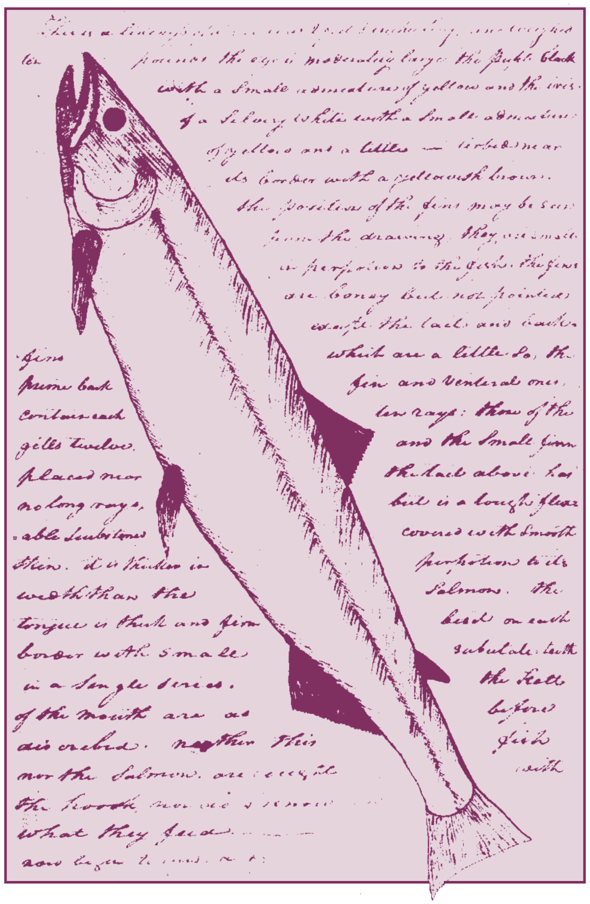

ILLUSTRATION: MERIWETHER LEWIS

Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon

Conditions, Programs and Challenges

Portland Multnomah Progress Board
1221 SW Fourth Avenue, Room 140
Portland, Oregon 97204

Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon

Conditions, Programs and Challenges

Prepared by Sharon Meross for the
Portland Multnomah Progress Board

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April 24, 2000

Dear Community Member,

We are pleased to release this benchmark report on *Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon*. The Portland Multnomah Progress Board, which we co-chair, was established in 1993 to develop a vision for our community and establish benchmarks that measure our progress. The board currently tracks 76 benchmarks across a range of areas, including:

- Health
- Education
- Families
- Special Needs
- Safety
- Governance
- Civic Participation
- Economy
- Environment
- Urban Vitality

In addition to regular reports on the condition of our community, the Progress Board produces detailed analyses of particular benchmarks. Our first benchmark report on *Children's Readiness to Learn*, released in 1998, has been an effective catalyst for community change. This year the Board will release two benchmark reports: *Salmon Restoration in Johnson Creek* and *Educational Success*.

These benchmark reports provide the Progress Board, other policy makers, and the larger community with:

- a better understanding of the forces that affect a benchmark,
- recommendations about future measurement of the benchmark,
- research about the best practices for improving the benchmark, and
- an assessment of the array of services and programs involved in addressing the benchmark.

Better measurement and collaboration among organizations are some of the immediate and direct results the Board hopes to achieve through these reports.

Salmon have become a cultural icon for what we value about the Pacific Northwest. Our benchmark report focuses on the Johnson Creek Watershed, a salmon habitat profoundly affected by urban development. The report describes the watershed and the ways it has changed over time. It measures the conditions supporting salmon, in a framework that could be used for studying other watersheds.

The report challenges us all to protect riparian areas, increase water flows in the summer, manage stormwater, clear channel obstructions, improve public awareness, and monitor for results. Some solutions, such as replacing road culverts, will be expensive. But many of our daily activities influence salmon as well.

Large scale improvements and changes in every day activities must be part of a collective vision for the watershed. The vision should recognize the multiple benefits of watershed restoration for local residents and for fish. Ultimately, the survival of salmon is a measure of how well we are integrated into the same environment.

This report calls for strong collaboration among agencies, across jurisdictional lines. It supports the Memorandum of Understanding to improve water quality and enhance fish and wildlife habitat, signed by Portland, Gresham, Happy Valley, Milwaukie, Metro, and Multnomah and Clackamas counties in May of 1999. We extend appreciation to Portland's Bureau of Environmental Services, the Johnson Creek Inter-jurisdictional Committee, the Johnson Creek Watershed Council, and to all the other organizations committed to a place where salmon and citizens can thrive.

Sincerely,

Vera Katz
Mayor, City of Portland

Beverly Stein
Chair, Multnomah County

April 17, 2000

Portland Mayor Vera Katz, Co-Chair
Multnomah County Commission Chair Beverly Stein, Co-Chair
Portland Multnomah Progress Board
1221 SW 4th Avenue, Suite 140
Portland, Oregon 97204-1987

Dear Mayor Katz and Commission Chair Stein:

A direct outcome of the first Johnson Creek Summit in November 1998 was a commitment to inter-jurisdictional cooperation and watershed-wide planning. The vision for the summit demonstrates the tenor of that commitment and reads as follows:

> "The Johnson Creek Watershed will become a healthy, vibrant watershed by effectively planning for and managing growth, promoting sustainable economic development, and respecting and enhancing the natural functions and benefits of the Creek. This will be achieved by a well-organized, well-equipped, motivated watershed-community (including a multi-jurisdictional coalition) ready and willing to work cooperatively and to take specific actions which will improve watershed health and livability in the region."

A Memorandum of Understanding which includes a list of specific action items was signed by all the jurisdictions in the watershed. Included in the action items is a commitment to coordinate planning efforts to ensure fish and wildlife enhancement within the watershed.

The Progress Board's Report: ***Salmon Restoration in an Urban Watershed: Johnson Creek, Oregon*** is a major step toward successful implementation of the action items put forth by our Memorandum of Understanding. We thank the Portland Multnomah Progress Board for the serious and frank analysis of our watershed and your recommended 'Strategies toward recovery.' Johnson Creek is a complex watershed and provides many challenges in developing mechanisms to truly restore salmon populations. We look forward to reviewing and considering all of your many recommendations. We would also like to commend the amount of research and work accomplished by this important work.

Very truly yours,

JOHNSON CREEK INTER-JURISDICTIONAL POLICY MAKERS COMMITTEE

Mike Burton
Metro Executive Officer

Mary King
Councilor, City of Milwaukie

Lisa Naito
Commissioner, Multnomah County
District 3

Randy Nicolay
City Council, City of Happy Valley

Dan Saltzman
Commissioner, City of Portland

Jeff Uebel
Chair, Johnson Creek
Watershed Council

Vicki Thompson
Council President, City of Gresham

Acknowledgements

Many thanks to the individuals at the following organizations who shared their expertise, information and time.

Also thanks to Kathy Fors, graphic design, and Penelope Sanders, cartographic design.

Coordinating Bodies

Johnson Creek Inter-jurisdictional Committee
Johnson Creek Policymakers Committee
Johnson Creek Watershed Council

Local Government

City of Gresham, Environmental Services
City of Happy Valley
City of Milwaukie
City of Portland, Bureau of Environmental Services
City of Portland, Endangered Species Act Program
City of Portland, Office of Planning and Development Review
City of Portland, Bureau of Parks and Recreation
Clackamas County Water and Environment Services
East Multnomah County Soil and Water Conservation District
Metro, Data Resource Center
Metro, Growth Management Services Department
Metro, Transportation Department
Multnomah County Department of Environmental Services
Washington County Soil and Water Conservation District
Washington County, Unified Sewerage Agency

State Government

Oregon Department of Agriculture
Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife
Oregon Department of Transportation
Oregon Division of State Lands
Oregon Water Resources Division
Oregon Watershed Enhancement Board

Federal Government

National Marine Fisheries Service
US Army Corp of Engineers
US Department of Fish and Wildlife
US Geological Survey
USDA Farm Service
USDA Natural Resources Conservation Service

Private and non-profit organizations

Center for Watershed Protection
Defenders of Wildlife
Elway Research, Inc.
For the Sake of Salmon
Friends of Trees
Oregon Business Council
Pacific Rivers Council
River Network
SOLV Team-Up! for Watershed Health
Trust for Public Lands
Wetlands Conservancy
Woodward-Clyde Consultants

Universities

Portland State University

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Tables, Charts, Figures and Maps *(in order of appearance)*

Executive Summary

Introduction

We all find beauty and meaning in Oregon's natural environment. Among these many riches, the salmon is the icon of the Northwest. Its life cycle contains metaphors and mysteries that challenge us and our science. And as the salmon disappears from our landscape, in a span of little more than 100 years, it is also an indicator of our values and our actions regarding the natural environment.

At one time, the entire length of Johnson Creek supported salmon. It is one of the major watersheds in Multnomah County, with about 72% of its 34,000-acre drainage area inside the urban growth boundary. As an urban stream, Johnson Creek is affected by a concentration of human activities that distinguishes it from other watersheds in less developed parts of the Northwest.

Jurisdiction	Acres	Stream miles	Estimated 1998 population
Portland	14,075	42	109,134
Unincorporated Clackamas County	8,750	32	10,967
Gresham	5,541	30	32,334
Unincorporated Multnomah County	4,127	9	1,948
Milwaukie	1,431	8	9,391
Happy Valley	111	1	340
Total land acres and stream miles	34,035	122	164,115

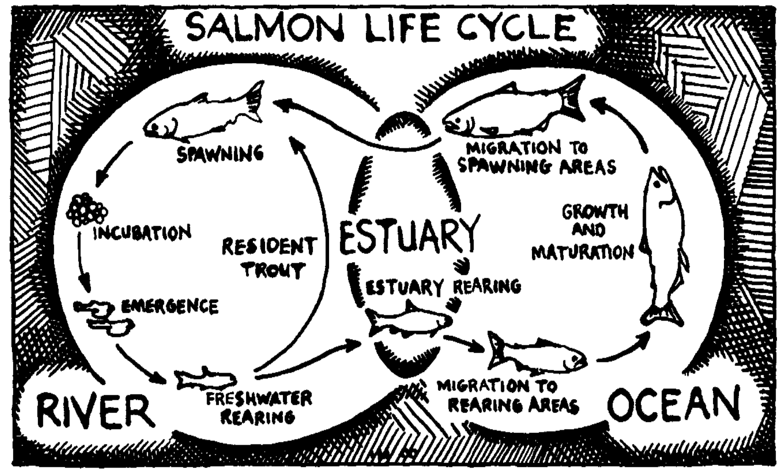
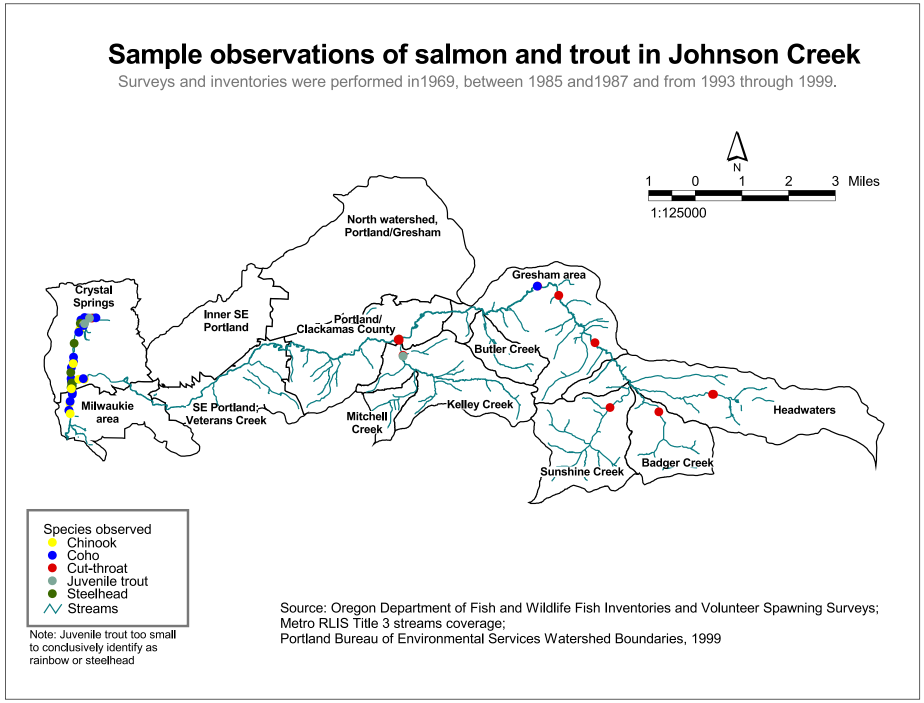


Illustration: Mark Anderson

Salmonid

It is first necessary to understand the biological forces built into the genetic code of salmon that help them thrive in this Northwest environment. The Salmonid family contains a variety of species - Coho and Chinook salmon, and Cutthroat and Steelhead trout. Their fertilized eggs need sheltered, freshwater gravel beds to develop into fry that, after a period of time depending upon the species, migrate downstream to the ocean. To adapt to a saltwater environment they must undergo complex physiological changes. After 18 months to five years later, again depending upon the species, they follow equally complex signals that guide them back from the ocean to the mouth of their native stream. They re-adapt to freshwater and seek the same gravel bed in which they hatched. Here they spawn and then die – their corpses nourishing the habitat which supports the next generation of salmon.

Three broad aspects of Johnson Creek affect the salmon: water, stream habitat, and interactions with other species. Salmon are also affected by domains outside the scope of this report such as nutrients in the ocean and problems reaching and returning from the ocean. Passage through the metropolitan area on the Willamette and Columbia rivers are equally important conditions that need to be addressed by larger groups representing these watersheds.

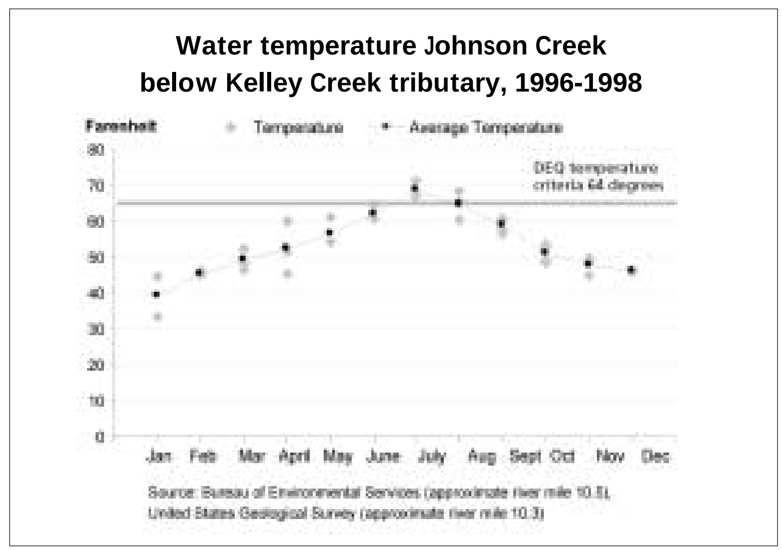


Monitoring results show that summer water temperatures often exceed this limit. Removal of streamside vegetation, heated industrial discharges, summer stormwater run-off, and shallow detentions of water may elevate stream temperature. Temperature and substances like animal waste and fertilizer runoff can also deprive the water of dissolved oxygen, which can impair salmon migration. Tests in the upper mainstem of Johnson Creek found unsatisfactory levels of oxygen dissolved in the water during low flows.

Water

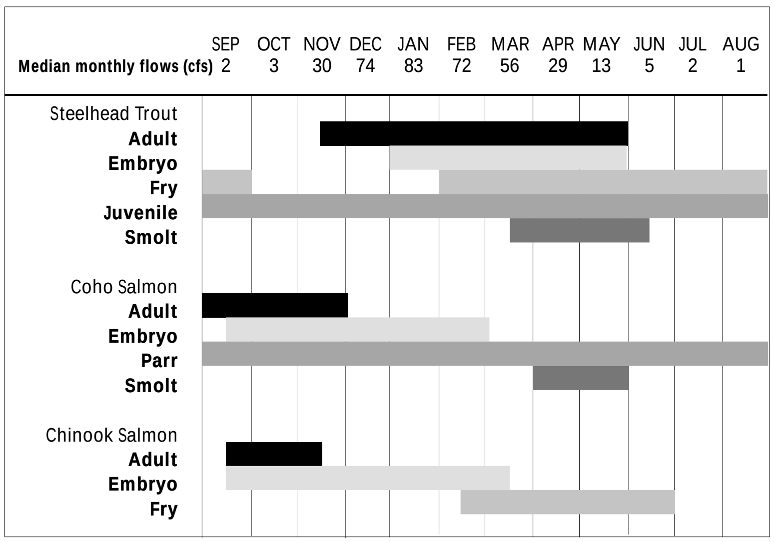
Water is the medium of salmon, and their survival is dependent upon its quality and quantity. Commonly used pesticides and herbicides are not being detected at significant levels in Johnson Creek, although DDT and Dieldrin still linger after their banning in the 1970s. Toxic spills may produce more damage. For example, draining chlorinated swimming pools or antifreeze and motor oil from vehicles into storm drains can destroy entire juvenile salmon populations. Periodic testing in Johnson Creek may never detect these incidents.

Water temperatures taken at various times and locations indicate that Johnson Creek can reach dangerously high temperatures in July. Water temperatures above 75° are lethal to steelhead, and above 79° are lethal to salmon. The Oregon Department of Environmental Quality has set a 64° F temperature limit for Johnson Creek.



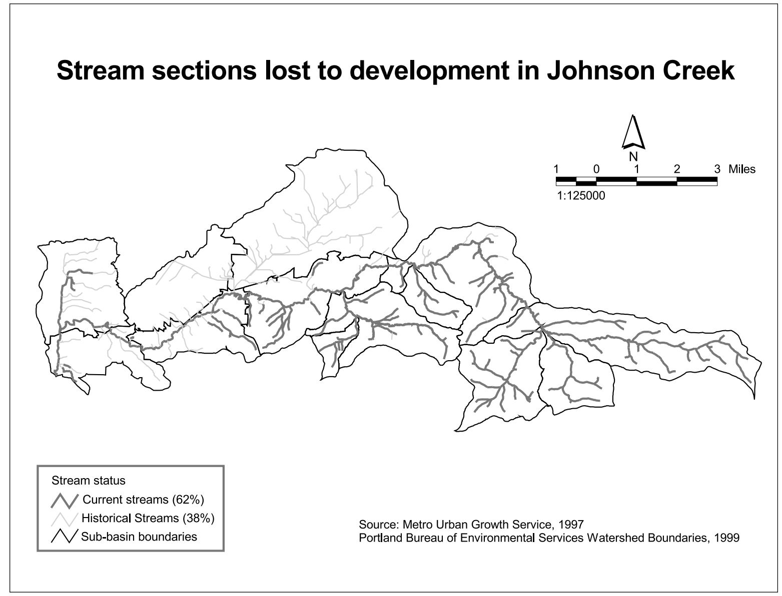
Equally critical is water quantity. High winter and spring flows can flush out spawning gravel, egg nests, and protective woody debris. Low summer flows force salmon into pools and intermittent tributaries that may dry up and strand them. Median flow in Johnson creek ranges from 83 cubic feet per second in January to 1 cubic foot per second in August. One tributary, Crystal Springs, is spring-fed and helps preserve Johnson Creek's flow in its lowest mile. However, upstream summer flows often drop below the necessary minimums determined by the Oregon Department of Fish and Wildlife.

Median Steam flow by month and fish activity



Stream Habitat

Meanders, pools, and riffles provide areas for feeding, breeding and cover for a wide variety of stream organisms. Development has removed streamside vegetation in the floodplains and along the banks of Johnson Creek and its tributaries. About 38% of the tributaries have been moved into pipes or filled. Segments of the creek have been straightened and lined with rock or riprap, which reduces shading vegetation and nutrients in the water.



Development also introduces fine sediments from soil erosion that can destroy spawning beds and egg nests, and reduce aquatic organisms as a food source for salmon. Research indicates that soil erosion may have a more serious and lasting effect on salmon than pollutants. Testing during storm events shows sediments at 5 to 8 times normal levels, although no standards have been set.

Wetlands and flood plains enhance water quality, regulate peak flows, contribute to nutrients, and provide shaded, off-channel juvenile rearing habitat. In Johnson Creek the level topography and rich soils have made these areas highly desired for building and agriculture. There have also be significant losses of the larger riverside ecosystem of rock, groundwater, insects, reptiles, mammals, and birds. Currently, there is no measure for these characteristics.

While Johnson Creek does not have any dams on its mainstem to block passage of migrating salmon, its road culverts create the same kinds of obstacles. Poorly designed or maintained culverts can block fish passage. The local and state transportation agencies are developing an inventory of the culverts and their conditions.

Species Interactions

Salmon have survived major climatic and geologic changes over the past 5,000 years because of their genetic diversity. Scientists have identified characteristics of salmon that vary for each tributary. When hatchery stocks are introduced to streams, their spawning may produce future generations without the characteristics needed for that particular stream. There has been no analysis of the earlier releases, but approximately 440,000 live fish or eggs have been released into Johnson Creek since 1978.

Fishing is another species interaction. Overharvesting can reduce the number of salmon as well as genetic diversity. No records exist of the harvest of salmon from Johnson Creek, or through their migratory route. In 1998 the Oregon Department of Fish and Wildlife discontinued stocking the creek with legal-size rainbow trout, which will reduce the incidental harvest of salmon.

Efforts in our watershed

Laws and regulations are the primary means of protecting Johnson Creek and other watersheds from the impacts of human activities. There is broad water quality legislation like the Clean Water Act, and there are more specific regulations directed to agriculture, industry, construction, wetlands, water diversions, and stormwater discharge. State agencies are generally responsible for monitoring and enforcement efforts in these areas. Local governments designate land use and establish zoning, enforce erosion regulations, and perform some monitoring and enforcement duties. Local governments can also directly affect watersheds through their management of stormwater, sewage treatment plants, transportation systems, and drinking water systems.

Some Strategies for Improvement

Collaboration among programs and jurisdictions throughout the entire watershed is the most critical strategy. To ensure consistent and effective efforts, at least five state departments, two federal agencies, and 18 local government departments must coordinate their efforts. A good model for the collective effort is the Memorandum of Understanding to improve water quality and enhance fish and wildlife habitat that was signed by Portland, Gresham, Happy Valley, Milwaukie, Metro, Multnomah County, and Clackamas County.

Adoption and enforcement of stronger water quality regulations is needed. These regulations must improve water temperatures, sediment and pollutant levels, and water flows. Some of the relevant regulations include Metro's Title 3 and Goal 5, Total Daily Maximum Loads, the Agricultural Water Quality Management Plan, and local erosion control and tree preservation ordinances.

Restoration, mitigation, and protection efforts are needed to address stream habitat and obstacles to fish passage. Streambanks, culverts, flood plains, and riparian areas should be inventoried for current conditions, restoration efforts to date, and modifications needed.

There is a need for improved monitoring by means of coordinated data collection, standards and methods throughout the watershed. Quality control, spatial distribution, and a centralized database will improve monitoring at the least cost. Developing a fair-share cost formula would allow comprehensive monitoring costs to be budgeted among the jurisdictions.

The program of public awareness and education can bring added volunteer resources and increased monitoring for a healthier watershed. Citizens can be strong allies in protecting the urban tree canopy, spotting violators of water regulations, and stream restoration activities.

The Memorandum of Understanding identified some of the strategies we have included in this report and efforts towards their implementation have already been undertaken.

The detailed list of strategies can be found on page 111.

Introduction

Historian Richard White believes that virtually the full modern list of environmental hazards to salmon was known and publicized long before the actual life history and ecology of salmon were fully understood. If this is so, why does news of declining salmon runs and endangered species listings fill the headlines today? Why haven't we taken corrective action earlier?

Part of the answer is that even though we knew the hazards, we tried to circumvent these hazards with technology. We replaced some of the salmon's natural migratory passages with barges and fish ladders. The second part of the answer is that we thought the capacity of our rivers and streams held unlimited potential to support salmon. We developed hatcheries and introduced fish with the belief that more fish was better, and that they would survive in their new and changing habitats. Now we know that we cannot replace ecological functions with technology. We know that salmon are a complex species—one that has adapted over millennia to many different kinds of conditions and environments.

Over the past 200 years the ecological systems upon which salmon depended and adapted have been rapidly altered. It takes salmon longer to adapt to their changing environment than it takes urban landscapes to be built and rebuilt, and humans to devise new solutions to save salmon. As a result, wild salmon runs decline as we try to "recover" them, while at the same time utilize the resources upon which they depend.

Conservation biologists refer to salmon as a keystone species. This means that salmon play a central role in aquatic and terrestrial food chains, and in nutrient cycling. They both depend on and are depended upon by many species. Salmon are a food source to wildlife, and their decaying bodies add nutrients to the aquatic system. Salmon depend upon the productivity and physical elements of many ecosystems—freshwater rivers and streams, estuaries and oceans. Salmon are therefore a good indicator of the collective ecosystem.

What makes salmon a good indicator also makes solving the salmon problem difficult. Their wide adaptation to different stream environments makes salmon susceptible to a wide range of human activities. As fish biologist and author Jim Lichatowich observes "[e]ach industry, institution, or individual that contributes to the salmon's depletion at some place in their extended ecosystem can readily point to some other industry, institution, or individual that affects the salmon at some other place in their ecosystem as the cause of the problem . . .Though it has sparked debate and study, the misguided search for a singular cause of salmon decline has wasted a great deal of time, effort, and money. More important, it accomplishes little in solving the salmon's problem, which has truly become everyone's problem." (Lichatowich, 2000)

Restoring some of the salmon's original habitat is one piece of the salmon solution. This report takes a close look at what is involved to improve the current conditions of freshwater salmon habitat in the Johnson Creek watershed of northwestern Oregon. The Portland Multnomah Progress Board, which tracks a wide variety of indicators throughout Multnomah County Oregon, chose salmon as one indicator of local environmental conditions. This report illustrates local watershed conditions from the perspective of conditions required by salmon.

Johnson Creek is the focus of this report for two reasons. First, one of forty watersheds that drain Multnomah County, the Johnson Creek watershed extends east to west through Multnomah County before emptying into the Willamette River, and is representative of freshwater habitat conditions in the County. Second, Johnson Creek's stream channel, flow patterns, and flood plain capacity have been significantly altered by development. Pressures from urban and rural activities continue to place negative pressures on the Creek's salmon populations. Alas, in many ways Johnson Creek represents a microcosm of the many problems, in whole or in part, of watersheds throughout Oregon. In describing the conditions and issues in the Johnson Creek watershed, this report demonstrates the complexities inherent with fish recovery efforts across the region.

Some may be surprised that coho and chinook salmon, and steelhead and cutthroat trout actually exist at all in Johnson Creek. Between 1985 and 1999, forty-nine coho, eight chinook, 24 steelhead and seven cutthroat adults were counted in the Johnson Creek watershed. Although their numbers pale in comparison to the salmon and trout counted at dams on the Clackamas and Willamette rivers upstream of Johnson Creek (in part because Johnson Creek salmon are only counted sporadically), their presence indicates a tenacity to hang on to their natal spawning waters despite many obstacles. Perhaps it is their tenacity, demonstrated by an incredible life cycle that takes them from freshwater tributaries to the ocean and back again, that make salmon a cultural icon of the Northwest.

The costs associated with salmon recovery and watershed restoration are huge. The amount of money local jurisdictions ultimately spend on these efforts may best be guided by a regionally developed strategy, and an understanding that sustainable changes in the watershed will take many decades, maybe several centuries. Fundamental to this strategy are answers to the following questions: given limited resources, what is the goal of salmon recovery? Is it simply to increase the number of native salmon returning from the ocean to spawn? Or is it to sustain and improve the ecological conditions that support salmon? The two are not mutually inclusive. Restoration efforts directed toward Johnson Creek most probably would not bring back, dollar for dollar, the same number of fish as efforts directed at a less disturbed watershed currently populated by strong salmon runs. Yet the benefits associated with watershed restoration go far beyond numbers of fish. Improvements in overall water quality, increased wildlife habitat, passive recreational areas, natural beauty, community pride, reductions in costs incurred by floods, and greater incorporation of natural processes into land-use practices may result from watershed restoration and protection. In short, if we begin to recognize that by improving conditions for salmon we improve our own economic and environmental vitality, we may find the courage to fundamentally rethink the way we approach our relationship with our watershed environments. But again, these benefits come with costs associated with removing land from development, revegetating waterfront views, and changing the way we work and live in the watershed.

This report cannot answer the question of how much money and how long it will take to "restore" Johnson Creek because we have not determined to what conditions we want to restore the creek. The first step in determining priority action areas and ultimate long-term objectives is to develop a coherent understanding of watershed conditions, issues and activities. This report builds upon the Johnson Creek Resource Management Plan (1995) in developing an understanding of Johnson Creek as it relates to the needs of the salmon that inhabit it.

This report looks at salmon in relation to the watershed conditions that support them and the activities over which we as citizens and policy makers have control. It does not address the pressures salmon face as they complete their adaptation to salt water—traveling downstream through the Willamette and Columbia rivers, through the Columbia River estuary, and out to the ocean. Nor does it address how other watersheds that drain to these rivers contribute to the genetic distribution and quantity of salmon populations. Nonetheless, many of the supportive conditions for salmon discussed in the report also apply to salmon outside of the Johnson Creek system. In addition, harvest practices, ocean conditions and predation affect the survival of these fish. All of these pieces comprise the puzzle of salmon and steelhead recovery.

Section 1 introduces salmon and their life cycle, outlines a conceptual framework of factors that support salmon, and lists human activities that disrupt these conditions. Section 2 provides the reader a brief background of the Johnson Creek watershed. Section 3 provides an in-depth discussion of factors in the watershed that support or hinder salmon. Section 4 discusses local programs, regulations and activities that impact salmon recovery. Section 5 suggests indicators for salmon and the Johnson Creek watershed. The report concludes with Section 6—a list of strategies to help improve salmon recovery in this watershed.

Data from Johnson Creek is used throughout the report whenever available.

Endangered Species Act, Steelhead, Fall Chinook, and Johnson Creek

The National Marine Fisheries Service (NMFS) recently listed winter Steelhead trout (March 1998) and Chinook salmon (March 1999) populations that travel through the lower Columbia River as "threatened" species. This listing includes Johnson Creek's populations of winter steelhead and fall chinook. The listings will require additional precautions that activities do not harm, and will place restrictions on activities that negatively impact these fish and their habitats.

