock). Human wastes can contribute to high bacteria levels through failing onsite septic systems and wastewater spills and overflows.

Figure 11 displays the effect of restoring individual habitat attributes on coho potential in Lower, Middle, and Upper Johnson Creek and in Crystal Springs, Errol, Veterans, Wahoo, Kelley, Butler, Hogan and McDonald (Sunshine) Creeks. Figure 11 also displays the relative protection and restoration benefit for each of the main stem segments and tributaries. The size of the black dot indicates the category of change in coho performance as a result of setting the attribute to the restored condition. Table 15 summarizes the habitat attributes or limiting factors affecting productivity in their order of impact.

Figure 11. Johnson Creek Coho Protection and Restoration Summary

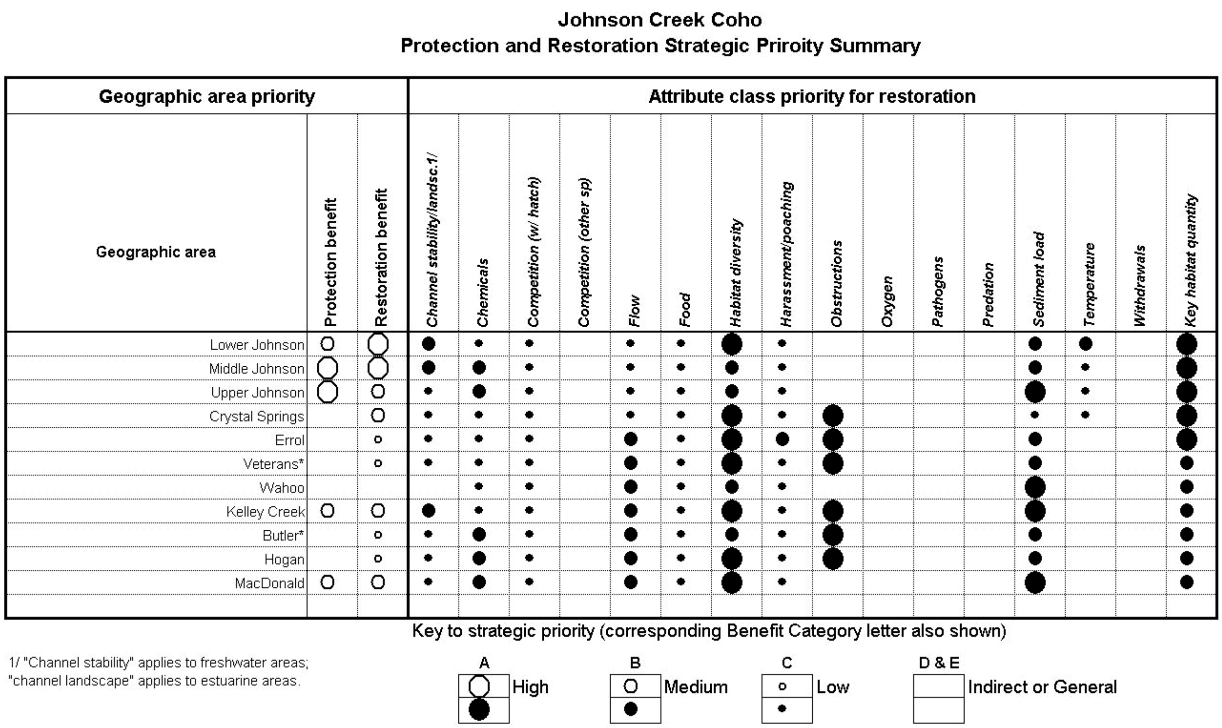


Table 15. Attributes Impacting Habitat Quality in their Order of Impact

Lower Johnson	Middle Johnson	Upper Johnson	Crystal Springs	Kelley Creek
1) Key Habitat Quantity	1) Key Habitat Quantity	1) Key Habitat Quantity	1) Key Habitat Quantity	1) Obstructions
2) Habitat Diversity	2) Sediment	2) Sediment	2) Obstructions	2) Key Habitat Quantity
3) Channel Stability	3) Habitat Diversity	3) Chemicals	3) Habitat Diversity	3) Habitat Diversity
4) Sediment	4) Channel Stability	4) Habitat Diversity	4) Harrassment/Poaching	4) Sediment
5) Temperature	5) Chemicals	5) Channel Stability	5) Sediment	5) Flow
6) Flow	6) Temperature	6) Food	6) Food	6) Channel Stability
7) Harrassment/Poaching	7) Flow	7) Flow	7) Flow	7) Chemicals

1) In addition to the above listed limiting factors, Crystal Springs and Kelley Creek have numerous culverts and barriers, most of which inhibit if not block fish access. Appendix E contains a strategic priority summary of areas to protect and restore and attributes to address on a reach level for Johnson Creek, Crystal Springs and Kelley Creek.

The EDT Model was also run for steelhead. Preliminary results indicate that Steelhead are not doing as well as coho, and although the overall degradation impacts/restoration potential patterns are similar, they are more exaggerated for steelhead. Restoration efforts show the most potential for steelhead in the middle Johnson Creek segments. EDT Model results for steelhead trajectories, diversity, productivity, capacity, and abundance are summarized in Table 16.

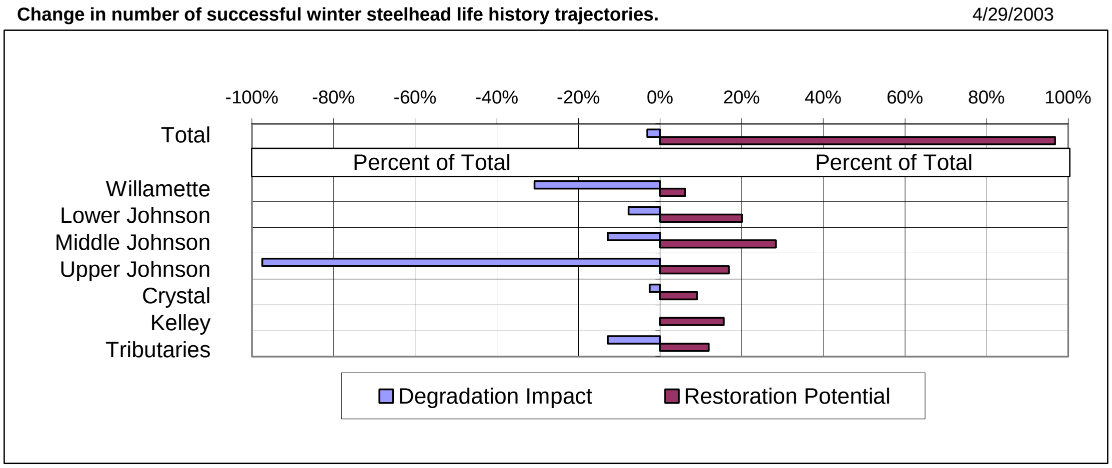
Table 16. Preliminary EDT Model Results for Steelhead

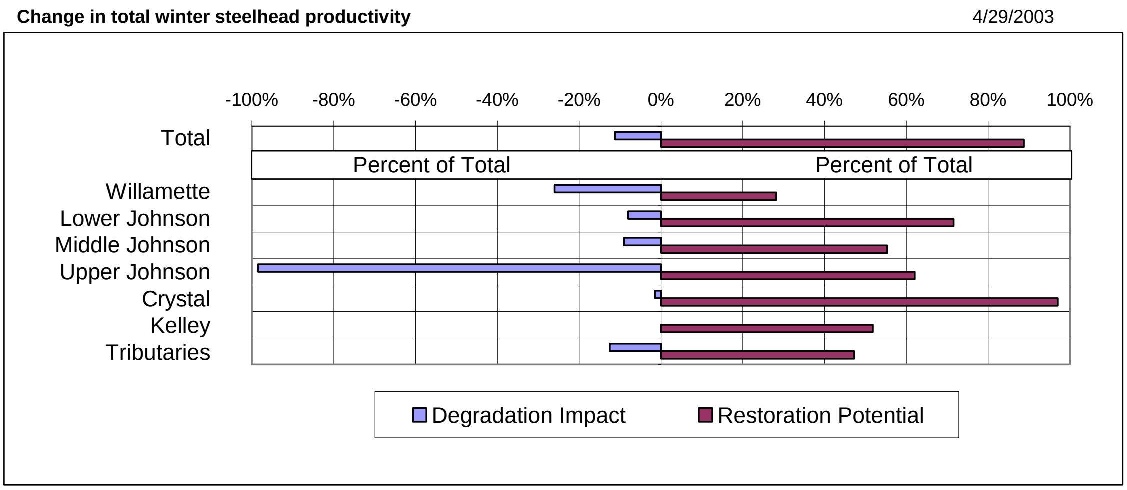
	Number of Trajectories	Number of Sustainable Trajectories	Diversity (percent)	Productivity (No. of fish)	Capacity (No. of fish)	Abundance (No. of fish)
Degraded	1232	0	0	0	0.50	0
Current	1232	39	3	2	41.3	20.6
Restored	1232	1227	100	17.75	411	388

Source: Portland ESA Program

Figures 13 and 14 summarize Preliminary EDT Model results for winter steelhead and changes in number of successful life history trajectories, total productivity, and total capacity within the Willamette and various subwatersheds of the Johnson Creek basin. Note, that although the capacity is very small for Kelley Creek, the productivity increase in a restored condition is extremely importan

Figure 13. EDT Model Results for Steelhead Trajectories, Productivity, and Capacity for the Willamette, Johnson Creek segments, and major tributaries.





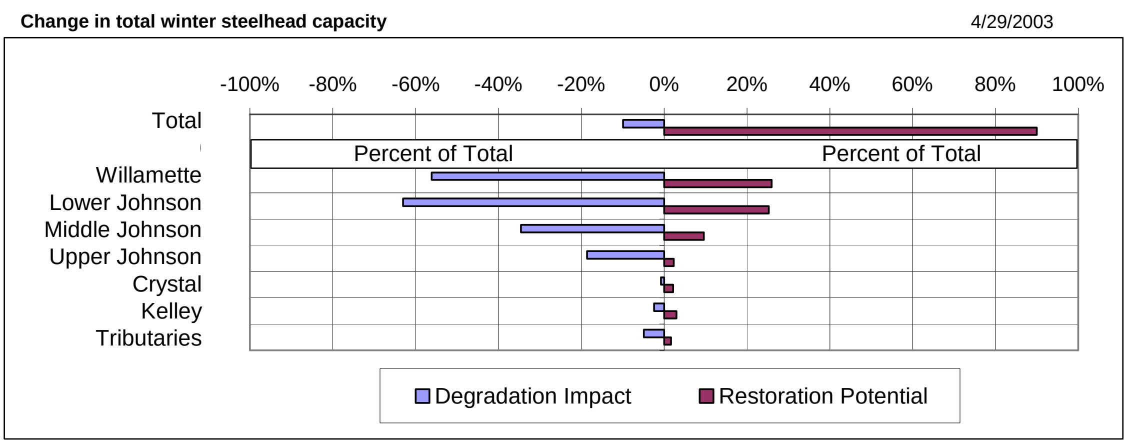
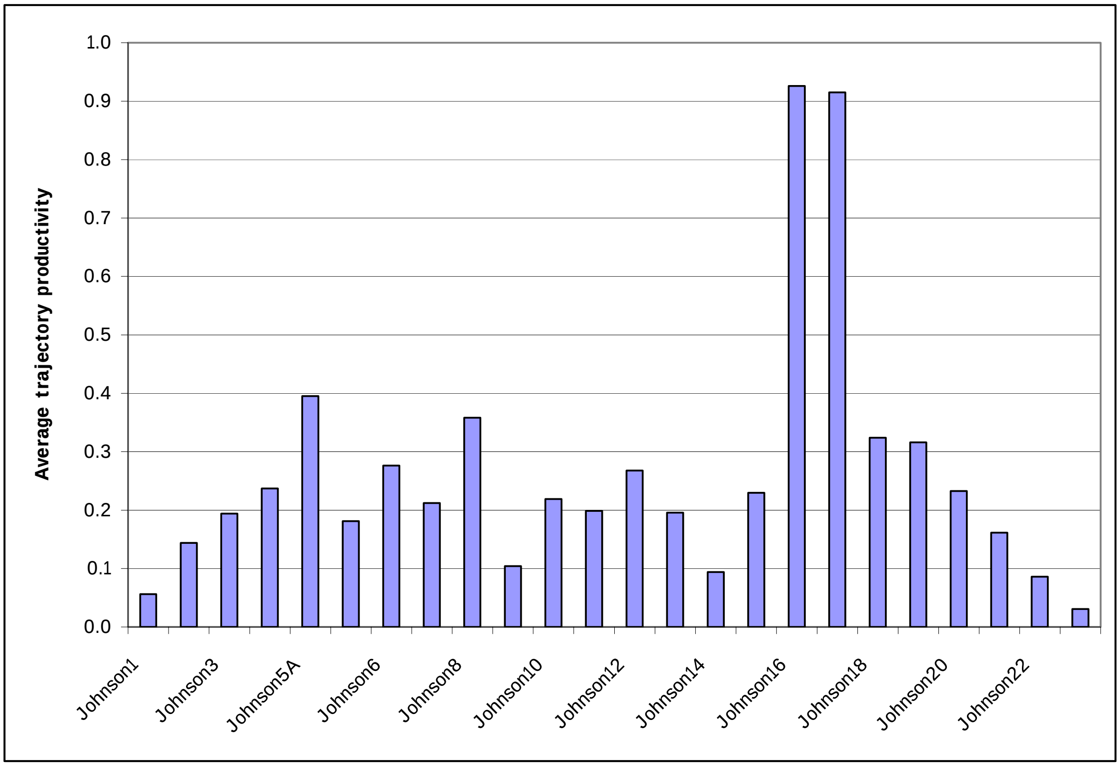


Figure 14. EDT Model Results for Steelhead Trajectory Productivity for Johnson Creek Reaches



	NumberTraj	TrajSustainable	DI	Productivity	Capacity	Neq_Abundance
Degraded	1232	0	0.00%	0.00	0.50	0.00
Current	1232	39	3.00%	2.00	41.30	20.60
Restored	1232	1227	100.00%	17.75	411.60	388.40

7.5. High Priority Areas and Actions

This section summarizes the highest priority areas and actions needed for protection and restoration, inventorying and monitoring, public policy and rules, and public involvement and education. Implementation funds for projects and actions in the near future will be scarce. It is important therefore, to prioritize efforts to achieve the most benefit. To begin focusing efforts to restore watershed processes, high priority areas were selected by the Johnson Creek Watershed Council Technical Advisory Committee (TAC).

The TAC selected priority areas based on ODFW habitat surveys, EDT model outputs, the Johnson Creek Watershed Characterization, and the best professional judgment of the committee. These areas were identified to distribute limited resources towards a strategy to protect, expand, and connect key refugia. Protection of existing functions is the highest priority because it is more economically and ecologically efficient to prevent degradation than correct it. High priority areas are shown on Figure 15 and include:

1) Areas of existing high quality core habitats and refuge areas. These areas will be the focus of **protection** efforts to ensure no further degradation.

2) Areas that contribute to or affect processes and watershed functions and provide the highest **restoration** benefit.

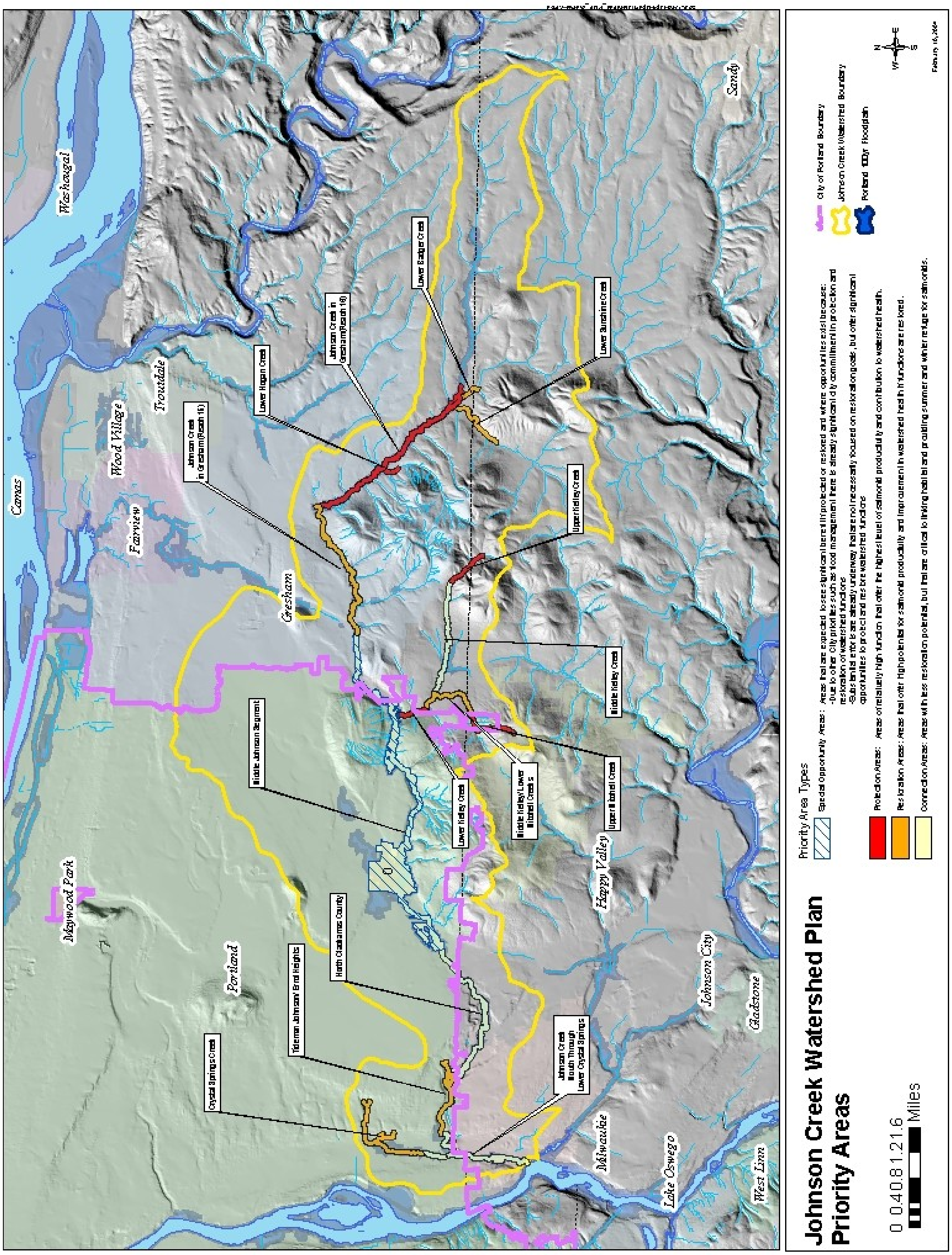
3) Areas with less restoration potential, but that are critical to **connecting** habitat and providing summer and winter refuge for salmonids.

4) Areas that are expected to see significant benefit if protected or restored and where there are **existing opportunities** because:

    a. Implementation funds exist or significant planning efforts are already underway; or
    b. A key watershed function can currently be protected or restored and could significantly reduce future risks; or
    c. A focused concentrated effort could greatly benefit, open other doors, or provide additional opportunities.

5) Areas that are known **contributors of water quality problems** or degradation to downstream core habitat areas or refuge areas.

Figure 15. High Priority Areas within the Johnson Creek watershed.



7.5.1. Protection

Protection values as used within the EDT model are the values of protecting a stream section from further degradation. The protection value indicates the decline in abundance in Johnson Creek coho salmon populations that would occur if the section were degraded, and represents the habitat value presently provided by the section.

By setting conditions in Johnson Creek to degraded the model shows that the upper segment has the greatest amount and quality of habitat. This supports the conclusion that this area is the highest priority for protection. Specifically, the section of Johnson Creek from Butler Creek to Hogan Creek (ODFW Reach 16) has the highest quality habitat along the entire mainstem and should receive additional protection measures. In fact, the EDT assessment of Johnson Creek habitat relative to coho salmon indicated that virtually all successful life history trajectories calculated originated from a two-mile stretch of the creek from about Gresham's Main City Park up to Hogan Creek. Due to the fact that overall productivity within Johnson Creek is relatively low and nearly all the production is somewhat dependent on these areas, protecting them is a high priority (McConnaha, 2002, 2003). The City of Gresham is proposing to develop an industrial area just upstream of this reach through the Springwater Community Plan. Planning efforts are underway for this area and are critical for proactively protecting and minimizing downstream impacts to high priority protection reaches.

However, the model also shows that the lower and middle segments provide the greatest capacity and overall abundance for salmonids and this supports the conclusion that Johnosn Creek needs more diversity of habitat and that protection efforts are important in areas outside of Reach 16 (McConnaha, 2003). Additionally, the TAC identified a number of tributary areas as providing key refugia and critical for protection.

The highest priority protection needs include:

1) Protect the highest quality habitat areas and current fish usage areas (listed below) through land use protections and by adding additional funds to land acquisition programs.

2) Protect those areas that are threatened by future development within the urban growth boundary and expansion areas.