Fall chinook are present in Johnson Creek for only a short period of time and they show a preference for spawning and rearing in its lower reaches. Consequently, their listing will influence activities and restoration opportunities in the lower sections of the watershed.

In contrast, winter steelhead prefer steeper, upstream reaches, and juveniles can spend three years in the creek before migrating downstream. Consequently, Johnson Creek and its tributaries offer significant potential habitat for winter steelhead.

Additionally, coho salmon, and resident and sea-run cutthroat trout have been proposed for listing, although no final decision had been made as of December 1999. Coho and cutthroat may have been the historically dominant species in Johnson Creek. A small population of naturally reproducing coho exists in the creek today. Cutthroat are the most widely distributed species found today in the Johnson Creek system with the resident form found in upstream areas unreachable by steelhead, coho and chinook. Its listing could have significant implications throughout the Johnson Creek watershed.

An extended discussion of the Endangered Species Act and its implications are beyond the scope of this report. Extensive documentation of the listing process, critical habitat designations and the proposed 4-D rules, can be found at the National Marine Fisheries Service web site—**http://www.nwr.noaa.gov/1salmon/salmesa/index.htm.**

The Salmon Life Cycle

Family *Salmonidae* ("sa-ma-ni-day")
Genus *Oncorhynchus* ("on-ko-rink-us")

What is a Salmon?

According to the *Field Guide to Pacific Salmon*, classification of Pacific salmon remains controversial. In 1989, the American Fisheries Society formally placed steelhead and cutthroat trout in the same genus as salmon. The reason for this classification is that scientists believe the seven species of salmon found in the Pacific Northwest originated from a common ancestor. This ancestor was a freshwater fish whose origin might date back a million years.

Since the end of the ice age and the onset of the Missoula floods, this ancestor and its descendents adapted to a rapidly changing and varied landscape. As the productivity of the oceans increased, these fish developed *anadromy*—the ability for a fish to cross over from fresh water to salt water and then back again. As the climate began to cool and shift to the moist maritime climate we know today, the saplings that became our old growth forests emerged. These trees helped create complex and highly productive stream habitats. Anadromy enabled salmon to take advantage of both the excellent spawning and rearing habitat provided by freshwater and the nutrient rich oceans necessary for growth and maturation. In this evolving landscape, salmon developed different life histories that helped them adapt to different sections of the watershed. The timing of salmon life cycle activities are so varied that what are now considered the five predominant species of salmon were once believed to be fifty.

Of the seven anadromous species of salmon and trout that inhabit the Pacific Northwest today, four reside in Johnson Creek. These are fall chinook and coho salmon, and steelhead and cutthroat trout (both the resident and sea-run forms).

Figure 1

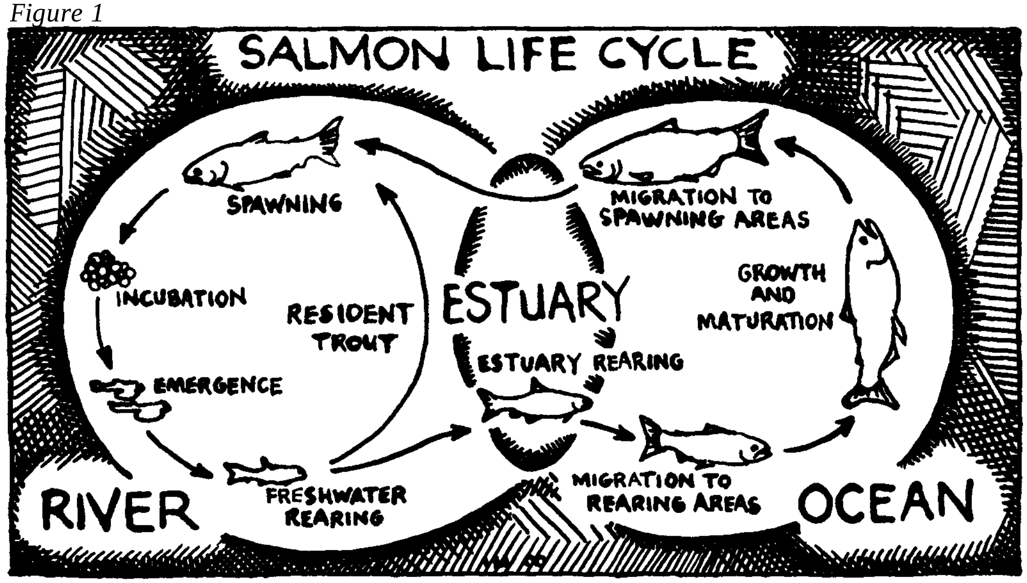


Illustration by Mark Anderson

The Salmon life cycle

Figure 1 illustrates a generalized salmon life cycle. The amounts of time fish spend in fresh and salt waters, and the months in which they spawn and migrate, vary by, and within, species.
In contrast to resident fish, such as rainbow trout, which

spend their entire lives in fresh water, anadromous fish also spend significant portions of their life cycles in the salt waters of estuaries and oceans.

Reproduction occurs in fresh water. Females lay their eggs (or spawn), and males fertilize these eggs, in fresh water gravel beds (*redds*). The eggs develop into larvae termed *alevins*, and emerge as free-swimming *fry* that grow-up in their stream of birth. Depending on the species, these fry live in fresh water anywhere between several weeks (fall chinook) and 4 years (winter steelhead). The fry feed and grow into juveniles—waiting for triggers that indicate it is time to move downstream. Water temperature and body size are two factors that trigger this migration towards salt water. During this downstream migration, juveniles undergo a transformation that adapts them to live in saltwater. This process, termed *smoltification*, involves complex physiological, biochemical, morphological, and behavioral changes. Before entering the ocean, *smolts* undergo their final adaptation to salt water in estuaries (bodies of water where fresh and salt water mix). Time spent in estuaries varies among species.

How long salmon stay and how far they travel in the ocean varies according to species and ocean conditions. Generally, coho and sea-run cutthroat spend the least time in the ocean and travel the shortest distance from the coastline. They return to spawn within 18 months. Chinook spend between 2 and 5 years in the ocean, and steelhead trout spend 1 to 3 years and travel the greatest distance into the open ocean. During their time in salt water, the fish feed and grow to full maturity. Poor ocean conditions may delay maturation and return to freshwater. Using their remarkable sense of smell, the fish return to their natal streams to spawn, a process called *homing*. Most salmon die within two weeks after spawning.

Behaviors peculiar to coho and chinook salmon, and steelhead and sea-run cutthroat trout, are worth noting. Runs of coho and chinook will often contain up to a third of its male population that return to the natal stream after only six months in the ocean. These precocious males are termed *jacks*. The second peculiarity occurs with steelhead and sea-run cutthroat trout. Unlike coho and chinook that die after spawning, up to 30% of steelhead and sea-run cutthroat adults may survive spawning and repeat migration to the ocean and back to spawn again.

Coho, chinook, cutthroat and steelhead each exhibit different life history patterns. These patterns are important because they indicate which life stages of each species are likely to be found in Johnson Creek at a given time of year, and identifies the creek conditions that need to be satisfied at each life cycle-stage if runs are to be sustained. Table 1 outlines the months and life stages of these species that one could expect to find in Johnson Creek, and also provides a summary of salmon and trout life histories.

To reduce technical jargon, the term *salmon* will refer to all species in the Salmonid family—to Coho and Chinook salmon, and Cutthroat and Steelhead trout—unless otherwise noted.

Table 1. **Life stages of salmon and trout species found in Johnson Creek**

LIFE STAGE:	Adults	Egg through Fry	Juvenile	Smolt	egg through smolt	smolt through adult	all stages
ACTIVITY:	upstream migration and spawning	emergence from spawning bed development into fry	feeding, rearing, smoltification	downstream migration	time spent in fresh water	time spent in salt water	most common age at maturity
ANADROMOUS SALMON							
Coho	late Sept. through early Dec	Oct. through early Feb.	all months	April through May	1 to 3 years	18 months	3 years
fall Chinook	late Sept. through early Nov.	Oct. through early March	none (migrate as fry)	none (migrate as fry)	3 months	2 to 5 years	4 or 5 years
ANADROMOUS TROUT							
winter Steelhead (some are repeat spawners)	late November through May	January through June	all months	late March through early June	2 to 3 years	1 to 3 years	4 or 5 years
sea-run Cutthroat (some are repeat spawners)	early November through December	December through March	all months	April through May	2 to 4 years	2 to 5 months	3 or 4 years
RESIDENT TROUT							
Cutthroat	all months	March to May	all months	not applicable	not applicable	not applicable	3 or 4 years

Adapted from Spence, et al, An Ecosystem Approach to Salmonid Conservation, 1996, with additional data from Ellis, Robert, Technical Memorandum No. 16, Johnson Creek Resources Management Plan, 1994; and Dick Caldwell, fish biologist, Oregon Department of Fish and Wildlife, personal conversation September 1999.

Conditions influencing Salmon

Each environment in which salmon reside and migrate is important to their survival. This report focuses on the conditions in Johnson Creek where salmon spawn and their embryos develop into migrating smolts. These conditions can be grouped into three categories:

Figure 2 illustrates the connections between the above components and the salmon life cycle. Table 2 illustrates how optimal conditions are degraded through human activity.

1. Water quality and quantity

Salmon need cool, clean water with flows that support different life cycle stages. Water temperature is widely regarded as the factor that most pervasively influences salmon and other aquatic organisms. Pollutants can enter the water directly or attached to soil particles. At worst, an acute pollutant flush like chlorine can immediately kill salmon. More likely pollutants will enter the stream chronically, often attached to soil particles from erosion. These particles slowly deposit and accumulate, ultimately altering the aquatic habitat upon which salmon depend. Water flows are naturally higher in the winter and spring when rainfall and snowmelt are greatest. Flows begin to decrease as summer approaches with September and October typically having the lowest flow. Extremely high and rapid flows may scour habitat and spawning beds in the winter. Extreme low flows may strand juveniles ready for downstream migration, completely dry-out freshwater habitat, and create shallow pools of water that heat to lethal temperatures in the summer.

2. Habitat and stream channel structure, including passage obstructions

The physical shape and habitat quality of the stream contributes to salmon development, food production, and water quality and flow regulation. Stream components create habitable conditions for a diversity of organisms. These components include *pools* (segments of deep and still water), *runs* (segments with swift, low turbulent water) and *riffles* (segments of shallow, fast moving water broken by rocks). Components adjacent to the stream include *floodplains* (low-lying areas that frequently flood when water levels rise), *wetlands* (areas where water is present long enough to form distinct soils and plant communities) and *riparia* (the vegetation, soil, rocks, wildlife, insects and microorganisms adjacent to a stream). These components are altered by bank stabilization structures, filling of wetland areas, removal of streamside vegetation or of the bank itself. These activities ultimately result in the reduction of the stream's natural productivity and alteration of its natural flow patterns.

3. Interactions within and between species

Interactions within and among species influence the ability of salmon to adapt and evolve. Excessive predation and harvest may disrupt food chain hierarchies. The introduction of non-native species and hatchery fish may create increased competition for food and weaken genetic "fitness" within a species.

Figure 2. **Conditions which support salmon**

These conditions focus on the life stage activities
for Salmon in the Johnson Creek watershed.
Most conditions support more than one life stage.

Environmental Components

Water quality and water flow

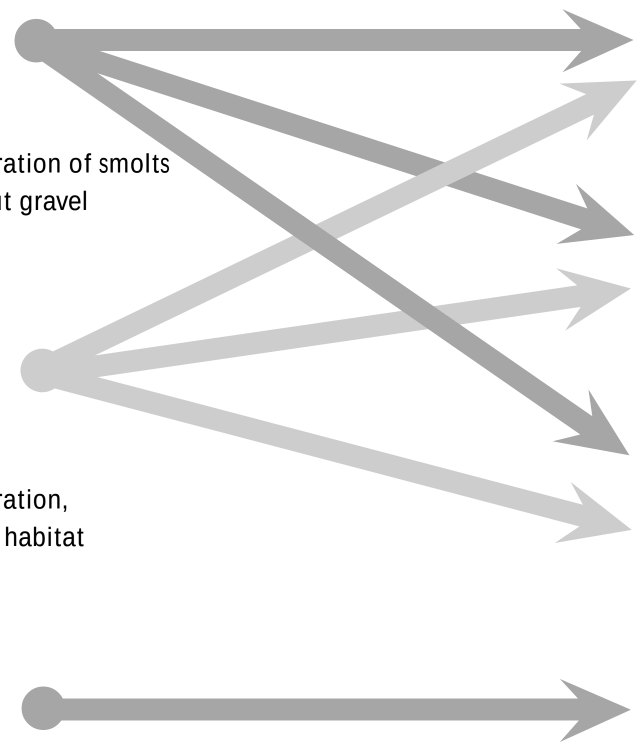
Water temperatures below 64 degrees Fahrenheit
High dissolved oxygen for respiration
Minimal toxins and suspended sediments
Summer and fall low flows adequate to provide for migration of smolts
No extreme winter and spring high flows which wash out gravel

Habitat and channel structure

Source and availability of marble to cobble-sized gravel for spawning
Places for resting, feeding and hiding
Substrate supportive to algae and insects
No artificial blockages which impede passage
Flood plains and wetlands for flood storage, flow moderation, pollutant filtering, nutrient cycling, off-channel habitat
Sources of organic material
Instream conditions supportive of food production
Adequate streambank vegetation

Species Interactions

No extreme selective pressure on a particular species or life stage
(through predation, disease, competition, interbreeding with hatchery fish)



Life-cycle stages

Spawning (reproduction)

Healthy development from fry to smolt life stages

Migration downstream and upstream

Ability to adapt over time to environmental changes

Table 2. **Supporting conditions and effects of human activity** (adapted from Karr, 1999)

Supporting conditions	*Effects of human activity*
Water quality and water flow	
Cool water temperatures generally below 64 degree Fahrenheit	Removal of streamside vegetation, shallow impoundments of water, and summertime water withdrawals that diminish stream flow may all increase water temperature.
High dissolved oxygen (above 8 milligrams per liter)	Certain pollutants deplete dissolved oxygen through decomposition. Elevated water temperatures also decrease dissolved oxygen levels.
Low suspended sediments	Erosion causing activities adjacent to the stream channel, coupled with the lack of streamside vegetation to trap sediment, causes increased sediment to enter the stream. Stormwater channeled into the stream may also carry sediments. Erosive flows caused by peak discharges of stormwater will also erode the streambank directly.
Low pollutants	A variety of human-based activities create pollutants that enter the stream directly or through stormwater.
Volume and timing of flows supportive to Salmon life cycle stages	The natural hydrology of the stream is disrupted when less rainfall infiltrates through the ground and more water runs over impervious surfaces. The primary effect is pronounced peaks and greater volumes of water rushing through the channel. Salmon life-cycles may not be able to adapt to these changing hydrological conditions.
Flows supportive to natural channel formation	More pronounced peaks and greater volumes of water rushing through the channel create undercut and incised stream banks, and channel deepening.
Habitat and channel structure	
Diverse substrates	Intentional lining of bed with rock or concrete reduces substrate diversity and biological processes in stream bed. Sediment in the stream can smother spawning gravel; high winter flows can wash-out spawning gravel.
Diversity of pools, riffles and runs	Straightening and lining of creek with rock; removal of water slowing structures.
Presence of natural water slowing structures	Removal of beaver dams and large woody debris.
Floodplains and wetlands connected to creek	Development on and filling-in of floodplains and wetlands.
Presence of native streambank vegetation	Removal of trees and shrubs along river corridor; invasion of non-native species such as Himalayan blackberry.
Free movement within stream and its tributaries	Permanent, man-made obstructions such as culverts and small dams impede movement of adult and juvenile salmon.
Stable streambanks	Removal of streamside vegetation coupled with peak flows destabilize streambanks.
Species interactions	
Competition, predation and disease exist in dynamic balance	Genetic swamping by hatchery fish having low fitness. Introduction of alien diseases, parasites and predators. Changes in stream temperature may give competitive advantage to predators.

Background information about the Johnson Creek Watershed

A watershed is the land area drained by a particular stream or river. The Oregon Plan for Salmon and Watersheds is primarily concerned with the capacity of Oregon's watersheds to naturally produce salmon. The rationale for this watershed focus is four-fold. First, activities that occur on the land that drains to a creek or river greatly impact that water body. As the adage goes, what we do *does* often end up in the river. Second, increased stream productivity supports more salmon. In return, salmon contribute more nutrients to the stream system upon death after spawning. Third, of the stream, estuary and ocean environments in which salmon exist, we have the greatest control in improving stream and river environments. And finally, recognizing that watersheds cross political boundaries, a watershed focus provides a natural spatial-context in which to organize and assess our activities.

Illustration by Sara B. Lauterbach, courtesy of River Network

Watersheds can have many geographic scales. For example, Multnomah County drains into five major water bodies that eventually make their way into the Pacific Ocean. These water bodies are the Columbia, Sandy, Willamette, and Tualatin rivers, and Multnomah Channel. Approximately forty smaller watersheds throughout the County drain to these water bodies. Map 1 shows watersheds in the region. For purposes of this report, watershed refers to the entire area of land drained by Johnson Creek. Johnson Creek drains to the Willamette River, which drains into the Columbia River that empties into the Pacific Ocean.

A watershed is made up of three components that in an undisturbed system are intricately intertwined. These are the stream, the floodplain, and the uplands. The way water flows above and below ground to and from these systems shapes and affects the health of the stream. For example, consider how rainwater runs off driveways and parking lots, collects in street storm drains, and is transported through pipes that ultimately drain into Johnson Creek. Along the way, this rainwater collects pollutants and sediments contributed by various upland activities. These pollutants and sediments affect the water quality of Johnson Creek. The runoff conveying these pollutants and sediments often flushes quickly and forcefully through the creek, resulting in unstable streambanks, and a scoured and deepened channel. Further, the fewer permeable surfaces available for stormwater infiltration, the more quickly stormwater reaches the stream channel—hence increasing the likelihood of flooding.

Map 2 shows Johnson Creek and its tributaries, and confluence (the point where Johnson Creek empties into the Willamette River). Note Crystal Springs, a large tributary near the confluence. Crystal Springs is often noted as a sub-watershed of Johnson Creek because of its unique cool and constant spring-fed waters. For this report, reference to the Johnson Creek watershed will include Crystal Springs, unless otherwise noted.

Change is constant in the Johnson Creek Watershed. In 1998, over 17 plans relating to development or resource protection in the watershed were identified. Of particular note is the planning of two urban reserve areas brought into the urban growth boundary in 1999. These areas are located near Kelley and Mitchell Creeks, which have been identified as good salmon habitat areas. Metro recently awarded the City of Portland $50,000 to conduct conceptual planning for Portland's portion of these areas.

Jurisdictional Boundaries

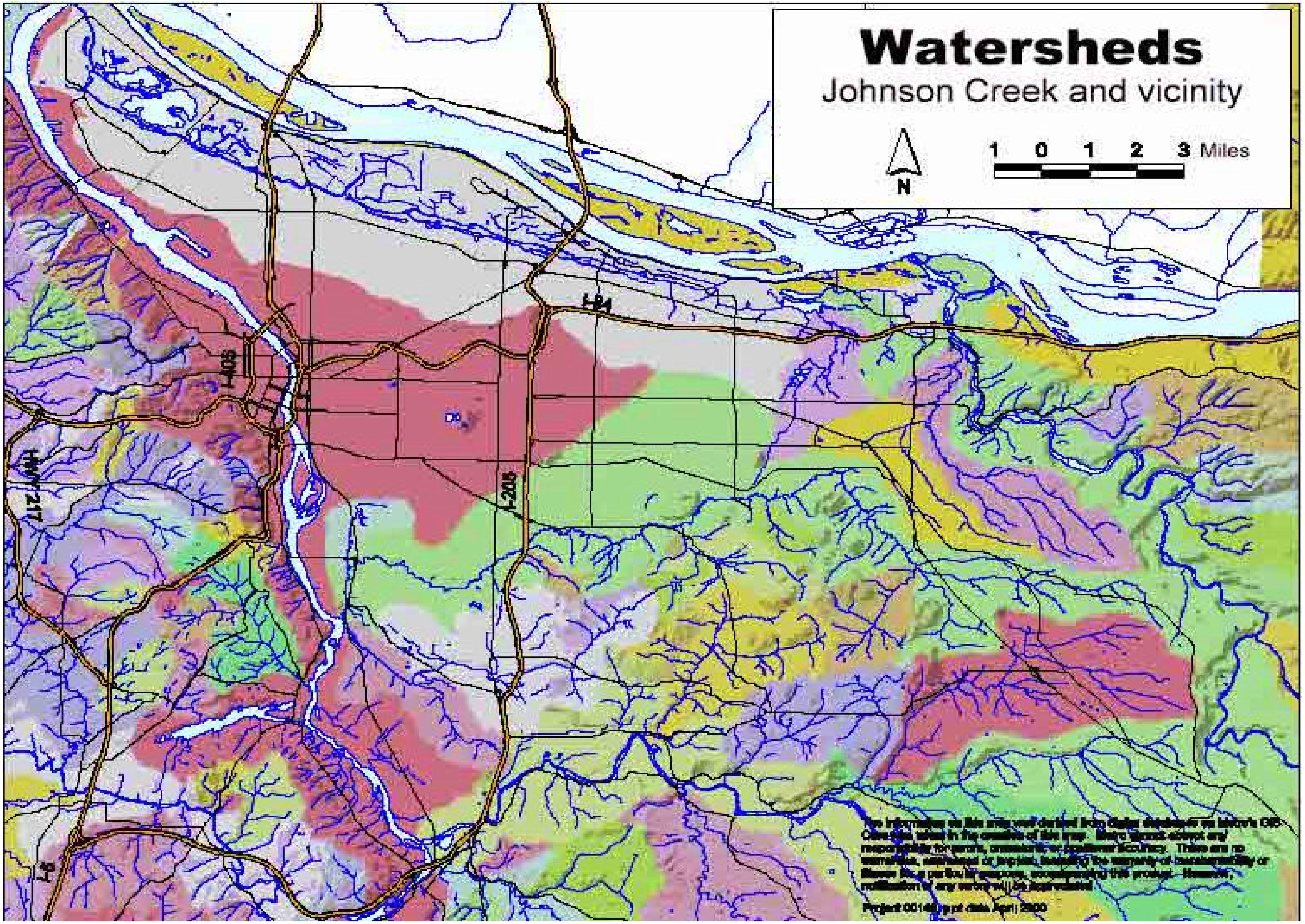
The headwaters of Johnson Creek begin in the hills near the small, unincorporated area of Cotrell. The creek flows westward approximately 25 miles to its confluence with the Willamette River in the city of Milwaukie. The watershed drains approximately 54 square miles (34,035 acres), and crosses six political boundaries—the cities of Gresham, Happy Valley, Portland, and Milwaukie, and the counties of Clackamas and Multnomah.

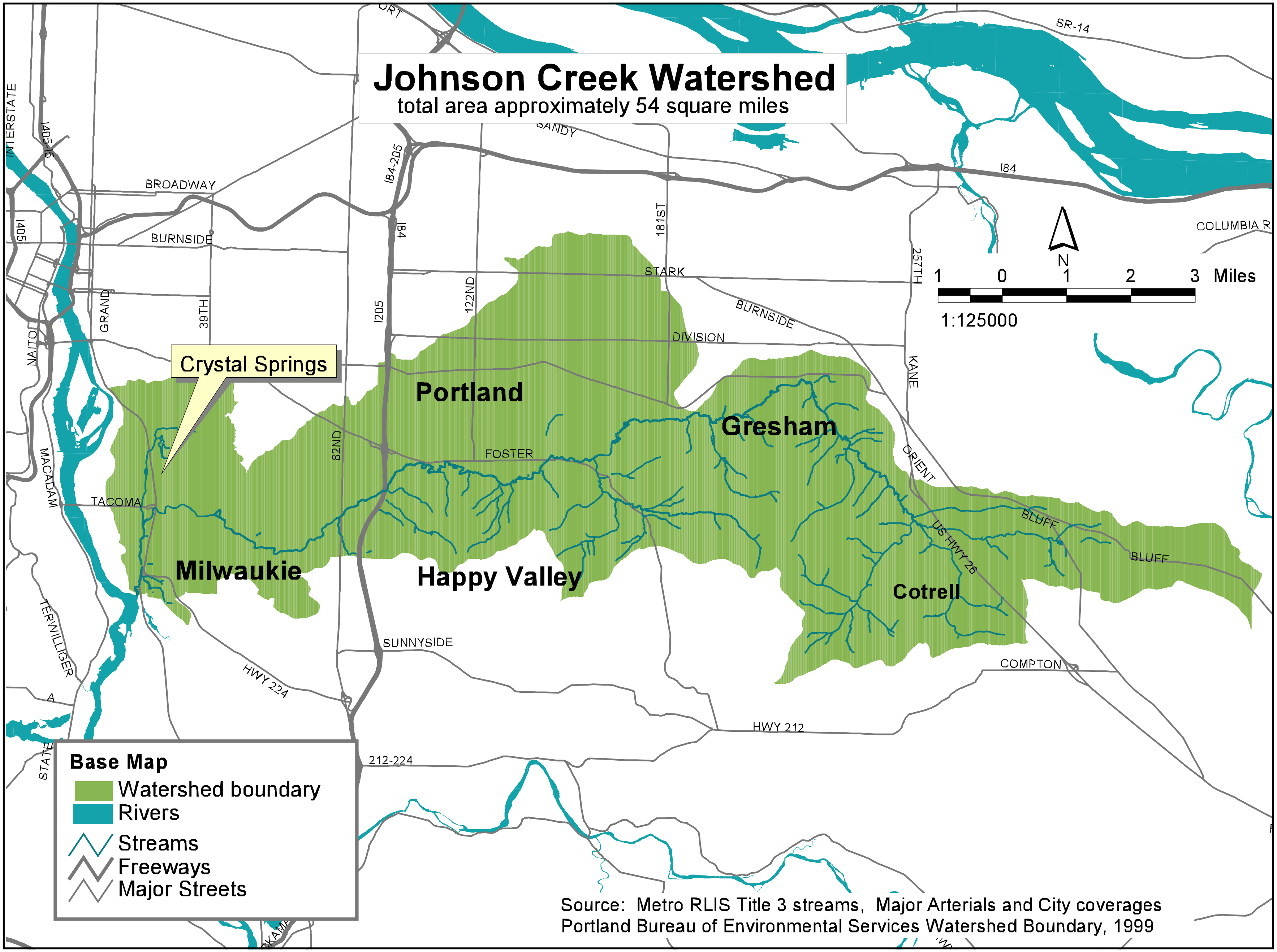
Portland contains the greatest amount of land and number of stream miles in the watershed, followed by unincorporated areas of Clackamas County. The following table, map and charts show the acres of land and miles of stream by jurisdiction. Stream miles represent the Johnson Creek mainstem and all active tributaries mapped by Metro.