3) Protect to ensure a diversity of habitats exist so that there are multiple nodes with high quality habitat dispersed along Johnson Creek and throughout the watershed.

4) Protect existing off-channel and known over-wintering habitat or areas with stable wintertime flows (Crystal Springs Creek, Brookside, etc.)

5) Protect remaining "pristine" areas on slopes.

Individual Priority Protection Areas

Lower Kelley Creek (H1): Lower Kelley Creek Protection Area is comprised of two distinct areas, ODFW Reach 1 below Foster Road, and ODFW Reach 2 from Foster Road to Clatsop Creek confluence. From its mouth to SE 159th Ave, Reach 1 consists of a newly completed restoration project sponsored by the City of Portland, BES. In the summer of 2004 the City of Portland completed construction of backwater channels for fish habitat and flood management on city owned property at the confluence. With these improvements this area will become a key refuge, rearing and spawning habitat area along Johnson Creek. From Se 159th Ave to the culvert at SE 162nd, the creek is heavily channelized and has impacted riparian zones consisting of broad floodplains and drained wetlands. However, in the summer of 2004, the Portland Department of Transportation modified a series of man-made concrete steps (built by the WPA to control the grade) to improve fish passage. During this process eight coho juveniles were found in this location, indicating that Kelley Creek provides habitat for coho.

In Reach 2, Kelley Creek is largely confined to a narrow canyon, which has inhibited development and allowed a mature second growth canopy to form. The canopy has some openings, which at least one landowner (the Hawthorne Ridge Homeowner's Association) is currently working to fill. Physical habitat is functional in this area, and steelhead and cutthroat have been sampled. Water quality and flow are problematic, and should be addressed.

The Kelley Creek watershed was added to the Urban Growth Boundary in 1997 and in 2002. Concept planning was completed in 2002 for half the watershed, and annexation is scheduled to begin by 2005. This will inevitably alter the condition of the Kelley Creek system. It is anticipated that urbanization will provide an opportunity to protect and restore riparian habitat, address passage barriers, and reduce erosion. Additional planning work is necessary for the areas of the watershed added into the UGB in 2002.

Target salmonid populations:

- coho, steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

Upper Mitchell Creek (H2): Upper Mitchell Creek (ODFW Reach 2 upstream of 162nd and tributary not surveyed by ODFW) is among the most pristine areas within the Johnson Creek Watershed. A well-formed second-growth forest serves the creek well. Flow is moderated by the forest and by instream structure. Temperatures are cool and water quality is impacted primarily by a point source scheduled for decommissioning. Fish presence has been noted, and 36 acres of the riparian area is publicly owned and protected.

Target salmonid populations:

- steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

Upper Kelley Creek (H3): Upper Kelley Creek (ODFW Reach 8 and part of 7), is home to a self-sustaining population of cutthroat trout. While several barriers downstream make this habitat no more than a fragment, it is functional for resident cutthroat. The functional riparian corridor composed of second-growth forest and pastures provides shade, organic and woody input, and stormwater filtration. Instream complexity is good, with some secondary channels, wood and some boulders providing refuge. Floodplain access is good, though off-channel habitat is limited.

The Urban Growth Boundary expansion of 2002 added this area for future urbanization. As urbanization proceeds, it will be critical to protect this resource from increased flow, decreased water quality, and riparian encroachment.

Target salmonid populations:

- coho, steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

Johnson Creek Reach 16 (H4): Johnson Creek ODFW Reach 16, is the most functional reach on the main stem of Johnson Creek. The functional riparian corridor composed of second-growth forest and well-managed pastures provides shade, organic and woody input, and stormwater filtration. Instream complexity is good, with some secondary channels, wood and some boulders providing refuge. Water quality and flow, however, are impaired by upstream uses. The EDT model indicates that Reach 16 is the only reach in Johnson Creek that functions sufficiently to support coho trajectories.

The Urban Growth Boundary expansion of 2002 added this area and some upstream areas for future urbanization. As urbanization proceeds, it will be critical to protect this resource from increased flow, decreased water quality, and riparian encroachment.

Target salmonid populations:

- Coho, Steelhead, and Cutthroat spawning and rearing habitat
- Resident Cutthroat and Rainbow

Lower Hogan Creek (H5): Lower Hogan Creek (ODFW Reach 1) is a functional confluence area where Hogan Creek drains into Reach 16. The functional riparian corridor is composed of second-growth forest. Upstream detention ponds help prevent sedimentation, but also contribute to higher water temperature. More information is needed on water quality and in-stream structure, though the reach is promising due to public ownership of riparian resources.

The Urban Growth Boundary expansion of 2002 added this area and some upstream areas for future urbanization. As urbanization proceeds, it will be critical to protect this resource from increased flow, decreased water quality, and riparian encroachment.

7.5.2. Restoration

Restoration value as described within the EDT model is the benefit that could be gained by restoring a given section. It indicates the increase in abundance in Johnson Creek coho salmon populations that would occur if the section were restored, and represents the increase in watershed function gained by restoring each section.

By setting conditions in Johnson Creek to restored the model shows that most life history trajectories begin in the lower and middle segments and that the greatest increase in the number of trajectories occurs when conditions in the lower segment are restored and that these are the best locations to restore. The model found that at the reach scale there is high restoration potential in two nodes or core areas- Reach 5 and Reach 16 and that the greatest increase in the number of trajectories when conditions are restored in Reach 5. Restoration should focus in these two core areas along with adjacent reaches (Reach 4 and 15) to expand the size of the node (McConnaha, 2003).

While the model found that restoration of the tributaries has only a slight increase in overall abundance of coho, tributary restoration significantly added to the potential coho life history diversity and to the overall strength of the population, particularly when faced with potential environmental changes (McConnaha, 2003). As a result, the TAC concluded that the tributaries of Crystal Springs, Kelley, Mitchell, Sunshine and Badger Creeks will provide significant benefit once restored.

The highest priority restoration needs in Johnson Creek include:

1) Expand and restore core habitat areas including Johnson Creek Reaches 4-5 and expand outward to include Crystal Springs Creek, and Johnson Creek Reaches 15-16 and expand outward to include Kelley Creek. Detailed restoration area descriptions are below;

2) Restore off-channel and over-wintering habitat areas;

3) Improve quality of reaches that connect habitat core areas including Johnson Creek Reaches 12-14, and off-channel habitats to the main channel;

4) Address watershed wide water quality problems such as sediment, temperature, toxics, and bacteria. Focus particularly on potential upstream sources including Johnson Creek Reaches 17-23, Sunshine Creek, and Kelley Creek that are contributing to problems in downstream habitat core, refuge, and high priority areas. Start with small early actions and demonstration projects aimed at sediment and temperature control once sources are identified.

Restoration activities should address the lack of large wood in the creek, grading of banks and lining of channels as a result of WPA work, high summer water temperatures, excessive sediment loading and sedimentation, and lack of food sources. Restoration priorities include funding projects identified in the Johnson Creek Restoration Plan, especially those in the middle section of Johnson Creek, implementing the Westmoreland Park Restoration project to remove a duck pond, and addressing other well-known heat sources in Crystal Springs Creek (Middaugh/Prescott 2002).

Crystal Springs Creek habitat restoration priorities include:

1) Reduce summer temperatures down to a reasonable level. Refugia may be present that would allow for some summer rearing of salmonids. A temperature budget should be performed to more completely understand the temperature regime.

2) Crystal Springs has numerous culverts, most of which inhibit if not block fishery access.

3) Crystal Springs, like most of the Johnson Creek watershed, has very little structure. In fact, Crystal Springs Creek has appreciably less structure than Johnson Creek even accounting for the WPA work in Johnson Creek. Many sections are totally lined by concrete and wood is almost non-existent.

Kelley Creek habitat restoration priorities include:

1) Create larger contiguous habitat areas rather than isolated pockets of habitat. Connect habitat in Kelley Creek with the relatively good areas in Johnson Creek just above the Kelley Creek confluence.

2) Protect and improve upper Kelley Creek tributaries for water quality (temperature and sediment).

Individual Priority Restoration Areas

Crystal Springs Creek (R1): The Crystal Springs Creek Priority area includes ODFW Reaches 3 and 4. The creek is fed by two sets of springs: one at Crystal Springs Rhododendron Garden and Eastmoreland Golf Course, and one at Reed College Canyon. The springs provide a steady cold water source of about 10 cfs throughout the year. Crystal Springs Creek receives very little stormwater runoff, as its highly urbanized watershed is drained by storm sewers and sumps. A flood in the area in 1997 is blamed on several years of unusually high precipitation, which eventually flowed out through the Reed Canyon springs.

Prior to development, most of the Crystal Springs system existed as a broad wetland complex with little or no distinct recurrent channel. Development, agricultural drainage, and finally channelization created the Crystal Springs system we know today. Therefore, it is irrelevant to refer to historical conditions. Targets are based on desired outcomes for watershed function in Crystal Springs. The subwatershed exhibits potential to function as a low-gradient, spring-fed wetland headwaters. The diversity of channel types provides an array of spawning, rearing, and refuge habitats.

The springs provide a cold water source, but impoundments on the creek negate that effect, with the result that Crystal Springs Creek is a warming influence on Johnson Creek by the time it reaches the confluence. In addition, there are a number of culverts and instream structures that inhibit access and there is little habitat structure in most of the creek. Several factors, however, recommend Crystal Springs Creek for restoration: its proximity to the mouth of Johnson Creek; the high percentage of publicly owned land in its watershed; and its potential for cold, stable base flows, potentially making it key refugia for summertime rearing.

Two key restoration efforts are ongoing in this area: Reed College has restored access to Reed Lake and is actively reforesting the canyon; and Portland Parks is working with the US Army Corps of Engineers to replace the shallow pond in Westmoreland park with a wetland channel.

Target salmonid populations:

- coho, steelhead, and cutthroat spawning and rearing habitat and migratory summer and winter rearing habitat
- Chinook migratory summer and winter rearing habitat

Tideman Johnson/ Errol Heights (R2): Tideman Johnson (ODFW Reach 5) and Errol Heights (ODFW Reaches 1 and 2) is bounded by Tacoma St to the west, and 45th Ave to the East. The restoration area includes Errol Creek and Errol Heights wetland and a large oxbow of Johnson Creek. The restoration area also includes ODFW Reachesfour of Johnson Creek as a strategy to increase the habitat node around Tideman Johnson.

The creek is channelized through this reach with the exception of the stretch through Tideman Johnson Park. Errol Creek flows out of a spring-fed wetland complex into a lined channel conveying the flow through several backyards before draining to Johnson Creek's oxbow. Prior to development, several large wetlands occupied this valley, and surveyors recorded the width of the creek at about 80 feet, including multiple side channels.

While erosion takes its toll on the unarmored banks of Johnson Creek in this reach, this area provides a key refugia opportunity for salmon. Fish can escape high winter flows into the protection of Errol Creek. Significant areas of publicly-held land in this area offer opportunities for more backwater channels and off-channel habitat areas for rearing. Unlined channels in Johnson Creek and Errol Heights offer potential spawning grounds as well.

Target salmonid populations: Coho, Steelhead, and Cutthroat spawning and rearing habitat

Kelley to Mitchell Creek (R3): In Restoration Area 3, middle Kelley Creek (ODFW Reach 3) and lower Mitchell Creek (ODFW Reaches 1 and 2) expand on the core habitats located in Lower Kelley and Upper Mitchell Creeks (Protection areas 1 and 2). This restoration area has high potential value for cutthroat trout, however parts of it suffer from severe incision and downcutting. While this area is not highly functional in the key areas, it is critical for expanding core habitat areas and providing a larger contiguous area of cutthroat refugia.

The Kelley Creek watershed was added to the Urban Growth Boundary in 1997 and in 2002. Concept planning was completed in 2002 for half the watershed, and annexation is anticipated to begin by 2005. This will inevitably alter the condition of the Kelley Creek system. It is anticipated that urbanization will provide an opportunity to protect and restore riparian habitat, address passage barriers, and reduce erosion. Additional planning work is necessary for the areas of the watershed added into the UGB in 2002.

Target salmonid populations:

- steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

Johnson Creek Reach 15 (R4): Priority Restoration area 4 (ODFW Reach 15) in Gresham offers high restoration value, particularly for coho and steelhead. The large riparian forest to the south of the creek, high potential for off-channel and over-wintering habitat, and proximity to the high quality habitat in Reach 16 (H4) make this area especially noteworthy.

Target salmonid populations:

- coho, steelhead, and cutthroat spawning and rearing habitat

Lower Sunshine Creek (R5): Restoration area five is the lower reaches of Sunshine Creek (ODFW Reach 1), which drains into Johnson Creek Reach 17, just upstream of H4. This restoration area has high potential value for cutthroat and steelhead, although vegetation in some parts of the riparian buffer is nonexistent. Erosion and lack of riparian cover upstream contribute to high levels of TSS and temperature. Despite these shortcomings, several areas of excellent riparian vegetation and wetland areas offer a promising habitat area. Erosion and severe downcutting in this area need to be addressed.

Major parts of the Sunshine Creek watershed were added to the Urban Growth Boundary in 2002. This will inevitably alter the condition of the Sunshine Creek system. It is anticipated that urbanization will provide an opportunity to protect and restore riparian habitat, address passage barriers, and reduce erosion. Additional planning work is necessary for the areas of the watershed added into the UGB.

Target salmonid populations:

- steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

Lower Badger Creek (R6): This short creek section serves as a key refuge area off of Johnson Creek Reach 17, just upstream of H4. Restoration of this area as a key refuge in the upper part of Johnson Creek will eventually develop into core habitat for spawning and rearing if water quality and erosion from upstream sources can be minimized. Significant riparian vegetation is impacted by rural residential use, but shows high potential for riparian function.

This area is within the 2002 urban growth boundary expansion, which will provide key opportunities for restoration and protection of resources in this area. Upstream areas in Badger Creek are not within the urban expansion area, though implementation of proposed Lower Willamette Agricultural Water Quality rules will help address pollution.

7.5.3. Connectivity

Connectivity is critical for those areas with lesser restoration potential that are necessary forconnecting Protection and Restoration areas. Critical connection areas exist from the mouth of Johnson Creek through lower Crystal Springs (JC Reaches 1 and 2, CS Reach 1), Johnson Creek Reach 3; the North Clackamas Area (Reaches 6 and 7); the Middle Johnson Creek Segment (Reaches 8 to 14); and Middle Kelley Creek (Reaches 4 to 6).

The overall vision for Connection Areas is to provide summer and winter migratory corridors. Restoration actions are focused on creating cool summertime water temperatures and providing off-channel over-winter resting areas during high winter flows.

The high level of public investment and a high potential for restoration in the Middle Johnson Creek Segment recommend Middle Johnson Creek as a Special Opportunity area as defined in Section 1.12. Pursuit of public health and safety goals by the City of Portland offers unique opportunities to improve connectivity and watershed health by integrating off-channel refuge areas into designs for flood management. As additional opportunities arise new special opportunity areas will be identified.

Individual Priority Connection Areas:

*Johnson Creek Mouth through Lower Crystal Springs(C1):*This connection area consists of Johnson Creek ODFW Reaches 1 and 2 and Crystal Springs ODFW Reaches 1 and 2. JC Reach 1 consists of the confluence with the Willametter River. Both JC Reaches 1 and 2 are dominated by industrial and urban uses, are heavily channelized, and have moderate shade cover. There is little refugia and both reaches lack deep pools, large wood and back water channels. Crystal Springs Reaches 1 and 2 are heavily urbanized with apartments, houses and backyard built up to the bank in many places. The channel itself is lined and is dominated by numerous culverts. The confluence of Crystal Springs at Johnson Creek is the location of Johnson Creek Park and contains a great deal of riparian restoration work. Restoration efforts in these reaches should include making passage improvements by retrofitting passage barriers and improving shade cover. Adding large wood can also enhance pool habitat.

Target salmonid populations:

- coho, steelhead, and cutthroat migratory corridor and winter refugia

North Clackamas (C2): This area consists of Johnson Creek ODFW Reaches 6 and 7 in Clackamas County. Land use in these reaches is urban and most of the channel is constrained by WPA tiles. It is a low gradient area with very low wood volume and narrow riparian zones. Reach 6 has some good shade due to the presence of some large trees. Reach 6 has some potential spawning gravels, a few backwater pools and a few anchored pieces of large wood. Reach 7 has many deep pools and undercut backs but also has actively eroding bank. Reach 7 also contains a broad floodplain area that has potential for flood storage and an exposed sewer pipe crossing the creek. Restoration efforts in this area should include improving shade cover, addressing bank erosion and incision, anchoring more large wood, and addressing the exposed sewer pipe.

Target salmonid populations:

- coho, steelhead, and cutthroat migratory corridor and winter refugia

Middle Johnson Creek (C3): Middle Johnson Creek consists of ODFW Reaches 8-14 and is characterized by its low gradient and relatively high level of development. Floodwater conveyance is a critical issue in this area as much of the floodplain is developed and does not offer safe floodwater storage or conveyance. Nonetheless, the extensive floodplain and low gradient in this area offers potential for over-wintering habitat, particularly in areas with a large amount of public land ownership. In addition, this area contains some contiguous areas with mature riparian coverage that could be expanded to improve water temperatures. However, additional areas not already in public may still be necessary for overwintering and summer migration.

Target salmonid populations:

- coho, steelhead, and cutthroat migratory corridor and winter refugia

Middle Kelley Creek (C4): Middle Kelley Creek consists of ODFW Reaches 4-8 and is dominated by rural residential land use. Wood volume is low and the substrate is dominated by fine sediments and gravels. Much of the riparian zone is narrow and the existing trees are small. There are a number of dams and culverts in this areas that act as fish barriers. Restoration should focus on retrofitting passage barriers, improving riparian shade cover and anchoring large wood.

Target salmonid populations:

- coho, steelhead, and cutthroat spawning and rearing habitat
- resident cutthroat and rainbow

7.5.4. Inventorying and Monitoring

The top-tier priority inventorying and monitoring activities identified by the TAC (see Watershed Action Plan Chapter 5 for a list of all high priority monitoring projects):

1) Conduct Total Suspended Solids (TSS) and Turbidity monitoring to identify point and nonpoint pollution sources.
2) Baseline monitoring of E. coli bacteria levels to support establishment and implementation of Total Maximum Daily Load (TMDL).
3) Identification of sources of toxics and sediment.
4) Perform EDT modeling for cutthroat trout.
5) Additional fish surveys to determine presence and extent of use of all tributaries.

7.5.5. Public Policy and Rules

The top-tier priority activities for developing or implementing public policies and rules identified by the TAC include (see Watetrshed Action Plan Chapter 5 for a list of all high priority public policies and rules):

1) Participate in creation of concept and implementation plans for the Springwater Concept Plan.
2) Support implementation of Clackamas County Water Environment Services (WES) new Development Standards related to Erosion Prevention and Sediment Control.

3) Support implementation of new Development Standards related to City of Portland Title 10 – Erosion Control

4) Participate in creation of concept and implementation plans for the Damascus Concept Plan.

5) Participate in creation of concept and implementation plans for the Pleasant Valley Concept Plan.

In addition, provide long-term sustainable funding sources for conservation programs and land acquisition. Priority Land Protection and Acquisition areas include:

a. Confluence of Sunshine, Badger, North Fork Johnson Creek and the mainstem of Johnson Creek
b. Just downstream in Reach 17 to connect to Reach 16
c. Large wetland complex in the middle of Sunshine Creek
d. Errol Heights Creek and Johnson Creek Oxbow areas
e. Small perennial unnamed tributary (referred to as "Wheeler Creek") and the confluence of the mainstem Johnson Creek
f. Lents area east of Freeway Land Company and south of Foster
g. Lents area west of I-205

7.5.6. Public Involvement and Education

The top-tier priority activities to reach out and engage the public identified by the TAC include (see Watershed Action Plan Chapter 5 for a list of all high priority public policies and rules):

1) Implement Lower Willamette Agricultural Water Quality Plan.

2) Implement Landowner Outreach Program in Upper Johnson Creek.

3) Work with private landowners to restore creek and riparian areas to provide flood storage and improve habitat and water quality in Middle Johnson Creek.

4) Implement watershed wide construction BMP program.

5) Implement a comprehensive stormwater/watershed Public Involvement & Education program that includes information, education, involvement, and stewardship.

7.5.7. Summary

For watershed action implementation to be successful, restoration and protection actions need to be prioritized in terms of need, effectiveness, and effect on future actions and programs. Actions need to be sequenced so that implementing one doesn't impact the effectiveness of another. As suggested in the City of Portland's Framework for Integrated Management of Watershed and River Health the following elements and their order is a matter of importance:

1) **Protect existing populations and their habitats.** Rebuilding an existing population is far more likely to be successful than reintroducing a population that has been lost.

2) **Reconnect favorable habitats.** This allows existing populations to provide ‘colonists” that can reestablish satellite populations in nearby habitat where populations have been extirpated.

3) **Identify and control sources of degradation.** Causes of degradation should be identified and quantified before their impacts within the watershed are addressed.