Table 3. **Acres and stream miles in watershed by jurisdiction**

Jurisdiction	Acres	Percent Acres	Stream miles	Percent stream miles
Portland	14,075	41%	42	34%
Unincorporated Clackamas County	8,750	26%	32	26%
Gresham	5,541	16%	30	25%
Unincorporated Multnomah County	4,127	12%	9	8%
Milwaukie	1,431	4%	8	7%
Happy Valley	111	less than 1%	1	less than 1%
Total land acres and stream miles	**34,035**	**100%**	**122**	**100%**
Watershed and streams within urban growth boundary	24,529	72%	72	59%

Map 1


Watersheds
Johnson Creek and vicinity
N
1 0 1 2 3 Miles
I-84
I-405
I-205
HWY 217


Johnson Creek Watershed
total area approximately 54 square miles
Crystal Springs
Portland
Gresham
Milwaukie
Happy Valley
Cotrell
1 0 1 2 3 Miles
1:125000
N
Base Map
Watershed boundary
Rivers
Streams
Freeways
Major Streets
Source: Metro RLIS Title 3 streams, Major Arterials and City coverages
Portland Bureau of Environmental Services Watershed Boundary, 1999
INTERSTATE
I405-I5
BROADWAY
BURNSIDE
I405
GRAND
39TH
NAITO
MACADAM
TACOMA
TERWILLIGER
82ND
I205
122ND
I84-205
I84
SANDY
STARK
181ST
DIVISION
FOSTER
SUNNYSIDE
HWY 224
212-224
HWY 212
257TH
KANE
ORIENT
US HWY 26
BLUFF
COMPTON
SR-14
COLUMBIA R

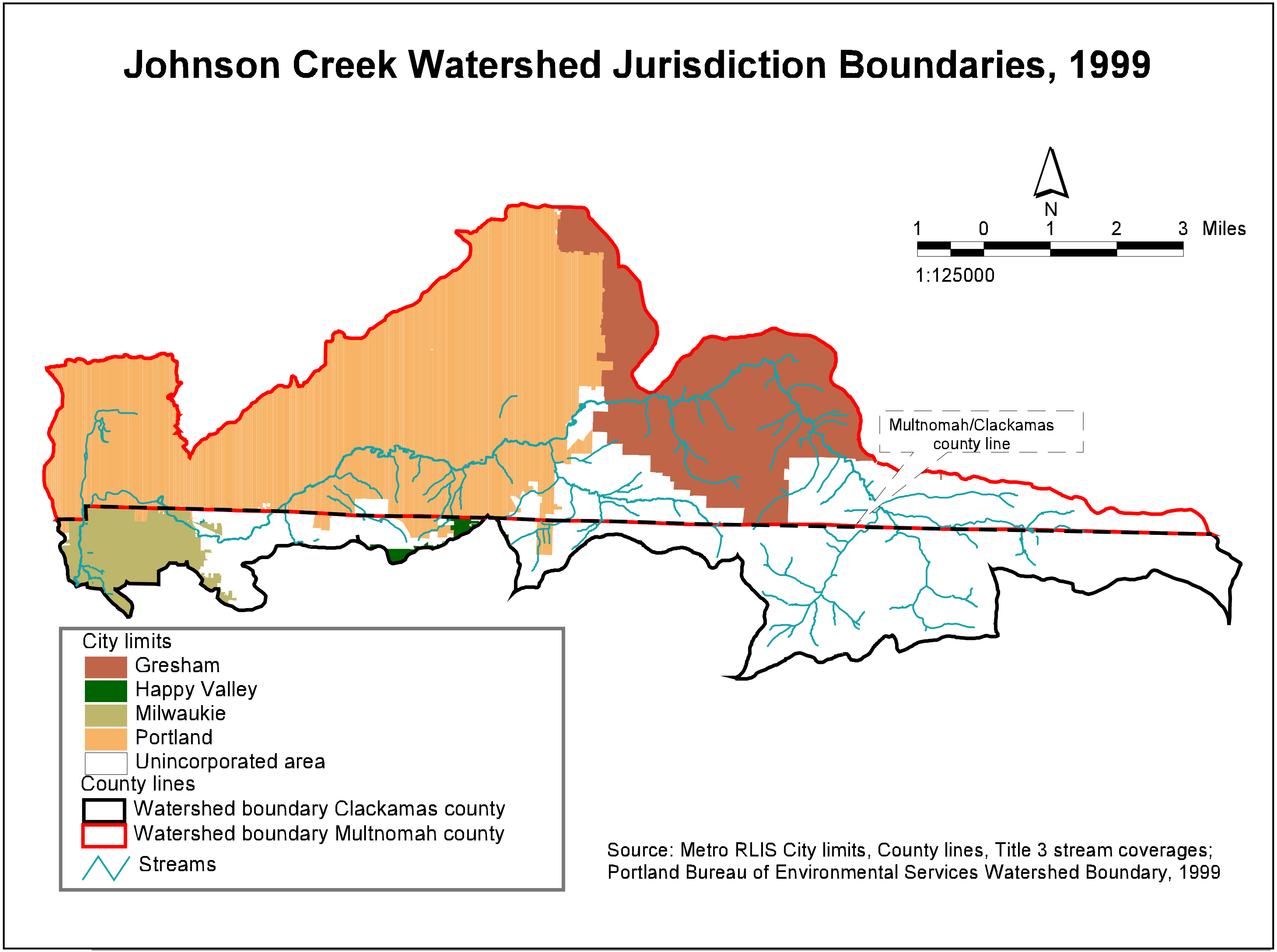

Johnson Creek Watershed Jurisdiction Boundaries, 1999
N
1 0 1 2 3 Miles
1:125000
Multnomah/Clackamas county line
City limits
Gresham
Happy Valley
Milwaukie
Portland
Unincorporated area
County lines
Watershed boundary Clackamas county
Watershed boundary Multnomah county
Streams
Source: Metro RLIS City limits, County lines, Title 3 stream coverages;
Portland Bureau of Environmental Services Watershed Boundary, 1999

Chart 1

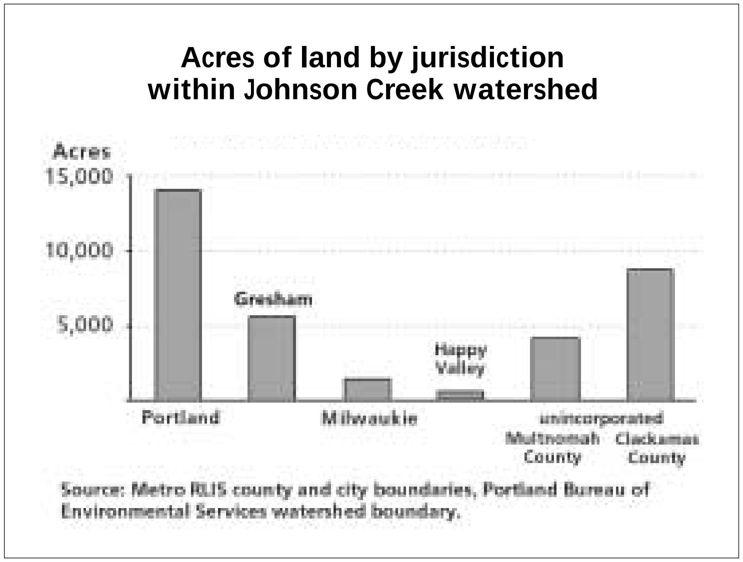
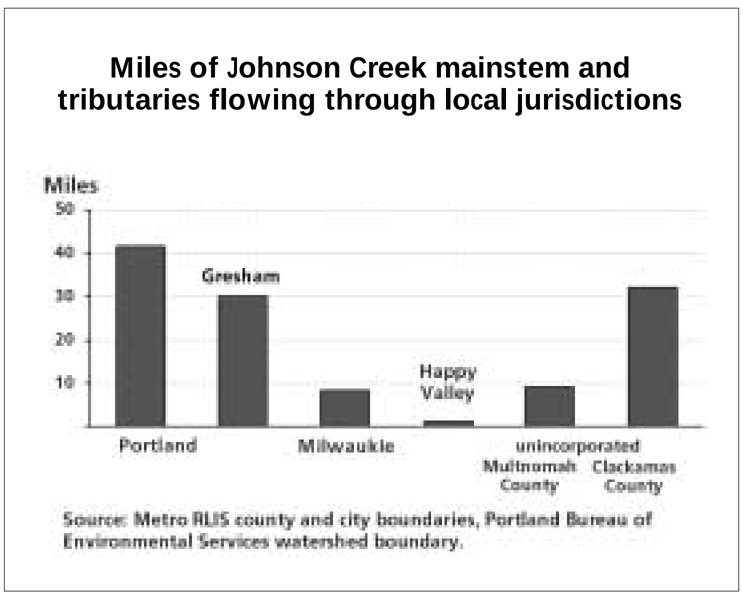


Chart 2



Land use

About 72% of the Johnson Creek watershed lies within the urban growth boundary, although not all of this land is fully developed. Prior to the January 2000 Oregon Court decision that nullified Metro's urban reserve areas, two urban reserves had been brought into the boundary. They comprise about 1,478 acres of land between Portland and Gresham, and are being carefully studied as to their development impacts on Johnson Creek and two of its tributaries, Kelley and Mitchell Creeks. An analysis by the City of Portland's Bureau of Environmental Services summarized current and future land-use in the watershed as follows.

Table 4. **Zoning in watershed**

Zoning Category* Acres (percent)	Current (1999) Acres (%)		Future (2040) Acres (%)	
Single Family Residential	15,399	(45%)	19,227	(57%)
Rural	11,175	(33%)	2,868	(8%)
Multi-Family Residential	2,930	(9%)	4,091	(12%)
Parks and Open Space	1,772	(5%)	4,385	(13%)
Industrial	1,499	(4%)	0	(0%)
Commercial	1,261	(4%)	3,466	(10%)
total	*34,035*	(100%)	*34,035*	(100%)

*This table reflects zoning. Not all areas within these zones may be developed or occupied.

Source: Portland Bureau of Environmental Services, Technical Memorandum: Johnson Creek Watershed Analysis and Pre-Design, 1999.

Rural areas in the watershed include agriculture, horse farms and cattle grazing. In 1994, Reininga and Davis described the following agricultural composition.

Table 5. **Agricultural uses in rural zoned areas**

Agricultural uses	Percent of Land
Cultivated crops or pastures	50%
Tree and ornamental nurseries, greenhouses, and Christmas tree plantations	29%
Cultivated raspberries, blackberries and other cane crops	2%
Not classified	19%

Population

According to an analysis by Metro, approximately 164,115 people currently live in the Johnson Creek Watershed. Only 4,831 (3 percent) of these people live outside the urban growth boundary.

Table 6 shows population within the watershed by jurisdiction.

Table 6. **Population within the watershed by jurisdiction**

Jurisdiction	Estimated 1998 population
Portland	109,134
Gresham	32,334
Unincorporated Clackamas Co.	10,967
Milwaukie	9,391
Unincorporated Multnomah Co.	1,948
Happy Valley	340
Total	**164,115**

Source: Metro Data Resource Center, September 1999.

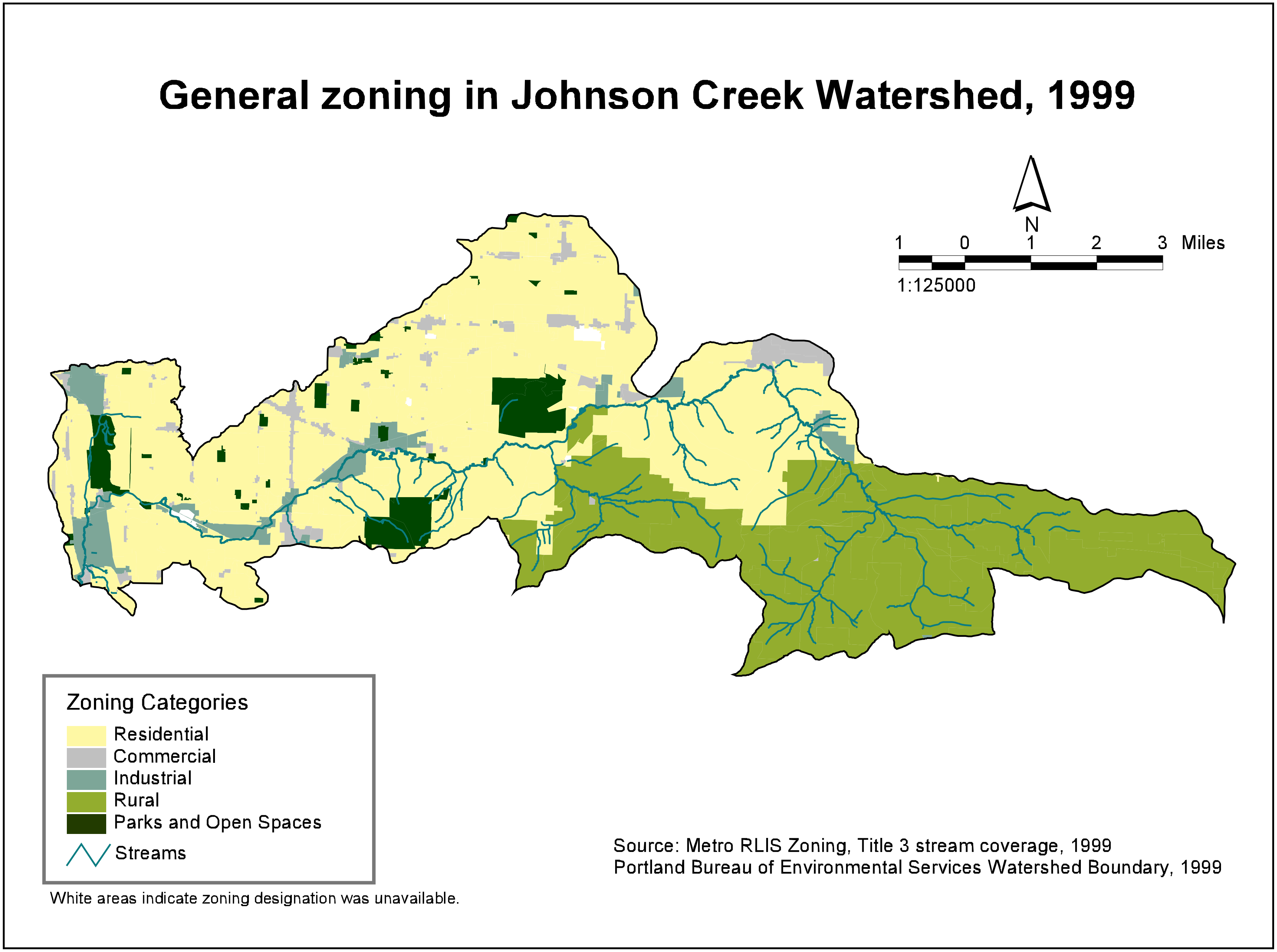
Map 5 shows population density across the watershed. The watershed is divided into thirteen units to depict sub-drainages within the watershed, and distinguish important tributaries like Crystal Springs, and Kelley and Mitchell Creeks. Population is most dense in the Portland areas of the watershed, and less dense outside the urban growth boundary (Badger Creek and headwaters).

Parks and natural areas

The Johnson Creek watershed contains several parks and natural areas including Johnson Creek Park, Tideman Johnson Nature Park, Beggars-tick Wildlife Refuge, Leach Botanical Garden, Powell Butte Nature Park and Gresham Main City Park. A former rail corridor that has been converted to a recreational trail also follows the creek. This trail is called the Springwater Corridor, is approximately 17 miles long, and travels east from Portland to the town of Boring.

Slope and flooding

The elevations through which Johnson Creek flows vary from about 750 feet in the headwater regions of the Boring Hills to sea level at the confluence with the Willamette River. Compared to many watersheds, the Johnson Creek watershed is relatively flat topographically, and the slope of its mainstem, from headwaters to confluence, is atypical. A typical mainstem is characterized by a steeper slope at the headwaters, and a flatter slope towards the confluence. As the following chart depicts, Johnson Creek displays a “geomorphologically inverted condition.” That is, from the headwaters to just below the Kelley Creek tributary (Portland), the slope is relatively flat. Slope continues to decrease considerably after this point (around river mile 8). The slope of the mainstem is important because it greatly influences where flooding tends to occur.


General zoning in Johnson Creek Watershed, 1999
N
1 0 1 2 3 Miles
1:125000
Zoning Categories
Residential
Commercial
Industrial
Rural
Parks and Open Spaces
Streams
White areas indicate zoning designation was unavailable.
Source: Metro RLIS Zoning, Title 3 stream coverage, 1999
Portland Bureau of Environmental Services Watershed Boundary, 1999

Population per square mile by sub watersheds of Johnson Creek, 1998

total population of watershed is approximately 164,115

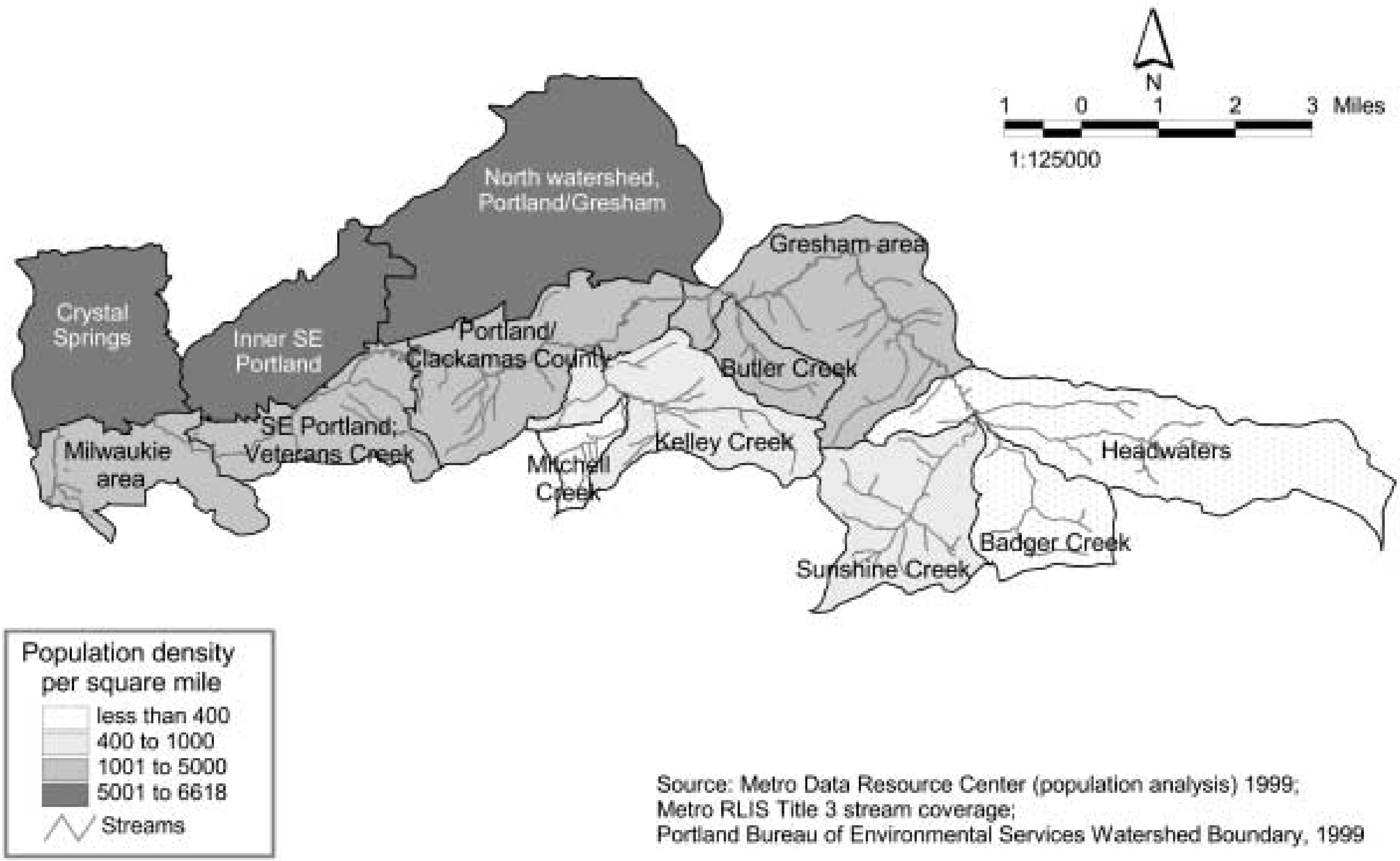
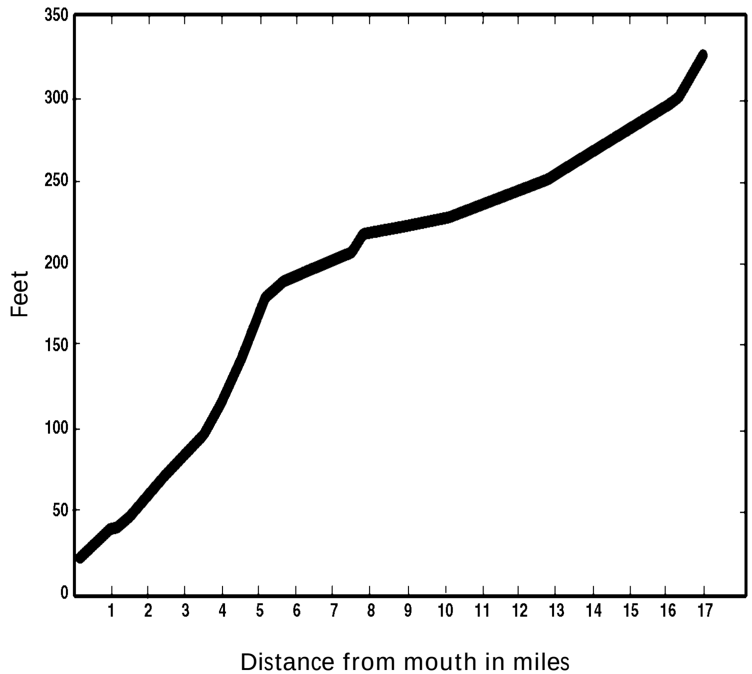


Figure 3. **Elevation of watershed by river mile**



Adapted from U.S. Geological Survey Water-Resource Investigations Report 93-4090, 1994, p.4

Flood remediation projects in the lower reaches of Johnson Creek during the 1930's through 1950's greatly altered the creek's shape and streambed below Kelley Creek. Segments of the channel were straightened, lined with rock, and its banks stripped of vegetation and stabilized with rock. These activities disconnected the natural floodplain from the channel, increased the speed of water traveling downstream, altered pool and riffle composition, and destroyed biological processes occurring in the streambed—irreversibly altering and decreasing spawning and rearing habitat for salmon.

Despite these flood "control" projects, flooding continues to be a major problem in Johnson Creek. Based on the 1992 Federal Emergency Management Agency (FEMA) floodplain delineation, approximately 937 acres of tax lots within the floodplain (or 55% of the floodplain's area) contain some sort of structure. Winter flooding in Johnson Creek in 1996 created an estimated $700,000 in damages within the City of Portland.

Impervious surfaces and stormwater run-off

Imperviousness is usually described as the "sum of roads, parking lots, rooftops, and other impermeable surfaces of the urban landscape." Much attention has been given to the relationship between impervious surfaces and the degree of stream degradation in urban watersheds. Horner and May, researchers at the University of Washington, point out that impervious surfaces "are the major contributor to the change in basin hydrologic regime that drives many of the physical changes affecting urban streams."

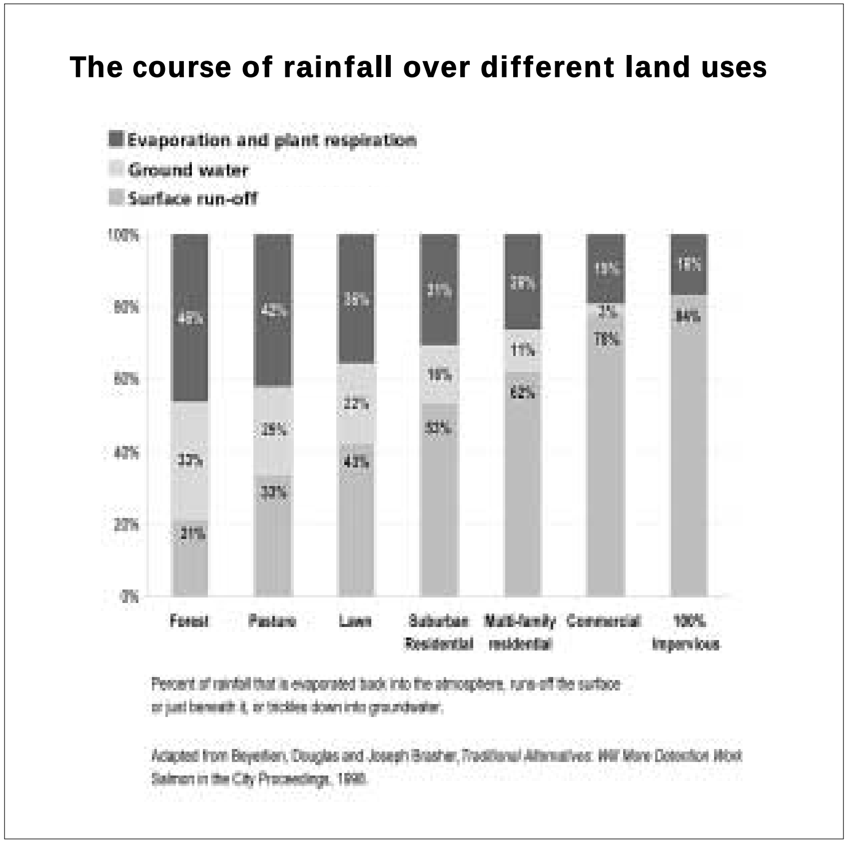
When surfaces that absorb and store rainfall, such as wetlands, forests and meadows, are replaced with impermeable surfaces and structures, the resulting run-off, called stormwater run-off, must be channeled through pipes to waterways or find its way to permeable surfaces. In the Johnson Creek watershed, about 65% of the watershed either drains directly, or is piped into Johnson Creek. Stormwater flow is most pronounced between November and April when rainfall is heaviest. Flows from the upper, non-urbanized areas of Johnson Creek, combined with increased run-off from impervious surfaces, create winter flows that scour the stream channel and destabilize its banks—what Horner and May mean by "physical changes" to the urban stream.

Increased imperviousness accompanies increased population as roads, houses, and semi-permeable landscapes such as lawns replace natural vegetation. Chart 3 shows how different land uses reduce groundwater infiltration and the return of water into the atmosphere through evaporation and plant respiration.

Road density has been used as a proxy for imperviousness because transportation contributes the most substantial components of impermeable surfaces. A study in the City of Olympia, Washington, concluded that impervious surfaces related to transportation (roads and parking lots) typically accounts for over 60% of imperviousness in suburban areas.

Tom Schueler, Director of the Center for Watershed Protection in Maryland, has reviewed numerous studies relating imperviousness to specific changes in stream function, shape and habitat. He found that greater impervious surface degrades salmon habitat by reducing spawning and rearing areas, and limiting the production of food resources upon which salmon depend.

Chart 3



Imperviousness is best understood on a sub-watershed basis. This means breaking the watershed down into smaller drainage units. Understanding imperviousness through smaller units is helpful in a watershed like Johnson Creek because the watershed is not uniformly developed. Schueler recommends studying and planning the watershed in sub-units of 2 to 10 square miles.

Schueler has classified stream areas into three categories related to the imperviousness of the area that drains it. These classifications are the results of numerous urban stream studies, which related multiple indicators (fish diversity, macroinvertebrates, pollutants, channel stability, stream temperature) with impervious area. Levels of imperviousness above 25% often indicate severely degraded stream conditions.

Sensitive tributaries (0-10% imperviousness) — These stream segments have suffered the least degradation and have the greatest potential for recovery.

Impacted tributaries (11-25% imperviousness) — These stream segments show clear signs of degradation. Stream banks are unstable, water quality drops to a fair/good category, sensitive fish and aquatic insects disappear from the stream.

Non-supporting tributaries (26-100% imperviousness) — These stream segments present the greatest challenges toward recovery. The stream channel is highly unstable, pool and riffle structure needed to sustain fish is diminished, and the stream substrate is no longer supportive of aquatic insects or spawning areas for salmon.

Impervious percentages in the Johnson Creek watershed have been estimated from aerial photography and zoning. These estimates, shown on map 6, illustrate the range of imperviousness in the watershed. These estimates are meant to be a guide to planners pursuing fish recovery strategies, and may point to where the best fish habitats, and greatest chances for protection and restoration, exist.

This classification system should be used with some caution. An area with high imperviousness may be supportive of salmon because of unique stream and drainage conditions. Such is this case with Crystal Springs—a spring and groundwater fed tributary near the mouth of Johnson Creek that contributes a cool and constant flow. Although imperviousness reaches 45% in this area, much of this area drains to sumps or the Combined Sewer System (areas shown outlined in red). Run-off in this area does not reach Johnson Creek as overland flow. Crystal Springs has historically and currently supports a diversity of salmon, and several habitat restoration projects are currently underway in this area.

Impervious projections provide a quick way to gauge how future development may affect stream health in localized areas. Horner's research, which focused on Puget Sound lowland streams, suggests that future increases in impervious surface be "severely limited, unless mitigated by extensive protection of the riparian corridor and [practices to reduce stormwater run-off]." He recommends preservation and protection of high-quality habitat areas as the first step towards improving watersheds for salmon. Sub-watershed units with low imperviousness percentages help to identify these high resource areas.

How stormwater drains throughout the Johnson Creek Watershed is shown on map 7. It is important to note that a large percentage (35%) of the lower watershed does not drain to Johnson Creek as overland flow. Run-off in these areas either infiltrates to groundwater through stormwater sumps (approximately 21% in the Portland region of the watershed), is directed to Portland's Combined Sewer System (approximately 8%), or is hydrologically disconnected from the watershed (approximately 6%).

The upper watershed has less impervious surface and hence more natural drainage area, although infiltration is limited by clay soils and agricultural "tiles" that reduce infiltration. Run-off from this area infiltrates into the ground until the vegetation and soils are saturated. Saturation typically occurs in the winter rainy season between November through February. During this time, the upper watershed generates a significant amount of stormwater run-off to the creek because its groundwater storage is at full capacity.

Historical and current presence of salmon

No information exists about fish populations in Johnson Creek prior to European settlement. Based on comparisons with less-disturbed streams in the lower Willamette watershed, it is likely Johnson Creek supported steelhead trout, sea-run and resident cutthroat trout, coho and chinook salmon. Historical accounts, and spawning and inventory surveys provide information about the presence of salmon in Johnson Creek and its tributaries.

Historical accounts of salmon in Johnson Creek are few. In 1917, the *Sellwood Bee* printed this anecdote. “While watering his horse in Johnson Creek near the end of Umatilla Avenue, T.A. Sinclair spied a large salmon going over a riffle. He pursued it with a pitchfork and impaled it. It was 3 feet long, and weighed 22 pounds.” Current interviews with long-time residents of Pleasant Valley describe residents around Kelley Creek pitchforking abundant spawning runs, probably steelhead, as late as the 1950’s.

For more scientific purposes, Salmon are counted in a variety of ways and at different life stages. The counts shown below reflect spawning surveys and fish inventories. Spawning surveys count egg nests (redds), and males and females found near these nests. Fish inventories record the number and size of each species found in selected samples throughout the creek. Spawning and inventory counts have not been collected consistently over the years throughout the mainstem and tributaries. These counts are most likely biased and skew fish distribution—areas where fish were likely to occur were the areas most often inventoried. It is likely that other segments of the creek, in addition to those shown on map 8, currently support salmon nesting and rearing.

Chart 4

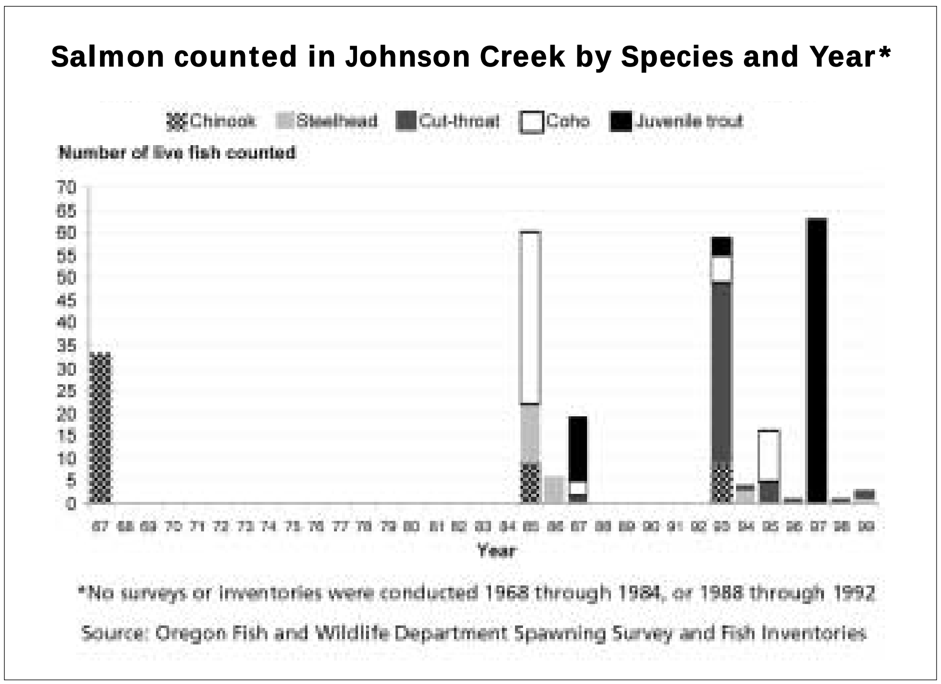
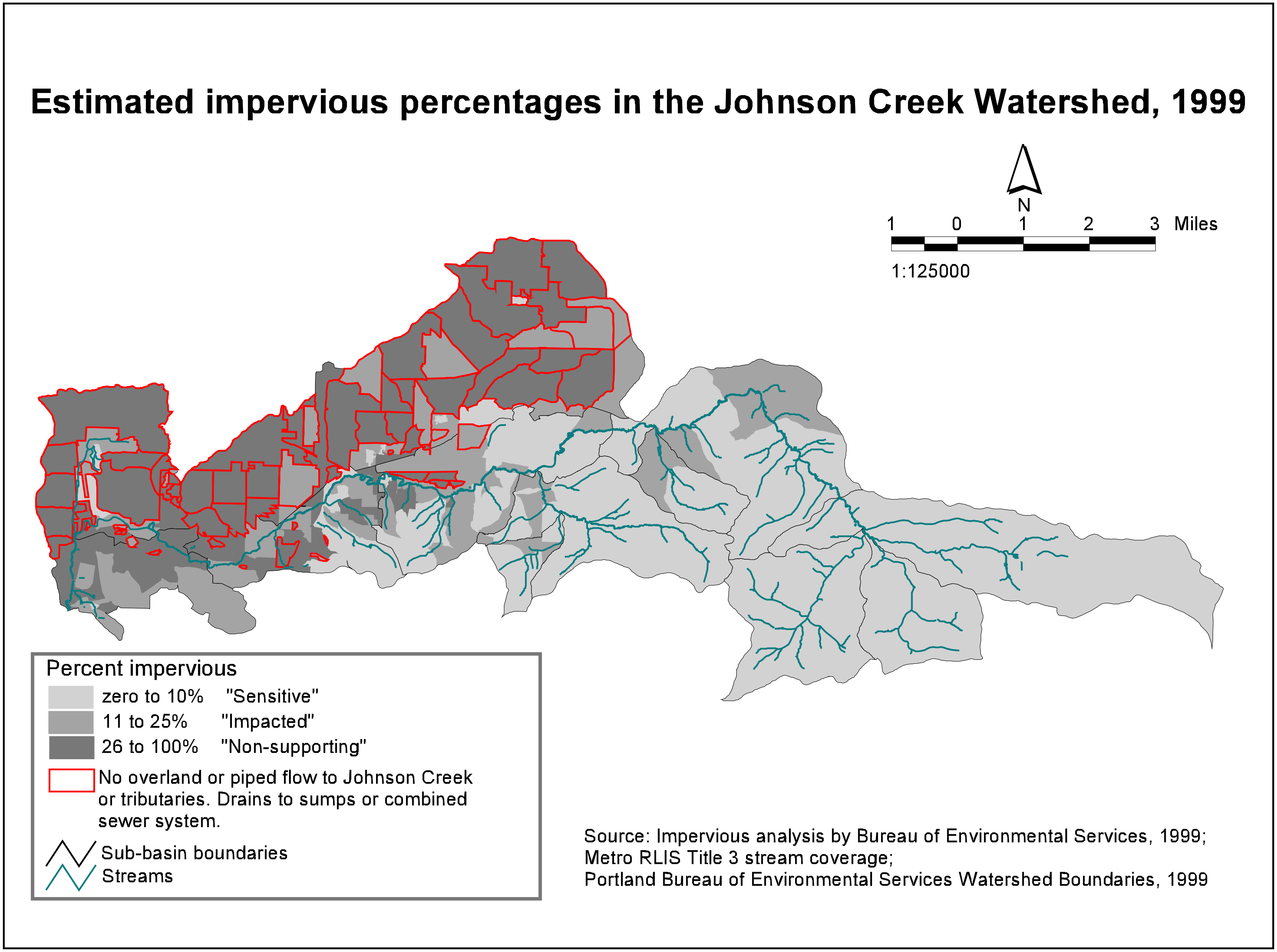
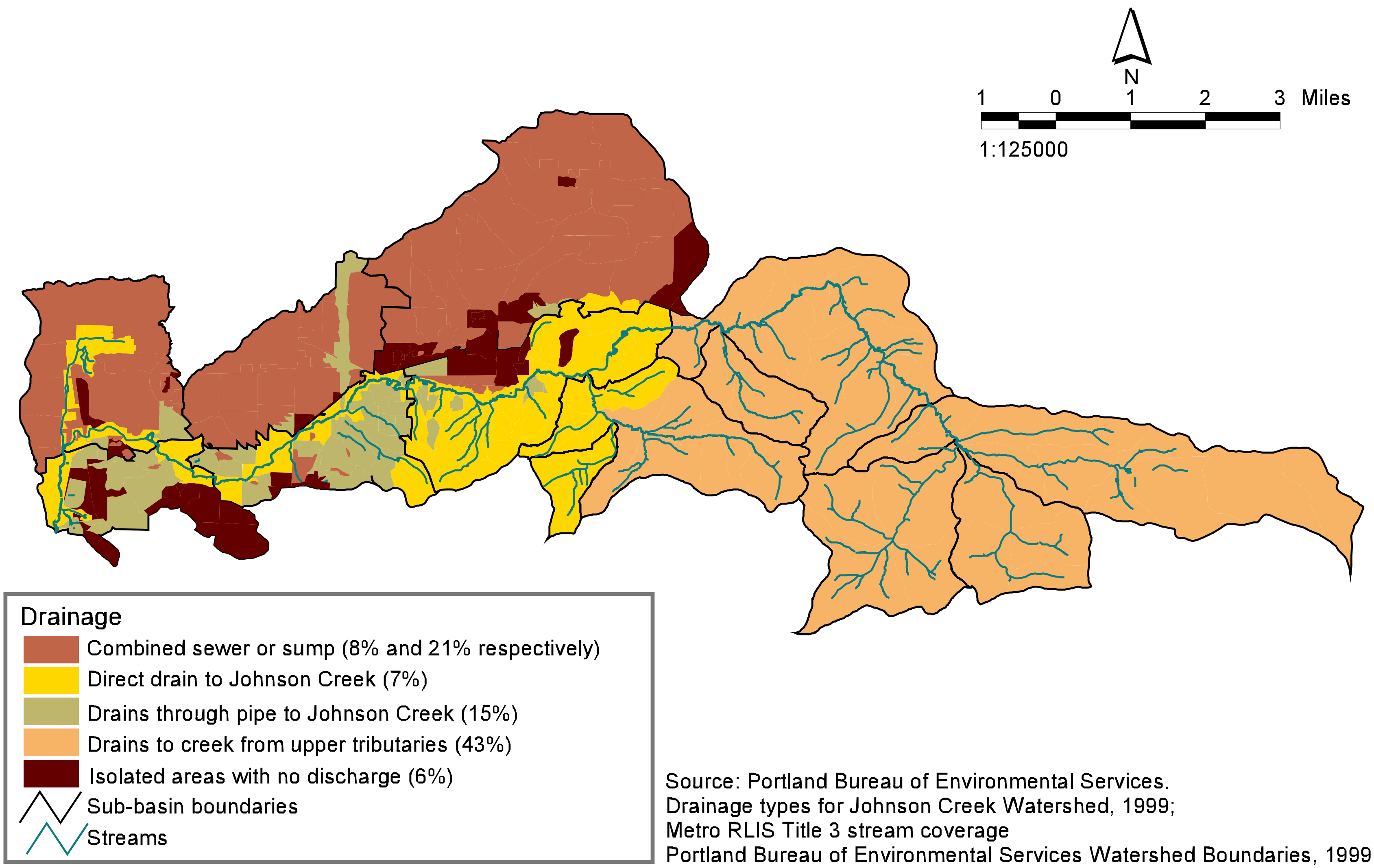


Table 7. **Salmon spawning and inventories, including redd counts 1967 through 1999**

Species	Live Adults	Live Juveniles	Dead Spawners	Redds
Crystal Springs Total number of locations — 27				
Chinook	0	9	1	0
Coho	39	8	15	1
Cut-throat	0	2	0	0
Juvenile trout	n/a	18	n/a	n/a
Steelhead	15	0	0	0
Johnson Creek Total number of locations — 36				
Chinook	41	9	10	58
Coho	10	1	6	1
Cut-throat	7	43	0	0
Juvenile trout	n/a	63	n/a	n/a
Steelhead	8	0	0	0


Estimated impervious percentages in the Johnson Creek Watershed, 1999
N
1 0 1 2 3 Miles
1:125000
Percent impervious
zero to 10% "Sensitive"
11 to 25% "Impacted"
26 to 100% "Non-supporting"
No overland or piped flow to Johnson Creek or tributaries. Drains to sumps or combined sewer system.
Sub-basin boundaries
Streams
Source: Impervious analysis by Bureau of Environmental Services, 1999;
Metro RLIS Title 3 stream coverage;
Portland Bureau of Environmental Services Watershed Boundaries, 1999

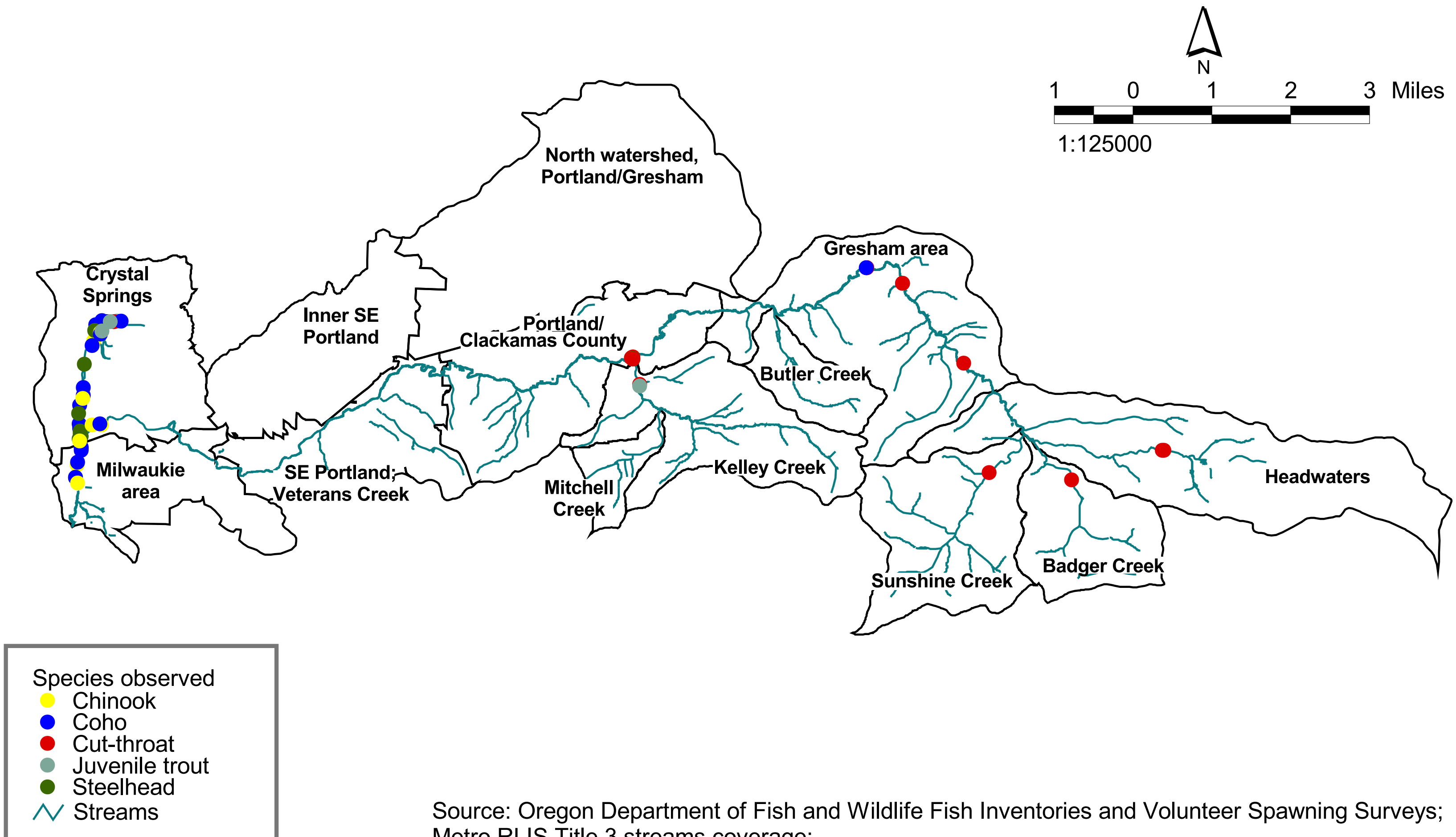
How water drains in the Johnson Creek Watershed, 1999



Source: Portland Bureau of Environmental Services.
Drainage types for Johnson Creek Watershed, 1999;
Metro RLIS Title 3 stream coverage
Portland Bureau of Environmental Services Watershed Boundaries, 1999

Sample observations of salmon and trout in Johnson Creek

Surveys and inventories were performed in1969, between 1985 and1987 and from 1993 through 1999.



Note: Juvenile trout too small to conclusively identify as rainbow or steelhead

Source: Oregon Department of Fish and Wildlife Fish Inventories and Volunteer Spawning Surveys; Metro RLIS Title 3 streams coverage; Portland Bureau of Environmental Services Watershed Boundaries, 1999

Based on the limited data available in 1994, Ellis summarized fish inventory data for Johnson Creek and its tributaries. Ellis found that:

- Cutthroat trout was the only salmon species found throughout the length (mainstem) of the creek.
- Some juvenile coho and steelhead recorded in these counts are likely of hatchery origin.
- With habitat enhancements, Crystal Springs could become a significant rearing area for both salmon and steelhead.
- Kelley, Hogan and Badger Creeks have, at least seasonally, potential for supporting salmon and steelhead.

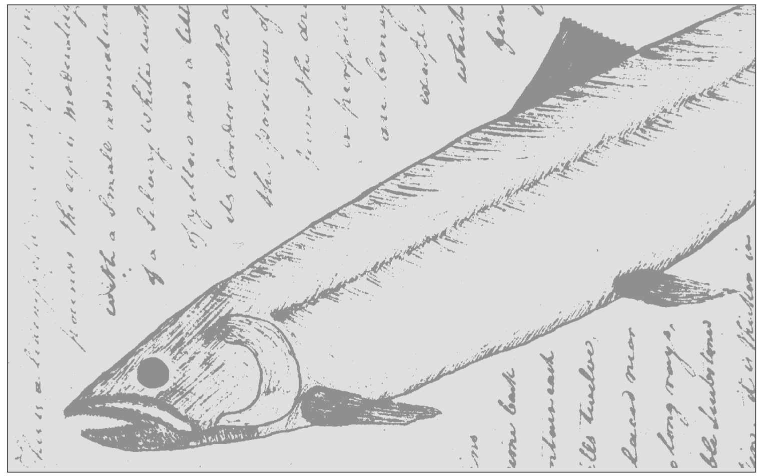
Fish Introductions

The continual return of salmon to their home streams depends upon local populations specifically adapted to the environmental conditions of these streams. Occasionally members of one population return to spawn in a stream other than their natal stream (*strays*). Some of these strays will produce progeny that continue to reproduce in this new stream. Hatchery fish can be likened to artificial strays that originate from very different watershed conditions than the ones to which they return. Eggs or fry planted in a stream will develop a "scent" for that stream as they mature. Those hatchery fish, if not harvested and survive the return journey to that stream to spawn, may interbreed with native fish.

Johnson Creek has a long history of hatchery introductions. Most of the salmon in the creek today are likely a genetic mix of hatchery, stray and wild origin. There may also be a remnant of fish purely representative of Johnson Creek's original, native populations.

Supporting Conditions

Changes in flow patterns and channel shape, water pollution, and degradation of the stream habitat have created unfavorable conditions for salmon. In addition, introduction of hatchery fish has altered the genetic composition of native salmon populations.



In 1994, fish biologist Robert Ellis identified major limiting and unfavorable survival factors for winter steelhead trout, coho and fall chinook salmon in Johnson Creek and its tributaries. Table 8 summarizes Ellis' findings and provides the basis for the supporting conditions highlighted in this section. High spring and summer temperatures, lack of pools, low summer flows, and excessive high winter flows were observed as limiting or unfavorable to the three salmon species evaluated. In addition, Ellis noted that the accumulation of fine sediments in the upper areas of the creek might also hinder the survival of developing embryos and limit production of the insects on which salmon feed. Although Ellis did not assess fish passage in his analysis, man-made blockages such as road culverts and small privately owned dams exist in Johnson Creek; these may completely impede downstream passage and access to good upstream habitat.

In the past five years, studies undertaken for planning new development and managing floods in the watershed have collected and assimilated much information regarding the current conditions and restorative potential of the watershed. These studies include the technical background information for the Johnson Creek Resource Management Plan (1995), water quality and flow data, a hydraulic model of the creek (1999), and a stream assessment by the Oregon Department of Fish and Wildlife (2000) .

Information from these efforts is described below in relation to the factors identified in the major literature as critical for salmon survival. (These primary sources are*: Return to the River*, Williams, et al. 1996; *Upstream*, National Academy of Sciences, 1996; *An Ecosystem Approach to Salmonid Conservation*, Spence, et. al. 1996; *A Limiting Factor Analysis for Anadromous Salmon in Johnson Creek with a Discussion of Habitat Rehabilitation Opportunities and Constraints*, Ellis, Robert, 1994.)

Table 8. Limiting and unfavorable factors for salmon species in Johnson Creek
(adapted from Ellis, 1994)

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
approximate river mile	**mouth to 1.0**	**1.0 to 6.5**	**6.5 to 10.5**	**10.5 to 15.3**	**15.3 to 18.0**
winter Steelhead					
Low flow (summer through fall)		Major	Major	Major	Major
High temperature during smoltification	Major	Unfavorable	Unfavorable	Unfavorable	Unfavorable
High temperature during rearing	Unfavorable	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Lack of pools for refuge	Major	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Lack of adequate spawning bed material (substrate)	Unfavorable	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Low dissolved oxygen during low flows				Major	Unfavorable
Low food production factors				Unfavorable	Unfavorable
High, potentially scouring flow (winter and spring)	Unfavorable	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Coho					
High temperature during smoltification	Major	Major	Major	Major	Major
High temperature during rearing	Major	Major	Major	Major	Major
Lack of deep pools	Major	Major		Major	
Lack of adequate spawning bed material (substrate)	Unfavorable	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Low dissolved oxygen during low flows				Unfavorable	Unfavorable
Low food production factors				Unfavorable	Unfavorable
Lack of cover for rearing and refuge	Major	Major	Major	Unfavorable	Major
High, potentially scouring flow (winter and spring)	Unfavorable	Unfavorable	Unfavorable	Unfavorable	Unfavorable
fall Chinook					
Low flow (fall)		Major	Major	Major	Major
High temperature for spawning (fall)	Major	Unfavorable	Unfavorable	Unfavorable	Unfavorable
Low dissolved oxygen during low flows			Major	Major	
Lack of pools for refuge	Major				
High, potentially scouring flow (winter and spring)	Major	Major	Major	Major	Major

Note: not all factors were assessed for each species. Factors often pertain to a specific life cycle phase.

(dark shading) = major limiting factor

(light shading) = unfavorable factor

Condition 1: Water

Water quality

Water quality has been the most frequently studied of all elements discussed in this report, and several water quality assessments of Johnson Creek have been published. These studies vary over time and geographic sampling frames, and have evaluated both in-stream water quality and sediment deposits. In this report discussion is limited to the parameters of water quality identified by Ellis and the Oregon Department of Environmental Quality as limiting to, or exceeding tolerances for salmon. These parameters are outlined in Table 9.

Table 9. **Limiting water quality parameters**

	Importance to Salmon	**General threshold** Thresholds vary by species and life history stage	**Regulated water quality parameter (Oregon DEQ 1998)**	**Status in Johnson Creek**
Temperature	Metabolism, growth, embryo development, fry emergence, smoltification	Depends on species and life-stage; e.g. tolerances for Coho range from 40º F for spawning to 60º F for adult migration; also see preferred and lethal temperature table	**Yes** — 64º F summer	Temperature exceeds 64º F in summer months (see temperature charts)
Dissolved oxygen	Oxygen supports high energy demands associated with upstream swimming	DO levels of 8-9 mg/L or more are needed to ensure that normal physiological functions of salmon are not impaired; low dissolved oxygen is correlated with high water temperature	**Yes** — a minimum of 11.0 mg/L for salmon spawning, with additional intergravel DO requirements until fry emergence. Standard is 8.0 mg/L for cold water fish, 6.5 mg/L for cool water fish.	In summer months upstream samples have approached 8.0 mg/l threshold
Sediments	Smothering of spawning gravels; pool filling; respiratory abrasion	No thresholds, although salmon typically prefer water with low turbidity and suspended sediment content. Some suspended sediment may actually be beneficial because it attaches with harmful chemicals (thus reducing the toxin's bioavailability to salmon).	**No** —although ground disturbing activities should not increase natural, "background" stream turbidity by more than 10%; total instream suspended solids should not exceed 100 mg/l (DEQ guideline)	Sediments peak during winter storm periods (see storm sediment chart)
Pesticides: DDT and Dieldrin	These pesticides can bio-accumulate in, and cause detrimental damage to, plants, animals, and aquatic organisms.	Water quality recommended criteria for aquatic life for chronic presence are 4,4'-DDT: 0.001 µg/l; Dieldrin 0.056 µg/l. For acute presence the criteria are 4,4'-DDT: 1.1 µg/l; Dieldrin: 0.24 µg/l. There are also EPA guideline criteria for the presence of DDT and dieldrin in sediment.	**Yes** — DDT: 0.001 µg/l; Dieldrin: 0.0019 µg/l (these are human health criteria). Although both of these pesticides have been banned since the 1970's, they remain in the creek through adsorption to sediment and transport into the water column.	Highest concentrations have been found in sediment in Kelley Creek and upper Johnson Creek mainstem, indicating prior agricultural use of these pesticides.

Water Temperature

Of all instream environmental factors, stream temperature probably has the most pervasive impact on all aquatic organisms. Temperature not only triggers and supports important salmon life-stage transitions such as embryo development and smoltification; it also affects the development rates of invertebrates upon which salmon depend for food. Temperature increases may also enable warm water species to gain a competitive advantage or facilitate predation on juvenile salmon. Removal of streamside vegetation, heated industrial discharges, summer stormwater run-off, and shallow detentions of water may all elevate stream temperature. While research describes ways to prevent stream temperature increases, it also indicates that cooling already elevated stream temperature is difficult.

Temperature tolerances and preferences vary by species, season and life stage. Ellis found that spring and summer temperatures were either severely limiting or unfavorable to juvenile rearing and smoltification for salmon found throughout the creek. A consolidated analysis of water temperature data collected between 1996 and 1998 along different segments of the creek generally showed the same pattern as in the graphs following. The average water temperature on the mainstem of Johnson Creek rises above 64º F in the months of July and August.

Table 10. **Preferred and lethal temperatures for selected salmon***

Species	Preferred temperature range °F	Lethal temperatures°F (lower/upper)
Chinook salmon	**53.6 — 57.2**	**33.4 / 79.0**
Coho salmon	**53.6 — 57.2**	**35.0 / 78.8**
Steelhead trout	**50.0 — 55.4**	**32.0 / 75.0**

*Adapted from Spence, et al., 1996, page 101

Chart 5

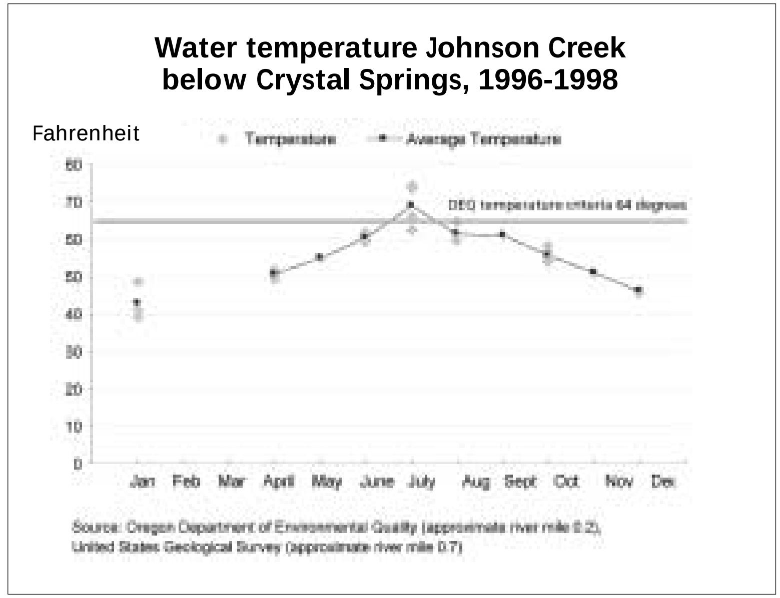


Chart 6

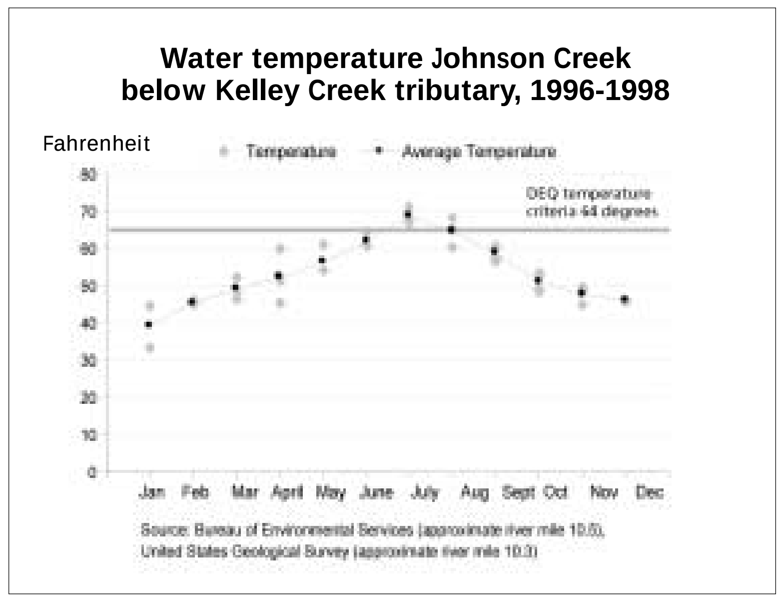
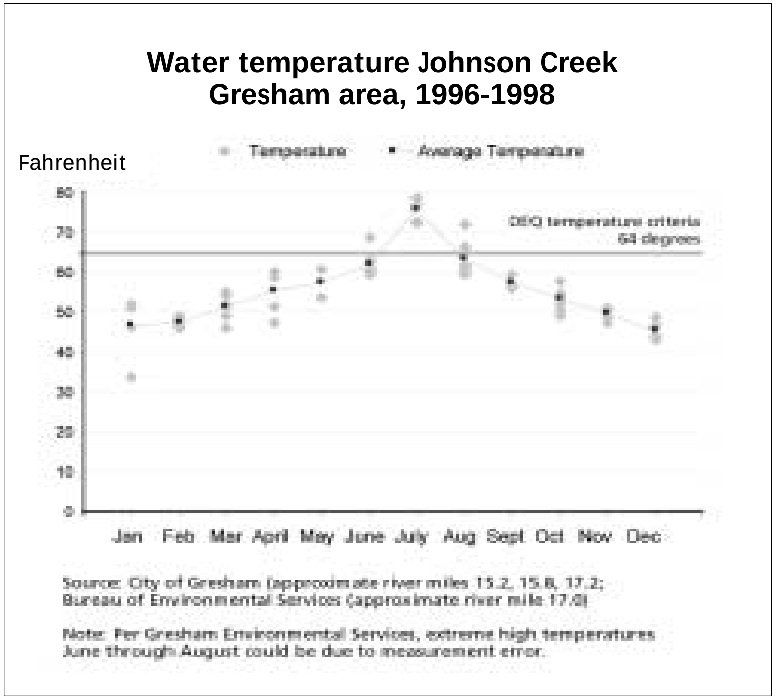


Chart 7



In the Johnson Creek watershed, data collection for water temperature extends to the east side of Gresham. Water temperature data for the upper mainstem and tributaries is lacking. Hence, it is difficult to understand the thermal flows and interactions within the entire system. Increased stream canopy and control of thermal releases into the creek could prevent further temperature increase, and a comprehensive picture of stream temperatures will significantly add to management objectives.

Dissolved oxygen

Salmon obtain oxygen necessary for respiration through the dissolved oxygen in water. The quantity of dissolved oxygen present in the stream is a function of atmospheric pressure, water temperature, water turbulence and dissolved oxygen uptake by aquatic species.

High levels of nutrients such as ammonia, nitrogen and phosphorus can decrease dissolved oxygen levels by supporting excessive algae growth. Elevated nutrient levels have been found in the upper reaches of Johnson Creek, Kelley Creek and Crystal Springs. Elevated nutrient levels are most likely the result of fertilizer use in residential and agricultural settings.

Ellis finds dissolved oxygen limiting or unsatisfactory in the upper mainstem during low flows. This finding is substantiated by recent water quality data gathered by Portland and Gresham.