4) **Restore the processes that maintain watershed health.**

    a. Normalize flow and hydrology;
    b. Restore physical habitat;
    c. Improve water quality; and
    d. Reestablish biological communities.

Other activities that require attention, program development, additional assessment and need to be implemented generally include:

- Water quality improvements in areas that are upstream and contributing to high priority areas;
- Low flow augmentation and irrigation efficiency improvements;
- Channel and floodplain reconnection;
- Fish passage improvement and connectivity.

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GLOSSARY

Adaptive Management: A dynamic planning and implementation process that involves applying scientific principles, methods and tools to improve management activities incrementally, as decision makers learn from experience and better information and analytical tools become available. Involves frequent modification of planning and management strategies – and sometimes goals and objectives – in recognition of the fact that the future cannot be predicted perfectly. Requires frequent monitoring and analysis of the results of past actions and application of those results to current decisions.

Anadromous fish: Fish that hatch in fresh water, migrate to the ocean to grow and mature and return to fresh water to spawn; includes salmon, steelhead, and sea-run cutthroat trout.

Backwater pool: Found along channel margins; created by eddies around obstructions such as boulders, root wads, or woody debris. Part of active channel at most flows; scoured at high flow. Substrate typically sand, gravel, and cobble.

Basin: See Drainage area.

Bedload: Sediment moving on or near the streambed and frequently in contact with it.

Benthos: Organisms living on or within a stream's substrate.

Best Management Practice: Nonstructural and low-structural measures that are determined to be the most effective, practical means of preventing of reducing pollution inputs from nonpoint sources in order to achieve water quality goals.

Canopy: That overhead branches and leaves of streamside vegetation.

Canopy cover: The vegetation that projects over the stream. Can arbitrarily be divided into two levels: **Crown canopy** is more than 1 m above the surface. **Overhanging cover** is less than 1 m above the water surface.

Canopy density: The percentage of the stream covered by the canopy of plants, sometimes

Carrying Capacity: The maximum average number of biomass of organisms or a given species that can be sustained on a long-term basis under a given flow regime by a stream or stream reach.

Cascade: Habitat type characterized by swift current, exposed rocks and boulders, high gradient and considerable turbulence and surface agitation, and consisting of a stepped series of drops.

Channel: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks, which serve to confine the water.

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

Channelization: Straightening of a stream or the dredging of a new channel to which the stream is diverted.

Confluence: The junction or union of two or more streams; a body of water produced by the union of several streams.

Cover: Anything that provides protection form predators or ameliorates adverse conditions of streamflow and/or seasonal changes in metabolic costs. May be instream cover, turbulence, and/or overhead cover, and may be for the purposes of escape, feeding, hiding, or resting.

Degradation: The geologic process by which stream beds and floodplains are lowered in elevation by the removal of material. It is the opposite of aggradation.

Deposition: The settlement or accumulation of material out of the water column and onto the streambed. Occurs when the energy of flowing water is unable to support the load of

Discharge: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second (cfs) or m^3/second.

Dissolved oxygen: The concentration of oxygen dissolved in water, expressed in mg/L or as a **percent saturation**, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature. Dissolved oxygen is absorbed by fish and other aquatic organisms through gills or membranes.

Diversion: A temporal removal of surface flow from the channel.

Diversity index: The relationship of the number of taxa (richness) to the number of individuals per taxon (abundance) for a given community.

Drainage area: Total land area draining to any point in a stream, as measured on a map, aerial photo or other horizontal plane. Also called catchment area, watershed, and basin.

Ecological services: The functions that a natural resource provides to benefit the environment and human uses.

Ecosystem: The living and nonliving components of the environment that interact or function together; includes plant and animal organisms, the physical environment and the energy systems in which they exist.

Embeddedness: The degree that larger particles (boulders, rubble, or gravel) are surrounded or covered by fine sediment. Usually measured in classes according to percentage of coverage of larger particles by fine sediments.

Endangered Species Act: A law passed by the U.S. Congress in 1973 that established programs for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service maintain the list of threatened and endangered species.

Enhancement: An improvement of conditions that provide for the betterment over natural conditions of the aquatic, terrestrial, and recreational resources.

Fine Sediment: The fine-grained particles in stream banks and substrate. These have been defined by diameter, varying downward from 6 millimeters (mm).

Fish habitat: The aquatic environment and the immediately surrounding terrestrial environment that, combined, afford the necessary biological and physical support systems required by fish species during various life history stages.

Flood: Any flow that exceeds the Bankfull capacity of a stream or channel and flows out on the floodplain; greater than bankfull discharge.

Floodplain: Any flat, or nearly flat lowland that borders a stream and is covered by its waters at flood stage.

Flow: (a) The movement of a stream of water and/or other mobile substances from place to place. (b) The movement of water, and the moving water itself. (c) The volume of water passing a given point per unit of time. See **Discharge**.

> **base flow:** The portion of the stream discharge that is derived from natural storage i.e., groundwater outflow and the drainage of lakes and wetlands or other source outside the net precipitation that creates surface runoff; discharge sustained in a stream channel, not a result of

direct runoff and without the effects of regulation, diversion, or other works of humans. Also, called sustaining, normal, ordinary or groundwater flow.

instream flow: Streamflow regime required to satisfy a mixture of conjunctive demands being placed on water while it is in the stream.

intragravel flow: That portion of the surface water that infiltrates the streambed and moves through the substrate pores. Also known as **interstitial flow**.

low flow: The lowest discharge recorded over a specified period of time. Also called **minimum flow**.

mean flow: The average discharge at a given stream location, usually expressed in m^3/sec, computed for the period of record by dividing the total volume of flow by the number of days, months, or years in the specified period.

minimum flow: (a) The lowest discharge recorded over a specified period of time (preferred definition). (b) Negotiated lowest flow in a regulated stream that will sustain an aquatic population at agreed upon levels. This flow may vary seasonally. Also known as **least flow**.

peak flow: The highest discharge recorded over a specified period of time. Often thought of in terms of spring snowmelt, summer, fall or winter rainy season flow. Also called maximum flow.

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

Geomorphologic: Relating to the form or surface features of the earth.

Glide: An area with generally uniform depth and flow with no surface turbulence. Low gradient, 0-1 percent slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity. There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993).

Gradient: (a) The general slope, or rate of change in vertical elevation per unit of horizontal distance, of the water surface of a flowing stream. (b) The rate of change of any characteristic per unit of length.

Habitat: The place where a population lives and its surroundings, both living and nonliving; includes the provision of life requirements such as food and shelter.

Habitat type: A land or aquatic unit, consisting of an aggregration of habitats having equivalent structure, function, and responses to disturbance.

Hydrograph: A graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water with respect to time.

Impervious surface: An impermeable ground coverage or surface, such as paved roads, sidewalks and structures, that alters the natural flow and quality of water.

Indicator Organism: Organisms that respond predictably to various environmental changes, and whose presence or absence, and abundance, are used as indicators of environmental conditions.

Instream Cover: Areas of shelter in a stream channel that provide aquatic organisms protection form predators or competitors and/or a place in which to rest and conserve energy due to a reduction in the force of the current.

Large organic debris: Any large piece of relatively stable woody material having at least a diameter greater than 10 cm and a length greater than 1 m that intrudes into the stream channel. Also known as LOD, large wood debris, log.

Macroinvertebrate: An invertebrate animal (without backbone) large enough to be seen without magnification.

Mainstem: The principal, largest, or dominating stream or channel of any given area or drainage system.

Microhabitat: That specific combination of habitat elements in the locations selected by organisms for specific purposes and/or events. Expresses the more specific and functional aspects of habitat and cover. Separated from adjoining microhabitats by distinctive physical characteristics such as velocity, depth, cover, etc.

Nonpoint source: Sources of pollution from diffuse sources such as stormwater runoff from agriculture, logging, and roadways.

Opportunities: Watershed conditions or features that are currently in a healthy, properly functioning condition and that are considered key to sustaining important watershed functions.

Optimal value: A value that reflects either a desired condition or response in an environmental indicator or the level below which ecological functioning is likely to be impaired.

Overbank storage: Flow of water out of the stream channel and onto the valley floor floodplain during flood flows.

Overhead cover: Material (organic or inorganic) that provides protection to fish or other aquatic animals from above; generally includes material overhanging the stream less than a particular distance above the water surface. Values of less than 0.5 m and less than 1 m have been used.

Permeability: A measure of the rate at which water can pass through a given substrate. Depends upon composition and degree of compaction of the substrate (usually gravel). The apparent velocity per unit of hydraulic gradient. Units: cm/hr.

Pool: (a) A portion of the stream with reduced current velocity, often with water deeper than the surrounding areas, and which is frequently usable by fish for resting and cover. (b) A small body of standing water, e.g., in a marsh or on the flood plain.

Pool-riffle ratio: The ration of the surface area or length of pools to the surface area or length of riffles in a given stream reach, frequently expressed as the relative percentage of each category.

Productivity: (a) Rate of new tissue formation or energy utilization by one or more organisms. (b) Capacity or ability of an environmental unit to produce organic material. (c) The ability of a population to recruit new members by reproduction.

Problems: Watershed conditions or features that are not properly functioning or that are contributing to impairment of watershed and river health.

Reach: A section of stream defined by some functional characteristic and possessing similar physical features such as gradient and confinement. A reach may be simply the distance surveyed. More frequently, reaches are defined as: stream segments between named tributaries, changes in valley and channel form, major changes in vegetation type, or changes in landuse or ownership.

Refugia: Locations and habitats that support populations of organisms limited to small fragments of their previous geographic range.

Restoration: Return of an ecosystem to a close approximation of its condition prior to disturbance.

Riffle: Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross section. Low gradient; usually 0.5-2.0 percent slope, rarely up to 6 percent.

Riparian: Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian area: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

Riparian vegetation: Vegetation growing on or near the banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season.

Riprap: A layer of large, durable materials (usually rock but sometimes broken concrete, etc.) used to protect a stream bank from erosion. May also refer to the materials themselves.

Rootwad: The root mass of the tree. Similar to butt ends.

Sediment: Fragmental material that originates from weathering of rocks and decomposition of organic material that is transported by, suspended in, and eventually deposited by water or air, or is accumulated in beds by other natural phenomena.

Sediment discharge: The mass or volume of sediment (usually mass) passing a stream transect in a unit of time. The term may be qualified, for example, as suspended-sediment discharge, bedload discharge, or total-sediment discharge, usually expressed as tons per day.

Sediment load: A general term that refers to sediment moved by a stream, whether is suspension (suspended load) or at the bottom (bedload). It is not synonymous with either discharge or concentration (see **bedload**).

Seep: An area of minor groundwater outflow onto the land surface or into a stream channel. Flows are too small to be a spring.

Stream Corridor: A stream corridor is usually defined by geomorphic formation, with the corridor occupying the continuous low profile of the valley. The corridor contains a perennial, intermittent, or ephemeral stream and adjacent vegetative fringe.

Substrate: The mineral and/or organic material that forms the bed of the stream.

Terraces: An embankment, or combination of an embankment and channel, constructed across a slope to control erosion by reducing the slope and by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.

Total suspended solids: The organic and inorganic material left on a standard glass fiber filter (0.45 µ filter); after a water sample is filtered through it; often referred to as Non-Filterable Residue.

Toxic metals: Metals present in industrial, municipal, and urban runoff, including lead, copper, cadmium, zinc, mercury, nickel, and chromium, in quantities that are harmful to humans or aquatic life.

Toxic substances: Any substances present in water, wastewater, or runoff that may kill fish or other aquatic life or could be harmful to public health. The substance may exhibit chronic toxicity or buildup in the food chain (biomagnification), or it may show acute toxicity and result in immediate death. Ammonia, acids, cyanides, phenols, toxic metals, and chlorinated hydrocarbons, among others, are examples of toxic substances.

Tributary: A stream feeding, joining, or flowing into a larger stream.

Turbidity: (a) Relative water clarity. (b) A measure of the extent to which light passing through water is reduced due to suspended materials. Measured by several non-equivalent standards (e.g., Nephelometric Turbidity Units, NTU; Formazin Turbidity Units, FTU; and Jackson Turbidity Units, JTU).

Watershed: A topographically discrete unit or stream basin that includes the headwaters, main channel, slopes leading to the channel, tributaries and mouth area. See Drainage area.

Weir: (a) A notch or depression in a levee, dam, embankment, or other barrier across or bordering a stream, through which the flow of water is measured or regulated. (b) A barrier constructed across a stream to divert fish into a trap. (c) A dam (usually small) in a stream to raise the water level or divert its flow.

Wetland: Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al., 1979). Wetlands include features that are predominantly wet, or intermittently water covered, such as swamps, marshes, bogs, muskegs, potholes, swales, glades, slashes, and overflow land of river valleys. According to the 1989 federal wetlands delineation manual, wetlands include lands saturated for at least 7 days to a depth of 12 inches. A newly proposed definition by the Bush Administration would be lands that have 15 days of standing water and 21 days of surface saturation. Land areas where excess water is the dominant factor determining the nature of soil development and the types of plant and animal species living at the soil surface. Wetland soils retain sufficient moisture to support aquatic or semi-aquatic plant life. An area subject to periodic inundation, usually with soil and vegetative characteristics that separate it from adjoining non-inundating areas.

Woody Debris: See large organic debris.

APPENDIX A: AQUATIC INVENTORIES PROJECT

Physical Habitat Surveys

Johnson Creek and Tributaries

ODFW, City of Portland, City of Gresham

Reach No.	Location	Ave. Unit Gradient	Dominant Habitat	Dominant Substrate	Ave. Residual Pool Depth (m)	Wood Volume (m^3/100m)	Riparian Vegetation (Most frequent/ Largest) (cm dbh)	Banks	Potential Refugia	Other
1	Conflunce to Hwy. 224	0.8	Riffles/ Scour Pools	Gravel, fine sediment, bedrock	0.13	0.2	3-15/ 90+	Stabilized by rip-rap, Builders waste, WPA	Few deep pools	Intense channel modifications No backwaters No LWD
2	Hwy. 224 to Crystal Springs Trib.	0.5	Riffles/ Glides	Cobble/ Gravel	1.03	0.4	3-15/ 30-50	WPA	One large backwater	Few backwaters Shade cover moderate Few spawning areas Lacks LWD and deep pools Parking lots/warehouses close to creek
3	Crystal Springs Cr. Trib to Old Tacoma Bridge Crossing	0.4	Scour Pools/ Riffles	Cobble/ Gravel	0.71	0.4	3-15/ 30-50	Builders Waste	Few pieces of LWD and Deep Pools	Riparian Shade Moderate JC Park Restoration Apt. complexes built close to stream
4	Old Tacoma Bridge to Tideman-Johnson	0.5	Scour Pools/ Riffles	Gravel/ Cobble	0.93	0.7	3-15/ 50-90	Earth slopes with significant erosion Incision reveals conglomerate bedrock	Lack of LWD, Scour Pools numerous – one very deep along backwater pool	Good shade Possible spawning gravels Golf course/residential maintenance practices Many seeps/springs

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5	Tideman-Johnson Park to Johnson Cr. Blvd.	0.6	Scour pools, Riffles, Glides	Gravel/ Cobble Significant sediment with Boulders	0.88	1.0	3-15/ 90+	Channel erosion and incision throughout lower half of reach Rock used to stabilize and protect exposed sewer pipe and WPA	Deep pools Need LWD Errol Cr. Trib. provides clear cool water	Trees provide good shade cover Numerous seeps Suitable substrate Heavily influenced by human activities
6	Johnson Creek Blvd. to SE Linwood Ave. Br.	0.8	Riffles, Scour Pools, Glides	Cobble/ Gravel	0.47	0.5	3-15/ 50-90	WPA	A few backwater pools and LWD Could benefit from more pools	Large Cottonwoods provide shade but width zone restricted by parking lots and residences Potential spawning gravels 11 culvert outfalls
7	SE Linwood Br. to SE 82nd	0.7	Riffles, Scour Pools, Glides	Cobble, Gravel, Boulders	0.84	0.4	3-15/ 90+	Single constrained channel Incision evident throughout First half of reach -WPA	Many deep pools (0.9-1.5m) Some smaller LWD and undercut banks	Small deciduous trees Riparian zone confined Some areas of channel complexity Exposed sewer pipe
8	SE 82nd to SE 106th	0.5	Glides, Scour Pools	Fine sed., Cobble,	0.48	0.7	3-15/ 15-30	Single constrained channel WPA lined-	Confined to undercut banks and woody debris	Small deciduous trees, riparian zone confined Two large culverts at 82nd Ave. S.E.

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				Gravel				secondary channel		Five bridge crossings including large amt. Of WPA, old bridge supports, secondary channel, some parts completely lined with concrete
9	I-205 to SE 106th Bridge	0.1	Scour Pools, Glides	Fine sediments	0.41	0.2	15-30/ 15-30	Earth eroding and cliffs	Backwater pools Three beaver dams LWD fairly abundant No aeration	Small deciduous trees A few areas of excellent overhanging vegetation Riparian confined by Freeway Land Co. Three areas of complex channels Lot of colluvial sloughing Old wood pilings
10	Se106th to SE 110th	0.2	Scour Pools	Fine sediments	0.61	1.6	3-15/ 30-50	Earth often eroding	Many deep pools w/ no backwater Woody debris offers best potential	Evidence of incision Flood control tunnel Deep and slow
11	SE 110th to Brookside Restoration	0.1	Scour Pools, Glides	Fine sediments	0.59	2.3	3-15/ 50-90	Grassy earth covered by retention cloth	Undercut banks, rootwads, "lake", alcove, and deep pools Secondary channel at high flows	Brookside Restoration site

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12	Brookside Restoration to SE 132nd	0.2	Glides	Gravel/ Cobble	0.46	3.8	3-15/ 50-90	Earth eroding and vegetative stabilized charact.	LWD and only pools w/ depths > 1-m	Riparian dominated by mature trees, some > 1-m dbh Multiple channels Le
13	SE 132nd to Kelley Cr. Trib.	0.2	Glides, Scour Pools	Boulders/ Cobble	0.64	0.7	3-15/ 90+	Earth with erosional attributes	Pools > 1-m Small amount of small woody debris	Many backyards degrade natural riparian flora Very channelized due to WPA tile Many small exposed pipes that traverse creek Numerous private driveways that are bridges USGS Sycamore gage Some areas of channel bottom composed of exotic rock boulders
14	Kelley Cr. Trib. to SE 190th	0.1	Scour Pools, Glides	Cobble/ Fine sediment	0.62	1.8	3-15/ 90+	WPA/ Others are earth and steep eroding	2nd half of Reach has abundant small woody debris Deep pools, steps, and riffles	Riparian canopy dominated by 3-15 cm dbh Dogwood/Willow often overhanging Few multiple channels and backwaters WPA first 25% Portland Waterworks outfall at SE Circle Ave-outflow from Powell

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										Butte Resv. Slow deep water Kelley Cr. contributing 20% of flow at time of survey
15	SE 190th to Main City Park	0.3	Scour Pools, Glides	Cobble/ Fine sediment	0.63	2.3	3-15/ 50-90	Eroding earth	Volume of LWD Many deep pools, but very few backwaters	Very few boulders Deep and slow Complex channels Main City Park Outfall
16	Main City Park to Palmblad Road	0.5	Scour Pools, Glides, Riffles	Cobble	0.55	2.5	3-15/ 90+	Earth eroding or stabilized	Greatest refuge of any Reach due to: LWD Backwaters Deep Pools Shade Cover	Riparian dominated by conif./decide. W/ dbh of 50-90 cm, and a few > 1-m Favorable characteristics throughout Reach Multiple channels with good complexity (Regner to Hogan Road) Hogan Rd. –very diverse w/ many LWD jams and associated deep pools Hogan Cedars Dam at time of survey Helpful Landowners
17	Palmblad Road to	0.8	Scour Pools,	Gravel/	0.39	3.3	3-15/	23% of Reach	Few areas of good off-	Riparian zone quite divers

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	*MacDonald*Cr.		Riffles	Cobble			50-90	actively eroding	channel habitat Boulders add to channel roughness Lacks deep pools	Some sections allow livestock to graze/water on banks Little evidence of interaction between creek and floodplain Few areas of heavy erosion due to livestock and unstable banks
18	*MacDonald* Cr. to Hwy. 26	0.8	Scour Pools, Riffles	Silt. Organics/ Sand/ Gravel/ Cobble	0.38	0.4	30-50/ 50-90	25% of Reach actively eroding	Off-channel habitat Very few long, slow sections and very few riffle-pool sequences	Riparian zone narrow Somewhat shaded Houses built very close to creek Channel very U-shaped Very little interaction between creek and floodplain Very little channel roughness and LWD
19	U.S Hwy. 26 to SE Stone Road	0.9	Scour Pools, Riffles	Silt Organics/ Sand/ Gravel/ Cobble	0.33	1.3	3-15/ 50-90	12% of Reach length has actively eroding banks	Numerous beaver ponds Increased sediment	Riparian zone poor Some patches of narrow but decent riparian buffer of willow/alder Great deal of clearing up to creek Intensive grazing Many long back-to-back pools and beaver ponds

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20	SE Stone Road to SE Orient Dr.	0.9	Riffles, Scour Pools, Dammed Pools	Silt/ Organics/ Sand/ Gravel/ Cobble	0.32	0.8	15-30/ 50-90	33% of Reach length has actively eroding banks	Couple of intermittent tribs. that can provide off-channel habitat	Active grazing Beaver activity continues Channel is U-shaped Extensive erosion Fine particulates prevalent in substrate
21	SE Orient Dr. to SE Altman Road	0.8	Riffles, Dammed Pools, Scour Pools	Silt/ Organics/ Sand	0.35	2.2	3-15/ 50-90	23% of Reach length has actively eroding banks	Boulders LWD including two log jams	Riparian zone best since Reach 17 Livestock fenced from creek Floodplain interaction Some areas where creek has been resectioned due to redirect, damming, or armoring FW mussels "Crystal Springs Resv." used by Nursery as a settling pond Large estate has two wooden dams (0.5 -m) high could be made "fish-friendly" passages with minimal work
22	SE Altman Road to last marked trib. junction on USGS map	0.8	Dammed Pools, Glides	Silt/ Organics	0.45	0.7	3-15/ 30-50	5% of Reach length has actively eroding banks	Some snags left standing in riparian area will eventually be recruited to creek	Grazing/Nurseries have resulted in impacts to riparian (shade and decreased bank stability) Several small patches of very nice

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									Some interaction with floodplain	riparian left alone Lots of beaver actv. Couple areas where creek disappears into bog areas Good habitat for birds Unit #1645 rearranged and rerouted (including dammed pool, road, and tributary)
23	Last tributary marked on USGS map to headwaters	1.4	Dammed Pools, Glides	Silt/ Organics	0.36	1.2	3-15/ 90+	8% of Reach length has actively eroding banks	Not much. Little wood, undercut, or off-channel habitat	Large bog areas and nurseries Channel is U-shaped with some erosion and unstable banks Groundwater/ nursery runoff
Crystal Springs 1	Conflunce to SE Lambert Bridge	0.3	Scour Pools Glides	Fine sediment Gravel	0.24	0.3	3-15/ 30-50 90+	Channelized Reinforced	Temp. ok Off-channel	Apt., houses on top of creek Very little wood or channel roughness Many bridges Flow swift even during dry conditions
2	SE Lambert Bridge to SE Glenwood Bridge	0.1	Scour Pools Dammed Pools	Fine sediment Gravel	0.32	0.1	30-50	Armored	Not much shade, wood, undercuts, or off-channel habitat	Westmoreland Park Concrete banks Large Duck Pond

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										Rectangular Casting Pond
3	Se Glenwood Bridge to "South Spring" trib. junction in Golf Course	0.1	Dammed Pools Glides	Fine sediment Gravel	0.38	1.0	No trees but GC does provide some riparian	GC grass Stream allowed to interact with floodplain	Some shade, undercuts, and pieces of large wood	Golf Course and Retirement Center S. Spring dam is fish barrier
4	South Spring Trib. to above Reed College Lake	1.2	Dammed Pools/ Scour Pools	Fine sediment Gravel	0.36	5.9	3-15/ 90+	Earth slopes with significant erosion Incision reveals conglomerate bedrock	Shade provided by 50-90 trees Temp. –good Some off-channel and undercuts and few deep pools	Riparian zone quite good (Reed College left it alone) Structure built over creek at college Lake outlet is passage barrier for fish Two springs
Errol Creek 1	J.C. Confluence to wall of blackberry where hillslope begins (private property)	1.6	Riffles, Glides	Sand Gravel	0.22	None	30-50/ 30-50	Very little erosion or incision Some retaining walls in backyards	Not much No boulders, undercuts Water quality good with steady flows and low temps. Home structures provide shade (?)	No wood Extremely narrow riparian Runs through many backyards 5 culvert crossings all passable

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2	Wall of Blackberry to last and most northern large pool in Amphitheater	1.4	Dammed Pools Glides	Fine sediment Gravel	0.71	1.8	30-50/ same		Shade is low due to width of large dammed pools Large ponds may be impassible at beginning	Restoration area/plantings Lot of blackberry Riparian somewhat degraded Five large dammed pools serve as R/D
Veterans Creek 1	Johnson Cr. confluence to second private driveway crossing creek	2.7	Dammed pools Riffles Scour pools	Equal amounts of Silt Sand Gravel Cobble	0.29	1.4	30-50/ 90+	Stream channelized Excessive alterations to create "fountain-like" atmosphere	Very LWD Little undercuts, few boulders, and no off-channel	Riparian zone significantly altered Culverts, concrete, Mt. Scott Blvd., and large buildings all impacting creek Channel altered by I-205 Exotic fish (Koi) Potential artificial barrier at confluence
2	Private driveway crossing to eastern end of Lincoln Memorial Cemetery Reservoir	9.2	Dammed Pools Cascades	Cobble Gravel	0.33	8.2	3-15/ 90+		Many boulders and some LWD	Decent riparian zone Cemetery Resv. irrigation and cycling is complex Very deep pools Very little off-channel habitat

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										High water temps
Wahoo Creek 1	Johnson Cr. confluence to SE Flavel	7.2	Cascades Dry Units Riffles	Equal amounts of Silt Sand Gravel Cobble	0.12	1.7	30-50/ 90+		Some off-channel Moderate LWD and Large Boulders	Riparian buffer good Lot of blackberry
McDonald or Sunshine Creek 1	J.C. Confluence to hillslope encroaches prior to private drive	0.5	Scour Pools Dammed/Back water Pools	Gravel Cobble	0.42	1.4	3-15/ 90+	Some erosion and incision	Deep pools Riffle/pool Sequences Meandering Few areas of multiple channels and Some LWD	Riparian decent in some areas and non-existant in others. Rural residential influences riparian with houses, backyards, and pastures
2	Private drive to southern most crossing of SE Hide-a-way Court	0.3	Scour Pools Dammed Pools	Fine sediment Gravel	0.60	1.1	3-15/ 90+		LWD Beaver Dams	Wide Riparian Channel is straight, deep, and U-shaped Very little wood and off-channel Some accounts of trout

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3	Hide-a-way Court to southern most trib on USGS map	0.6	Scour Pools Dammed Pools	Sediment Gravel	0.43	1.5	3-15/ 50-90		Large Beaver Ponds only	Riparian is poor Pasture up to Creek Small pocket of good riparian at end of reach Channel is long, straight, deep, and U-shaped.
4	Trib. marked on USGS map to private drive on Gentry Nuresry (north of Tillstrom Rd.)	1.6	Scour Pools Riffles	Gravel Sand	0.33	1.4	15-30/ 50-90		LWD Riffle-pool	Riparian is decent up to SE Tillstrom Rd. Decent riffle-pool sequences Gentry and Dillard Nurseries impacts
5	Gentry Nursery to small cedar grove in Dillard Nursery	3.0	Riffles Scour Pools	Fine sediment Gravel	0.36	0.5	3-15/ 90+	Silt from banks Heavy incision with deep channels	None	No riparian zone Only shade is blackberry Incision and erosion U-shape channel Nursery plants in pots covering the area up to and far away from Creek GW erupts
Butler Creek	J.C. Confluence to south side of Binford	2.5	Dammed Pools of Resv.	Fine sediment Gravel	31 cm	3.4	3-15/ 90+	Moderate amount of erosion and	Pools Woody Debris	Good quality riparian Dense blackberry

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1	Reservoir		Riffles Scour Pools					incision		Sewer manhole w/i main channel of Creek Binford Resv. Overflow channel with two 1.5 m outfalls (manually operated) Signs of intense discharges with heavy incision, and land slides. Fish barriers.
2	Binford Resv. To southside of Butler Resv.	2.2	Dammed Pools of Resv. Riffles	Gravel Cobble	35 cm	1.7	3-15/ 90+	Quite a bit of erosion	Pools LWD	Riparian zone better quality than Reach 1 with less blackberry Secondary channel with wetland just upstream of Resv. Very little bank undercuts Needs boulders and meanders Resv. drained by impassable culvert Narrow stream corridor
Hogan Creek 1	J.C. Confluence to south side of Cedar Lake Resv.	2.6	Dammed Pools of Resv. Riffles Scour Pools	Fine sediment Gravel Cobble	48 cm	4.2	3-15/ 90+	Eroding	Small pools Some LWD	Riparian zone is natural up to Cedar Lake Culvert crossing assoc. with Cedar Lake is a fish barrier Good habitat above Lake with another impassable culvert at G.C.

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Kelley Creek 1	J.C. Confluence to SE Foster Road	1.1	Dammed and backwater pools	Equal amounts of vaious particle sizes	0.6	1.3	3-15/ 90+	Lined with blackberry WPA Channel incision where WPA not present	Deep pools created by steps	Riparian zone narrow due to houses Concrete steps and deep pools downstream of Foster Rd. culvert crossing Concrete diversion with metal floodgate supplies water to pond at Lakeside Gardens Outflow is potential fish barrier Reach needs large boulders and LWD for channel surface roughness
2	SE Foster Road to clearing of north end of Kelley Cr. Farms	1.8	Riffles	Cobble Gravel	0.3	1.0	3-15/ 90+		Pools Large Boulders and Wood	Riparian zone = 200 m wide Riffle-pool Upper section heavily affected by 96 flood Multiple channels Cutthroat Recent slides
3	Kelley Cr. Farms to Mitchell Cr. Trib. junction	1.1	Dammed Pools Scour Pools	Cobble Gravel	0.57	0.4	30-50/ 50-90		Large Pools but little refugia	First half is grassy ditch Second half is a wide riparian zone 1.7 m steel dam on Kelley Cr. Farm is a fish barrier.

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4	Mitchell Cr. Trib. to trib. junction just before the Richey Road crossing	0.6	Scour Pools Riffles Glides	Fine sediment Gravel	0.40	0.20	3-15/ 50-90	Lots of erosion	Many pools and some riffle-pool sequences	Poor riparian zone Narrow buffer Channel is ditch that transects many farms and backyards Very little off-channel, LWD, or undercuts.
5	Richey Road crossing to SE 190th	0.8	Dammed Pools Scour Pools	Sediment Gravel	0.42	0.3	3-15/ 90+		Undercut banks but no off-channel or LWD Very narrow and immature riparian with low quality fish habitat	Small pocket of good riparian buffer Christmas tree farms Channel ditch-like Multiple terraces from human and natural influences Two dams creating large ponds and 1 culvert - all are impassable.
6	SE 190th to middle of grazing field	2.5	Riffles Glides	Gravel Sand	0.28	0.4	3-15/ 50-90		Limited	Riparian zone is poor Blackberry Grazing on Creek Grass edging up to shrubs Fencing needed
7	Middle of grazed field to125 m past	3.1	Riffles	Gravel	0.23	0.4	3-15/	Some areas of significant	A few large pools	Blackberry but grazing is less

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	the first private drive off of Rodlun Rd.		Scour Pools	Cobble			90+	erosion		Channel is U-shaped Cutthroat trout
8	Private drive off of Rodlun Rd. to first trib. junction past Alder Ridge Road	3.6	Riffles Cascades	Gravel Cobble	0.20	1.5	30-50/ 50-90		LWD Riffle-pool sequences	Riparian is excellent Southern side is pristine, northern side has good buffer Natural wetland marshes Trout in every pool Closeness to paralleling road
9	Alder Ridge Road to where creek dries up	4.1	Riffles Glides	Fine sediment Gravel	0.20	0.20	30-50/ 30-50		Poor area for refuge	Northern side close to Rodlun Road Constricted by grade No off-channel and very little LWD and few pools Restoration area
Mitchell Creek 1	Kelley Cr. Confluence to 140 m upstream of SE Baxter Road crossing	1.7	Dammed Pools Riffles Scour Pools	Fine sediment Gravel	0.29	0.90	3-15/ 90+	Erosion and incision Hard pan substrate which seems quite soft and easily eroded	Few pieces of wood but no pools or undercuts 2nd half provides cover by overhanging blackberries	Nice wide mature, functioning riparian buffer 2nd half of reach is poor, narrow zone with blackberry and completely cleared areas Very little off-channel Landowners heavily impacting creek with dammed pools, gray water

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									and willows.	outfalls, bank armoring, and clearing activities.
2	140 m upstream of the SE Baxter Road crossing to trib. junction where WWTP is located	1.1	Scour Pools Riffles	Fine sediment gravel	0.29	7.3	15-30/50-90 90+	Erosion and evidence of high flows	Deep pools and LWD	Cedar forest Riparian zone is wide and mature Some backyard owners have cleared up to creek No boulders, few off-channel, and little undercuts Trout in pools Culvert at SE 162nd is a potential artificial barrier that is causing severe erosion Landowner annually stocks Rainbow trout Large concrete structure in creek bed. Maintenance and water quality issues with WWTP
3	WWTP to spring found adjacent to SE Sagar Road	12.3	Cascades Riffles	Equal amounts of all substrate types	0.14	6.0	50-90/ 90+		LWD Undercuts Cool temps.	Riparian zone is good, wide, and mature Clean water source One of the most pristine subwatershed reaches within the JC

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									Boulders	watershed
Clatsop Creek 1	Kelley Cr. Confluence to Barbara Welch Rd. crossing	3.1	Scour Pools Riffles	Fine sediment Gravel	0.18	2.0	30-50/ 90+	Erosion and increased sediment	LWD Many pools	Development with 30-40 m of riparian No undercut or off-channel habitat Erosion and sedimentation Drain maintenance needed
Church Creek 1	Kelley Cr. Confluence to just past the Pleasant Valley Church	0.7	Dammed Pools Glides	Fine sediment Gravel	0.18	0.2	3-15/ 50-90	Some erosion	Off-channel	Riparian is poor Blackberry Mowed lawns Road grade Pasture Grassy ditch No LWD, undercut, or large boulders.

APPENDIX B: CITY OF PORTLAND AMBIENT MONITORING PROGRAM

Selected Water Quality Results from Portland's Ambient Monitoring Program during July –Oct 1998-2002

Station	Year	Minimum D.O. (mg/L)	Geometric Mean E. Coli (org./100mL)	Mean pH	Maximum Temperature (°C)
East of 21st (Crystal Springs Cr.) (JC-1)	1998	8.3	544	7.15	19.4
	1999	9.6	591	7.2	17.4
	2000	8.8	764	7.1	17.5
	2001	9.3	712	7.3	19.0
	2002	8.1	949	7.2	17.5
S.E. Umatilla Street Br. (Main Channel) (JC-2)	1998	9.1	802	7.6	20.3
	1999	9.8	482	7.7	16.5
	2000	9.3	566	7.5	17.9
	2001	9.0	379	7.7	19.6
	2002	6.7	712	7.4	17.3
East of Johnson Cr. Blvd. (Main Channel) (JC-3)	1998	8.3	925	7.5	21.4
	1999	9.2	1,505	7.4	17.2
	2000	8.8	1,894	7.2	18.2
	2001	8.7	1,128	7.4	19.3
	2002	6.9	1,598	7.2	17.5
S.E. 92nd Ave. Br. (Main Channel) (JC-4)	1998	6.2	258	7.4	24.3
	1999	6.2	212	7.4	19.7
	2000	6.2	468	7.15	20.4
	2001	5.5	309	7.25	21.2
	2002	6.7	595	7.15	18.7
S.E. 159th Dr. Br. (Kelley Cr. Trib.) (JC-5)	1998	8.5	126	7.5	20.6
	1999	8.1	215	7.4	15.8

	2000	8.3	177	7.4	17.9
	2001	8.0	444	7.4	17.8
	2002	7.8	939	7.3	16.9
S.E. 158th Ave. Br. (Main Channel) (JC-6)	1998	7.6	157	7.3	21.7
	1999	7.4	333	7.2	17.1
	2000	6.9	178	7.1	19.6
	2001	7.6	404	7.2	19.8
	2002	6.2	554	7.15	18.4
S.W. Pleasant View Dr. Br. (Main Channel) (JC-7)	1998	7	262	7.3	22.9
	1999	7.4	425	7.2	18.5
	2000	6.3	328	7	20.9
	2001	6.7	122	7.2	20.6
	2002	7.5	781	6.98	17.6
S.E. Hogan Ave. Br. (Main Channel) (JC-8)	1998	7	217	7.5	22.4
	1999	9.2	44	7.4	17.4
	2000	8.3	596	6.8	19.6
	2001	8.7	202	7.4	19.9
	2002	8.5	238	7.25	16.9

APPENDIX C: EXCERPTS FROM JOHNSON CREEK CULVERT CROSSING INVENTORY

Culvert Crossing Inventory Developed by The Johnson Creek Joint Culvert Crossing Inventory Committee

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
G	3550J362	Butler	0.019	C	SW 14th Dr	?	
G	3550J234	Butler	0.234	O	Butler Cr. Res. O. Flow	Y	Dam "Spillway" No Flow
G	3550J374	Butler	0.2	D	SW Binford Lk Pkwy	Y	Up Stream End Subm. In Pond
PV	3650J472	Butler	0.669	D	Marpole Ridge Pond	Y	Not Assessed (Dn. Stream Barrier)
G	3650J400	Butler	0.832	D	SW 27th Dr	Y	Not Assessed (Dn. Stream Barrier) Willowbrook Pond
G	3651J396	Butler	0.835	C	Butler Crk E. @ SW 27th Dr	N	Not Assessed (Dn. Stream Barrier) Submerged Outfall
G	3750J168	Butler	0.974	C	Butler Crk W. @ SW Willow Pkwy West	Y	Not Assessed (Dn. Stream Barrier)
G	3751J004	Butler	1.1	C	Butler Crk W. @ SW Willow Pkwy East	Y	Not Assessed (Dn. Stream Barrier)
P	3751J032	Butler	1.262	C	Butler Rd Pvt Ranch	?	Not Accessable
PV	3751J036	Butler	1.525	C	Butler Cr. @ Pvt. Dwy. Butler Rd		Not Assessed (Dn. Stream Barrier)
G	PED004	Butler		B	Pedestrian Bridge	N	Not Assessed
G	PED005	Butler		B	Pedestrian Bridge	N	Not Assessed
MC	313-01	Butler		C	Butler Cr. E. @ Towle Ave		Not Accessable; Uncertain location and ID
MC	375-03	Clatsop	0.5	C	SE Barbara Welch Rd	Y	
P	JC12	Clatsop	1.1	C	SE 162nd	Y	Enters JC at river mile 11.3, enters Kelley Cr. At river mile 0.6.
P	JC21	Clatsop	1.1	C	SE 147th Ave.	Y	Enters JC at river mile 11.3, enters Kelley Cr. At river mile 0.6. Steep slope.
P	CS01	Crystal Springs	0.2	C	SE Umatilla St.	Y	Enters JC at river mile 1.4.
P	CS02	Crystal Springs	0.2	C	SE Tenino St.	Y	Enters JC at river mile 1.4.
P	CS03	Crystal Springs	0.3	C	SE Tacoma St.	Y	Enters JC at river mile 1.4.
P	CS04	Crystal Springs	1	C	SE Bybee Blvd.	Y	Enters JC at river mile 1.4.