Suspended solids and sediments

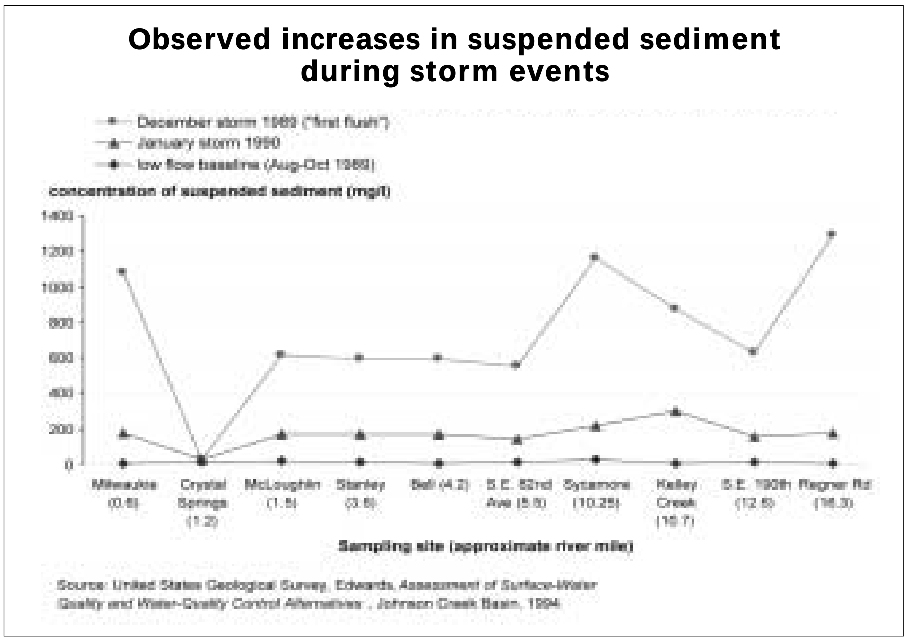
Particles in water may stay suspended indefinitely, or eventually settle out. Deposited sediments have a greater impact on salmon than suspended sediments. Turbidity and total suspended solids (TSS) are two measurements of these particles. Because TSS directly measures the particle weight, rather than water clarity (turbidity's measure), this discussion refers to TSS because it more directly correlates with sediment quantity. Readers are advised that both measures are sometimes used interchangeably.

The detrimental effects of sediment on salmon habitat are many and well documented. Small sediments fill in the spaces between streambed materials, hence reducing space and dissolved oxygen flow for aquatic organisms. Sediments may smother salmon eggs and entrap emerging fry. Large and chronic inputs of sediment may result in pool filling. Finally, suspended sediments may hamper respiration by abrading gills, and decrease visibility during food capture.

Flushes of sediment into the stream are often episodic and exacerbated by high flow and storm events. Erosion causing activities in wet weather months, such as housing construction and agricultural crop rotation, even those that are accompanied by erosion control efforts, may cause sediment to wash directly into the stream. Structures intended to stop erosion or settle particles before release into storm drains or water bodies are not fully effective. Research shows that constructed settling ponds may only be effective between 1 to 12 hours. This may not be enough time for absorption and settling of all contaminants. The short efficacy of these pollution reduction facilities, coupled with the lack of riparian corridor to further filter sediment, or the complete bypass of the corridor by stormwater pipes, indicate that sediment entering Johnson Creek and its tributaries is a significant problem. Regulations and best practices to reduce erosion will be discussed in the Supporting Programs section of this report.

Finally, in the lower sections of Johnson Creek, stormwater piped into the creek through outfalls may contain sediment with attached pollutants such as nitrates, phosphates, herbicides, heavy metals, organochlorines, and petroleum residues. Research in the early 1990's compared sediment concentrations during low flow conditions against storm events. The largest sediment concentration recorded was at Regner Road (approximately mile 16.3), which receives eroded sediment from the predominately agricultural headwater area. During storm events, all sites except for Crystal Springs exceeded the 100 mg/l recommended DEQ instream benchmark. The markedly lower concentrations at the Crystal Springs confluence may be explained by the diluting effect of the springs' constant flow. The larger sediment quantity in the December storm is due to the intensity of the storm and absence of wet weather prior to the storm. This storm characterizes the "first flush" storm event where more sediments and pollutants are on the ground because they have not been washed away by previous storms. An intense storm following a dry period is more likely to result in greater pollutant loads than a mild storm that follows a period of wet weather.

Chart 8



Although total suspended sediment (TSS) has been monitored in Johnson Creek, it is not measured consistently over space and time. In addition, TSS monitoring results are difficult to interpret because the concentration of sediment in a sample is affected by the frequency and duration of storm events, and the intensity of different land use activities at the time samples are taken. Nonetheless, TSS and its relationship to surrounding land use activities are important to understand. TSS data assists in evaluating if erosion control standards are reducing sediment input to the creek. These data also aid the development of required management strategies to improve water quality in agricultural and urban settings (Senate Bill 1010 and the Department of Environmental Quality's TMDL process—see Supporting Programs section).

Pesticides

The most significant threat posed by pesticides and toxins to aquatic life is acute, direct spills into waterways. However infrequent, these spills can kill hundreds of juvenile salmon instantly. In Johnson Creek, the Oregon Department of Fish and Wildlife recorded 22 reports of fish kills in the 16-year period between 1972 and 1988. Only four of the sources for the kills were identified.

Even in small concentrations, pesticides may be harmful to aquatic organisms. Laboratory studies on the rainbow trout and fathead minnow have shown that low concentrations of certain pesticides can inhibit swimming, schooling and alter sex differentiation during development. Some pesticides such as DDT accumulate in tissues and spread throughout aquatic food chains. Many pesticides are highly water soluble, and will percolate down into ground water. Others will attach to sediment particles until erosion transports them into streams. The long-term impacts to aquatic life caused by constant, low-level exposure to pesticides is not well documented.

The City of Portland Bureau of Environmental Services recently stopped testing for pesticides and herbicides in water due to the prevalence of non-detects at the 0.01 microgram per liter detection level (detection at lower levels becomes cost-prohibitive). Recently, two studies have been published which relate land use and pesticide concentrations in streams across the United States and in the Willamette River Basin. Johnson Creek was **not** one of the streams included in these studies.

These studies found that pesticides and herbicides are entering streams throughout the United States and in the Willamette Basin in varying concentrations. The National Water Quality Assessment (1997) found the highest concentration of contaminants in agricultural and urban areas. The following table summarizes the most frequently detected pesticides in the Willamette River Basin, and their toxicity to cold water fish (rainbow trout). Lethal concentrations and doses are provided to remind the reader that the quantity of substance and exposure time are the primary factors used to determine compound toxicity.

These studies also found that the amount of forested land in a basin negatively correlated with pesticide occurrence, suggesting that run-off through riparian growth or forested lands can help reduce pesticide concentrations. Considering that only 5% of the stormwater that reaches Johnson Creek has been filtered through some vegetative structure or settling pond, the creation of functional wetlands and riparian buffers near the stream channel could significantly reduce the movement of these substances into the stream.

The new pesticide reporting law passed in 1999 will provide geographic based information on the agricultural and residential use of pesticides (the reporting is to start January 2002 by the Oregon Department of Agriculture). Information on the quantities, types and spatial applications of pesticides can be correlated with sediment, and ground and surface water assessments. This information will greatly improve our understanding of how different land use practices influence the movement of pesticides through local environments, and help evaluate best management practices to control the dispersion of these compounds.

Table 11. **Herbicides detected in the Willamette Basin**

Most frequently detected compounds found in Willamette Basin study ‡	Percent of samples compound detected	Detection limit (micrograms per liter)	Maximum found (micrograms per liter)	EPA pesticide risk assessment (rainbow trout)	Lethal Concentration ‡ ‡ (LC_{50}) (micrograms per liter)	Exposure time (hours)	General use and sample trade name
atrazine and its by product	99%	.001	90.0	slightly toxic	9,900	96	Herbicide (AAtrex)
metolachlor	85%	.002	4.5	moderately toxic	2,000	96	Herbicide (Dual)
simazine	85%	.005	1.0	low toxicity	56,000	48	Herbicide (Princep)
diuron	73%	.020	29.0	moderately toxic to fish; highly toxic to aquatic invertebrates	3,500	96	Herbicide

‡ These compounds are used both in agricultural and urban settings.

‡‡ Lethal concentration is amount needed to kill 50% of tested species. In rainbow trout, a variety of sub-lethal effects can occur at levels below lethal concentrations, such as reduced growth, impaired reproduction.

Sources: 1) United States Geological Survey, Distribution of Dissolved Pesticides and Other Water Quality Constituents in Small Streams, and their Relation to Land Use in the Willamette River Basin, USGS, Oregon, 1997.

2) EXTONET http://ace.orst.edu/info/extoxnet/ghindex.html

3) United States Geological Survey, Pesticides Detected in Urban Streams During Rainstorms and Relations to Retail Sales of Pesticides in King County, Washington, 1999.

Assessment of the effects of these compounds on salmon is hampered by several factors. These include:

- Most studies of the effects of pesticides are performed in the laboratory on rainbow trout and fathead minnow. Few studies have been carried out on salmon species other than the resident rainbow trout, or on the food sources upon which they depend. Pesticides may most pervasively impact salmon indirectly through their food chain.
- Interactive and cumulative effects of compounds are rarely considered in laboratory studies.

Although a recent study reported that pesticides were a factor in salmon decline in the region (Oregon Pesticide Network, *Diminishing Returns: Salmon Decline and Pesticides*, 1998) there appears to be no conclusive evidence that chronic pesticide use is a causative factor of salmon decline in Johnson Creek. This is not to say pesticides pose no risks to salmon, or that salmon do not have contact with pesticides in Johnson Creek. As noted previously, pesticides may bind to soil particles that settle in the stream channel, and acute pesticide spills could kill fish immediately.

The substantiating scientific evidence that supports pesticide risk assessments is hotly debated. On one side of the issue are those that feel assessments are too stringent. Others believe the assessments have not gone far enough in addressing all the possible impacts. Continued research around the effects of pesticides and salmon, ongoing efforts to reduce pesticide use, and education and regulations around their application, will continue to play an important role in overall water quality. Sediment samples may also tell more about pesticides in particular, and pollutants in general. This is because many compounds are "hydrophobic" and will attach themselves to soil particles before entering the water. Sediment studies are lacking in the Johnson Creek watershed.

Other toxins entering the creek

Finally, the prevention of acute, toxic spills into the creek plays a significant role in salmon recovery. Often overlooked, but potentially lethal to juvenile salmon, are acute flushes of chlorine, heavy metals, or motor oil that enter the creek through storm drains or is purposefully, and illegally "hosed-in." For example, the draining of swimming pools and hot tubs into the sewer system delivers toxic chlorine to the stream. During flood events, waters rushes through auto-yards, parking lots and backyards, and carries debris, household chemicals and industrial materials to the creek. Public education is key to eliminating the damaging effects of toxins entering storm drains, and left exposed on properties.

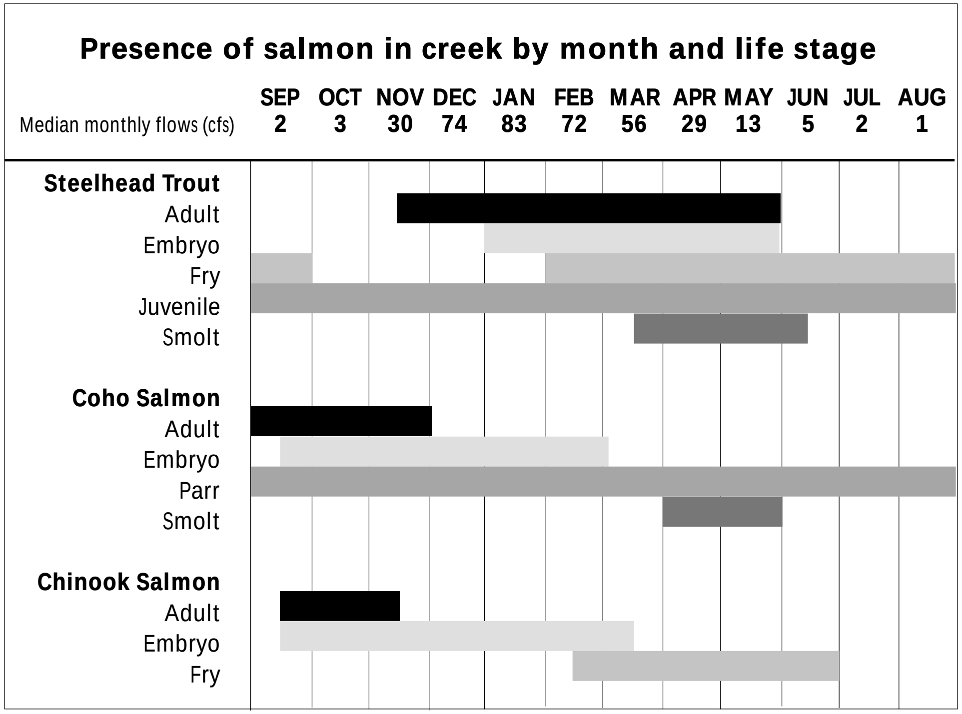
Water quantity (flow)

One of the most important environmental adaptations salmon make is life cycles that correspond to the specific flow patterns of their natal stream. The watershed has undergone continual hydrologic change in the past 100 years. Since only a remnant of the original wild salmon may exist in Johnson Creek today, it is difficult to know how well the salmon have adapted to these changes. Indeed, correcting hydrology to correspond with what we know about salmon preferences has been noted as one of the greatest challenges to bring salmon back to our urban waters.

There are two significant problems with Johnson Creek water flow that impact salmon. These are: 1) high flows that scour the channel and flush out spawning gravels and egg nests, and 2) extremely low summer flows during rearing times that may force salmon into pools and intermittent tributaries that dry up and may ultimately strand them. Extreme low flows also result in elevated water temperatures and low dissolved oxygen.

The life stages of the salmon in relation to median monthly flows are shown in chart 9. Note that adults, particularly steelhead, are nesting and spawning at the onset of winter storms which deliver scouring flows to the stream. In the summer months, when flows are lowest, juvenile steelhead and coho parr are seeking cool ponds.

Chart 9



(Chart adapted from The Johnson Creek Resource Management Plan, 1995, p. 142)

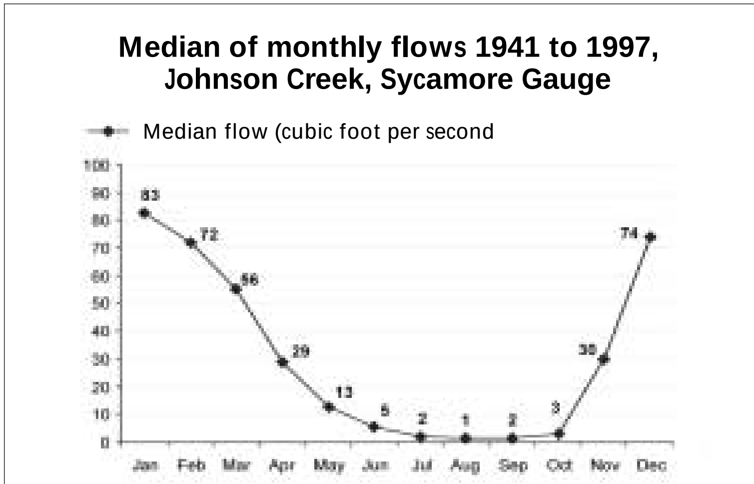
Salmon prefer slower water velocities in the winter months because swimming ability decreases with decreased water temperature. As a result, salmon will often seek marshes and wet meadows adjacent to the channel, and spaces formed between rocks along it. The amount of off-channel habitat and spaces between rocks, and in the stream beds and banks that are available to salmon in the winter months is unknown. Loss of active floodplain and riparian corridors has significantly decreased these habitats for over-wintering salmon.

Analysis of peak flow data taken at the Sycamore gauge is inconclusive as to whether peak flows have been increasing since 1941. While there appears to be an increase, peak flow also positively correlates with corresponding increases in rainfall during this period.

Peak flows

The flow in the channel increases considerably between November and March. Chart 10 shows the median monthly flows from 1941 to 1997 as measured by the Sycamore flow gauge at river mile 10.3. Flows are measured in cubic feet per second (cfs). Median monthly flow increases from 3 cfs in October, to 30 cfs in November, and peaks at 83 cfs in January. Below the gauge around river mile 8, flows quicken as a result of the creek's steep slope. The quickened flow, combined with stormwater flows to the creek, increase winter flows from this point to the confluence—probably making this section of the creek inhospitable to spawning salmon during winter storms.

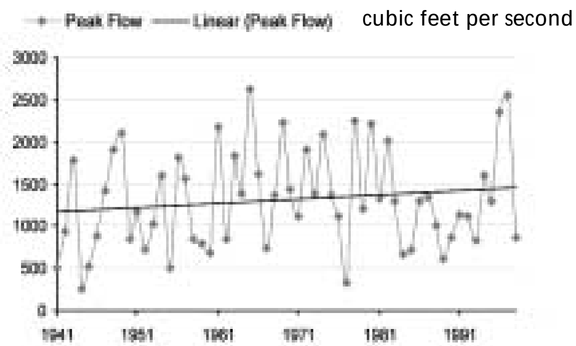
Chart 10



Source: United States Geologic Survey, Sycamore Gauge

Chart 11

Yearly peak flows at Sycamore Gauge 1941-1997, Johnson Creek, Portland, OR



Peak flow for each water year (October through September)

Source: United States Geologic Survey, Sycamore Gauge

Low flows

For salmon that spend a summer or more in the stream before migrating to the ocean, summer flow must be adequate to prevent streams from becoming excessively warm, depleting dissolved oxygen, or drying up. Ellis noted low flow as a limiting factor to steelhead in four of the five reaches he studied. (The reach where flow was not limiting was adjacent to Crystal Springs which provides a fairly constant summer flow). Ellis also associated low levels of dissolved oxygen with low flow for steelhead, coho and fall chinook. Finally, low October flows may not provide sufficient cover to the egg nests of early spawners.

Quantifying sufficient summer flows for the Johnson Creek watershed is difficult. Lacking pre-development flow information, it is difficult to know how salmon have adapted to low summer flows. It is possible the cool constant flow of Crystal Springs, and the spring fed pools adjacent to the intermittent tributaries in the upper watershed, serve as summer refuges. Since low flows increase water temperature and concentrate pollutants, increasing summer flows is a desirable strategy regardless of the number of fish refuges available upstream.

In an effort to protect summer flows for fish, the Oregon Department of Fish and Wildlife (ODFW) obtained instream water rights for Johnson Creek and Crystal Springs on April 30, 1991. The water rights apply from Reed Lake to the mouth of Crystal Springs, and from river mile 19 on the mainstem to the mouth of Johnson Creek. Because water law in Oregon is one of prior appropriation, all water rights assigned before April 30, 1991 take precedence over the ODFW right. That is, enforcement means turning-off surface water rights gained after April 1991, of which there are none. This effectively makes the ODFW flows suggestions rather than mandates. Water rights will be discussed more fully in the following Supporting Programs section.

Table 12 shows the number and percent of times ODFW instream rights were not met, as measured at the three gauges in Johnson Creek.

Of particular note are the months of July, August and September when average daily flows did not meet the instream requirement for the Regner Road and Sycamore gauges. The newly installed Regner Road gauge near Gresham, operational only since late February 1998, did not meet instream flow at all in August 1998, and only 10% in September 1998. Daily data from the Sycamore gauge show that summer instream flows are met more often than at the upstream Regner gauge, but flows from April 30, 1991 through September 1998 did not meet the instream standards 31% of the time (838 out of 2,711 days). The Milport gauge expectedly shows the lowest percentage of unmet instream flows. This is because the gauge is close to the mouth of Crystal Springs, which contributes approximately 16 cfs towards this gauge. This is important to note because the Oregon Water Rights Division measures compliance to the Johnson Creek

Table 12. **Percent of days average daily flow failed to meet minimum instream requirements between April 30, 1991 and September 30, 1998**

		DOWNSTREAM →		
Minimum flow to be maintained in cubic feet per second (ODFW standard)	Month	River mile 16.3 Regner Road Gauge operational since 2/26/98	River mile 10.3 Sycamore Gauge operational since 10/1/1940	River mile 0.6 Milport Gauge operational since 4/22/98
25	January	no data	3%	---
25	February	---	20%	3%
25	March	26%	20%	---
24	April	73%	28%	---
10	May	16%	27%	---
5	June	13%	24%	---
4	**July**	**81%**	**58%**	**---**
3	**August**	**100%**	**75%**	**---**
2	**September**	**90%**	**47%**	**---**
2	October	no data	30%	---
9	November	no data	19%	---
25	December	no data	8%	5%

instream right at the Milport gauge. Measurement at river mile 0.6 is a poor indicator of upstream summer flows because, as the data show, flows are lower upstream of this gauge.

Groundwater

Little is known about groundwater interaction with stream channel flow, although the United States Geological Survey is currently undertaking a study concerning groundwater and stream interaction in the watershed. The increasing amount of surface water that is diverted to sumps or disconnected septic systems raises concerns about the concentration and movement of pollutants in groundwater. Groundwater studies have shown that pollutants from leaking septic systems in the watershed have contributed to polluted groundwater flows to the Columbia Slough, a watershed adjacent to Johnson Creek in the north. The Oregon Department of Environmental Quality is also concerned about pollutants that enter groundwater from infiltration through sumps. According to a recent analysis by Portland Bureau of Environmental Services, at least 21% of the Portland area-watershed runoff is infiltrated by underground sumps.

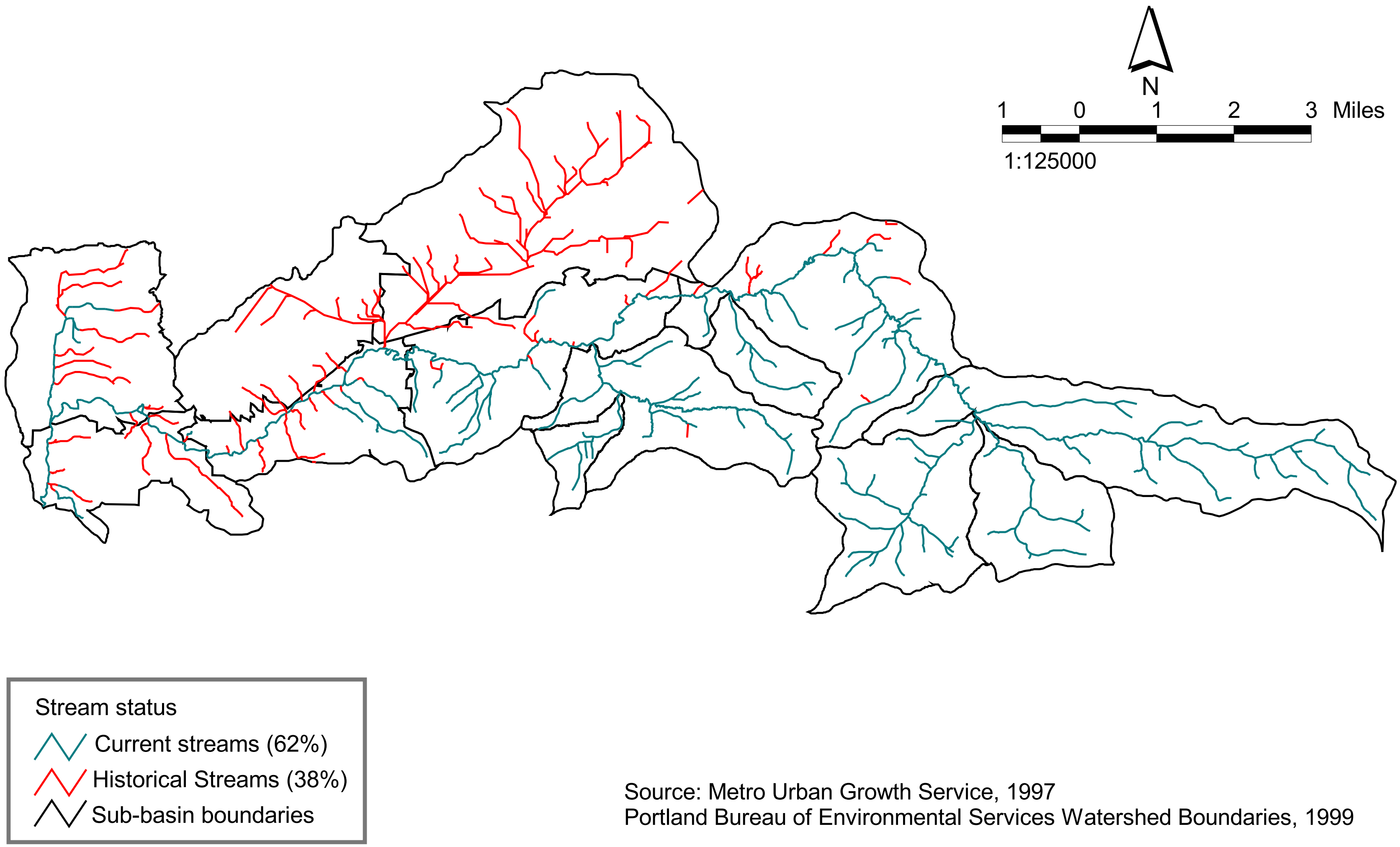
Condition 2: The Stream Channel and its Habitat, including Passage

Stream Components

Components of the stream include meanders, pools, runs, riffles and the composition of the stream bed (substrate). These components provide areas for feeding, breeding and cover for a wide variety of stream organisms. Pools provide deep, cool water for resting, and protection from high winter flows. Riffles provide shallow, swift moving water that facilitates movement throughout the creek and provides feeding areas. Changes to the stream caused by development in the floodplain, small water impoundments, removal of trees, and the straightening of the channel greatly modify these stream components. These activities alter the depth and rate at which water flows through the system, reduce the number of pools and habitat niches, and impede nutrient cycling.

Johnson Creek has undergone significant changes since settlement. Development in floodplains and along banks, flood control practices, and transportation networks have resulted in removal of streamside vegetation and loss of active tributaries. In 1998, Metro mapped historical streams in the Portland Metropolitan area. Stream sections that had been piped or filled were identified. The Johnson Creek portion of Metro's *Disappearing Streams* map, illustrates the loss of active streams, and hence fish habitat loss, in the watershed. According to Metro's estimates, 38% of the historic stream network of Johnson Creek has been filled or piped.

Stream sections lost to development in Johnson Creek



Source: Metro Urban Growth Service, 1997
Portland Bureau of Environmental Services Watershed Boundaries, 1999

Segments of banks have been disconnected from their floodplains, straightened, and lined with rock or riprap. In addition to directly destroying habitat, these changes prevent the lateral movement of water and concentrate its flow to the deepest part of the streambed. Hence, high flows erode away stream banks and beds, and wash out gravel, large woody debris, and nutrients utilized by fish and the organisms they feed upon. In areas where the stream bed is lined with rock, the *hyporheic* zone— the sections of the stream bed and banks involved with the production and exchange of nutrients to the water— is essentially eliminated. Changes to the physical structure of Johnson Creek have undoubtedly diminished salmon populations.

Until recently, there has not been a thorough, complete mapping, or hydrologic and habitat assessment of Johnson Creek. The Oregon Department of Fish and Wildlife is currently completing a comprehensive assessment of hydrologic components in the creek. This assessment will provide valuable information to understanding the physical processes forming the channel and its components, and guide future in-stream fish enhancements.

Large woody debris

The importance of fallen limbs, root wads and other vegetative debris in the stream channel has received increasing recognition. Indeed, large woody debris has been identified as playing a key role in sustaining salmon habitat throughout the year. The obstructions posed by woody debris causes water to carve pools and side channels, hence providing and protecting pools and off-channel areas for juvenile rearing. Benefits of woody debris also include:

- Streambed stabilization
- Contributions to instream food webs through decomposition and provision of habitat for aquatic invertebrates
- Capture and storage of sediments and organic materials, including spawning gravels
- Provides salmon places of refuge from high flows and predators

In his assessment of potential salmon habitat improvements for Johnson Creek, Ellis doubted that large quantities of woody debris would be an acceptable habitat improvement strategy because of the perception of possible flooding impacts. Woody obstructions in the channel are often viewed by neighboring residents as a flood threat. While this may be a reasonable concern if woody debris is placed through the mid-section of the stream channel, careful placement of woody debris in upper tributaries and back channel areas is a good strategy to create backwater areas for spawning and rearing. Woody debris may be placed near public lands and in areas where excess water would not encroach on the stream channel or human improvements.

Substrate and sediment

The bottom of the streambed is composed of organic and mineral (rock) materials. Its composition and structure provide several functions. Substrate contributes to nutrient exchange and habitat for aquatic organisms, and contains the gravel that supports spawning, and embryo development and protection. The hydrologic conditions creating this streambed of large rock, substrate, and fine sediments are complex.

High winter flows tend to wash out spawning gravels. In Johnson Creek, Ellis observed both the lack of suitably sized gravel for spawning, and high concentration of fines (sediment) in spawning gravels that did exist. The latter is sometimes less of a problem because salmon flush-out sediments through the act of spawning. Nonetheless, consistent sediment input fills in spawning gravel after eggs are laid, hence smothering embryos and preventing their emergence as free swimming fry. Sediments entering the stream in the summer, during low flows, have a greater potential to settle in pools, gravels and backwater channels, hence filling these areas and making them unsuitable to salmon and steelhead. The amount of fine sediment that renders streams unproductive to spawning and embryo development is unknown, and dependent on the unique flow patterns of the stream itself.

Floodplains and wetlands

Development on areas adjacent to the stream channel has largely diminished off-channel habitat for rearing juvenile salmon. Floodplains are lowland areas that border the stream, and receive water when flows exceed the channel bank. As such, floodplains usually contain nutrient-rich deposits of soil and plant material, and play an important role in the redistribution of nutrients and plant material throughout the stream system. Wetlands are typically transitional areas between upland and stream systems, and contain plant and animal communities unique to areas of surplus water. Wetlands may or may not be contained within, or adjacent to the floodplain.

The importance of floodplains and wetlands to salmon in particular, and watersheds in general, is well documented. Wetlands and floodplains, and their associated vegetation, enhance water quality, regulate peak flows, provide shaded, off-channel juvenile rearing habitat, and contribute to nutrient cycling. Unfortunately, their level topography and rich soils have made these areas highly desired for building and agriculture.

Projects to recover the function of the floodplain are gaining popularity. Most notable is the Brookside Project at 110th and Foster Road in Johnson Creek. Recreating functional wetlands may help to mitigate flooding while providing habitat, although Kentula has observed from her research of compensatory wetland mitigation in Oregon that created wetlands contain only a simplification of the native wetland structure and function. While protection of a native resource is preferable to reconstruction, in the Johnson Creek watershed most, if not all, of native wetlands have been filled. This means constructed wetlands are the only option to attaining this vital resource.

Streamside vegetation and habitat corridors

While floodplains provide the connection between the stream channel and upland areas, it is the vegetation alongside the stream channel that extends onto the floodplain which provides many of the benefits associated with floodplains and wetlands. This vegetation belongs to the larger riverside ecosystem of rock, groundwater, insects, reptiles, mammals, and birds called the *riparium*. Significant loss of riparian corridors, or buffers, is a common problem for both urban and rural streams. The loss of important functions associated with riparian corridors has long been noted, and riparian widths have been both suggested and required for specific land-use practices.