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
P	CS05	Crystal Springs	1.1	C	SE Glenwood St.	Y	Enters JC at river mile 1.4.
P	CS06	Crystal Springs	1.7	C	SE 28th Ave.	Y	Enters JC at river mile 1.4.
G	3654J010	Hogan	0.213	D	SE 26th Dr / Cedar Lake Res.	Y	Cedar Lake Dam (Private Reservoir)
G	3654J016	Hogan	0.4	C	SE Cleveland/Cedar Lk Res. Inlet	N	Not Assessed (Dn. Stream Barrier)
PV	3654J018	Hogan	0.444	C	Pvt Dwy @ S. of Gresham Bdy.	?	Not Assessed Private Crossing
G	3853J002	Hogan	1.59	C	Hogan Cr. @ SE 46th Ct		Not Assessed (Dn. Stream Barrier)
MC	330-11	Hogan		C	SE Butler Rd	N	
P	JC10	Kelly	0.2	C	SE Foster Rd.	Y	Enters JC at river mile 11.3.
PV	JC??	Kelly	0.7	D	Kelly Creek Farms		This dam is at Kelly Cr. Farms. This dam is being removed by 4-1-01. ESA map
MC	300-03	Kelly	1.2	C	SE Foster Rd	N	
MC	395-02	Kelly	1.4	C	SE 190th Av	Y	
MC	328-01	Kelly	1.7	C	SE Richey Rd	N	
PV	JC??	Kelly	1.8	D	Ralph Norrander (near Richey Rd.)		Dam and pond; fish barrier. This is at "The Christmas Tree Place" at 18124 SE Richey Rd. - no water right- OWRD has been notified 1-20-01.
CC	CV-43	Kelly	0.50	C	162nd Ave 0.20	Y	
CC	CV-457	Kelly	0.89	C	172nd Ave 0.03	Y	
P	JCB01	**mainstem**	0.4	B	SE 17th Ave.	N	N. of Milport and d/s of Ochoco St. shows a crossing on GIS, not on Thomas Guide.
P	JCB02	**mainstem**	0.5	B	SE McLaughlin Blvd./HWY 224 on ramp	N	
P	JCB03	**mainstem**	0.6	B	HWY 224	N	
P	JCB04	**mainstem**	0.9	B	SE Milport Rd.	N	
P	JCB05	**mainstem**	1.3	B	SE Ochoco St.	N	
P	JCB06	**mainstem**	1.5	B	SE Sherrett St.	N	
P	JCB07	**mainstem**	1.6	B	SE 24th Ave.	N	

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
P	JCB08	**mainstem**	1.6	B	SE Harney St.	N	
P	JCB09	**mainstem**	1.7	B	SE 25th Ave	N	
P	JCB10	**mainstem**	1.7	B	SE Umatilla St.	N	GIS shows it crossing???
P	JCB11	**mainstem**	1.8	B	SE Tacoma St. - McLoughlin Ramp	N	
P	JCB12	**mainstem**	1.8	B	SE McLaughlin Blvd.	N	
P	JCB13	**mainstem**	2	B	SE 26th Ave.	N	
P	JCB14	**mainstem**	2.1	B	SE Tacoma St.	N	Does JC also cross Berkley St.??
P	JCB15	**mainstem**	2.1	B	SE Tacoma St.???	N	GIS says the road is Tacoma but I don't think it is. Road is adjacent to Berkley. Does JC also cross Berkley St.??
P	JC33	**mainstem**	3	O	Lents Crossing/T.J. Park	Y	This is a sewer pipe that crosses the stream and is now exposed due to channel incision.
P	JCB16	**mainstem**	3	B	SE Umatilla St.	N	
P	JCB17	**mainstem**	3	B	SE Harney St.	N	This is on the Oxbow/WPA???
P	JCB18	**mainstem**	3.1	B	SE Johnson Creek Blvd.	N	This is on the Oxbow/WPA???
P	JCB19	**mainstem**	3.7	B	SE 55th Ave.	N	
P	JCB20	**mainstem**	4	B	SE Stanley Ave.	N	
P	JCB21	**mainstem**	4.2	B	SE Wichita Ave.	N	
P	JCB22	**mainstem**	4.4	B	SE Linwood Ave.	N	
P	JCB23	**mainstem**	4.7	B	SE Bell Ave.	N	
P	JCB24	**mainstem**	4.9	B	SE Johnson Creek Blvd.	N	
P	JCB25	**mainstem**	5.4	B	SE Luther Rd.	N	
P	JCB26	**mainstem**	5.7	B	SE Harney St.	N	
P	JCB27	**mainstem**	5.7	B	SE 82nd Ave.	N	
P	JCB28	**mainstem**	6.1	B	SE Lambert St.	N	
P	JCB29	**mainstem**	6.4	B	SE 92nd Ave.	N	
P	JCB30	**mainstem**	6.4	B	SE Flavel St.	N	
P	JCB31	**mainstem**	6.5	B	I-205 South	N	

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
P	JCB32	**mainstem**	6.5	B	I-205 North	N	
P	JCB33	**mainstem**	7	B	SE 100th Ave.	N	
P	JCB34	**mainstem**	7.4	B	SE 106th Ave.	N	
P	JCB35	**mainstem**	7.7	B	SE 108th Ave.	N	
P	JCB36	**mainstem**	8	B	SE 110th Ave.	N	
P	JCB37	**mainstem**	8.1	B	SE 110th Dr.	N	
P	JCB38	**mainstem**	9.1	B	SE 122nd Ave.	N	
P	JCB39	**mainstem**	9.7	B	SE Deardorff Rd.	N	
P	JCB40	**mainstem**	10.1	B	SE 142nd Ave.	N	
P	JCB41	**mainstem**	10.4	B	SE Foster Rd.	N	
P	JCB42	**mainstem**	11.2	B	SE 158th Ave.	N	
P	JCB43	**mainstem**	11.9	B	SE Circle Ave.	N	
P	JCB44	**mainstem**	12.3	B	SE Circle Ave.	N	
P	JCB45	**mainstem**	12.4	B	SE 174th Ave.	N	
CC	CV-621	**mainstem**		C	307th Ave 0.45	Y	
CC	CV-672	**mainstem**		C	327th Ave 0.06	Y	
CC	CV-702	**mainstem**		C	Bluff Rd 0.12	Y	
G	3452J002	**mainstem**		B	Walters Rd	N	
G	3453J034	**mainstem**		B	S Main Ave	N	
G	3549J396	**mainstem**		B	SW Pleasant View	N	
G	3554J232	**mainstem**		B	SE Regner Rd	N	
G	SEW001	**mainstem**		O	Elev. San. Sewer Crossing	N	Not Assessed
G	PED003	**mainstem**		B	Pedestrian Bridge	N	Not Assessed
G	PED001	**mainstem**		B	Pedestrian Bridge	N	Not Assessed
G	PED002	**mainstem**		B	Pedestrian Bridge	N	Not Assessed
G	3452J004	**mainstem**		B	SW 7th St		
MC	330-02	**mainstem**		C	SE Butler Rd	Y	

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
MC	493-06	**mainstem**		C	SE 282nd Av	Y	
MC	433-04	**mainstem**		C	SE Cottrell Rd	N	
MC	415-01	**mainstem**		C	SE Pleasant Home Rd	N	
MC	409-01	**mainstem**		C	SE Short Rd	N	
MC	449-01	**mainstem**		C	SE 267th Av	N	
MC	447-10	**mainstem**		C	SE Telford Rd	N	
MC	25T08	**mainstem**		B	SE 252nd Av	N	
MC	25T07A	**mainstem**		B	SE 242nd Av/Hogan Rd	N	
MC	16383	**mainstem**		B	SE 209th Av/Towle Av	N	
MC	51B002	**mainstem**		B	SE Highland Dr	N	
MC	25T16	**mainstem**		B	SE Jenne Rd/174th Av	N	
MC	51C15	**mainstem**		B	SE Circle Av	N	
MC	51C34	**mainstem**		B	SE Circle Av	N	
O	3453J030	**mainstem**		B	Springwater Trail B3	N	
O	3453J036	**mainstem**		B	Springwater Trail B2	N	
O	3549J394	**mainstem**		B	Springwater Trail B1	N	Springwater Trail Ped. Bridge
O	GAS001	**mainstem**		O	Elev. High press. Nat. Gas Line	N	Not Assessed
PV	3655J004	**mainstem**		D	Ambleside	Y	Being Assessed By Metro
PV	3655J006	**mainstem**		B	Ambleside Pvt B-1	N	
PV	B0002	**mainstem**		B	PVT Pedestrian Bridge	N	Not Assessed
PV	B0001	**mainstem**		B	PVT Dwy	N	Not Assessed
U	??	**mainstem**		P	SW Towle Ave	Y	Not Assessed (Piped Sys)
M	02	Minthorne Spring	.038	P	McLoughlin Blvd	U	Pipe from MH on Main St.
M	03	Minthorne Spring	.131	O	McLoughlin Blvd	Y	Drop MH
M	04	Minthorne Spring	.131	P	McLoughlin Blvd	U	pipe from drop MH to weir

Owner	Owner ID#	Stream Name	Stream M.P.	Structur e	Crossing Name	Fish Barrier	Comments
M	05	Minthorne Spring	.154	D	McLoughlin Blvd	Y	weir
M	06	Minthorne Spring	.269	P	Harrison St.	U	pipe under Harrison ST. to pond at Jr High
M	07	Minthorne Spring	.298	D	Harrison St.	U	weir at Jr High next to falls
M	08	Minthorne Spring	.304	O	Harrison St.	Y	Water fall at Jr High
M	09	Minthorne Spring	.345	P	Harrison St.	U	pipe under driveway at Jr High
M	10	Minthorne Spring	.352	D	Harrison St.	Y	weir at Jr High on north side of NE driveways.
M	11	Minthorne Spring	.372	P	Harrison St.	U	pipe under NE driveways at Jr High and RR-tracks, Apt driveway and old police station driveway. This pipe basically travels East.
M	12	Minthorne Spring	.412	D	Harrison St.	Y	Weir at East end of driveway at old police station.
M	01	Minthorne Spring	0.0	C	McLoughlin Blvd	U	Mouth of culvert at Johnson Creek and stretches under Mcloughlin Blvd and SE Main St.
PV	JC??	Mitchell	0.1	D	Kelly Creek Race track	Y	Race track; has a screen on outfall. OWRD has been notified 1-20-01., no water rifht.
MC	326-01	Mitchell	0.5	C	SE Baxter Rd	N	
P	JC18	Mitchell	0.8	C	162nd Ave.	Y	Enters JC at river mile 11.3, enters Kelley Cr at river mile 0.9.
G	3453J032	No Name	0.001	P	3453 P-Sys-1	Y	Not Assessed (Piped Sys)
G	3453J038	No Name	0.001	P	3453 P-Sys-2	Y	Not Assessed (Piped Sys)
G	3453J040	No Name	0.001	P	3453 P-Sys-3	Y	Not Assessed (Piped Sys)
O	3554J222	No Name	0.011	C	Springwater Trail C2	N	Beaver Dam 25' Upstream
PV	3655J010	No Name	0.011	B	Poss. Ambleside Pvt B-2	?	Need To Field Verify
O	3553J230	No Name	0.027	C	Springwater Trail C1	Y	
G	3549J284	No Name	0.051	C	14TH Dr W. of Pleasant View	?	Outfall & Inflow Not Accessable, Need Field Verification
O	3654J014	No Name	0.055	C	Springwater Trail C3	N	
G	3554J234	No Name	0.059	C	SE Regner Rd	Y	Collapsed Segment of Pipe
PV	3554J224	No Name	0.095	C	Pvt Dwy S. of Cedar Crk Pl	?	

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
G	3654J008	No Name	0.096	C	COG Operations Ctr	N	
G	3454J004	No Name	0.098	C	SE Roberts Dr	?	Outfall Not Accessable, Need Field Verification
PV	3551J354	No Name	0.1	C	Pvt Dwy Heiney Rd & 14th	N	48" Dn/42" Up
G	3551J270	No Name	0.178	P	SW Towle Ave	Y	Not Assessed (Piped Sys)
PV	3554J226	No Name	0.203	C	McCarthy Mfg. Inc	N	
G	3654J004	No Name	0.213	C	SE Cleveland Ave	Y	Need Further Downstream Passage Assessment
G	3649J278	No Name	0.3	C	SW Highland Dr	Y	Not Assessed (Dn. Stream Barrier)
G	3553J228	No Name	0.356	C	19th St	Y	Not Assessed (Dn. Stream Barrier)
G	3653J016	No Name	0.374	C	Stone Ridge	N	Not Assessed (Dn. Stream Barrier) Submerged Outfall
G	3553J226	No Name	0.446	C	N. Fork Btwn 16th and Meadow Ct	N	Not Assessed (Dn. Stream Barrier)
G	3649J592	No Name	0.54	P	SW Heartly Ave	Y	Not Assessed (Start of Pipe Sys-No Habitat Up Stream)
G	3651J092	No Name	0.568	C	SW Binford Lk Pkwy W.of SW Towle	Y	Not Assessed (Little Habitat Up Stream)
G	PED006	No Name		B	Pedestrian Bridge	N	Not Assessed
G	PED007	No Name		B	Pedestrian Bridge	N	Not Assessed
G	PED008	No Name		B	Pedestrian Bridge	N	Not Assessed
PV	1	No Name		U	Butler Cr. Pvt 1 SE	?	Not Assessed Other Owner
PV	2	No Name		U	Butler Cr. Pvt 2 SE	?	Not Assessed Other Owner
ST	??	No Name		P	Wetlands South	Y	Not Assessed (Piped Sys)
MC	447-07	North Fork	0.1	C	SE Telford Rd	Y	
MC	493-05	North Fork	0.8	C	SE 282nd Av	Y	
MC	445-02	North Fork	2	C	SE 262nd Av	Y	
MC	449-03	North Fork		C	SE 267th Av	N	
MC	330-10	Unknown	1	C	SE Butler Rd	Y	
MC	422-02	Unknown		C	SE Bluff Rd	N	
MC	415-02	Unknown		C	SE Pleasant Home Rd	N	

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
MC	413-01	Unknown		C	SE Clark Rd	N	
MC	493-07	Unknown		C	SE 282nd Av	N	
MC	409-02	Unknown		C	SE Short Rd	N	
MC	409-04	Unknown		C	SE Short Rd	N	
MC	443-01	Unknown		C	SE 257th Av/Kane Rd	N	
MC	401-02	Unknown		C	SE 242nd Av/Hogan Rd	N	
MC	401-03	Unknown		C	SE 242nd Av/Hogan Rd	N	
MC	401-04	Unknown		C	SE 242nd Av/Hogan Rd	N	
MC	401-05	Unknown		C	SE 242nd Av/Hogan Rd	N	
MC	309-02	Unknown		C	SE Highland Dr	N	
MC	385-01	Unknown		C	SE 182nd Av	N	
MC	300-01	Unknown		C	SE Foster Rd	N	
MC	300-02	Unknown		C	SE Foster Rd	N	
P	JC02	Unknown trib.	0.1	C	SE 45th	Y	Unknown trib. Enters JC at river mile 3
P	JC19	Unknown trib.	0.1	C	SE 145th Ave.	Y	Enters JC at river mile 10.5. Culvert is of little appropriatly placed with stream channel-stream has been moved-LOW priority.
P	JC09	Unknown trib.	0.2	C	SE Flavel St.	Y	Enters JC at river mile 9.6.
P	JC22	Unknown trib.	0.2	C	12029 SE Brookside Dr.	Y	Enters JC at river mile 8.8. Couldn't Access outfall because it is privatly owned and covered with blackberries.
PV	JC30	Unknown trib.	0.2	C	12024 SE Brookside Dr.	Y	No flow in summer. Culvert installed by City but private ownership. Field inlet at headwall preventing fish passage. Couln't measure diameter due to structure type.
P	JC23	Unknown trib.	0.3	C	SE Knapp St.	Y	Enters JC at river mile 6.6. Out fall is on private land (fenced industrial).
P	JC24	Unknown trib.	0.3	C	12632 SE Flavel St.	N	Enters JC at river mile 9.4.
P	JC25	Unknown trib.	0.3	C	12925 SE Flavel St.	Y	Enters JC at river mile 9.4.
P	JC26	Unknown trib.	0.4	C	12955 SE Flavel St.	Y	Enters JC at river mile 9.4.
P	JC08	Unknown trib.	0.5	C	11412 SE Flavel St.	Y	Enters JC at river mile 8.0.

Owner	Owner ID#	Stream Name	Stream M.P.	Structure	Crossing Name	Fish Barrier	Comments
P	JC27	Unknown trib.	0.5	C	114th Ave.	N	Enters JC at river mile 8.0.
P	JC29	Unknown trib.	0.5	C	11830 SE Flavel St.	Y	Just west of Henderson Dr. Outfall is broken off.
P	JC31	Unknown trib.	0.7	U	11930 SE Lexington St.	U	Enters JC at river mile 8.8. Culvert must be barried-couln't find it. Low priority, low flow.
P	JC32	Unknown trib.	0.7	C	11728 SE Lexington St.	Y	Enters JC at river mile 8.8. Low priority, low flows and steep.
PV	JC20	Unknown trib.	0.8	C	SE Deardorff Rd.	N	Enters JC at river mile 9.6.
P	JC01	Unknown trib.	3.0	C	SE 44th	Y	Unknown trib. Enters JC at river mile 3
P	JC07	Unknown trib.	< 0.1	C	SE Brookside Dr.	Y	Enters JC at river mile 8.0.
PV	CS07	Unknown trib. To C.S.	1.9	D	Reed College	Y	At Reed College- has dam and culvert.
P	JC11	Unknown trib. to Kelly	0.1	C	SE Foster Rd.	Y	Enters JC at river mile 11.3.
P	JC28	Unknown trib. To Veterans	0.02	C	105th Ave.	U	Enters JC at river mile 6.6, enters Veterans Cr. at river mile 0.3 Outfall is on private property, no flow, covered with black berries-LOW priority.
P	JC05	Unknown trib. To Veterans	0.1	C	SE 101st Ave.	Y	Enters JC at river mile 6.6. This culvet has a drop of approx. 9'.
P	JC06	Unknown trib. To Veterans	0.2	C	SE Mt. Scott Blvd.	Y	Enters JC at river mile 6.6, enters Veterans Cr. at river mile 0.3
CC	CV-704	Unnamed	0.07	C	Bluff Rd 0.55	Y	
CC	CV-733	Unnamed	0.09	C	Stone Rd 0.03	Y	
CC	CV-593	Unnamed	0.18	C	Eastmont Dr 0.08	Y	
CC	CV-519	Unnamed	0.19	C	Sunshine Valley Rd 0.90	Y	
CC	CV-518	Unnamed	0.2	C	Sunshine Valley Rd 0.83	Y	
CC	CV-613	Unnamed	0.34	C	Wheeler Rd 0.20	Y	
CC	CV-493	Unnamed	0.43	C	Tillstrom Rd 0.08	Y	
CC	CV-706	Unnamed	0.44	C	Bluff Rd 1.26	Y	
CC	CV-3370	Unnamed	0.45	C	Telford Rd 1.24	Y	
CC	CV-491	Unnamed	0.48	C	Sunshine Valley Rd 0.23	Y	
CC	CV-601	Unnamed	0.5	C	257th Dr 0,42	Y	

Owner	Owner ID#	Stream Name	Stream M.P.	Structur e	Crossing Name	Fish Barrier	Comments
CC	CV-482	Unnamed	0.51	C	Borges Rd 2.41	Y	
CC	CV-614	Unnamed	0.53	C	Wheeler Rd 0.90	Y	
CC	CV-627	Unnamed	0.58	C	Revenue Rd 1.59	Y	
CC	CV-3378	Unnamed	0.76	C	Telford Rd 2.38	Y	
CC	CV-462	Unnamed	1	C	Rugg Rd 0.66	Y	
CC	CV-512	Unnamed	1.9	C	Sunshine Valley Rd 0.04	Y	
CC	CV-495	Unnamed	2.6	C	Tillstrom Rd 0.37	Y	
CC	CV-3316	Unnamed	0.04	C	242nd Ave 2.02	Y	
CC	CV-611	Unnamed	0.40	C	287th Ave 1.07	Y	
CC	CV-720	Unnamed	0.51	C	282nd Ave 0.99	Y	
CC		Unnamed		C	Monroe St 0.08	Y	
P	JC03	Veterans	0.001	C	SE Mt. Scott Blvd.	Y	Enters JC at river mile 6.6
P	JC04	Veterans	0.1	C	SE Aspen Summit Dr.	Y	Enters JC at river mile 6.6
PV	JC16	Veterans	0.2	C	9800 SE Mt. Scott Blvd.	Y	Enters JC at river mile 6.6. South of street.
PV	JC17	Veterans	0.4	C	9950 SE Mt. Scott Blvd.	Y	Enters JC at river mile 6.6. South of street.

APPENDIX D: ODFW 2001-2003 FISH INVENTORIES IN JOHNSON CREEK WATERSHED

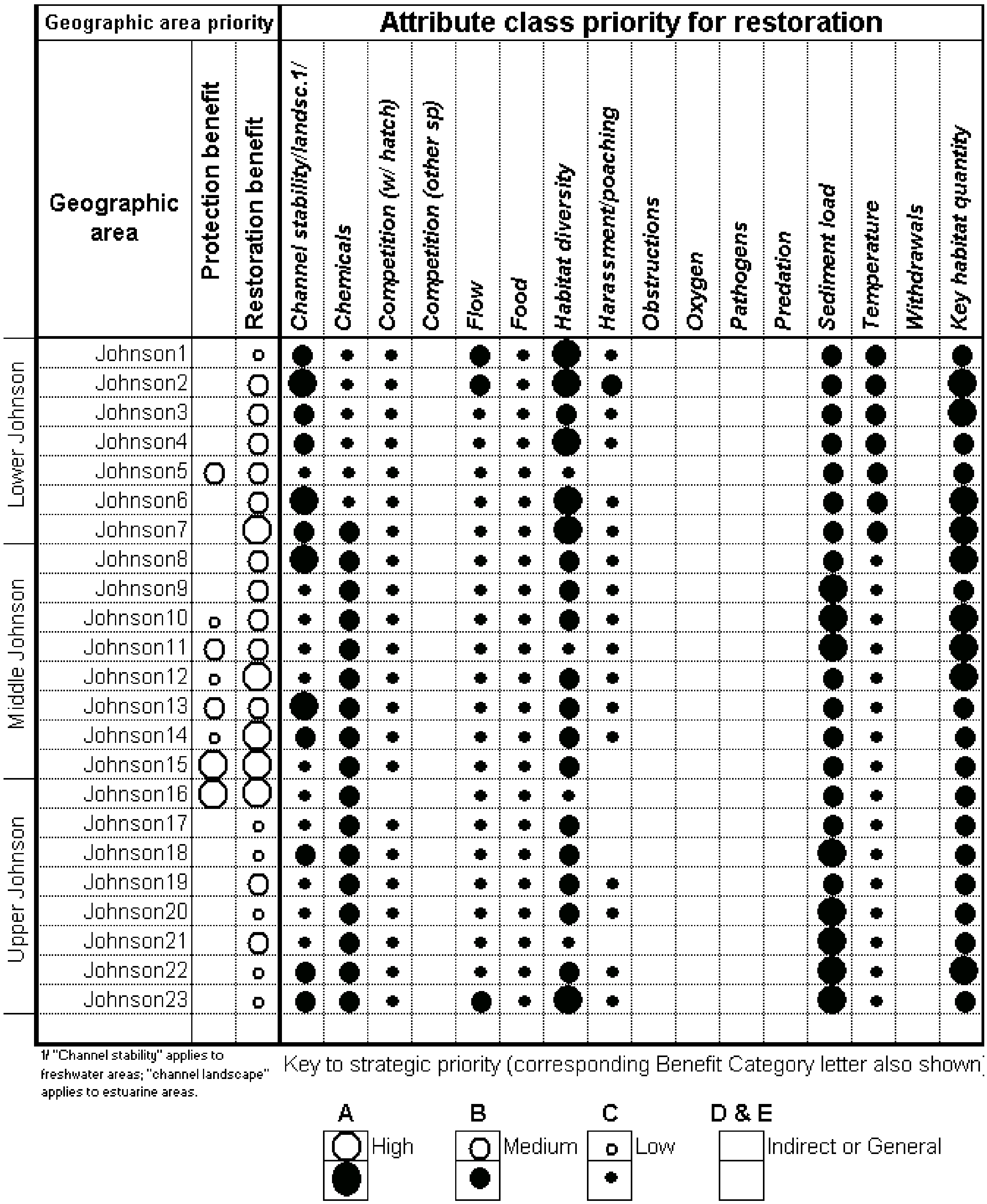
Summary of the estimated number of salmonids per 100-m of selected reach sampled during the summer 2001 through spring 2003 surveys.

Stream, reach	Season	Cutthroat Trout	Rainbow trout/ Steelhead	Coho salmon	Chinook salmon
Crystal Springs 1	Summer 2001	0	0	0	0
	Fall 2001	0	1	0	0
	Winter 2002	2	5[a]	0	0
	Spring 2002	0	0	5	4
	Summer 2002	1	0	0	0
	Fall 2002	0	0	0	0
	Winter 2003	2	0	0	0
	Spring 2003	0	0	7[a]	0
Johnson 2	Summer 2001	0	0	0	0
	Fall 2001	0	0	0	1[a]
	Winter 2002	0	1	0	0
	Spring 2002	0	6	0	13
	Summer 2002	0	0	3	0
	Fall 2002	0	0	0	0
	Winter 2003	0	0	0	6[a]
	Spring 2003	0	0	6	3
Johnson 4	Summer 2001	0	0	00	0
	Fall 2001	1	0	0	0
	Winter 2002	-	-	-	-
	Spring 2002	0	0	0	0
	Summer 2002	6	0	0	0
	Fall 2002	2	4[a]	0	0
	Winter 2003	0	0	0	0
	Spring 2003	0	0	0	0
Johnson 6	Summer 2001	0	0	6	0
	Fall 2001	0	0	0	0
	Winter 2002	-	-	-	-
	Spring 2002	0	0	0	0
	Summer 2002	0	0	0	0
	Fall 2002	1	0	0	0
	Winter 2003	0	0	0	0
	Spring 2003	0	0	0	0

Johnson 12	Summer 2001	0	0	0	0
	Fall 2001	0	0	0	0
	Winter 2002	-	-	-	-
	Spring 2002	0	0	0	0
	Summer 2002	4	0	0	0
	Fall 2002	2	0	0	0
	Winter 2003	0	0	0	0
	Spring 2003	0	0	0	0
Johnson 14	Summer 2001	0	0	0	0
	Fall 2001	0	0	0	0
	Winter 2002	-	-	-	-
	Spring 2002	0	0	0	0
	Summer 2002	4	0	0	0
	Fall 2002	2	0	0	0
	Winter 2003	0	0	0	0
	Spring 2003	0	0	0	0
Johnson 16	Summer 2001	1	0	0	0
	Fall 2001	9	3	0	0
	Winter 2002	-	-	-	-
	Spring 2002	8	0	0	0
	Summer 2002	6	0	0	0
	Fall 2002	7	0	0	0
	Winter 2003	4	0	0	0
	Spring 2003	3	0	0	0
Kelley 1	Summer 2001	8	0	0	0
	Fall 2001	19	0	0	0
	Winter 2002	13	0	0	0
	Spring 2002	8	0	0	0
	Summer 2002	10	0	0	0
	Fall 2002	6	0	0	0
	Winter 2003	7	0	0	0
	Spring 2003	80	0	0	0
Kelley 2	Summer 2001	0	0	0	0
	Fall 2001	1	0	0	0
	Winter 2002	16	0	0	0
	Spring 2002	[a]	0	0	0
	Summer 2002	[a]	0	0	0
	Fall 2002	[a]	0	0	0
	Winter 2003	7	0	0	0
	Spring 2003	3	0	0	0

a = Data provided is upper confidence limit; distribution of catch among passes resulted in negative abundance estimate.

APPENDIX E: JOHNSON, CRYSTAL SPRINGS, AND KELLEY CREEK COHO PROTECTION AND RESTORATION STRATEGIC PRIORITY SUMMERY



Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Crystal1A		Medium	Low	Low	Low		Low	Low	High	Low					Low	Low		Medium
Crystal1B		High	Low	Low	Low		Low	Low	Medium	Medium						Low		High
Crystal1C		Low	Low	Low	Low		Low	Low	Medium	Medium					Low	Low		High
Crystal1D			Low	Low			Low	Low	Medium	Medium								High
Crystal1DrivewayObstr											High							
Crystal1E			Low	Low	Low		Low	Low	Medium	Low						Low		High
Crystal1F		Low	Low	Low	Low		Low	Low	Medium	Low						Low		High
Crystal1SherettObstr											High							
Crystal1TacomaObstr											High							
Crystal1TeninoObstr											High							
Crystal1UmatillaObstr											High							
Crystal2A		Low	Low	Low	Low		Low	Low	Medium	Medium						Low		Medium
Crystal2APond			Low	Low	Low		Low	Low	High	Low					Medium	Low		High
Crystal2B			Low	Low	Low		Low	Low	High	Medium						Low		High
Crystal2BybeeObstr											High							
Crystal2C			Low	Low	Low		Low	Low	High	Medium								High
Crystal2GlenwoodObstr											High							
Crystal3A			Low	Low	Low		Low	Low	Medium	Medium								High
Crystal3B			Low	Low	Low		Low	Low	Medium	Low					Low	Low		High
Crystal3McLoughlinLength			Low	Low	Low		Low	Low	Medium	Medium								High
Crystal3McLoughlinObstr											High							
Crystal428thObstr											High							
Crystal4A			Low	Low	Low		Low	Low	High	Low					Low			Medium
Crystal4B			Low	Low	Low		Low	Low	Medium	Medium					Low			Medium
Crystal4C				Low			Low	Low	Medium						Low			Medium
Crystal4CartObstr											High							
Crystal4D				Low			Low	Low	Low						Low			High
CrystalReedDamObstr											Medium							
CrystalReedPond				Low			Low	Low	Medium						Medium	Low		High
CrystalRhodyDamObstr											Medium							
CrystalRhodyPond			Low	Low	Low		Low	Low	High	Low					Medium	Low		High
CrystalSouthSpA			Low	Low	Low		Low	Low	High	Medium						Low		High
CrystalSouthSpB			Low	Low	Low		Low	Low	Medium	Medium						Low		High
CrystalSouthSpCartObstr											High							

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯ / ●	High	○ / ●	Medium	° / •	Low	(blank)	Indirect or General

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability/landsc.1/	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Kelley1A	C	A	B	C	C		C	C	B	C					B			A
Kelley1B		C	B	C	C		C	C	B	C					B			A
Kelley1FosterObstr																		
Kelley1Obstr											B							
Kelley2	A	A	C	C			C	C	B						B			A
Kelley3A		B	B	C	C		B	C	A	C					B			B
Kelley3B	C	C	B	C			C	C	B						C			B
Kelley3Obstr		C									A							
Kelley4A		B	B	C	C		B	C	A	C					B			B
Kelley4B		C	B	C	C		C	C	B	C					B			B
Kelley4CulvertObstr											A							
Kelley5A		C	B	C	C		B	C	B	C					A			B
Kelley5ADamObstr											A							
Kelley5APond			B	C	C		C	C	A	C					A			A
Kelley5B			B	C	C		C	C	B	C					A			B
Kelley5BDamObstr											A							
Kelley5BPond			B	C			C	C	A	C					A			A
Kelley5C			B	C	C		B	C	A	C					A			B
Kelley5CulvertObstr											A							
Kelley6			B	B	C		B	C	A	B					A			A
Kelley7			B	B	C		B	C	A	C					B			A
Kelley8			C	B			B	C	A						B			A
Kelley9			B	B			B	C	A	C					A			A

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
High	Medium	Low	Indirect or General

APPENDIX F: SUMMARY OF COMPLETED PROJECTS IN JOHNSON CREEK WATERSHED

Property	**Project Lead**	**Objective**	**ongoing?**
Klein Property	JCWC	Reveg	
ODS Property	Reveg	Reveg	
Milport	FOT	Reveg	
Waldorf School Bioswale	Waldorf School	stormwater	y
Johnson Creek Park	PPR	Reveg	
Crystal Springs - 21st and Tenino	SOLV	Reveg	
Crystal Springs - 21st and Spokane	BES	Reveg	
Westmoreland Park	PPR	Reveg	y
Union Pacific Wetlands	Union Pacific RR	Reveg	
Eastmoreland Golf Course	JCWC	passage	
Crystal Springs Rhody Garden	JCWC	reveg	y
Reed Canyon	Reed College	passage	
Eastside Plating/PacHoe	Reveg	Reveg	
Eastmoreland Racquet Club	REveg	reveg	
Tideman Johnson Park	PPR	Reveg	
45th and Johnson Creek Stormwater	BES	stormwater	
Brookside Apts	JCWC	Reveg	y
Errol Heights	PPR	Reveg	
Johnson Creek BLvd.	Reveg	Reveg	
Lents Springwater Habitat Restoration	Ed Kerns	Reveg	y
South of Foster	BES	stormwater	
Brookside	BES	stormwater	y
Beggar's Tick	Metro	habitat	y
North of Foster	BES	stormwater	y

Zenger Farm	BES	stormwater	y
Bundy Wildlife Refuge	JCWC	habitat	y
Powell Butte Enhancement	PPR	habitat	y
Alsop/Brownwood	BES	stormwater	y
Kelley Creek Confluence	BES	habitat	
Foster Culvert	PDOT	passage	y
Hawthorne Ridge Habitat Area	JCWC	Reveg	
Pleasant Valley Grange	JCWC	Reveg	
Pleasant Valley Elementary School	JCWC	Reveg	y
Mitchell Creek Nature Park	PPR	Reveg	
Pumpelli Property	Reveg	Reveg	y
Gresham Woods	Gresham	Reveg	
Butler Creek Greenway	Gresham	Reveg	
Gresham Main City Park	Gresham	Reveg	
Hogan Cedars	Metro	passage	

APPENDIX G: JOHNSON CREEK WATERSHED COUNCIL WATERSHED ACTION PLAN ANNOTATED BIBLIOGRAPHY

Adolfson Associates, Inc. 2000. *Wildlife Assessments, Wetland Delineations, and Functional Value Assessments.* Prepared for the City of Portland Bureau of Environmental Services (BES).

Adolfson Associates conducted field surveys in the spring and summer of 2000 and describe the results for 36 wetlands in four target areas of the Johnson Creek floodplain: Tideman/Johnson, Errol Heights, Lents, and Lower Powell Butte. These wetlands occur on public and private parcels designated by BES as priorities for the Johnson Creek Predesign Project. Information is provided for sub-areas (groups of wetlands) and includes: wetland delineation data sheets; a description of vegetation, soils, and hydrology; a wetland functional value assessment; a wildlife habitat assessment (WHA); a list of observed wildlife species; a basic site map; and recommendations for restoration. Figures illustrating key features are provided for selected wetlands. Unique wetlands identified during the inventory include Oregon ash forested wetlands and obligate-dominated emergent wetlands in the Lower Powell Butte area; open water aquatic systems in the Lents, Errol Heights, and Tideman/Johnson target areas; and wetlands in the Brownwood/Alsop, Circle Avenue, and Zenger Farm sub-areas that contain dense breeding populations of red-legged frogs and other amphibians.

Adolfson Associates, Inc. 2001. *Crystal Springs Creek Fish and Wildlife Habitat Assessment*. Prepared for the City of Portland.

Using data from field surveys of instream, riparian, and upland habitat conducted along Crystal Springs Creek (CSC), a spring-fed tributary to Johnson Creek, Adolfson devised an assessment matrix for evaluating a wide range of prototypical fish habitat restoration projects for seven creek segments or "reaches." Results of the analysis indicate that no single project or reach is essential for restoring anadromous fish habitat in the CSC basin, but that a suite of projects would be beneficial. Adolfson also created an analytical tool for assessing the costs and benefits of acquiring private property in the CSC basin for the purpose of conserving or enhancing anadromous fish habitat. Results indicate that the highest priority property acquisitions should occur in Reach 1 (below the confluence with Johnson Creek), and in Reach 6 (Rivelli Farms). In addition to describing historical and current conditions of CSC, this document also compares fish and wildlife habitat characteristics of Oaks Bottom with the CSC basin.

Bowker, J., D. Brod, C. Fromuth, L. Gailey, J. Gladson, T. Kurtz, and K. Wadden. 2001. *Lents 2040 Technical Memorandum 1.* City of Portland Bureau of Environmental Services (BES).

As part of a series of memoranda, this document addresses the existing and historic conditions of Johnson Creek in the Lents project area, as well as factors to consider in the development of alternatives to manage nuisance floods (10-year flood events). The intent of the memoranda is to refine flood management options that satisfy the goals of the Johnson Creek Restoration Plan and the Lents Town Center Urban Renewal Plan. The Johnson Creek Restoration Plan provides reach-specific strategies for enhancing fish habitat, reducing flooding, and improving water quality. Objectives of the urban renewal plan are to: improve public places (e.g. parks, streets, utilities, and flood management projects), enhance economic and commercial development, revitalize the community, and rehabilitate housing. Technical, policy, and regulatory issues to consider in the refinement of flood management alternatives are discussed.

Bowker, J., D. Brod, C. Fromuth, L. Gailey, J. Gladson, T. Kurtz, M. Skenderian, and K. Wadden. 2002. *Lents Technical Memorandum 2 (TM2).* City of Portland Bureau of Environmental Services (BES).

As a follow-up to Technical Memorandum 1 on the historical and existing conditions of the Johnson Creek floodplain along SE Foster Road between SE 122nd Avenue and Interstate 205, this memorandum evaluates the benefits and constraints of different alternatives to managing nuisance flooding (a 10-year flood or less) in the Lents area. Evaluation criteria were: the ability to store nuisance flood waters; difficulty of construction; long term stability of proposed modifications; long term maintenance requirements; use of existing public lands, downstream impacts, environmental impacts and permitting. The four alternatives were: 1) Modify the creek south of Foster Road between SE 112th and Interstate 205 to create a two-stage channel. Remove SE 106th and SE 108th Avenues to create off-channel flood storage 2) Same as previous alternative but SE 106th and SE 108th would remain, 3) Route floodwater in culverts and channels north under SE Foster Road through private properties into Beggars Tick Marsh, and 4) Same as #3, but water would be routed around private properties. The first alternative was selected as the preferred option and will be submitted to the Portland Development Commission for further consideration in the Lents Urban Renewal process. The rejected alternatives were deemed too difficult to implement, not sufficient for long-term flood management; and not adequate for natural resource protection and community redevelopment.

City of Gresham. 2001. *National Pollutant Discharge Elimination System Annual Compliance Report, Permit Year 6.* Prepared for the Oregon Department of Environmental Quality (EPA). EPA Reference No. ORS 108013.

This annual compliance report, required for municipal stormwater discharge permittees, summarizes the progress of the City of Gresham's and Fairview's stormwater management plan (SWMP). The SWMP highlights the implementation of best management practices in five categories: 1) structural/non-structural controls for residential and commercial areas; 2) controls for illicit discharges and improper waste; 3) controls for industrial and similar facilities; 4) construction site controls; and 5) system planning controls. The report also describes additional water quality data collected during permit year six (September 1, 2000 through August 2001) for Johnson Creek, Kelly Creek, and Fairview Creek. For each month of permit year six and during storm events, Gresham stormwater staff conducted water sampling at two locations in Johnson Creek, four locations in Kelly Creek, and two locations in Fairview Creek. For each creek, monthly *in situ* water quality sampling is summarized for the following parameters: dissolved oxygen, pH, temperature, conductivity, and turbidity. Results on a variety of water quality parameters are presented for four storm events from December 2000 to April 2001 for each in-stream sampling location. Data on bacteria, turbidity, fecal coliform, and conductivity in Johnson Creek are presented for a storm event in August 2001 that resulted in 0.75 inches of precipitation. Monitoring of E. coli has been conducted for Johnson Creek since 1993 and will continue. Sediments from each creek were sampled for pesticides, but the results were not complete at the time the compliance report was prepared.

City of Milwaukie. 2000. Milwaukie Downtown and Riverfront Land Use Framework Plan.

Adopted September 19, 2000.

This ancillary document to the Milwaukie Comprehensive Plan provides land use policies and strategies for revitalizing the City's downtown and riverfront. These policies are aimed at creating a livable community and a thriving business center by improving main street, reconnecting downtown to the river, restoring natural areas and parks, and providing quality housing. Natural areas to restore include Johnson Creek and Spring Creek. Specific restoration goals are not provided.

City of Portland Bureau of Environmental Services. 2000. *Integrated Watershed Plan Baseline Report.*

Prepared as part of BES' Clean River Plan, this document characterizes the existing conditions of four watersheds within the City of Portland that drain to the Willamette River: the Johnson Creek Watershed, Columbia Slough Watershed, Tryon Creek Watershed, and Willamette Watershed. The goal of the Clean River Plan is to provide guidance to BES for improving its ability to effectively collect, treat, and dispose of wastewater and stormwater. Based on information from BES' Geographical Information System (GIS) and various existing reports, each watershed is described according to its socioeconomic, physical, and biological characteristics, water quality, pollutant sources, and sewerage infrastructure. Regulatory issues are also summarized for each watershed. Approximately 20 citations are provided for the chapter on the Johnson Creek Watershed.

City of Portland Bureau of Environmental Services. 2001. *Johnson Creek Restoration Plan.*

The primary focus of this restoration plan is to provide restoration goals for each reach of the creek for the purpose of reducing flooding, enhancing fish and wildlife habitat, and improving water quality. The restoration plan is intended as a work in progress and as a tool for implementing restoration within the watershed. This document is built upon previous management plans designed to address frequent flooding in the watershed but also is written in response to the listings of steelhead and chinook under the federal Endangered Species Act. The recommendations provided for 58 "reaches" of the mainstem creek serve as a starting point for identifying and implementing restoration solutions. The following information is provided for each reach: a description of existing conditions, possible restoration opportunities and costing, ODFW stream habitat results, and reach-specific restoration goals.

City of Portland Bureau of Planning. 1995. *Revisions to the ESEE Analysis for the Johnson Creek Basin Protection Plan.* Proposed draft, Planning Bureau Proposal to the Planning Commission.

This document supplements the Economical, Social, Environmental, and Energy (ESEE) Analysis of the Johnson Creek Basin Protection Plan (Plan) with explanations of why particular decisions were made for the thirty resource sites in the Plan. The proposed additional text was prepared in response to the Land Conservation and Development Commission's first periodic review of the Plan for compliance with Administrative Rule Goal 5.

City of Portland Bureau of Planning. 1998a. *Flood Management Amendments to the Johnson Creek Basin Plan District: Draft Planning Commission Recommendation to the Portland City Council.*

This report describes proposed amendments to the Johnson Creek Basin Plan District (JCBPD) that were written by the City's development bureaus in response to flooding concerns raised in the Outer Southeast Community Plan. The intent of the proposed amendments, targeting the area of SE Foster Road and SE 108th, is to prevent additional flood damage by dictating where and how development occurs in the floodway. Proposed changes to Chapter 33.535.100, General Development Standards, of the JCBPD prohibit: 1) certain types of development in the floodway (as defined by the Federal Emergency Management Agency, 1991); 2) land divisions and PUDs within the Johnson Creek Flood Risk Area (maps included); and 3) more than 50% of any site from being developed in impervious surface. The report includes a discussion by the planning commission on the proposed amendments and recommendations to the City Council.