A review of the literature explicitly outlining the beneficial functions of riparian buffers is too exhaustive for this report. As part of incorporation of water and wildlife quality, and flood mitigation objectives into Title 3 of the Regional Functional Plan, Metro and the City of Portland Bureau of Planning have published separate scientific literature reviews regarding the benefits of riparian buffers. In short, these reviews demonstrate that riparian buffers provide the following benefits to salmon:

- Determine the structure of the stream channel
- Provide areas of refuge
- Stabilize stream banks
- Provide shade which helps regulate stream temperature
- Filter sediments and pollutants
- Regulate flow by holding water in the rainy season and discharging water in drier months
- Provide and cycle organic nutrients used by aquatic organisms
- Contribute large woody debris to the stream

The two primary dimensions of riparian corridors are quantity and quality. That is, their size and plant-species composition. Regulations regarding riparian buffers focus primarily on size. Riparian resources are protected through specific width, or buffer, requirements. To comply with Statewide Planning Goals, Metro has recommended riparian corridor widths to protect water quality and mitigate flood damage. The width is determined by the size of the drainage basin and bank slope. Local jurisdictions are required to adopt the principles of the model ordinance, called Title 3, by the end of 1999. The buffers do not apply to land outside Metro's jurisdiction. It is important to remember that the buffer requirement does not mean that riparian buffers border the entire creek system. Title 3 simply protects removal of existing riparian vegetation. For Johnson Creek, the required stream buffer for new development is 50 feet in all areas except those bordered by steep slopes (steep slopes have a 200 feet buffer requirement). Local jurisdictional compliance to Title 3 is addressed in the Supporting Programs section.

Metro is also required to incorporate fish and wildlife protection measures into Title 3 under what is commonly called Goal 5. Metro has recently completed its first analysis on the measures needed to protect fish and wildlife resources near stream environments. One of these measures is streamside buffer widths. For Johnson Creek, Metro has suggested protection widths of the streambank that range from 200 feet in the headwater areas to the 100-year floodplain demarcation in the lower sections of the stream, whichever is greatest. Metro has presented several enforcement scenarios for these requirements, and expects to finalize its recommendations in the summer of 2000.

The width of riparian buffer necessary to protect water and wildlife resources is a hotly debated topic. Considerations for determining buffer widths include surrounding land-uses (pollutant and sediment loads), stream-channel configuration (flooding potential), and wildlife resources (functional value to salmon and other fish/wildlife). Further, although the direct influence of riparian vegetation on the stream (such as shading) decreases with increased distance from the stream, the number of ecological functions provided by riparian vegetation increases with its width. To maintain the array of ecological functions riparian vegetation provides for salmon, buffers of at least 230 feet (70 meters) have been recommended in the scientific literature. While these buffer-width recommendations may soundly protect existing, functioning resources, it is difficult to establish setback widths needed to protect and restore streambanks that currently lack vegetation.

Re-establishing a connective corridor along Johnson Creek and its tributaries involves not only protection of existing resources, but restoration of degraded riparian areas. Map 10 shows the preliminary results of aerial photography interpretation of riparian vegetation along Johnson Creek and its tributaries. The assessment found that only 7% of active stream segments (calculated in linear feet) contain riparian corridor that extends well beyond the adjacent stream channel. Thirty-two percent of the segments contained little or no riparian vegetation. These areas are predominant in the lower sections of the watershed where homes and apartment buildings backup to the creek, as well as the headwater area where agricultural lands extend to the creek. Given the high percentage of stream miles that lack riparian vegetation and the pressures that accompany urban and agricultural land uses, restoring the full array of ecological functions to many of these degraded areas is highly improbable. Nonetheless, the primary objective of restoration should be the creation or protection of ecological functions, rather than simply the number of trees planted or acres "restored."

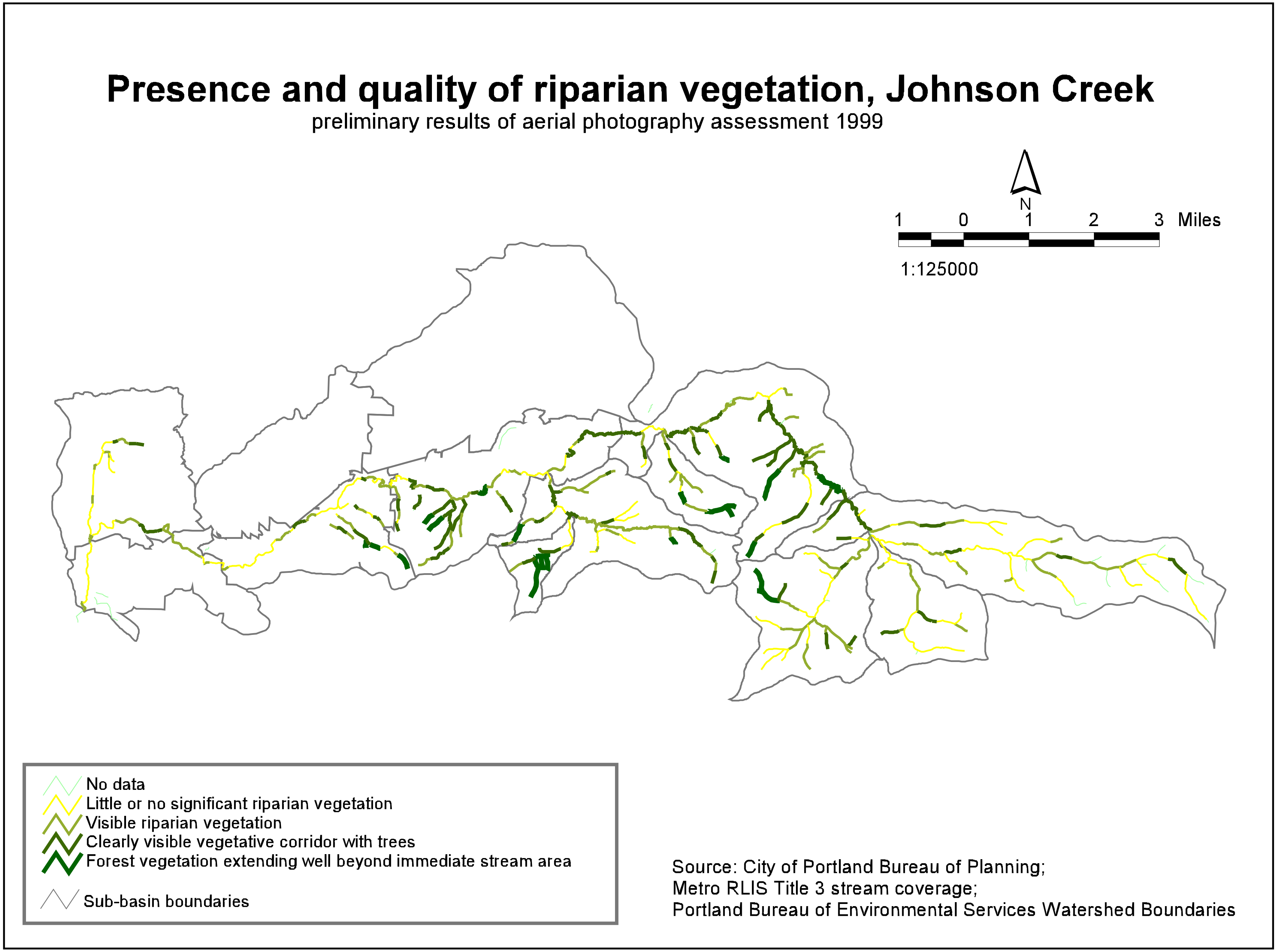
Another recent interpretation of aerial photography of the mainstem of Johnson and Kelley Creeks estimated that 136,950 linear feet (about 26 miles) of private streamside property either completely lacked, or contained degraded, riparian vegetation (e.g. mowed turf, undeveloped canopy, and predominance of invasive species such as Himalayan blackberry). This represents roughly 43% of stream banks on the Johnson Creek mainstem and 22% of Kelley Creek's stream banks. Multiplying these linear feet by a 50-foot buffer yields a significant 157 acres of potential riparian area. Incentives for landowners to protect and restore riparian habitat, and the challenges of habitat restoration, will be discussed in the Supporting Programs section.

Barriers to Passage

Movement of salmon throughout the watershed is necessary to their life cycle needs. These include:

- Upstream access to spawning areas.
- Migration throughout the stream network necessary to find areas of rest, cover from predators, and to adjust to changes in stream flow and temperature.
- Continuity of sub-populations adapted to stream conditions. Disruptions in the stream network may fragment a population by preventing upstream or downstream migration, hence resulting in the loss of that sub-population.

Although fish blockage usually conjures images of hydroelectric dams, road culverts have substantially impacted the migration of fish populations. In the Johnson Creek watershed, culverts pose a significant blockage to migrating salmon and steelhead. Culverts block passage in a number of ways. The slope of the culvert may be so excessive that the velocity of water passing through is accelerated at a speed that hinders upstream migration. Or the bottom of the culvert may not provide enough "roughness" to create eddies in the flow, hence creating a sheet-flow of water that fish cannot swim against. Or the streambed may erode away underneath the culvert at its upstream or downstream end. Generally, culverts that rest a foot above the water surface are considered impassable by fish. Culverts that rest closer to the water surface but open out to shallow substrate may also be considered impassable.



Presence and quality of riparian vegetation, Johnson Creek
preliminary results of aerial photography assessment 1999
N
1 0 1 2 3 Miles
1:125000
No data
Little or no significant riparian vegetation
Visible riparian vegetation
Clearly visible vegetative corridor with trees
Forest vegetation extending well beyond immediate stream area
Sub-basin boundaries
Source: City of Portland Bureau of Planning;
Metro RLIS Title 3 stream coverage;
Portland Bureau of Environmental Services Watershed Boundaries

The Oregon Department of Fish and Wildlife has developed a protocol for assessing culverts for fish passage. It has been used to develop inventories of impassable culverts by ownership (that is, those culverts on roads maintained by Oregon, Multnomah and Clackamas counties, and Portland and Gresham.) A map of culverts with fish passage problems, based on preliminary results from several culvert surveys, is presented in the Supporting Programs section.

The costs of culvert replacement are huge. The Oregon Department of Transportation spent $4 million dollars retrofitting 55 culverts on state owned highways in 1998 and 1999. The agency estimates it costs approximately $150,000 to retrofit one culvert. The cost to replace a culvert is much higher. For example, an impassable city-owned culvert in need of replacement at the intersection of Foster Road and 162nd Avenue is expected to cost the City of Portland $600,000.

Without upstream access to spawning and rearing areas, the regenerative potential of salmon throughout the Johnson Creek stream network is limited. Identifying and replacing culverts that most impede access to valuable habitat is critical. This means that before culvert removal is considered, key habitat areas for steelhead, coho and sea-run cutthroat must also be identified. In addition, the degree to which passage is impeded must also be assessed. For example, several culverts in Crystal Springs have been assessed as impassable, yet recent fish surveys have found chinook and coho above some of these culverts. Finally, the sequence of culverts by ownership must be considered so that resources aren't spent "opening-up" a culvert that is above an impassable culvert.

There also exist many culverts on private roads and several small dams in the upper tributaries of the watershed. Most recently, an abandoned road has been discovered that crosses the creek and impedes salmon passage above 242nd street (Metro has initiated a grant proposal to remove this obstruction). Since it is presumed most or all of these dams are on private property, requiring the removal of these water detentions will be difficult unless redevelopment forces environmental review during the permitting process.

Table 13. **Live fish and egg releases into Johnson Creek and Crystal Springs, 1978 through June 1999**

Water Body	Species	Live fish *	Eggs	Number of sources	Last month/ year stocked
Johnson Creek	Coho	331,611	108,506	2	June 1999
	Cutthroat (sea-run)	2,004	0	1	May 1988
	Fall Chinook	99,008	32,451	2	April 1998
	Spring Chinook	0	1,948	1	May 1998
	Winter Steelhead	33,455	51,315	2	June 1997
	Rainbow trout	35,367	0	2	May 1999
Crystal Springs	Coho	49,484	193,592	3	March 1999
	Fall Chinook	0	12,402	1	April 1998
	Spring Chinook	0	982	1	January 1997
	Winter Steelhead	35,200	135,083	4	June 1997
	Rainbow trout	3,998	0	1	May 1998

*Live fish were stocked at fry through smolt life-stages
Source: Oregon Department of Fish and Wildlife Fish Division

Condition 3: Species Interactions

Genetics

Perhaps the greatest key to salmon recovery lies within the genetic resources of the salmon themselves. Collectively their life histories comprise a diversity of ongoing adaptations to the environmental conditions of their local watersheds. This is why scientists advocate for the preservation and conservation of as many diverse, wild population segments as possible.

As noted earlier, Johnson Creek, like many rivers in the Pacific Northwest, has a long history of hatchery introductions. Based on hatchery practices in the Pacific Northwest, it is likely that salmon from other streams were released into Johnson Creek as early as the 1900's. Table 13 shows hatchery introductions since 1978.

It is difficult to assess the impact these hatchery introductions have had on Johnson Creek's native salmon populations. Generally, hatchery fish with the genetic composition best suited to the local environmental conditions of their new home are most likely to produce naturally spawning populations. Distance from the natal stream may be inversely related to the reproductive success of hatchery-reared fish. Therefore, many of these introductions may not have returned to spawn. Additionally, since the primary purpose for live fish introduction was angling, live fish introductions may have been caught before maturing. Nonetheless, all of these introductions added stress and competition for resources within the stream system.

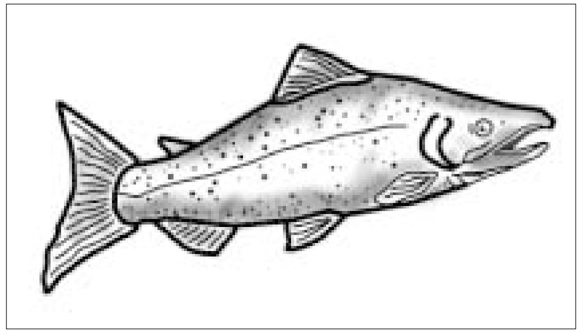
Harvest

Previous "put and take" rainbow trout stocking practices may have negatively impacted juvenile steelhead populations in Johnson Creek and Crystal Springs. A study in the Wenatchee River in Washington found that between 72% and 91% of hatchery rainbow trout were caught soon after being released into the stream. Anglers, attracted by reports of successful fishing in the river, subsequently arrived at the river after most of the hatchery fish had been caught. What was left to catch, and was caught by the anglers, were wild juvenile steelhead. The high fishing pressure, coupled with wild steelhead's aggressive reaction to lures and bait, resulted in the death of many wild juvenile steelhead.

The effect of angling on the salmon populations of Johnson Creek is unknown. In 1998 the Oregon Department of Fish and Wildlife (ODFW) discontinued stocking legal-size rainbow trout in Johnson Creek. The ODFW closed Johnson Creek to steelhead angling in 1999.

Supporting Programs, Agencies and Regulations

This section focuses on programs, agencies and regulations fundamental to salmon recovery. Also discussed, at the end of this section, are watershed monitoring and assessment, and public awareness. These elements broadly influence program direction and funding for watershed restoration and salmon recovery.



It is widely recognized that successful watershed restoration and salmon recovery depend upon the efforts of multiple and disparate government agencies, private and non-profit businesses and organizations, and citizens. Current thinking in watershed management suggests that not only do "interests" need to be coordinated, but the issues involved, such as water quality, water use and habitat concerns, need to be addressed jointly rather than separately. Considering the many agencies, programs and regulations that in some way touch watershed management issues, coordinating activities and integrating issues are challenging at best. As Kathryn Mutz of the Natural Resources Law Center observes, "the modern 'watershed movement' constitutes a broad and ambitious experiment in natural resource governance."

Table 14 provides a snapshot of the agencies, regulations and programs that influence salmon and watersheds. For simplification, programs are discussed in context of supporting elements for salmon.

Within a jurisdiction, several departments such as transportation, planning, and public works engage in activities or enforce regulations that impact stream health and salmon. And within these departments, several different programs exist that provide services such as education, code enforcement, code review, facility maintenance, monitoring and reporting. In the Johnson Creek watershed, the interagency interactions among six jurisdictions, each in some way containing this departmental layering, combined with Metro, state and federal regulations, make unified salmon recovery efforts challenging.

An assessment of Oregon's state agency efforts towards watershed and salmon restoration performed in 1999 found that agencies must act together as an enterprise to perform two key objectives—coordination of activities and development of a unified vision or goal. Coordination includes the following three elements:

- Providing each other with the support needed to address individual legal mandates
- Minimizing confusion that results from having several agencies address different and overlapping aspects of watershed management
- Reducing red tape and inefficiencies resulting from watershed health issues which cross multiple agencies

While the assessment concluded that agencies do show substantial interagency coordination (as defined by the three elements above), it concluded that there did not appear to be significant joint action or joint management towards integrating watershed management issues. The report recommends that agencies work together in prioritizing regional watershed activities and planning. Developing a coherent understanding of the environmental conditions, activities, and progress in each watershed is key to this prioritization.

Inter-jurisdictional coordination

Several Johnson Creek coordinating bodies exist. Since 1995, stormwater program managers from each of the local jurisdictions, in addition to members of the Johnson Creek Watershed Council, have formed the **Johnson Creek Inter-jurisdictional Committee**. The Inter-jurisdictional Committee provides an efficient discussion platform for watershed strategy and cooperative funding issues. The committee has taken an active role in assessing the uniformity of regulations across the jurisdictions, issues related to the City of Portland flood management strategies (including cooperative funding of the ODFW habitat assessment), planning for the annual Johnson Creek Summit, and advocating for the Johnson Creek revegetation program. As the implementing arm of policy and programs, the Inter-jurisdictional Committee also makes recommendations and responds to requests from the Johnson Creek Policymakers Committee.

The Johnson Creek Policymakers Committee is comprised of elected officials from the local jurisdictions, the Johnson Creek Watershed Council and Metro, and was an outcome of the first Johnson Creek Summit in 1998. The Committee was instrumental in formalizing a memorandum of understanding among the jurisdictions. Signed in May of 1999, the memorandum set 13 priority items for the watershed. Among these are:

- Coordinate funding to complete the revised floodplain delineation for the entire watershed.
- Adopt stream-side buffers and balance cut and fill requirements based on Title 3 regulations.
- Conduct a watershed-wide site inventory to prioritize key areas for revegetation.
- Identify key properties for public acquisition within the 100-year flood plain.

Funding for the entire floodplain remapping has not yet been secured; the jurisdictions have or are in the process of adopting Title 3 requirements (except the City of Portland which is rewriting its environmental zoning codes to meet the requirement). A partial watershed restoration inventory has been conducted by Portland's Bureau of Environmental Services Watershed Revegetation Program. Purchases of floodplain properties are limited by funding, but are in process. A list of target acquisition areas has been developed by the jurisdictions.

The Inter-jurisdictional and Policymakers Committees represent evolving coordinating bodies essential for addressing and integrating watershed management issues.

Watershed Councils

The **Johnson Creek Watershed Council** formed in 1995 and was one result of the Johnson Creek Management Plan. The council has about 65 dues paying members and an annual operating budget of approximately $65,000 (about $40,000 of that from the Oregon Watershed Enhancement Board, the rest is from local jurisdictions and dues). Its mission is to "inspire and facilitate community investment in the Johnson Creek watershed for the protection and enhancement of its natural resources." To achieve this mission, the council participates in public policy process, local natural resource technical advisory committees, watershed education and restoration projects, grant writing for watershed initiatives, and archives information about the watershed.

A cornerstone of the Oregon Plan for Salmon and Watersheds, about 94 watershed councils have formed in Oregon. The councils play many roles. The extent of these roles differs among councils depending upon the particular challenges faced in the watershed, resources available to each council, and stakeholder interactions. Because of the importance attributed to watershed councils in watershed management initiatives, there has been much discussion on measuring and assessing the effectiveness of watershed councils. A lengthy discussion of the literature and studies on watershed council effectiveness is beyond the scope of this report. Readers desiring more information on this topic should consult the following studies for more information.

Establishing Watershed Benchmarks, River Network's River Voices Vol. 8, No. 3 (Fall 1997)

Evaluation of Selected Watershed Councils in the Pacific Northwest and Northern California, Trout Unlimited and The Pacific Rivers Council (January 2000)

Arguing About Consensus: Examining the Case Against Western Watershed Initiatives and Other Collaborative Groups in Natural Resources Management, Natural Resources Law Center (January 2000)

Seeking Signs of Success, Conservation Resource Alliance (expected 2000)

The Johnson Creek Watershed Summit

The Johnson Creek Watershed Summit provides a festival-like forum for information sharing and problem solving in the watershed. Summits have been held in the fall of 1998 and 1999, with over 500 people, largely from government agencies, attending in the past two years. Initiated by U.S. Representative Earl Blumenauer, the summit convenes local elected officials, government agency personnel, businesses and residents. The summit provides an opportunity for participants to voice their concerns and share information about the changes occurring in the watershed. Although it consumes numerous staff resources in preparation, the summit is truly a unique and positive capacity building tool for the watershed community.

Table 14. **Programs influencing supporting conditions for salmon**

	RESPONSIBLE AGENCIES	REGULATION OR PROGRAM (IF APPLICABLE)
Surface Water Management	Oregon Department of Environmental Quality	Clean Water Act / NPDES permitting
Includes street drainage maintenance and development standards for on-site stormwater control (such as impervious surface limitations, detention requirements and structural design standards)	City of Portland Bureaus of Environmental Services and Transportation	Stormwater Management Program
	City of Gresham Environmental Services Department	Stormwater Management Program
	City of Milwaukie Public Works	Stormwater Management Program
	Clackamas County Water Environment Services and Department of Transportation & Development (includes Happy Valley)	Stormwater Management Program
	Multnomah County Environmental Services and Transportation Division	Stormwater Management Program
	Oregon Department of Transportation	Stormwater Management Program
Riparian Corridor Protection	Oregon Department of Land Conservation and Development	Statewide Planning Goals 5, 6, 7
	Metro	Title 3 model ordinance (buffer requirements); Goal 5 fish and wildlife habitat requirements in process
	Oregon Department of Forestry	Oregon Forest Practices Act
	City of Portland Bureau of Planning	Environmental and greenway zones
	City of Gresham Community Services Department	full Title 3 adoption expected 2000
	City of Milwaukie Planning	full Title 3 adoption expected 2000
	City of Happy Valley	Title 3 adopted
	Clackamas County Water Environment Services and Department of Transportation & Development	Title 3 adopted
	Multnomah County Environmental Services	Significant Environmental Concern areas
Natural Resource Protection	Oregon Department of Land Conservation and Development	Statewide Planning Goals 3, 5, 14
Other than riparian resources; includes wetland protection, tree ordinances, open space acquisition, and soil and water conservation practices	Oregon Division of State Lands	Removal fill regulations with compensatory wetland mitigation requirements
	Metro	Urban Growth Boundary / Regional Functional Plan / Goal 5 / Greenspaces program
	Oregon Department of Forestry	Oregon Forest Practices Act
	City of Portland Bureau of Planning	Tree protection ordinance; environmental zones
	City of Gresham Community Development	Tree protection ordinance; natural resource overlay
	City of Milwaukie Planning	Developing tree protection ordinance for private property; natural resource overlay
	City of Happy Valley Planning and Public Works	Tree protection ordinance
	Clackamas County Planning	River and stream conservation areas; conservation wetland districts
	Multnomah County Environmental Services	Rural area management plans, areas of Significant Environmental Concern
	East Multnomah County Soil and Water Conservation District	Fiscal agent for some conservation grants; soil and water education and technical assistance

	RESPONSIBLE AGENCIES	REGULATION OR PROGRAM (IF APPLICABLE)
Flood Plain Management	Federal Emergency Management Agency (with local jurisdictions and Army Corp of Engineers)	periodic remapping and approval of floodplain delineation; FEMA also subsidizes flood insurance premiums and grants funds for flood-prone property acquisition
	Oregon Department of Land Conservation and Development	Statewide Planning Goal 7
	Division of State Lands	Removal Fill Program
	Metro	Title 3 model ordinance (balanced cut and fill)
	City of Portland Office of Planning and Development Review	structural requirements for building in floodplain adoption of Title 3 balanced cut and fill
	City of Gresham Community Development	structural requirements for building in floodplain adoption of Title 3 balanced cut and fill
	City of Milwaukie Planning	structural requirements for building in floodplain Title 3 balanced cut and fill (adoption in 2000)
	Multnomah County Department of Environmental Services	structural requirements for building in floodplain balanced cut and fill
	Clackamas County Water Environment Services and Department of Transportation & Development	structural requirements for building in floodplain Title 3 balanced cut and fill
	Happy Valley Building Requirements	structural requirements for building in floodplain Title 3 balanced cut and fill
	City of Portland Willing Seller Land Acquisition Program (Portland Parks and Bureau of Environmental Services with Metro)	acquires lands subject to repeated flooding
Water Quality Protection and Improvement *Includes erosion control ordinances and illicit discharge control*	Oregon Department of Environmental Quality	Water quality standards / TMDL development / NPDES permitting / Industrial and construction discharge permits
	Oregon Department of Agriculture	Senate Bill 1010—Agricultural water quality management plan development
	Oregon Department of Forestry	Oregon Forest Practices Act
	City of Portland Bureau of Environmental Services	Stormwater Management Program
	City of Portland Office of Planning and Development Review	Erosion control ordinance
	City of Gresham Environmental Services Department	Stormwater Management Program and erosion control ordinance
	City of Milwaukie Public Works	Stormwater Management Program and erosion control program
	Clackamas County Water Environment Services (includes Happy Valley also)	Stormwater Management Program and erosion control ordinance
	Multnomah County Environmental Services	Stormwater Management Program and erosion control ordinance

Table 14. **Programs influencing supporting conditions for salmon** *(continued)*

Pesticide Application and Tracking	**RESPONSIBLE AGENCIES**	**REGULATION OR PROGRAM (IF APPLICABLE)**
	Oregon Department of Agriculture Oregon Department of Transportation Local jurisdiction parks and roads departments	Pesticide applicator permits and new pesticide tracking law Pesticide application on or near roads Management programs for pesticide application on park lands such as City of Portland Parks' Integrated Pest Management program
Surface water (instream) and groundwater extraction	Oregon Water Resources Division	Oregon Water Law
Fisheries harvest and supplementation management	Oregon Department of Fish and Wildlife	Oregon Sport Fishing regulations Fish propagation program
Fish habitat and streambank restoration *Generally restoration involves obtaining project funding, technical and materials coordination, and all applicable permits.*	Army Corp of Engineers Oregon Division of State Lands Oregon Department of Fish and Wildlife Local jurisdiction land-use review and permitting property owner National Marine Fisheries Service / US Fish and Wildlife Service Funding agencies Volunteer environmental, conservation or other friends group Oregon Watershed Enhancement Board Local jurisdictions environment service departments	permitting permitting / instream work window project approval, if ODFW funds involved permitting permission to be on site Endangered Species Act consultation, if federal connection exists restoration guidance and project tracking technical assistance, help with land acquisition
Fish passage	Oregon Department of Fish and Wildlife Oregon Department of Transportation City of Portland Transportation Office City of Gresham Environmental Services City of Milwaukie Public Works Multnomah County Environmental Services Clackamas County Transportation Dept. and Water Environment Services	ORS 498.351 and 509.605 requires the ODFW Director to conduct periodic passage assessments of dams or artificial obstructions. The Director may notify the owner "to provide free passage within a reasonable time." Placement, repair and maintenance of culverts

	RESPONSIBLE AGENCIES	REGULATION OR PROGRAM (IF APPLICABLE)
Instream monitoring	Oregon Department of Environmental Quality	water quality monitoring
	Oregon Water Resources Division	flow and temperature monitoring
	United States Geologic Survey	flow and temperature monitoring
	Oregon Department of Fish and Wildlife	Aquatic Inventories Project (current stream channel inventory and assessment); periodic fish inventories
	City of Portland Bureau of Environmental Services	water quality monitoring
	City of Gresham Environmental Services Department	water quality monitoring
	Portland State University with City of Portland Bureau of Environmental Services	Prototype of multi-metric index using biological monitoring
	All jurisdictions contributed to recent habitat and channels assessment performed by ODFW	
Monitoring (other than instream)	Cities of Portland, Gresham and Milwaukie, Multnomah and Clackamas counties	Monitoring related to NPDES permit. Includes selected stormwater outfall and BMP monitoring.
	United States Geological Survey	Groundwater and stream interaction study, see http://oregon.usgs.gov/projs_dir/or175/htmls_dir/background.html

	NAME	STATUS
Coordinating intergovernmental bodies	Metro - Water Resources Policy Advisory Committee (WRPAC)	meets monthly
	Johnson Creek Inter-jurisdictional Committee	meets monthly
	Johnson Creek Policy Makers Committee	meets quarterly (steering committee meets monthly)
	Department of Environmental Quality (TMDL development)	Willamette Basin coordinator hired January 2000
	East Multnomah Soil and Water Conservation District (Healthy Streams Initiative / SB 1010)	Group to initiate Agricultural Water Quality Management Plan not yet formed
Watershed Council	Johnson Creek Watershed Council	Meets monthly

Condition 1: WATER

Water is the life substance of salmon. Programs, activities and regulations that influence water quality, water temperature, and water quantity, are discussed below.

Water Quality

The federal Clean Water Act (CWA) is the primary mechanism for water quality protection and improvement in the United States. In Oregon, the CWA is administered through the Oregon Department of Environmental Quality (DEQ). Two regulatory programs under the CWA apply to Johnson Creek. One is water quality limitations, or 303D listings, that identify specific water quality parameters that do not meet designated uses for Johnson Creek. These limitations apply to the entire mainstem of Johnson Creek—in both agricultural and urban areas. The second regulatory program applies to stormwater management, which is primarily an urban issue.

As outlined below, the entire mainstem of Johnson Creek is considered water quality limited by three parameters that affect four designated uses.