City of Portland Bureau of Planning. 1998b. *Johnson Creek Watershed: Summaries of Resource Site Inventories.*

This document summarizes the location, quantity, and quality of 40 resource sites within the Johnson Creek Watershed based on information from the Johnson Creek Basin Protection Plan, the Brentwood-Darlington Neighborhood Plan, the Outer Southeast Community Plan Addendum, and the Boring Lava Domes Supplement. The purpose of the document is to serve as a reference for planners, designers, developers, citizens, environmental consultants, and resource agency personnel. All resource sites were surveyed in the field two or more times, with the majority of sites surveyed in 1987 and 1990. Information provided for each resource site includes: site name, size, and location; associated neighborhood; date of inventory; habitat classification (developed by the USFWS); general description; significant resource values; quantity and quality of the resource; management recommendations; the amount of land affected by proposed environmental zones; site-specific ESEE (Economic, Social, Environmental and Energy analysis) comments; and site-specific compatible uses and activities.

City of Portland Bureau of Planning. 2001. *Inventory of Significant Riparian and Wetland Resources: Johnson Creek Basin Resource Sites.* Healthy Portland Streams, Discussion Draft.

This draft inventory, created for the purpose of better regulating activities that affect stream health, is a condensed and slightly altered version of the *Johnson Creek Watershed Summaries of Resource Site Inventories.* Healthy Portland Streams is part of the River Renaissance Project, a city-wide effort to restore the Willamette River for the benefit of people, fish, and wildlife. This document provides basic site information for each resource in the Johnson Creek Watershed including a general description, field survey dates, and a Wildlife Habitat Assessment rating as well as supplemental information such as indication of whether an aquatic inventory was conducted for the site by the Oregon Department of Fish and Wildlife, an illustration of a new environmental zone called the "transition zone", and a description of any additional functional values identified for the site. These functional values are the basis for determining if significant resources exist within the resource site beyond the existing environmental zones. The inventory also includes a map of each site illustrating environmental zoning, streams, riparian resources, the resource boundary, and significant resource areas not already within the environmental zone. The updated inventory was prepared using aerial photographs and existing information.

City of Portland Bureau of Planning. 2002. *Inventory of Natural, Scenic and Open Space Resources for Multnomah County Unincorporated Urban Areas.* Prepared for the Multnomah County Department of Environmental Services, Division of Planning and Development.

This inventory describes the quantity, quality, and location of significant resources at four sites in unincorporated Multnomah County consistent with the requirements of Goal 5 Administrative Rule and Metro's Title 3 of the Urban Growth Management Functional Plan. One of the four sites, Resource Site 28 totals 56 acres and is in the Johnson Creek Watershed located between Powell Butte and Jenne Butte. The following information is described for each resource site: size, location, legal description, county zoning, proposed city zone, existing land uses, landscape setting, resource types, inventory dates, functional values, terrestrial habitat, aquatic habitat, habitat rating, and presence of special status species. A Geographic Information System (GIS) map is also provided for each resource site. With a wildlife rating of 81, Resource Site 28 ranks high among the Johnson Creek sites which range from 18 to 83. This site contains upland and wetland forested areas along with substantial wooded riparian habitat.

City of Portland Endangered Species Act Program. 2002a. *Draft Criteria for Ranking Culverts and Other Passage Obstructions for Replacement.*

This draft document describes the City of Portland's criteria for prioritizing the replacement of culverts blocking fish access in response to the listing of salmonids under the Endangered Species Act. The criteria for rating culverts and other obstructions are as follows: degree of blockage; quantity and quality of habitat above the culvert; maintenance considerations; environmental zone designation; proposed future land use; presence of steelhead; downstream fish access; and cost of replacement. Some factors such as the degree of blockage are weighed more heavily than other factors. The City ranked a number of urban streams and tributaries based on the criteria and determined that Johnson Creek is a priority watershed for culvert replacement. Three of the five culverts that ranked highest (out of 60) for replacement are along the Johnson Creek mainstem. This initial list of high priority culverts is intended to change as more information is collected regarding habitat quality and fish presence. Also provided is a database characterizing over 200 culverts, bridges and other obstructions in the Johnson Creek Watershed. This database is a result of a committee made up of jurisdictions within the watershed known as the Jonson Creek Joint Culvert Crossing Committee. This committee was formed to inventory and characterize culverts in the watershed according to fish passage.

City of Portland Endangered Species Act Program. 2002b. *Internal and 1st Review Draft: Framework for Integrated Management of Watershed and River Health.*

Prepared in response to federal environmental regulations, city council resolutions, and citizen interest, this adaptive management tool addresses general methods for the City of Portland to achieve watershed health within its jurisdiction. This work-in-progress is relevant to the Johnson Creek, Tryon Creek, Fanno Creek, Columbia Slough, Balch Creek, Willamette River, and Bull Run watersheds. The following information is included in the framework: a summary of federal regulations that protect rivers; ecological and restoration guidelines; environmental indicators for measuring and improving watershed health; methods for identifying and solving ecological problems; recommendations for additional scientific and policy measures to improve watershed health.

Clark, J. L. 1999. *Effects of Urbanization on Streamflow in Three Basins in the Pacific Northwest.* MS Thesis, Portland State University.

The author compares historical and current streamflow data from USGS gauging stations with precipitation data to determine if urbanization has changed streamflow characteristices in two Oregon watersheds: Johnson Creek and Tualatin, and one Washington watershed: Newaukum. Soil and precipitation data as well as land use is summarized for each watershed. Streamflow characteristics evaluated include: the ratio of peak flow to the volume of a peak event (Qp/Qv), and the ratio of this value (Qp/Qv) to preceding precipitation. The findings indicate that storm events in post-urbanized Johnson Creek result in a more flashy basin response. Although the ratio of peak flow to volume increased in the Johnson Creek Watershed (the smallest watershed in the study), peak flow and volume as individual variables did not increase, possibly due to drought and storm drainage modifications. The two smallest watersheds (Johnson Creek and Newaukum) experienced increases in stormflow, but the larger Tualatin watershed did not, suggesting that larger basins may be more resilient than smaller urbanized basins.

Dames & Moore. 1998. *Final Crystal Springs Watershed Assessment.* Prepared for the City of

Portland Bureau of Environmental Services.

Dames & Moore prepared this assessment of Crystal Springs Creek to determine potential causes and solutions for persistent high water levels in the creek following flooding in 1996. This document is a first comprehensive evaluation of Crystal Springs Creek prepared using existing data from a variety of public and private sources (e.g. Oregon Department of Fish and Wildlife, U.S. Geological Survey, Portland Parks Bureau, Union Pacific Railroad, Reed College, etc.) as well as field reconnaissance visits. Preliminary findings include: a lag time exists between groundwater recharge and discharge due to soil and aquifer properties; multiple sources contribute to groundwater recharge in the basin; the recharge area is much larger than the topographic watershed, although the size and influencing factors are unknown; consistent high precipitation prior to 1997 likely caused reduced groundwater storage capacity; streamside erosion in Westmoreland Park and Eastmoreland is due to failure of concrete sidewalls, waterfowl and human activity, and lack of riparian habitat; erosion has resulted in substantial amounts of sediment build-up in the creek; high nutrient concentrations are contributing to the excess growth of aquatic plants such as *Elodea canadensis*; elevated water temperatures are in part due to the lack of riparian habitat; effectiveness of the Tacoma and Tenino Street culverts is unknown; the estimated cost of flood damage ranges from $124,000 to $132,000. Short-term and long-term recommendations are provided to restore the creek as a more biologically diverse and geologically stable environment.

Edwards, T. K. 1994. *Assessment of Surface-water Quality and Water-quality Control Alternatives, Johnson Creek Basin, Oregon*. U. S. Geological Survey. Water-Resources Investigations Report 93-4090. Prepared in cooperation with the City of Portland Bureau of Environmental Services.

Results from water sampling at 12 sites in the Johnson Creek Basin (river mile 0.6 to 16.3) indicate that sources of one or more of the following constituents exist in every stream reach: dissolved cadmium, copper, lead, mercury, zinc, and silver; and total recoverable chlordane, dieldrin, and dichlorodiphenyltrichloroethane (DDT) plus metabolites. Water sampling was conducted during low flow conditions in 1989 and during two winter storms in 1989 and 1990. Crystal Springs Creek was a major source of dissolved nitrate, ammonia, and orthophosphorous during low flow. Total recoverable DDT plus metabolites (DDD and DDE) were detected at all sampling sites during storm runoff events, with the largest concentrations at RM 16.3 (Regner Road). Neither DDT nor its metabolites were detected in Crystal Springs Creek. Recommended methods to reduce basin contamination include: source control, construction of detention / retention settling ponds, and the creation of wetlands. Recommended methods to reduce non-point source pollution include 1) controlling pesticide application to forests, crops, lawns, and parks; 2) improving city sewer systems to eliminate septic-tank and drain-field seepage; 3) removing inorganic debris from streambanks; and 4) increasing the frequency of street sweeping.

Ellis, R. H. 1994. Technical Memorandum No. 8: Summary of Existing Fish Population and Fish Habitat Data for Johnson Creek. Johnson Creek Resources Management Plan. City of Portland, Bureau of Environmental Services.

The status of fish in the Johnson Creek Watershed was summarized as part of the process of determining whether the creek could be restored to support viable populations of anadromous fish. Electrofishing was conducted in 1992 and 1993 throughout Johnson Creek and seven tributatries: Crystal Springs, Kelly Creek, Hogan Creek, Butler Creek, Badger Creek, and Sunshine Creek. The 1992 survey effort targeted riffles, pools, and runs and was funded by the City of Portland. ODFW and interested citizens conducted the 1993 survey and emphasized pool habitat and longer reaches. Overall, results indicate that salmonid habitat is marginal throughout the Johnson Creek watershed and returning runs of steelhead, Chinook, and coho consist of only a few adults.

Johnson Creek Results: Fourteen fish species were collected from 10 sampling locations (RM 0.5, 4.5, 9.8, 12.5, 14.5, 16.3, 17.7, 19.9, 20.8, and 24.5). The total catch of steelhead, Coho, and Chinook salmon in Johnson Creek was meager (17 of 1,562) and was restricted to only a few sampling locations downstream of RM 15. The total steelhead catch, consisting entirely of juveniles, probably originated from two small hatcheries (hatch boxes) located on Crystal Springs Creek and RM 2.5 of Johnson Creek. With the exceptions of RM 4.5 and 12.5, cutthroat trout was collected at every sampling site in both survey years and comprised three percent of the total catch (1,562). Reticulate sculpin and redshide shiner, the most abundant and widely distributed species in Johnson Creek, may negatively impact salmonids by ingesting fry or by inhibiting juvenile growth. The lack of juvenile steelhead in upper Johnson Creek indicates that few adults are spawning above RM 10 or that juvenile survivorship is low. Based on ODFW sport catch data from 1989 to 1992, three adult Chinook were caught in 1990 in Johnson Creek and steelhead were caught each year totaling 51 adults (specific locations are not available). Other than a juvenile Coho salmon caught at RM 14.5 in 1993 and observations of a few adults in Crystal Springs, there is little evidence that adult coho are spawning in Johnson Creek.

Crystal Springs Creek Results: Fourteen species were caught at seven sampling locations. Reticulate sculpin comprised 56% of the total catch (709) and was collected at all sampling sites. Steelhead, Chinook salmon, and coho salmon comprised 4% of the catch (29 of 709) and were caught at two sampling sites. Cutthroat was absent from the total catch. The two locations where salmonids were caught contained exposed gravel, were narrower and of a slightly higher gradient than the other sampling locations that were covered with a layer of silt. Silt removal would improve salmonid rearing habitat and may be accomplished by narrowing the stream channel in selected areas or by controlled releases of flow from Reed Lake.

Other Tributaries: Three fish species were caught in Kelly Creek: reticulate sculpin (21), cutthroat trout (12), and juvenile steelhead (3). Low summer flows in Kelly Creek limit salmonid rearing habitat. Butler Creek did not contain any salmonids and is probably not a significant reach to restore due to its short length and fish barriers. Other than cutthroat trout, no salmonids were caught in Hogan Creek, Badger Creek, or Sunshine Creek.

Ellis, R. H. 1994. Technical Memorandum No. 16: A Limiting Factor Analysis for

Anadromous Salmonids in Johnson Creek with a Discussion of Habitat Rehabilitation Opportunities and Constraints. Johnson Creek. Johnson Creek Resources Management Plan. City of Portland, Bureau of Environmental Services.

This document summarizes the results of habitat limiting factor analyses performed in five reaches of Johnson Creek for steelhead, coho, and Chinook salmon using the Habitat Suitability Index (HSI) Approach developed by the USFWS. Various habitat parameters (e.g. maximum temperature, percent cover, and substrate size) were rated from 0 to 1 for up to five life stages (adult, embryo, fry, juvenile, and other) of each of the study species. A suitability index of "1" indicates optimal conditions while a "0" indicates unsuitable habitat. Reach 1 extends from RM 0.5 to the confluence of Crystal Springs Creek (RM 1.3); Reach 1 is from RM 1.3 to approximately RM 6; Reach 3 is from RM 6 to the confluence of Kelly Creek (RM 11.4); Reach 4 is from RM 11.4 to approximately RM 15; and Reach 5 is from RM 15 to just before the confluence of Sunshine Creek (approximately RM 18). Results of the limiting factor analysis for steelhead show that the quality of pool habitat and maximum temperature during smolt development are limiting in Reach 1; low flow conditions are the limiting factor in Reach 2, 3, and 5; and minimum dissolved oxygen and low flow conditions are the two limiting factors for Reach 4. Results of the limiting factor analysis for Chinook indicate that quality of pool habitat, maximum temperature during first month of spawning, and peak flow conditions are limiting in Reach 1; low flow conditions in fall and peak flow conditions are limiting in Reach 2; dissolved oxygen and low flow are limiting in Reach 3; dissolved oxygen, low flow and peak flow are limiting in Reach 4; and low flow and peak flow are limiting in Reach 5. The recommended priority for steelhead and Chinook habitat restoration is: Reach 1, 2, 5, 3, and 4. The habitat limiting factor analysis for coho indicates that four to five habitat factors are limiting in Reaches 1, 2, and 3. Only Reach 5 contained some rearing habitat for Coho. Due to the numerous limiting habitat factors and coho's preference for spawning in small, headwater streams, it is unlikely that the lower reaches can be restored to support a viable coho population. Overall salmonid habitat restoration efforts are hampered by the continued urbanization of the Johnson Creek watershed, specifically the resulting altered hydrograph from run-off and the loss of riparian vegetation.

Tinus, Eric S., James A. Koloszar, David Ward 2003. *Abundance and Distribution of Fish in City of Portland Streams- Final Report 2001-2003*. Oregon Department of Fish and Wildlife, Clackamas, Oregon. Prepared for City of Portland Bureau of Environmental Services.

With funding from the City of Portland Endangered Species Act Program, the Oregon Department of Fish and Wildlife (ODFW) inventoried fish communities in eight Portland streams from the summer of 2001 to the spring of 2002 to determine species richness and distribution; seasonal fish use, and to calculate an index of biotic integrity (IBI) for comparing biotic health among streams and reaches. Using backpack electrofishing equipment, ODFW surveyed the following creeks: Johnson, Crystal Springs, Kelly, Balch, Miller, Saltzman, Stephens, and Tryon. Eight even-numbered reaches of Johnson Creek were surveyed from reach 2 to 16, as were Reach 1 of Crystal Springs Creek and Reaches 1 and 2 of Kelly Creek. Johnson Creek and Crystal Springs Creek had the highest native species richness each with 11 species. Non-native fish were found only in Miller Creek and Stephens Creek. Chinook, coho, cutthroat trout, and steelhead were found in Johnson Creek and Crystal Springs Creek, but cutthroat was the only salmonid collected from Kelly Creek. Lamprey were collected in Crystal Springs, Johnson, Kelly, and Stephens Creeks, with the most found in Reach 2 of Kelly Creek. IBI was calculated based on taxonomic richness, habitat guilds, trophic guilds, and individual health and abundance. The highest possible IBI score is 100, with a score $\leq$ 50 indicating a severely impaired reach or stream. Seasonal IBI's for the mainstem Johnson Creek ranged from 30 (Reach 6 and 14) to 50 (Reach 16). Seasonal IBI's for Crystal Springs Creek ranged from 40 to 66. Seasonal IBI's for Kelley Creek ranged from 30 to 59, with the latter score indicating a moderately impaired stream. The overall low IBI scores calculated for all streams sampled indicate the presence of fish barriers and degraded habitat.

Hoy, R. S. 2001. *The Impact of Fine Sediment on Stream Macroinvertebrates in Urban and Rural Oregon Streams.* Master's Thesis, Portland State University.

The objectives of this master's thesis were to determine if urban stream basins (Johnson Creek and Tryon Creek) differ significantly from rural stream basins (Clear Creek and Deep Creek) with respect to fine sediments and macroinvertebrates, and to quantify the relationship between fine sediments and macroinvertebrate species composition. Results from transect surveys in each basin indicate that urban streams had significantly higher amounts of fine sediments than non-urban streams, most likely due to the increased amount of impervious surfaces and differences in land use. The streambed of Johnson Creek contained three times the amount (mean = 23%) of fine sediments compared with Clear Creek (mean = 7%). Taxa richness of macroinvertebrates that are reportedly "pollution-sensitive" [Ephemeroptera (E), Plecoptera (P), and Trichoptera (T)] was significantly lower in Johnson Creek and Tryon Creek. In contrast, the relative abundance of macroinvertebrates that are considered "pollution-tolerant" (Diptera, Gastropoda, Oligochaeta, and Amphipoda) was highest in Johnson Creek. Regression analysis did not reveal strong relationships between fine sediments and macroinvertebrate species composition.

Inter-fluve, Inc. 2002. *Alsop-Brownwood Flood Mitigation and Restoration Project #6908: Phase I Design Technical Memorandum.* Prepared for the City of Portland Bureau of Environmental Services.

This technical memorandum examines project goals and associated costs for one of the high-priority restoration sites (Alsop-Brownwood area) described in the Johnson Creek Restoration Plan (2001). This memorandum lists the design concepts for the Alsop-Brownwood site (located between SE 158th and Circle Drive), summarizes the technical memoranda prepared for the project design, and prioritizes four restoration areas within the project site. Technical memoranda regarding design issues are included in the appendices and are entitled as follows: Permitting Technical Memorandum; Geotechnical Investigation / Environmental Assessment; Hydrauic Modeling Technical Memorandum; Geomorphic Analysis Technical Memorandum; Sediment Transport Analysis Technical Memorandum; Channel Stability Technical Memorandum; Channel and Wetland Grading Design Drawings; Plant Communities; Earthwork Disposal / Reuse Evaluation Technical Memorandum.

Lee, K. K., and J. C. Risley. 2002. *Estimates of ground-water recharge, base flow, and stream reach gains and losses in the Willamette River Basin, Oregon.* Water-Resources Investigations Report 01-4215. U.S. Geological Survey. On-line at http:/oregon.usgs.gov/pubs/wrir01-4125/ Prepared in cooperation with the Oregon Water Resources Department.

The authors examine ground-water recharge and base flow of 21 major subbasins of the Willamette River Basin using precipitation models, base-flow-separation techniques, and stream-gain-loss measurements. The Willamette River Basin covers 12,000 square miles and includes areas surrounding Portland, Gresham, Salem, and Eugene. The Johnson Creek Watershed is considered part of the "Portland" subbasin. Specific information on the Johnson Creek Watershed in this report is limited to an estimation of the base flow component of stream flow for 1995 and 1996. Using base-flow-separation techniques based on USGS streamflow-gauging stations, Johnson Creek had one of the lowest percent-base-flow components of streamflow compared with other streams. The authors attribute this to a lack of infiltration and consequent rapid runoff due to the extensive impervious surfaces in the basin.

McConnaha, W. E. 2002. *Assessment of Habitat Potential in Johnson Creek for Coho and Chinook Salmon.* Prepared for the City of Portland.

This report summarizes the City of Portland's first comprehensive study to determine the potential of Johnson Creek to sustain healthy coho and chinook salmon populations. The City used the Ecosystem Diagnosis and Treatment (EDT) methodology, a species-specific tool for assessing habitat conditions. Based on preliminary results, Johnson Creek was found to be severely habitat limited and unlikely to support self-sustaining populations of either species due to channelization, decreased water quality, and lack of habitat complexity. Summer water temperature and sediment were also determined to be significant limiting conditions for coho and other fish. According to the authors, the future health of Johnson Creek will be determined by the City's commitment to restore and preserve the watershed.

Meross, S. 2000. *Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon.* Prepared for the Portland Multnomah Progress Board. Portland, Oregon.

Intended as an extension to the Johnson Creek Management Plan (1995), this document examines the conditions, regulations, and programs related to salmon recovery in the Johnson Creek Watershed. In addition to summarizing salmonid life histories, essential habitat characteristics, and the history of the Johnson Creek watershed, Meross identifies the numerous regulations and corresponding governing agencies that affect salmon habitat in the watershed, such as stormwater management programs administered by various city and county governments, statewide planning goals 5, 6, and 7, tree protection ordinances, the removal/fill program admininstered by the Oregon Division of State Lands, floodplain development requirements, pesticide applicator permits, Endangered Species Act consultation, culvert repair, and erosion control ordinances. Challenges to salmon restoration include the coordination of more than six local jurisdictions within the watershed in addition to state and federal regulations.

Middaugh and Prescott. 2002. *Priority Watershed Problems and Solutions: Lower Willamette River and Johnson Creek.* Prepared for the City of Portland.