Table 15. **303D listed parameters**

Parameter (303D water quality limitation)	Designated Use*
Temperature (summer)	Resident fish and aquatic life; salmon spawning and rearing
Toxics (DDT and Dieldrin)	Resident fish and aquatic life; drinking water‡
Bacteria (fecal coliform and e.coli)	Water contact recreation‡‡

*Designated uses may apply to specific times of year.

‡ With adequate pretreatment; Johnson Creek is not currently used as a drinking water source

‡‡ Bacterial contamination is not discussed in this report because its concentrations have not been noted as a factor limiting salmon spawning and rearing. However, huge concentrations of fecal matter require dissolved oxygen to decompose, hence limiting dissolved oxygen required by aquatic organisms.

The steps taken to improve a 303D listed stream include characterizing thresholds for each pollutant of concern, and developing management plans to improve water quality. These thresholds and plans are known as Total Maximum Daily Loads, or TMDL's. Generally, these plans identify pollution sources, determine reductions necessary to improve water quality, and assign responsibility for needed actions. All jurisdictions are directed to work together with the Johnson Creek Watershed Council to develop and implement the plans.

The TMDL process has been criticized for consuming funds and staff time over a limited set of chemical quality parameters, such as phosphorous, rather than considering broader biological parameters, such as habitat and species diversity. Recognizing this, the DEQ has developed measures and models that extend beyond a direct chemical measurement. For example, the DEQ has developed a heat source model for temperature that considers the amount of shade a stream receives as a factor in water temperature. The use of biological indicators in the TMDL process, such as the quantity and diversity of fish or insects in a stream, may further assist in monitoring water quality more comprehensively.

The Oregon DEQ is responsible for prioritizing water bodies for TMDL development, and setting the TMDL's. This schedule is reviewed every two years. DEQ set a completion TMDL target date of 2003 for all 303D listed streams in the Willamette basin, although the TMDL process for Johnson Creek has yet to begin. Considering the endangered species listings throughout this basin, prioritizing the TMDL process for Johnson Creek would greatly assist in coordinating local jurisdictions' programs and activities around similar objectives, and incorporate biological considerations into the process.

Water quality in agricultural areas

A significant portion of the upper Johnson Creek watershed is utilized for agriculture. Since farm and ranching operations are not licensed with the Oregon Department of Agriculture, a proxy for the intensity of agricultural use in the watershed is shown on map 11. Here, currently licensed nursery, greenhouse, and Christmas tree growing operations are shown to illustrate the intensity of agriculture in the upper watershed.

The Oregon Department of Agriculture (ODA) is responsible for working with landowners to develop water quality management plans for agricultural lands. This agricultural component of water quality improvement is authorized under Senate Bill 1010 (a result of the 1996 Healthy Streams Initiative), and implemented according to Management Areas designated by ODA. As of 1999, a group had not formed in the Lower Willamette Management Area (which includes the Johnson Creek watershed) to begin the development process of an agricultural water quality management plan. The original agreement designated all 303D listed stream segments to have completed management plans by July 2001; it is unlikely Johnson Creek will have a plan in place by then. The East Multnomah Soil and Water Conservation District has been identified as the coordinating body for the SB 1010 agricultural plan.

The goal of SB 1010 is to educate agricultural landowners about the impacts of their activities on water quality, and offer suggestions and expertise on installing best management practices to reduce those impacts. It is a fairly weak statute since it is based primarily on volunteer compliance. Once a plan is developed in an Agricultural Water Quality Management Area, the Oregon Department of Agriculture has the authority to fine a farmer or rancher for non-compliance with the water quality plan. Since these management plans are very new, it is unknown how strongly the ODA will pursue suspected violations, or how many complaints will be filed. The *Healthy Streams Agreement* outlines a process for implementing enforcement of SB 1010. This process includes a $200 non-refundable complaint-filing fee that may discourage reporting of suspected violations to ODA, although the ODA has not included this language in any of its Agricultural Water Quality Management plans.

Although SB 1010 does not direct funds to improve water quality on specific lands, it does direct Oregon Department of Agriculture personnel to assist landowners in pursuing funds from the National Resource Conservation Department, Soil and Water Conservation Districts, and others. Funding from grant programs is discussed below under Habitat.

According to the SB 1010 Water Quality Coordinator for Washington County who helped develop the Tualatin River Sub-basin Plan—the first Water Quality Management Area Plan in the state— the SB 1010 process shows some early signs of success. The plan has been helpful in educating farmers and ranchers on topics including erosion, riparian stream management, irrigation return to stream, and manure management. And although twenty-five water quality problems were observed or reported in the past year, these problems were resolved before penalties were assessed. Nonetheless, it may be too early to judge how well complaints will be processed and reconciled as more agricultural operations are recognized and brought into the process.

Development of the management plan consumes much volunteer effort and time, and funds are limited to implement plan objectives. The Tualatin River Sub-basin Group received a $100,000 grant over three years from EPA to assist in program implementation (such as development and distribution of educational materials). As this was the first plan developed there was no competition for those funds. Future groups may not have access to this magnitude of funds.

Water quality in urban areas

The second regulated water quality concern is pollutants that enter the creek through stormwater systems. In Johnson Creek, stormwater that is not captured and processed by vegetation (primarily the urban tree canopy) or absorbed by the soil either drains to underground sumps, flows overland or through pipes into Johnson Creek, or is diverted to the combined sanitary sewer system (which occasionally overflows to the Willamette River).

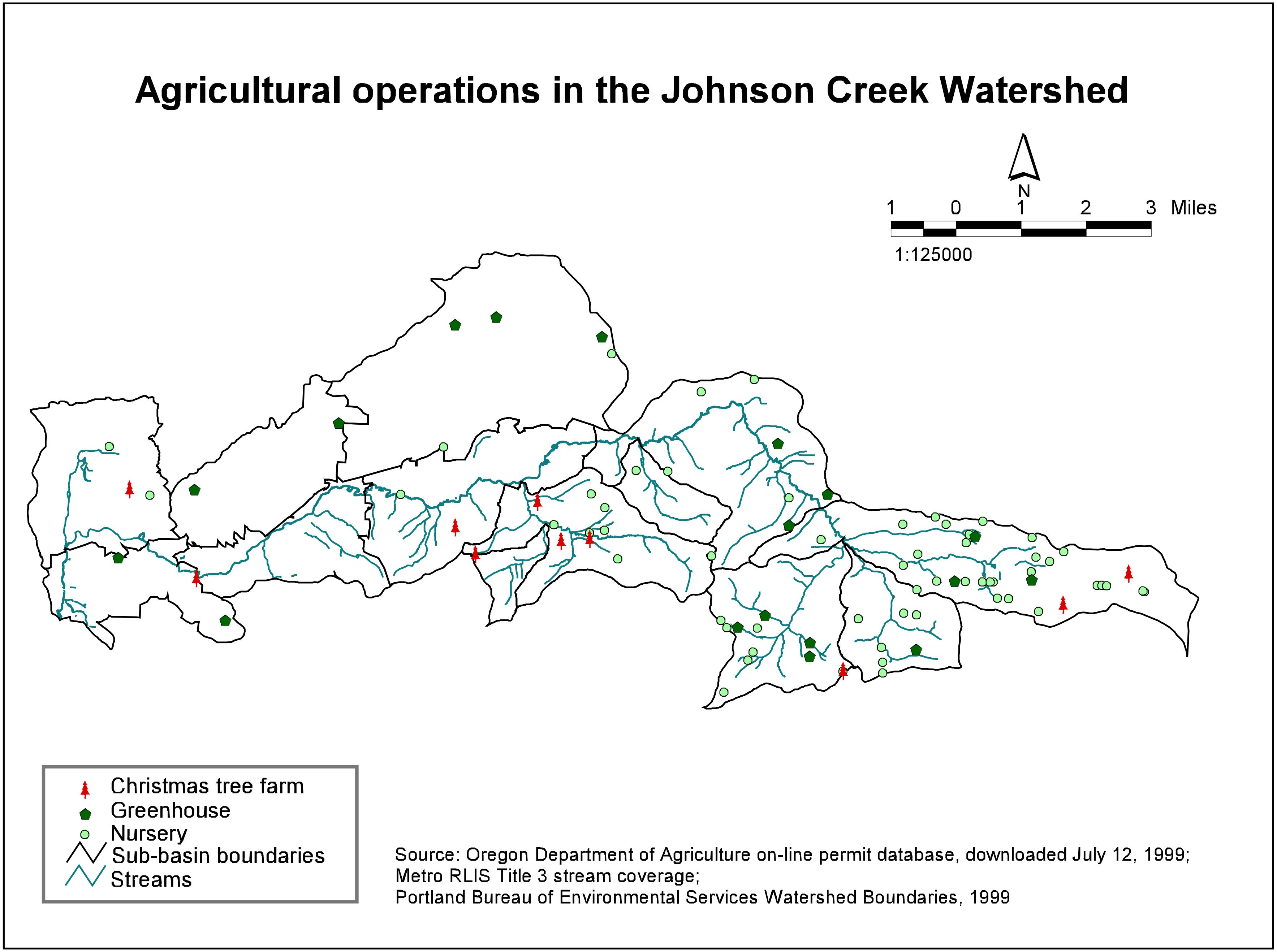
Stormwater discharged into Johnson Creek is regulated under the National Pollutant Discharge Elimination System (NPDES). Permits are issued by DEQ which allow stormwater release directly into the creek. Permittees include construction firms (disturbing over 5 acres; this will change to over 1 acre over the next three years), industries discharging directly into water bodies, and municipalities with a population greater than 100,000. (A new set of rules, called Phase 2, will be implemented over the next three years for municipalities with populations between 50,000 and 100,000). As of July 1999, 17 construction, 15 industrial and 3 municipal permits, and over 100 stormwater outfalls, were active in the Johnson Creek watershed. Industries discharging into municipal sanitary sewers, and construction activities at sites smaller than 5 acres, are also regulated through municipal stormwater permits and local development standards. Agricultural activities are currently exempt from the NPDES program.

The **industrial permits** (1200-Z) require that pollutants discharged, such as sediment, oil and grease, and certain metals, remain below defined thresholds. Certain industries are required to periodically monitor the pollutants in their stormwater discharges and report their results to DEQ. Beginning in the year 2000, the City of Portland will administer 1200-Z permits for all industries within its limits.

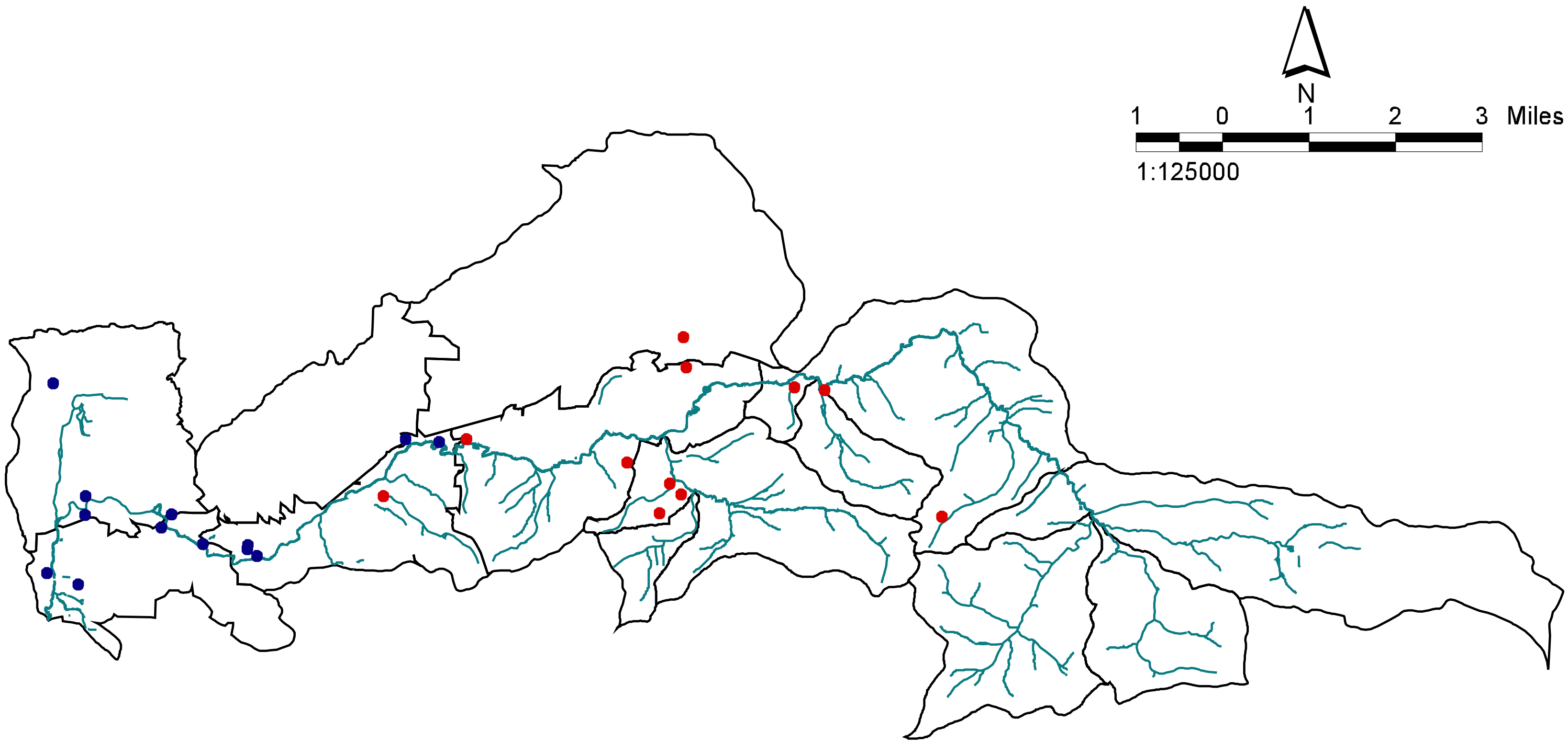
Permitted industries do not represent all entities discharging to the creek. Illicit discharges also occur. Between 1996 and 1999, the City of Portland confirmed thirty-one pollution incidents in Johnson Creek ranging from accidental oil spills to the release of horse manure from a nearby ranch. The DEQ and municipalities work together to identify and eliminate illegal discharges as part of the NPDES permit. Identifying occasional illegal discharges is difficult because of the comparatively long time frames involved to detect, trace, and coordinate a response to the discharge incident. Salmon can be quickly killed by releases of warm water, oil, chlorine and large quantities of certain herbicides toxic to aquatic life long before a suspected discharger is tracked-down.

Construction permits (1200-C) regulate sediment entering the creek during ground disturbing activities. These permits are authorized and enforced by DEQ (with the exception of Clackamas County, which issues and enforces 1200-C's under a memorandum with DEQ). The permits regulate contractors so that sediment leaving the site during storms does not compromise water quality under the Clean Water Act. Local jurisdictions also have their own erosion control codes. Construction companies are required to install "best management practices", commonly referred to as erosion control BMP's, that minimize erosion from the site. Recently, attention has focused on the failure of erosion control at single-family construction sites. Several factors that contribute to this failure are outlined below.

1. **Technical deficiencies in erosion control measures**. The type of BMP's that are available and affordable to permittees may only be marginally effective. Poor installation and maintenance compound technical deficiencies. For example, a study of common erosion measures recommended that the widespread use of silt fences be re-evaluated in light of their "dismal performance" in the field. New technologies, such as "electronic floculation" that coagulates suspended particles, show promising use in settling ponds.


Agricultural operations in the Johnson Creek Watershed
N
1 0 1 2 3 Miles
1:125000
Christmas tree farm
Greenhouse
Nursery
Sub-basin boundaries
Streams
Source: Oregon Department of Agriculture on-line permit database, downloaded July 12, 1999;
Metro RLIS Title 3 stream coverage;
Portland Bureau of Environmental Services Watershed Boundaries, 1999

Permitted point discharges in the Johnson Creek Watershed



Source: Oregon Department of Environmental Quality NPDES permits by watershed;
http://waterquatlity.deq.state.or.us/SISData/FaclityHome.asp. Downloaded August 16, 1999;
Metro RLIS Title 3 stream coverage;
Portland Bureau of Environmental Services Watershed Boundaries, 1999

2. **Compliance**. Often permittees either fail to install structural BMP's, or do so inadequately. DEQ has estimated that only 30% of BMP's are installed correctly, and only 10% are maintained. One jurisdiction noted that only one third of construction sites do not have problems with its erosion control practices. Clackamas County has developed a four-hour class to better educate contractors about erosion control practices. Contractors who attend the class are eligible for a reduction on permit fees.

   Local jurisdictions employ stop work orders and fines if voluntary corrections are not made in response to erosion control violations. Generally, local jurisdictions use a "visible and measurable" threshold for compliance. DEQ also inspects sites for adherence to 1200C requirements. If after three warnings, BMP's still have not been installed properly, DEQ begins non-compliance enforcement. Violations occurs if a contractor fails to comply with its erosion control plan, or if stream turbidity directly downstream of the construction site is found to be 10% or greater than the turbidity directly upstream of the construction site.

3. **Poor standards to measure compliance**. The turbidity measurement is problematic because it gauges turbidity in relation to a system where turbidity is constantly fluctuating. Several concurrent construction activities on a small stream can increase turbidity levels significantly. So high levels of run-off from one construction site may pass the 10% test because its run-off is reaching a water body with already elevated levels of turbidity due to ground disturbing activities upstream. In addition, the 10% test fails to take into account the cumulative impact of several construction sites discharging to the stream concurrently. A uniform numeric threshold, which measures turbidity at the discharge point of the erosion control device, may create greater consistency in evaluating compliance, and afford better protection to the receiving water body.

4. **Lack of adequate enforcement resources**. Lack of personnel to inspect construction sites delay timely inspections and responses to complaints of suspected water quality violations. One jurisdiction noted it has 3 inspectors to monitor about 600 active permits. It is important to note that under the 1200C permit DEQ inspectors do not have the authority to issue a stop work order, but local jurisdictions do.

5. **Long rainy season**. The long duration of the rainy season in the Pacific Northwest makes it difficult to limit construction during wet weather months. Hence construction activities occur during periods of heavy rainfall, which exacerbates erosion and reduces the efficacy of structural BMP's. Early unexpected rainfall may also catch contractors off-guard if they have yet to install sufficient erosion control devices.

Despite the regulation of construction activities through the DEQ 1200C permits, erosion control regulation and enforcement falls largely on local jurisdictions through their development and erosion control standards, which are more restrictive. Table 16 outlines general erosion control standards for jurisdictions in the Johnson Creek watershed. Other development standards, such as tree requirements, impervious surface limits, and on-site stormwater management, also influence the quality and quantity of stormwater that reaches Johnson Creek. Assessing the consistency of these regulations and adequacy of their enforcement for all jurisdictions in the watershed is key to finding and closing gaps among these development standards.

Table 16. **Erosion Control Standards by Jurisdiction**

Jurisdiction	Last updated	Enforcement if voluntary corrections not made	Frequency of Inspection During Construction	Applicable Activity	Notes
Portland	1999	Stop work order / Fines	Three visits which include pre and post development inspections.	All new and re-development regardless of acreage.	Erosion Control Handbook updated 1999
Milwaukie	1992 with update planned for 2000	Stop work order / Fines	Regularly as needed.	All new and redevelopment.	In process of adopting Clackamas rules and regulations. This includes reduced permit fees for contractors who attend erosion school
Gresham	1991	Stop work order / Fines	As needed.	New development of commercial sub-divisions.	Erosion Control Handbook updated 1995
Clackamas County and Happy Valley	1999	Stop work order and fees, or fines, for return inspections	Two visits minimum and as needed.	Activities that disturb 800 sq. feet or more of ground.	Contractors who attend erosion control school eligible for reduced permit fees
Multnomah County	1999	Stop work order / Fines	As required by the Erosion Control Plan or as otherwise deemed necessary.	Activities that disturb 50 cubic yards of soil; activities within 100 feet of high watermark of water bodies.	Educational outreach program on erosion control

Adapted from the Johnson Creek Inter-jurisdictional Committee Simplified Erosion Control Matrix, October 1999.

Municipal Separate Storm Sewer System (MS4) Permits are very complex and time consuming to develop. This is because the geographic area covered by these permits is quite large, and there are multiple sources and types of pollutants that drain to municipal stormwater outfalls. The permittees are required to reduce the pollutants associated with stormwater to the "maximum extent practicable." Because the quantity and force of water entering stormwater systems has hydrologic impacts on the receiving stream channel, these MS4 permits include strategies to minimize flow as well as pollutants.

Stormwater systems that direct run-off into pipes that drain to the creek through outfalls may prove to be the greatest obstacle in improving hydrologic and pollutant problems in urban streams. In the Johnson Creek watershed, there are over 100 stormwater outfalls permitted under three NPDES municipal permits. Outfalls have become the artificial drainage endpoints for a large portion of the watershed, and they cannot be readily removed. By discharging stormwater collected from large land areas, outfalls release concentrated pollutants and flows rather than treating or dispersing them over a large, absorptive land area. Even riparian buffers cannot mitigate the effects of these discharges if an outfall-pipe extends through the buffer and into the creek. While reducing the amount of water and pollutants before they reach the stormwater system is critical to maintaining stream channel stability and overall water quality, the stormwater drainage system needs to be given greater attention in watershed planning too. Diverting outfalls so they drain to off-channel detention ponds or through large riparian areas may be one solution to attenuate the flow and filter pollutants leaving these pipes.

Table 17. **Municipal stormwater permits active in Johnson Creek**

Permit	Co-permittees
Permit Number 101314	City of Portland, Multnomah County, Port of Portland, Oregon Department of Transportation*, Multnomah County Drainage District No. 1, Peninsula Drainage District No.1, Peninsula Drainage District No.2
Permit Number 108013	City of Gresham, Multnomah County, Oregon Department of Transportation*
Permit Number 101348	Clackamas County, Cities of Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Oregon City, River Grove, West Linn, Wilsonville, Oak Lodge Sanitary District, Oregon Department of Transportation*

*Future reissue of permits will not include Oregon Department of Transportation (ODOT) as a co-permittee. Rather, the ODOT will have its own NPDES permit which covers its stormwater activities in the state.

The MS4 permits outline a wide range of activities directed at reducing non-point, stormwater pollution. The categorization of stormwater strategies is useful in understanding the diversity of efforts involved in municipal stormwater run-off management. These are:

- Creating regulations (such as impervious surface limitations and requiring on-site management of stormwater for new development and redevelopment)
- Inspecting and enforcing regulations such as illegal connections to, and improper discharges into, the sewer system
- Design, construction, operation and maintenance of municipal facilities such as infiltration basins, detention ponds, and in-ground sumps

- Promoting public education and partnership around pollution prevention and small scale detention facilities (e.g. proper disposal of household chemicals, native gardening techniques)

The extent to which these activities are undertaken, or "the maximum extent practicable," is determined by the permittee. Hence, regulations, education programs and stormwater facilities vary among jurisdictions, and are to a large extent a function of funding.

In recent years, several attempts have been made to assess the effectiveness of stormwater programs, and particularly structural stormwater controls. The effectiveness of outreach activities such as environmental education and pollution prevention programs is more difficult to assess.

Structural controls of stormwater range from large constructed wetlands that detain, cleanse and slowly release water captured from a large land area, to small, site-specific structures, such as a vegetated trench along a parking lot. A review of studies reveals five areas that impact the success of these facilities.

Factors impacting the success of stormwater control facilities

1. **Challenges in measuring effectiveness**

   Structures designed to reduce pollutants and divert or slow the release of surface run-off take many forms. Common terms for these structures are vegetative swales, settling ponds, infiltration basins and constructed wetlands. Studies on the efficacy of these facilities show mixed results, and suggest that the effectiveness of these systems is complicated by environmental, geological and technical factors.

   For example in 1998 and 1999, the City of Portland's Bureau of Environmental Services evaluated the impact of a vegetated swale on pollutant levels (this example is selected because the swale is representative of current City of Portland design requirements). After one year, only one of three measurements showed measurable soil particle reductions. The other two measurements showed more soil particles leaving the swale than entering it. The following year, once the swale's vegetation matured, the monitoring results showed that the swale was achieving an average 78% soil particle reduction. Consistent monitoring of selected sites is critical in order to evaluate the success of the facility, and understand the factors that may hamper evaluation or the functioning of the facility itself.

   In addition to establishment time, the amount and duration of rainfall, groundwater patterns, and pollutant deposition from the atmosphere also influence results. It may prove very difficult to accurately assess the performance of structural stormwater facilities because it is very difficult to hold constant these other factors.

2. **"Constructability" constraints**

   Generally, stormwater controls will be applied when new or redevelopment of a property triggers development standards that require additional, on-site stormwater management. The type of stormwater control selected, and the ability to construct the control are constrained by amount of vacant land, soil conditions, and configuration of existing drainage systems. Rather than waiting for development to trigger additional stormwater management, retrofitting existing properties offers an aggressive approach to on-site stormwater control. The City of Portland Environmental Services recently completed a preliminary evaluation of how specific technologies could be retrofitted into commercial properties in Portland's Hollywood Commercial District. The study found that only one of eight technologies—parking lot drywells—has good retrofit potential "depending on soil conditions." The remaining seven technologies were rated as having some or very limited potential, or the technology could not be sufficiently analyzed (unknown potential).

The results of the assessment are shown in Table 18. Estimated construction costs per acre for these technologies are also included. Retrofit stormwater controls will likely be more costly than controls

Table 18. **"Constructibility" of stormwater retrofits in the Hollywood Commercial District ***

Technology	Potential	Construction cost per acre
Parking lot drywell	**Good potential depending on soil conditions.** This technology may have widespread technical feasibility. Water quality concerns, pretreatment requirements, and operations and maintenance costs may affect applicability. DEQ is beginning to regulate subsurface infiltration of water because of groundwater quality concerns.	Depending on estimation, either between $20,000 and $40,000, or greater than $40,000
Roof drain disconnection to the landscape	**Some potential**, but more than 80% of the buildings have internal drains that would require major alterations.	Less than $20,000
Roof drain disconnection to drywells	**Some potential** for buildings that have separate storm lines, depending on soil conditions and the depth of any separate stormwater lines.	$20,000 - $40,000
Parking Lot Swales	**Some potential**. Team members identified a number of potential sites, but space constraints limit widespread implementation as simple retrofits. For lack of space, most swales will require a drywell for final disposal.	Less than $20,000
Parking Lot Detention	**Very limited potential** without reconstruction – few of the surveyed lots have a configuration that lends itself to surface detention (slopes, location of catch basins, etc.)	Less than $20,000
Porous Pavement	**Unknown potential.** These systems are technically feasible, but the team did not consider them for application because of a lack of information about costs and long-term performance.	Greater than $40,000
Rooftop solutions: eco-roofs and rooftop detention	**Unknown potential.** The team only partially evaluated the potential for roof top systems because of the time and resources needed to complete a preliminary assessment of structural integrity, etc.	Greater than $40,000
Regional landscaped system	**Unknown potential.** BES hopes that in the longer term it will identify a potential green space that might also serve for stormwater treatment. This goal will be taken up as part of the Hollywood Town Center Plan.	$20,000 to $40,000

Source: Adapted from Update on Research Concerning Expanded Inflow Control in Areas Served by the Combined Sewer, City of Portland Environmental Services, December 1999

* The Hollywood Commercial District is not in the Johnson Creek watershed. It is located in northeast Portland and drains to Portland's combined sewer system.

that are incorporated through new and redevelopment.

If retrofits are subsidized, funding formulas will require an accurate accounting of the difference between retrofitted and redevelopment improvements, so that landowners paying for stormwater controls for new and redevelopment are treated fairly. Grants may also be available to offset these additional costs.

3. Adequacy of design

In order for any structural facility to function properly, its design must adequately suit the flow and pollutant reduction it strives to achieve. A primary element of design is size. Given the length and duration of Pacific Northwest rainfall events, infiltration and detention ponds must be large enough to catch, absorb and release flow over an extended period of time.

The design criterion for most detention ponds specifies accommodating the flow at its peak during a storm. It usually does not account for the duration of the flow. As impervious surfaces increase in the watershed, flows become drawn out over longer periods of time—more water and more peaks need to be managed. An analysis of detention ponds in the Puget Sound area concluded detention pond sizes should be increased between 186% and 572%, depending on surrounding land uses. Additionally, settling ponds may never be able to remove all sediment from stormwater. Although research on settling ponds shows that suspended solids can be reduced by 75%, small sized particles such as silt and clay remain suspended far longer after larger particles, such as sands, have settled. The slow settling time for fine silts and clays is further complicated by frequent winter storm events that force water out of settling facilities prematurely. The technological challenges and amount of space required to accomplish fine sediment reduction may prove cost prohibitive.

Improving the effectiveness of pollutant removal and flow mitigation facilities is of concern across the country. The American Society of Civil Engineers is currently leading an initiative to develop a database of stormwater management practices that can be evaluated by a set of consistent criteria. The long-term goal of the project is to develop a clearinghouse of best management practices that promotes design improvements and better selection to match local situations. (For more info see **http://www.asce.org/peta/tech/nsbd01.html**)

The best match for local situations may be projects that mimic as closely as possible the run-off process of the site in its natural state. Such projects work in tandem with pollution prevention controls that reduce excessive pollutant loads, such as sediment, into the creek. In fact, the goal of a settling facility should not be total removal of fine silts and clays since these naturally occur in streams (unless the facility is to capture erosion during construction or other ground disturbing activity). Further, facilities that do not incorporate elements of the natural environment are not “adaptable” solutions in the long term. For example, a pond within a constructed wetland will fill with sediment over time. This sediment can be removed through excavation, or may provide a fertile foundation for tree seedlings if the pond is no longer needed for stormwater storage.

4. Maintenance

Stormwater facilities are intended to be permanent processing facilities. Hence, proper design, construction and maintenance of these facilities are crucial to functional longevity.

Costs of maintenance vary depending on the size and complexity of the facility. Generally, the more complex the facility the more maintenance required. Regardless of complexity, maintenance is required on all facilities to achieve optimum performance, and little research exists on the costs of maintenance.

The first step in developing a maintenance system for both public and private stormwater facilities is developing a database that includes the type and location of each facility. While most municipalities maintain this information for their own facilities, there is no comprehensive database for private stormwater facilities. Finally, maintenance costs must be considered as part of the facility design process.