This document highlights the findings of a study by the City of Portland that rated the quality and quantity of salmonid habitat in the Lower Willamette River and Johnson Creek. Protection and restoration priorities presented for the Willametter River and Johnson Creek are based on Oregon Department of Fish and Wildlife habitat and fish surveys, water quality monitoring data collected by the Bureau of Environmental Services, United States Geological Survey flow monitoring data, as well as field work by City of Portland staff. According to the study's findings, the protection of upper Johnson Creek is critical for salmon production whereas the middle and lower sections of Johnson Creek contain the best opportunities for restoration. The middle and lower sections of the creek are limited for large wood, temperature, sediments, aquatic food, and channel diversity. Recommendations for the protection of Johnson Creek include preserving habitat from Butler Creek to Hogan Creek, providing immediate protection for reaches 8, 10, 12, and 13, funnel more money to the Willing Seller Progam, and ensuring that implementation of the Pleasant Valley Plan does not degrade high-quality habitat.

Mobrand Biometrics, Inc. 2003. *Draft Executive Summary: Johnson Creek Habitat Assessment Project.* Prepared for the City of Portland Endangered Species Act Program.

Using the Ecosystem Diagnosis and Treatment (EDT) methodology and existing data from ODFW, USGS gaging stations, and the City of Portland, Mobrand Biometrics assessed current and potential future conditions of salmonid habitat in twenty-three reaches of Johnson Creek. Over twenty attributes were assessed for each reach, including flow, sediments, pollutants, and riparian function, to name a few. Results indicate that reach 16 and adjacent reaches are ranked the highest for protecting salmonid habitat and reach 5 rated the highest for restoration. Habitat attributes are prioritized according to restoration potential for lower, middle, and upper Johnson Creek. Findings suggest that habitat diversity is the greatest limiting factor for healthy salmonid populations in the lower and middle creek portions and sediment is severely limiting in upper Johnson Creek. Restoration recommendations include removing the Works Progress Administration (WPA) channelization and introducing large wood to the stream in the lower and middle creek as well as establishing riparian buffers to reduce summer temperatures.

Montgomery, Watson, and Harza (MWH) Engineering Company. 2002. *Water Quality Data Assessment Project.* Prepared for the City of Gresham Department of Environmental Services.

MWH summarizes and plots the trends of surface water data collected during various monitoring projects from 1996 to 2001 for 42 locations along Fairview Creek, Johnson Creek, and Kelly Creek. The following constituents were compared with standards from Oregon Administrative Rules (OAR) and the Columbia Slough Total Maximum Daily Load (TMDL): total suspended solids (TSS), temperature, dissolved oxygen (DO), E. coli, fecal coliform, ortho-phosphate, total phosphate, total copper, total zinc, and total lead. Results indicate that high concentrations of constituents (e.g. zinc, copper, lead, fecal coliform, etc.) were often associated with storm events exceeding 0.5 inches of rainfall. Additionally, concentrations of constituents at outfalls were similar to instream concentrations. The authors recommend coupling water quality monitoring with regulatory requirements and reducing monitoring of certain constituents (i.e. chloride and nickel) that are generally not a concern for the study areas.

Oregon Department of Fish and Wildlife (ODFW). 2000. *Aquatic Inventory Project Physical Habitat Surveys.* Prepared for the City of Portland Bureau of Environmental Services.

ODFW quantified habitat conditions of 23 reaches of the mainstem Johnson Creek as part of a long-term effort to provide baseline information on Oregon's streams. Field surveys were conducted in 1999 and 2000 using a methodology intended for compatibility with other stream survey techniques. Information provided for each reach includes, but is not limited to, channel length, surrounding land use, presence of large woody debris, average residual pool depth, substrate type, channel characteristics (e.g. eroding banks, channel width, etc.), wildlife presence, potential refugia, riparian vegetation, and presence of culverts or fish barriers. Extensive tabular data is provided related to riparian vegetation. The report also includes representative photos of each reach. Most homeowners encountered during the field surveys expressed interest in improving the creek conditions.

Pan. Y, C. Walker, R. Hoy, C. Weilhoefer, and T. Sampere. 2001. *Bioassessment of Urban*

Streams (Johnson Creek and Tryon Creek), Portland, Oregon. Prepared for the City of Portland Endangered Species Act Program.

The objectives of this study were to 1) compare the spatial variation of biota in two urban streams (Johnson Creek and Tryon Creek) with two rural streams (Clear Creek and Deep Creek), 2) classify stream sites according to biota, and 3) compare the temporal variation of biota in urban versus rural streams. In August and September of 1999, a total of 65 sites were sampled (45 in the two urban streams and 20 in the rural) for physical habitat characteristics, nutrients, diatom assemblages, and macroinvertebrates. Deep Creek was the only stream not sampled in 2000. Consistent with previous studies, results indicate that pollution-sensitive taxa (Ephemeroptera, Plecoptera, and Tricoptera) and overall taxa richness were significantly lower in the urban stream sites versus the rural sites. Nitrogen-tolerant diatoms were significantly higher in Tryon Creek for both sample years (74% mean relative abundance) than in Johnson Creek (47%), and Clear Creek (49%). Clear Creek, the rural stream, probably has similar levels of Nitrogen-tolerant diatoms as Johnson Creek due to surrounding agricultural land use. Overall, macroinvertebrate and diatom assemblages were significantly different between urban and rural streams. The authors recommend conducting routine monitoring to develop a long-term database on the biota of urban streams.

Reese, E. 2001. *Johnson Creek Land Acquisition Partnership and Implementation Strategy*.

Johnson Creek Watershed Program, City of Portland Bureau of Environmental Services.

In addition to summarizing the status of the Willing Seller Program, a land acquisition strategy recommended in the Johnson Creek Restoration Plan, this report rates areas for land acquisition in the watershed and describes characteristics of potential partnering agencies and organizations for the program. Approximately 56 properties have been purchased in the watershed since 1997 (mostly in the Lents and Lower Powell Butte target areas), but current funding is lacking by 75% to meet the acquisition goals listed in the restoration plan. Reaches of the mainstem were organized into target areas based on location, property ownership, acquisition feasibility, amount of high-quality salmon habitat, number of fish barriers, and number of priority outfalls. Of the fifteen target areas, seven are considered a priority.

Sonoda, K. 2002. *Watershed Sources of Nutrient Input to an Urbanizing Stream.* Unpublished Doctoral dissertation. Portland State University.

Sonoda conducted surface water, soil, and groundwater sampling at thirteen sites throughout the Johnson Creek watershed to determine the sources and pathways of nutrients, especially Phosphorous (P) to the creek for the purpose of water quality management in the watershed.

Land use within the watershed appears to influence stream nutrient levels with P significantly higher in urban areas and Nitrogen higher in rural and agricultural areas. Sonada examined both natural and anthropogenic sources of P loading to Johnson Creek and concluded that storm drains and soil chemistry account for a significant source of P input. The more basic soil pH of urban riparian zones facilitates the release of P into streams. Direct precipitation had little effect on P loading to Johnson Creek. Stormwater drain improvements (i.e. retention chambers or holding tanks) and reducing direct links of runoff to the creek may decrease P levels in Johnson Creek.

Woodward-Clyde Consultants. 1994. *Technical Support Document for the Johnson Creek Resources Management Plan.* Prepared for the Johnson Creek Corridor Committee.

This document contains 18 technical memoranda prepared in 1993 and 1994 to support the Johnson Creek Committee during its development of concepts for the Johnson Creek Resources Management Plan (RMP). The RMP targets the following issues: flood management, water quality improvement, fish and wildlife habitat enhancement, and watershed stewardship. The technical memoranda address topics related to these four main areas and are entitled as follows: 1) Johnson Creek and its Watershed – A Profile; 2) Summary of Land Use Regulations for Minimizing Hydrologic Impacts; 3) Water Quality in Johnson Creek – A Summary of Existing Studies and Data; 4) Land Use Trends in the Johnson Creek Watershed; 5) Potential Sources of Water Quality Pollutants in the Johnson Creek Watershed; 6) Johnson Creek Benthic Macroinvertebrate Survey; 7) Johnson Creek Natural Resources Field Surveys and Existing Conditions Summary; 8) A Summary of Existing Fish Population and Fish Habitat Data for Johnson Creek 9) Potential Institutional Arrangements for Long-term Watershed Management in Johnson Creek; 10) Summary of Land Use Regulations Designed to Protect Johnson Creek; 11) Hydraulic Analysis of Early-action Flood Reduction Projects; 12) Temperature Modeling Results from Johnson Creek; 13) Program Support for Johnson Creek RMP Elements – A Survey of Public and Private Sector Possibilities; 14) Cultural Resources Analysis for Johnson Creek Waterfall, Harney Street Fish Ladder, and Rock-lined Creek Bed; 15) Hydrologic Model for Flood Reduction Element; 16) A limiting Factor Analysis for Anadromous Salmonids in Johnson Creek with a Discussion of Habitat Rehabilitation Opportunities and Constraints; 17) Wildlife Habitat Limiting Factors and Recommendations for Restoration, Enhancement and Protection; and 18) Water Quality Monitoring in Johnson Creek to Detect Trends and Measure the Effectiveness of the Resources Management Plan.

Woodward-Clyde Consultants. 1995. *Johnson Creek Resources Management Plan.* Prepared for the Johnson Creek Corridor Committee.

Using information from previous technical studies on the Johnson Creek Watershed, Woodward Clyde prepared a comprehensive management plan prescribing methods to 1) prevent pollution; 2) manage flooding; 3) enhance fish and wildlife habitat; and 4) foster stewardship in the watershed. Non-point pollution, such as urban and rural runoff, is identified as the most significant source of pollution to the watershed. Recommended actions to reduce pollution include: implement urban stormwater management plans, eliminate illicit industrial discharges to the municipal stormwater systems, and construct stormwater pollution reduction facilities for all new development and in selected drainage subbasins. Recommended flood management actions include: construct in-stream detention basins in the upper watershed, provide off-stream storage capacity and ultimately build a flood relief channel in the Lents neighborhood, restrict filling in the 100-year floodplain, acquire vulnerable properties in the floodplain. Methods to improve fish and wildlife habitat include: replace non-native vegetation with native shrubs and trees, acquire ecologically sensitive properties, construct off-channel ponds for salmonid refugia, and modify selected channel segments for salmonid spawning and cover habitat. Stewardship actions include: establish a Johnson Creek watershed management organization with diverse stakeholders, coordinate plans for creek improvements with improvements to the Springwater Corridor Trail, protect historic structures, and modify land use regulations to prevent insensitive development. The estimated initial public sector cost for implementing the management plan is $15.6 million. Private sector cost for implementing the plan, primarily revegetating the creek, is $1.4 million. Jurisdictions may generate funding for the plan by charging property owners fees for stormwater management and other services. The to-be-created watershed management organization should seek grant funds or contributions from governments and private foundations.

Young, A., J. Howington, J. Halsted. 2001. *Kelley Creek Watershed Stream Habitat Assessment.*

Johnson Creek Watershed Program, City of Portland Bureau of Environmental Services.

Based on data from Rapid Bio-Assessment Protocol (RBP) surveys conducted by the Bureau of Environmental Services (BES) and the Aquatic Inventory Project conducted by the Oregon Department of Fish and Wildlife (ODFW), BES characterizes in-stream habitat quality of Kelley Creek (nine reaches), and two of its tributaries – Clatsop Creek (two reaches) and Mitchell Creek (three reaches). Results from ODFW surveys completed in 1999 and 2000 for each reach include information regarding flow and channel characteristics (e.g. presence of riffle habitat, pools etc.), amount of large wood, average pool depth, substrate, and surrounding vegetation. RBP scores for each reach are based on ten habitat characteristics (e.g. channel sinuosity and bank stability), and are described as either properly functioning, impacted, or non-supporting. Only one reach in Kelley Creek and one in Mitchell Creek ranked as properly functioning; all other reaches were either impacted or non-supporting. Despite the low RBP rankings in Kelley Creek, trout (including cutthroat) were observed in many pools. Heavy erosion and siltation occur in portions of Clatsop Creek and Mitchell Creek due to exposed soils and fill-dirt.

City of Gresham

JOHNSON CREEK MASTER PLAN UPDATE

BIBLIOGRAPHY

This bibliography is limited to published documents that relate directly to surface water and stormwater planning and related topics in the Johnson Creek watershed.

MWH Energy and Infrastructure. *Water Quality Data Assessment*, City of Gresham, Department of Environmental Services, May 2002, 67 pp.

Subjects: Water quality data, water quality monitoring, pollutant concentrations, water quality criteria, water quality criteria exceedences

Annotative Text: The document presents the results of an examination of historical surface water quality data throughout the City of Gresham. Data examined were collected from 42 locations between 1996 and 2001 under a variety of monitoring projects. Seven of these locations were within the Johnson Creek watershed. Pollutants examined and discussed are total suspended solids, pH, temperature, dissolved oxygen, e-coli, fecal coliform, ortho-phosphate, total phosphate, total copper, total zinc, and total lead. The document presents the appropriate water quality criteria for each constituent that was adopted as part of the development of TMDLs on the Columbia Slough. Also, the frequency with which each constituent exceeds these criteria was presented in tabular form for the whole dataset and graphical form for each constituent and each of the following groupings: Fairview Above Lake; Fairview Below Lake; Fairview Tributaries; Johnson Creek; Kelly and Burlingame; and Land Use Based.

Portland, City of, Bureau of Environmental Services. *Baseline Environmental Conditions in Johnson Creek*, 2002, 16 pp.

Subjects: Environmental conditions, watershed health indicators, flow and hydrology, physical habitat, water quality, biological communities

Annotative Text: This document provides an overview of existing environmental conditions in Johnson Creek and its major tributaries. It provides a brief narrative overview of conditions, and then evaluates a series of key indicators of watershed health by summarizing and presenting data available on each of the indicators. The importance and justification for the selection of the indicators is described in the *Framework for Integrated Management of Watershed and River Health* (City of Portland 2002). The flow and hydrology indicators that are assessed include hydrograph alteration, impervious surfaces, hydrologic sources and floodplain connectivity. Physical habitat indicators include riparian vegetation condition, bank condition, channel substrate, pool quality, off-channel habitat, wood volume,

urban encroachment and fish passage. Water quality indicators include temperature, eutrophication, toxic materials and sediment. Biological communities indicators include benthics, salmonids and interspecific interactions. Most of the data used in the assessments were collected by the USGS or ODFW as part of previous on-going programs or studies.

Portland, City of, Bureau of Environmental Services. *Johnson Creek Restoration Plan*, June 2001, 243 pp.

Subjects: Urban natural resources, history, stream restoration, water quality, land acquisition, fish passage, fish habitat improvement, vegetation management, flood reduction

Annotative Text: Well-written and colorful document that recommends a reach-by-reach implementation plan whose intent is to solve the nuisance flooding, water quality problems and fish and wildlife declines experienced along the creek by restoring natural watershed functions. The recommended actions involve the restoration of floodplains, riparian buffers, wetlands and in-stream habitat complexity. Johnson Creek and its major tributaries are divided into 56 reaches each with a detailed description of existing natural resources conditions, identified opportunities, ODFW survey results and recommended actions. The City of Gresham has jurisdiction over Reaches 28-38. The plan includes a discussion and itemized listing of the watershed's history from 1933 to the present. This document essentially presents the City of Portland's recommended implementation program for the Johnson Creek Resources Management Plan.

HDR Engineering, Inc. *NPDES Stormwater Management Plan – Final Report*, City of Gresham, Department of Environmental Services, December 2001, 32 pp.

Subjects: National Pollutant Discharge Elimination System, NPDES, Stormwater Management Plan (SWMP), Best Management Practices (BMPs), stormwater related regulations, stormwater pollution control, water quality

Annotative Test: Well-written document that outlines and updated the City of Gresham's stormwater management plan for maintaining compliance with their NPDES stormwater permit. The plan provides a history of the City's NPDES regulatory compliance, an overview of the water quality problems known to exist throughout the various local watersheds and a discussion of various stormwater related regulations and programs that include ESA, TMDL, UIC, WHP, and Title 3. The document also describes the roles and responsibilities of the various City divisions and its co-permittees in implementing the plan. The bulk of the document outlines the City's implementation plan for permit years 2000-2005 that includes a BMP development overview (for its current list of 18 BMPs), a program evaluation and prioritization, a monitoring plan, a communication and coordination plan and a discussion of potential funding options.

Kurahashi & Associates, Inc. *Calibration Update: Johnson Creek Flood Hydrograph and Flood Profile Models*, City of Portland, Bureau of Environmental Services, January 1998, 91 pp.

Subjects: Hydrologic modeling, hydraulic modeling, flood hydrographs, flood profiles, floodwater elevations.

Annotative Text: Detailed and highly technical documentation of a recalibration of both the hydrologic (*i.e.*, HEC-1) and hydraulic (*i.e.*, HEC-2) models of the Johnson Creek watershed and waterway. These models were originally constructed and documented as part of the Johnson Creek Resource Management Plan work in 1994. Data from the historic floods of 12/21/64, 1/10/72, 1/19/72, and the recent floods of 2/23/94, 2/15/95, 2/5/96, and 11/18/96 were used to recalibrate the models. (The November 1996 flood was later determined to be a 70-year return interval event.) The document includes a discussion of the improved methods used: the calibration update; and the resulting peak flows and floodwater elevations for the 1/3 of the 2-year, 2/3 of the 2-year, 2-year, 5, 10, 25, 50, 100, and 500-year events at points throughout the entire watershed and along the mainstem of the creek.

KCM. *Storm Water Master Plan for Johnson Creek Basins (Final Draft),* City of Gresham, Department of Environmental Services, August 1995, 66 pp.

Subjects: Water resource planning, hydrologic and hydraulic modeling, flood reduction, CIP development, recommended management practices.

Annotative Text: The document provides a plan for the quantity management of stormwater runoff from urban development throughout the City's tributary areas of Johnson Creek. The EPA-SWMM program was used to simulate peak flows for the 2, 5, 10, 25, 50, and 100-year return interval 6-hour storm throughout the 3400-acre study area under both existing and future development conditions. The plan presents a 4.4 million dollar capital improvement program that includes 25 projects that recommend upsizing of storm sewer pipes or the construction of high flow bypasses. The plan also recommends standards and criteria for the design of conveyance systems, on-site detention facilities, and natural drainage systems.

Woodward Clyde Consultants. *Johnson Creek Resource Management Plan,* Johnson Creek Corridor Committee, 1995.

Subjects: Water resource planning, hydrologic and hydraulic modeling, flood reduction, land acquisition, water quality improvement, natural resources planning, fish habitat improvement

Annotative Text: This comprehensive document presents a wealth of information that was used to develop a basin-wide Resources Management Plan to reduce flooding, improve water quality and enhance natural resources throughout the Johnson Creek basin. The flood management element of the plan offers a recommended program designed to provide a reasonable level of flood protection to existing structures while preventing new development from adding to flooding problems. The intent of the flood management provisions is to manage the creek as a natural waterway in an urban area rather than a flood control channel. The plan recommends the construction of on-stream detention basins in the upper watershed and off-stream flood storage facilities in the Lents neighborhood east of

Interstate 205. The acquisition of land and the most vulnerable structures in the floodplain as they become available from willing sellers is also recommended as a non-structural flood reduction measure. The plan also recommends fifteen sites for water quality improvement facilities along with numerous non-structural water quality related actions. The plan also identifies specific actions needed to improve fish habitat and increase the diversity and complexity of natural resources throughout the watershed. The plan was adopted by each jurisdiction in the watershed in 1995

United States Geological Survey. *Water Quality and Flow Data for the Johnson Creek Basin, Oregon, April 1988 to January 1990*, Water Resources Investigation Report 92-73, 1992, 29 pp.

Subjects: Stream water quality, urban stormwater quality, water quality monitoring, bottom sediments, streamflow measurements

Annotative Text: This report presents the results of bottom material and stream water sample analysis and associated on-site streamflow measurements that were obtained from April 1988 to January 1990 at up to twenty-five combined sampling sites located along the mainstem, at two major outfalls, and on two major tributaries. Stream water quality was sampled during both dry weather and wet weather conditions. Results were reported for trace metals associated with fine (*i.e.,* less than 63 microns) suspended sediment along with trace metals, nutrients, dissolved oxygen, temperature, turbidity, specific conductance and manmade organics found in the streamflow.

Beak Consultants, Inc. *Johnson Creek Resources Management Program Abstract of Previous Work*, Portland Bureau of Environmental Services, June 1991, 44 pp.

Subjects: History, Johnson Creek ecosystem, interagency coordination, public outreach

Annotative Text: This excellent document provides a detailed discussion and description of approximately 50 references related to past planning related work in the Johnson Creek basin dating back to 1964. The history of the basin and the waterway dating back to 1847 is also presented as part of the discussion on each topic. Topics include developmental history, attempted problem solutions and their results, existing ordinances and laws, the Johnson Creek ecosystem, interagency coordination and cooperation, and public outreach. Within the comprehensive discussion on the Johnson Creek ecosystem the following environments are addressed: physical, chemical, biological and human.