5. **Inspection and enforcement**
   Employing adequate staff to inspect and enforce increasingly stricter development standards is an important issue for local jurisdictions. Inspectors may also need additional training in areas such as native plant vegetation and "bioengineering" as erosion and stormwater control guidebooks incorporate more non-traditional methods.

   Even if uniform development standards were established among jurisdictions, they may be enforced at varying degrees dependent on local funding. The Johnson Creek Inter-jurisdictional Committee has earmarked the task of comparing enforcement capacity for erosion control and other development standards in its year 2000 work plan. Inspection and enforcement may require local jurisdictions to raise permit fees and fines, or seek additional funding sources to cover the costs of additional inspection personnel.

Water temperature

The lack of canopy covering the stream, coupled with low and slow moving summer flows, contribute to elevated temperatures in Johnson Creek. Decreasing summer temperatures can be achieved through flow supplementation, and by replacing canopy through stream bank revegetation. Restoration of riparian tree canopy must occur from the headwaters to confluence and include major tributaries to be successful. Increasing summer flows and revegetating streambanks is discussed more fully in the discussion below.

Water quantity

Water quantity has two dimensions—too much water in the winter months and, too little water in the summer months. The problems associated with these conditions are washing and scouring-out of the stream channel in the winter, and high water temperature, and loss and fragmentation of fresh water habitat in the summer.

While stormwater management has historically focused on reducing pollutants in run-off, attention has shifted to reducing the impacts of peak water flows entering sewer systems and water bodies. Many of the strategies to reduce and filter stormwater pollutants are designed to concurrently slow and attenuate peak flows. With the exception of devices such as sumps that trap and release run-off underground, flow-mitigating structures may have limited effectiveness due to design limitations, as described in the stormwater permit discussion above. Further, soil types in the southern portion of the watershed prevent groundwater infiltration, and approximately one quarter of the watershed already drains to sumps. Given these limitations, the primary solution to mitigating heavy winter flows may be creating more functional floodplain along the creek. Funding and projects related to floodplain restoration will be discussed more fully in the next section.

In contrast to winter flows, summer flows in Johnson Creek often do not meet minimums established for salmon by the Oregon Department of Fish and Wildlife. It is likely that water extractions diminish summer flows. No baseline of summer flows exists before monitoring began in 1947, although water diversions were granted as far back as the 1920's. Throughout Oregon, curbing water diversions is seen as a critical action for salmon recovery.

The first step in assessing the impact of water diversions from Johnson Creek is quantifying the amount of water taken from the stream. This picture is extremely difficult to develop because it requires estimates of losses from illegal diversions, and totaling losses from active water rights. (A water right must be exercised at least once every five years in order to remain active. Unused rights are subject to cancellation).

Water rights are administered and regulated by the Oregon Water Resources Department (OWRD). Although the OWRD maintains a database of assigned water diversions by property description in the Johnson Creek watershed since the 1920's, it is difficult to know with certainty, which of these diversions are active.

The state is divided into 19 water districts with a water master in charge of each district. The Johnson Creek watershed lies within a water district that extends from Columbia County east to Hood River, south to the Sandy River in Clackamas County. The sheer number of stream miles and water rights within this district makes assessment of water rights and illegal diversions overwhelming. Further, since property rights in Johnson Creek extend at least to mid-stream, simply walking the stream to spot diversions may be considered trespassing. OWRD must notify property owners before staff can search for illegal diversions. And since water rights stay with a property when the property is sold, the economic value of a water right may encourage an owner to report an unused right as active.

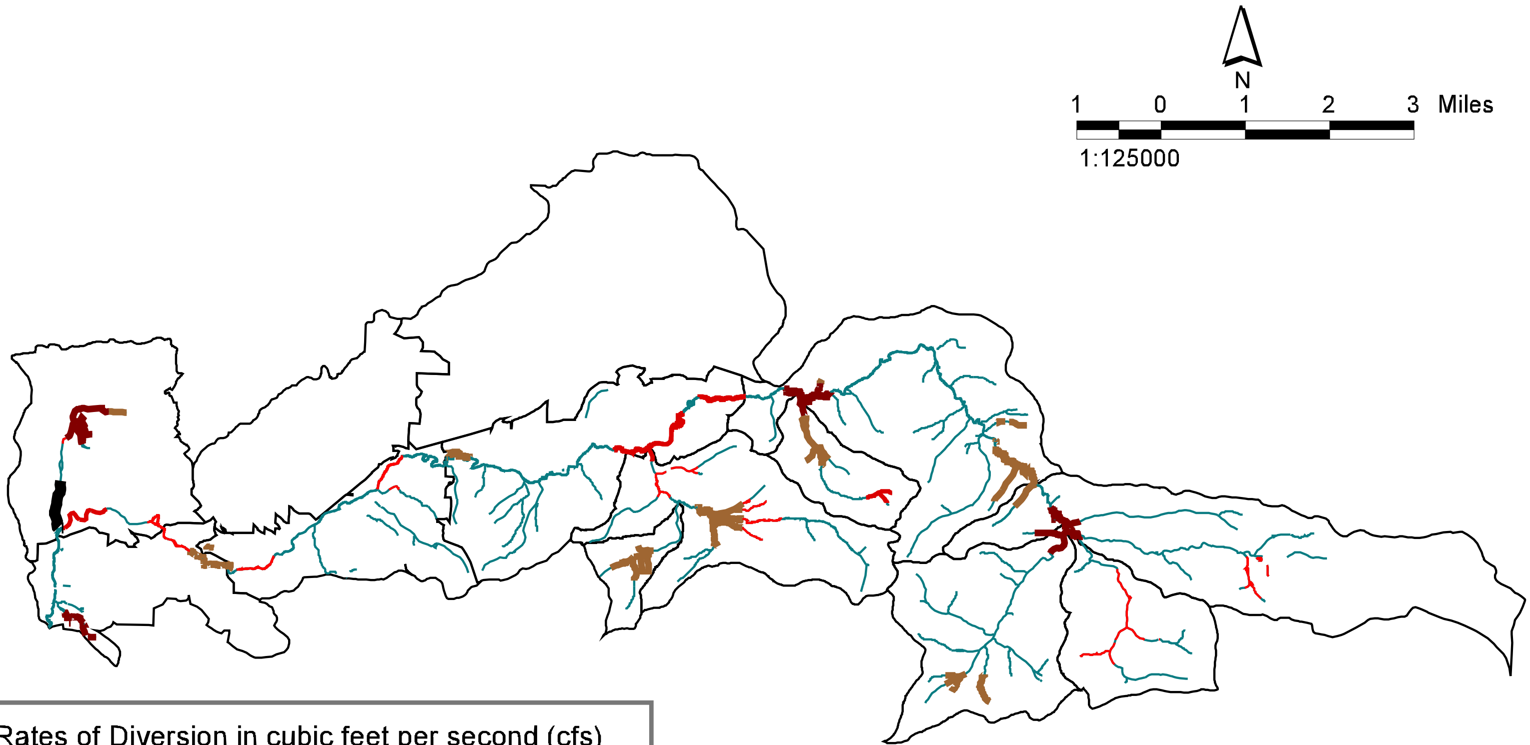
The water rights database maintained by OWRD shows that water diversions from Johnson Creek may be "over-appropriated." This means that more permission for water withdrawals exists than the flow of Johnson Creek may be able to sustain at certain times. For example, although individual water rights do not exceed the creek's flow (measured at Sycamore), the sum of all water permitted to be withdrawn from the Johnson Creek mainstem above the Sycamore flow gauge is almost 5 cfs. This is two and a half to five times the average summer flow, when water is most likely being diverted. Permitted withdrawals, based on the OWRD database and applied to stream segments by quarter section, are shown on map 13. While the map illustrates where potential water diversions exist, the accuracy of this data is unknown without identifying unused water rights and quantifying active rights.

In partnership with the Oregon Water Trust, the OWRD encourages water right holders to donate, lease or sell all or part of an unused water right "to the stream." As of fall 1999, only one water right in Johnson Creek watershed had been transferred to instream water rights (Reed College in Crystal Springs).

Although the OWRD will not grant future surface-water withdrawals from Johnson Creek and Crystal Springs, small groundwater withdrawals in the watershed may still be permitted.

A final note of interest is that there does not appear to be a decrease in Johnson Creek mainstem summertime flow since 1947. One may think that greater run-off would lead to less groundwater recharge, but flows have remained fairly steady since measurement began at the Sycamore gauge in 1947. Schueler also notes this finding. "Because infiltration is reduced in impervious areas, one would expect groundwater recharge to be proportionately reduced. This, in turn, should translate into lower dry weather stream flows. Actual data, however, that demonstrates this effect is rare. Indeed, Evett et al. could not find any statistical difference in low streamflow between urban and rural watersheds after analyzing 16 North Carolina watersheds."

Existing (potential) water diversions from Johnson Creek and Crystal Springs (cubic feet per second)



Rates of Diversion in cubic feet per second (cfs)

- 0.001 - 0.05
- 0.051 - 0.10
- 0.110 - 0.50
- 0.51 - 2.50
- 11.3 maximum
- Streams segments with no recorded water rights
- Sub-basin boundaries

Source: Metor RLIS Title 3 stream coverage and quarter sections;
Oregon Water Resources Divsion, Point of Diversion file, August 16, 1999;
Portland Bureau of Environmental Services Watershed Boundaries, 1999

Note: Permitted water extractions are totaled by quarter section and applied to the corresponding stream segment. Does not include diversions from wells or reservoirs within the Johnson Creek watershed.

Condition 2: The stream channel and its habitat, including passage

The theme that continually emerges when looking at salmon's relationship to Johnson Creek is the absence of areas of refuge adjacent to the main channel. Regaining off-channel habitat is achieved through streambank revegetation and floodplain restoration. Protection of existent streambank resources is also a necessary strategy in order to prevent further loss of valuable habitat. Hence, habitat conditions can be addressed by conservation, protection and restoration (what Metro coined "CPR").

Habitat conservation and protection

Several ordinances that protect existing riparian vegetation are listed in Table 19.

Within the urban growth boundary Metro's Title 3 ordinance, which will be expanded to address fish and wildlife habitat protection, is the primary tool in urban areas to protect existing riparian areas from development. A rough analysis of aerial photography of the Johnson Creek mainstem showed that 43% of the area lacked or contained severely degraded riparian buffer. Revegetation of the riparian buffer is a necessary step towards improved salmon habitat.

Streambank restoration

Revegetation and restoration produces benefits in addition to improved salmon habitat. Through the creation of a more complex vegetative environment—from evergreen trees, that provide a year-round layer of shade and absorptive needles, to moisture loving winter shrubs—surface run-off is absorbed and slowly released into the creek. Consequently, the stream channel is less subject to scour and the extreme peak flows associated with flooding are reduced. Mature deciduous trees provide a large canopy above the stream, which by shading the water helps prevent the water temperature from becoming elevated during summer months. The vegetation also traps and filters sediment and pollutants, and adds organic material to the stream environment through decomposition.

Sound streambank restoration is not easy to achieve and involves coordination of many different resources. Restoration works best when it responds to a watershed assessment that has identified the specific goals of the project, rather than restoration that is approached opportunistically because, for example, a site is available. Restoration involves willing landowners, multiple permits, site grading, multi-disciplined technical expertise, abundant and healthy native plant seedlings, labor/volunteer coordination, and post-planting maintenance and monitoring. Restoration projects often succeed in getting a project planted, but fall short in sustaining the project thereafter—especially when volunteer labor is the expected means of maintenance. On public property, it may be best to designate a fund at project inception for maintenance of restoration projects to pay for this service. Depending on the size of the project, maintenance of restoration projects on private property may more likely be performed by the landowner.

Streambank restoration brings together many different individuals from government, business and volunteer groups. The civic infrastructure developed through these projects is another benefit often unnoticed and unmeasured. Restoration projects usually involve several organizations that pool resources and volunteer labor. For example, six salmon restoration projects undertaken in Crystal Springs in the fall of 1999 involved the Johnson Creek Watershed Council, the City of Portland, Oregon Department of Fish and Wildlife, the Northwest Steelheaders, SOLV's Team-up! for Watershed Health program, Portland General Electric, and Ross Island Sand and Gravel. Coordinating materials, technical input and labor for these projects is a time consuming task. SOLV's Team-Up! program is focused on providing this service. Although in its infancy, the program shows promise for coordinating complicated restoration efforts.

Table 19. **Riparian setback standards in Johnson Creek Watershed**

Land type affected	Riparian setback	Governing agency	Status	Civil penalties for non-compliance?
Agricultural land outside Metro jurisdiction	None established	Oregon Department of Agriculture through Agricultural Water Quality Management Plan (SB 1010)	No group has yet to come together to complete a plan.	Yes
Forested land where trees are logged for sale, or logged for conversion to agricultural land. City tree ordinances supercede Oregon Forestry Practices Act, although permit must be filed with ODF.	50' to 100' depending on stream size and seasonality.	Oregon Department of Forestry under the Oregon Forest Practices Act	Active	Yes
Wetlands, includes riparian areas of Johnson Creek; Johnson Creek is classified essential salmon habitat.	Compensatory wetland mitigation required; this program is actually compensatory restoration rather than conservation	Division of State Lands (DSL) under Removal-Fill law	Active – DSL estimates less than 2 acres of mitigation has occurred. The low acreage is due to historic loss of wetlands that left very little wetland area to mitigate under this rule.	Yes
Urban / Rural lands within Metro's jurisdiction: required by Model Ordinance Title 3	15' to 200' depending on stream type and slope (this will be expanded when Goal 5 is incorporated into Title 3)	Responsibility of individual jurisdictions to codify and enforce: see below	see below	permits for development dependent upon compliance
Portland	15' to width of resource; but all activity within 50' of stream requires environmental review		current; codified revisions expected July 2000	
Gresham	15' to 200'		adoption planned for 2000	
Milwaukie	50' to 200'		adoption planned for 2000	
Happy Valley	50' to 200'		current	
Clackamas County	50' to 200'		current	
Multnomah County	100' to 300'		current, under Significant Environmental Concern streams	

Restoration projects, such as the one mentioned above, have been most prevalent on public property. This is because public land is generally more accessible and its habitat value recognized by local naturalists. Since most of the land along Johnson Creek is privately owned, the largest challenge to streambank restoration is creating incentives for private landowners to make these improvements. Several incentive programs exist for agricultural landowners (see Table 20) to create riparian buffers, although few projects have been implemented along Johnson Creek and its tributaries. As for urban and rural lands, the City of Portland's Watershed Revegetation Program, in concert with the other jurisdictions in Johnson Creek, is seeking funding from the Oregon Watershed Enhancement Board to expand its activities along Johnson Creek and its tributaries. Despite the difficulties of convincing landowners of the benefits of, and providing incentives for stream bank revegetation, private property is key to salmon recovery and overall watershed health. Possibly the largest challenge in private property revegetation is convincing landowners that the benefits of riparian vegetation outweigh their backyard view of the creek.

Table 20. **Restoration and conservation funding**

Program Name	Agency	How it works	Amount available
Conservation Reserve Enhancement Program (CREP)	USDA Farm Service; Natural Resources Conservation Service	Provides annual payments to landowners who plant riparian buffers (35' to 150'); provides costs share on planting materials	Total program costs for Oregon estimated at $250 million over 15 years
Wildlife Habitat Incentive Program (WHIP)	USDA Natural Resources Conservation Service	Provides technical and financial assistance for landowners to install wildlife habitat improvements on their land; five to ten year agreement; focus on endangered species	Congress did not fund for FY2000
Wetlands Reserve Program (WRP)	USDA Natural Resources Conservation Service	Purchases conservation easements or provides financial assistance for wetland restoration; conservation easement range from 30 years to perpetuity; restoration agreements a for a ten year minimum	Oregon portion unknown FY 2000
Environmental Quality Incentives Program (EQIP)	USDA Farm Service; Natural Resources Conservation Service	Provides technical and financial support to implement agricultural and livestock best management practices aimed at sol conservation, and water quality and habitat improvement	Approximately $4.0 million for Oregon FY 1999; Oregon portion yet unknown FY 2000
Metro Greenspaces Grants Program	US Fish and Wildlife Service / Metro	Provides technical and financial support to small partnerships performing restoration on public greenspaces.	$210,000 per year (Individual habitat restoration projects up to $20,000; projects with Salmon connection up to $5,000; education programs up to $8,000)
Oregon Department of Wildlife Restoration and Enhancement Program	Oregon Department of Fish and Wildlife	Supports watershed enhancement and salmon restoration projects which benefit Oregon anglers.	Total for state $3 million 2000-2001, funds come from fishing licenses

Type of land eligible	Johnson Creek projects as of Dec. 1999	Program challenges / Notes
Crop or pasture land active within two of last five years; certain crops, such as orchards, vineyards and Christmas trees operations, are excluded; only applies to lands that contain active streams	None in Johnson Creek watershed; about 3500 acres (200 producers) in Oregon since 1998 start-up	Low riparian-rent payment incentive ($75 to $150 per acre enrolled) compared to crop-acre value; landowner fear of eventual loss of water rights; length of commitment (10 to 15 years). Low participation in Oregon. Difficult to apply program to urban situations.
All lands except those enrolled in other USDA programs; urban lands eligible	None in Johnson Creek watershed	Program not funded FY 2000. The lengthy amount of time spent up-front by NRCS staff in developing plan for grantee's application impedes time spent on program outreach.
Agricultural land with wetland or riparian characteristics	None in Johnson Creek watershed	Small land parcels in Johnson Creek make incentives unattractive; state selection process (called ranking) gives precedence to large land parcels
Farms, nurseries and ranches (horses, cattle)	None in Johnson Creek watershed	Small land parcels in Johnson Creek make incentives unattractive; state selection process (called ranking) gives precedence to large land parcels
Public lands in Multnomah, Clackamas, Clark and Washington Counties; urban land focus	About 13 restoration projects since 1991	Metro reports that over 217 projects with a value of $4.5 million have been completed from $1 million in grant funds since 1991; maintenance of projects in first two years critical and sometimes difficult to sustain.
Generally streamside properties—project must relate to fisheries enhancement	1 project: Crystal Springs Fish and Habitat Restoration project received $33,700 from this fund in 1999	Budget cuts; the program received only half its previous budget this new fiscal year. ODFW also offers a riparian tax-reduction incentive.

Table 20. **Restoration and conservation funding** *(continued)*

Program Name	Agency	How it works	Amount available
Bureau of Environmental Services Stewardship Grants Program	City of Portland Environmental Services	Provides technical and financial support to small partnerships performing education or restoration related to City of Portland watersheds	$35,000 per City fiscal year (July 1 through June 30)
Watershed Revegetation Program	City of Portland Environmental Services	Provides technical and financial support to specific streamside revegetation projects. Highly successful pilot project in Columbia Slough now being expanded to Johnson Creek watershed.	City of Portland $230,000 FY 00/05. Program in process of seeking matching funds from local jurisdictions and OWEB to extend program throughout Johnson Creek.
Watershed Enhancement Grants	Oregon Watershed Enhancement Board	Provides financial support to any Oregon entity (other than state) for watershed assessment, monitoring, restoration, strategic-action plans. Process is competitive with two grant rounds per year.	$30 million total for Oregon FY 2000-2001
Metro Open Space Acquisition Bond Measure 26-26	Metro and local jurisdictions	Taxpayers within Metro's jurisdiction approved a general obligation bond that allows Metro to purchase targeted land for open space. Lands include river frontage, wetlands, and forest. Goal was 6,000 acres; thus far 5,200 acres have been acquired.	$135.6 million for acquisition including local share component
Salmon Friendly Power / Pacific Salmon Watershed Fund	Portland General Electric (PGE) and For the Sake of Salmon	New program where PGE customers can elect to pay between $5 and $10 a month to support salmon local restoration projects and low-impact hydropower, and other renewable energy sources	New program — unknown

Other watershed restoration funding exists. These sources are not listed here because either they are not consistent funds, offer small monetary incentives, or are tied to large grant programs not specifically related to environmental conservation. To find out more about these programs, contact Metro Greenspaces Grants Program, go to For the Sake Of Salmon web site: **http://www.4sos.org/**, and see The Defenders of Wildlife publications *Stewardship Incentives* (1998) and *Incentives for Conservation* (1999).

Type of land eligible	Johnson Creek projects as of Dec. 1999	Program challenges / Notes
Public and private lands within the City of Portland	13 projects totaling $32,450 in grant funds since 1995	Permitting of projects; time involved in coordination and support of varying levels of volunteer technical and organizational abilities; maintenance of projects in first two years critical and sometimes difficult to sustain.
Public and private lands within the City of Portland	Eight property owners have signed-up, totaling about 10 acres.	Private landowner issues such as access to site, privacy and aesthetics. Ensuring plantings are maintained and not cleared during establishment phase.
Public and private lands, as well as private and non-governmental organizations, where critical concerns in the watershed area addressed from a systems perspective.	None for restoration. Grants have been awarded for Watershed Council Support.	Permitting, maintenance, project evaluation.
Private lands are purchased under willing seller agreements. Target areas for purchases were outlined in the original bond measure. Quality of resource, accessibility to people, and connectivity to other natural areas are criteria for acquisition.	About 346 acres (7% of total purchases thus far) have been acquired in the Johnson Creek watershed.	The bond measure only acquires land, it does not fund improvements. Restoration of acquired lands may be supported by restoration grants noted above.
For Sake of Salmon will be in charge of distributing proceeds among salmon habitat improvement projects.	New program — unknown	New program — unknown.

Reclaiming floodplain

Because of their relatively level topography and rich soils, most flat lands bordering streams have been developed for housing and agriculture. As a result, off channel habitat for salmon, such as marshes and wetlands, have been filled, and connecting streambanks elevated and straightened to convey water downstream rather than onto the floodplain. These activities effectively disconnect the stream from its functional floodplain.

Since the 1980s, flood management in Johnson Creek has included a focus on water quality and habitat improvements. Rather than conveying water rapidly downstream as a flood control strategy, flood management has focused on allowing rivers and streams to actively move within their 100 year-floodplain. This strategy mitigates rather than exacerbates downstream flooding, and also achieves aquatic habitat re-connection. In recent years the Federal Emergency Management Agency (FEMA) has begun to grant funds that allow local jurisdictions to purchase flood prone residences and allow the rivers and streams to actively reclaim their floodplains. This management strategy gained momentum nationally as it has proven to be more cost effective than replacing and repairing damage from repeated flood events, and also has the potential to reclaim fish habitat, improve water quality, and provide flood storage.

This strategy may also be the most technologically feasible. Preliminary hydrologic models of Johnson Creek suggest that the upper watershed (above river mile 8) receives the majority of rainfall in the watershed. This rain falls upon impermeable clay soils where infiltration may have been further reduced due to the agriculture practice of *tiling* (lining soil with layers of tile or shingle in order to divert water quickly to the stream so to prevent water from ponding in the field). The large amount of water entering the stream channel that needs to be detained in the upper watershed makes detention strategies difficult and costly to employ, and may only achieve modest reductions in lower watershed flooding. Further, large detention facilities such as detention ponds may not be publicly acceptable to the community that lives around them. Given these limitations, allowing floods to occur naturally and moving structures out of flood prone areas may prove to be the most cost-effective, multi-benefit strategy to reducing flood damage. This strategy has great potential for flood mitigation, passive recreation opportunities, improved water quality, and increased fish and wildlife habitat. This strategy should be explored throughout the watershed as a first step to recover off-channel fish habitat.

Using about $6.3 million in funds from Metro's 26-26 Open Space Bond, FEMA, Multnomah County Community Development Block Grant and City of Portland capital budgets, the City of Portland has developed the Johnson Creek Willing Seller Acquisition Program. The program has acquired 71 acres (36 properties) since June 1997. In addition to these properties, target acquisition areas have been identified along the mainstem of Johnson Creek.

Currently, the Willing Seller Acquisition Program is limited to City of Portland capital funds. Metro and Multnomah monies were one-time grants. FEMA only offers its dollars when a disaster is declared (hence its $1.5 million in funds was linked to the 1996 flooding in Johnson Creek). Exploring funding sources for land acquisition, and determining a fair-share formula so that all jurisdictions participate in acquisition, is key to this strategy.

Once acquired, flood prone lands may be left alone to simply function as open space or, may be actively restored to regain its flood storage potential and habitat value. In 1996, the City of Portland began a 14.5-acre restoration site in Johnson Creek at a construction cost of $1.3 million. This constructed wetland, named Brookside, includes water detention, water quality improvement, and bank stabilization structures. Despite the increased urban wildlife habitat the project provides, more monitoring is necessary to evaluate the project's effectiveness as a stormwater facility. Results from a recent monitoring study of swales at the wetland concluded design and environmental constraints hampered accurate evaluation. The City of Portland Bureau of Environmental Services has recently developed a comprehensive evaluation protocol for the site.

Passage

Habitat must be accessible by salmon if it is to serve their spawning and rearing functions. Culverts placed in the stream to support road crossings may impede up and downstream fish passage. In separate surveys, the Oregon Department of Fish and Wildlife recently inventoried and assessed state, county and city culverts along active streams in Johnson Creek. These surveys have been combined to show how culverts may impede fish passage along Johnson Creek. The preliminary results are shown on map 14.

Although minimally enforced, the Oregon Revised Statutes requires that the Oregon Department of Fish and Wildlife (ODFW) ascertain that owners of fish passage obstructions provide clear passage for salmon. But the permitting process during routine culvert repair does not always receive a passage assessment by ODFW as required. It is likely endangered species listings will force greater compliance to this statute, minimize the placement of new culverts in the stream and improve notification to ODFW for routine repair of existing culverts.

Culverts are a huge issue because of their expense to replace and their significant impact on salmon access throughout the stream. A clear picture of the degree of impedance, the sequence of the culverts throughout the stream, and surrounding habitat value must be developed to accurately prioritize culvert replacement. An analysis of the culvert inventories raises questions as to accuracy and thoroughness of the existing inventories.

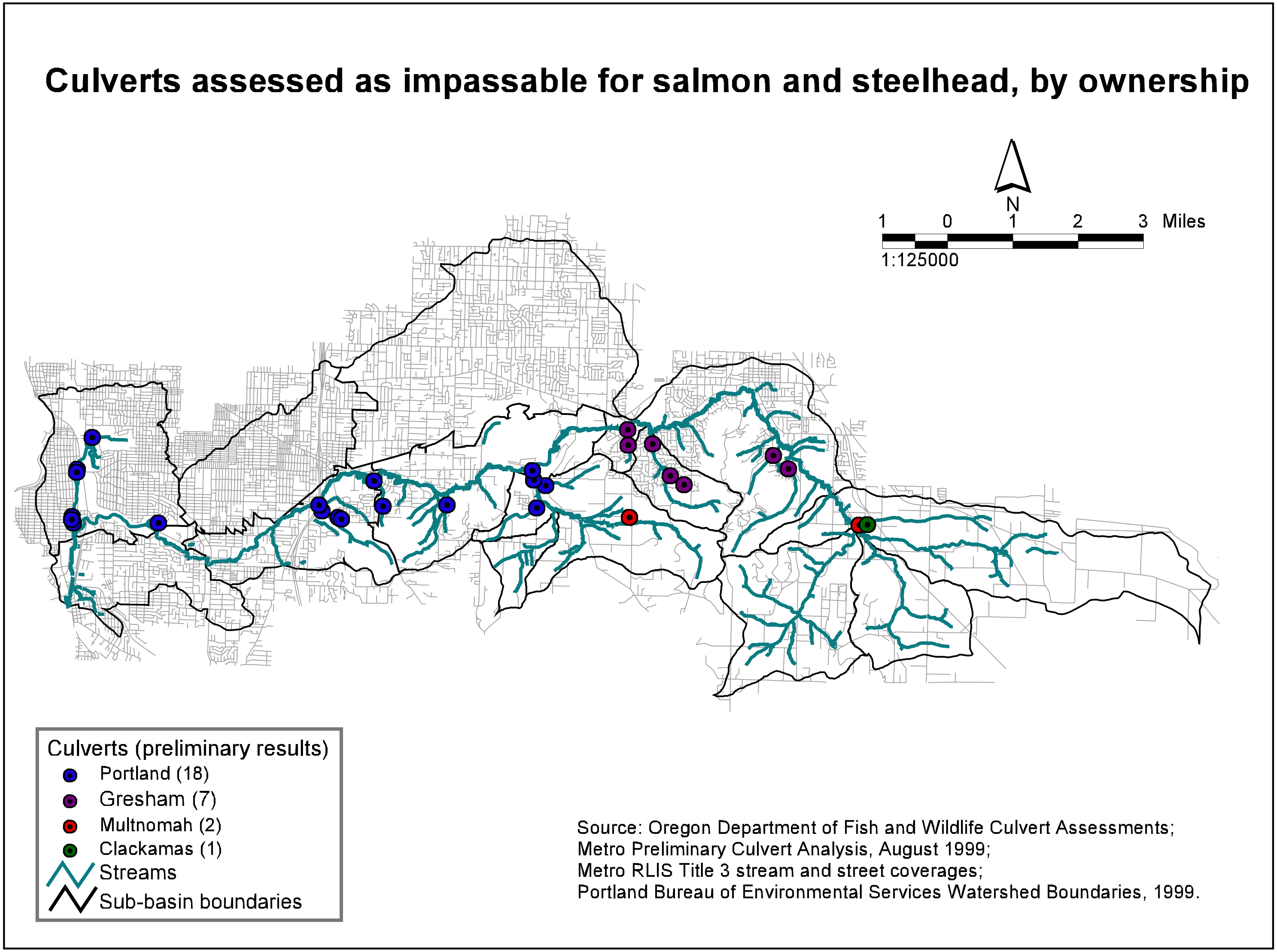
First, several culverts noted as impassable occur *below* areas where sea-run salmon have been spotted (i.e. Crystal Springs). Culverts in areas of known salmon presence may need to be reassessed based on degree of impedance—a culvert identified as posing some barrier to passage may not necessarily mean fish cannot pass at all. Passage must be assessed seasonally since the amount of water passing through the culvert is a result of seasonal flow.

Second, not all known culverts were assessed. The culvert assessments need to be compared to city and county culvert inventories to ensure that all culverts are evaluated for fish passage. Some jurisdictions have already done so.

Third, surrounding and upstream habitat value needs to be folded into the assessment.

Finally, culvert assessments are not a one-time event. Dynamic stream conditions may create impassable conditions at culverts currently rated as passable.

The City of Portland's Endangered Species Act response program is developing a process to strategize and assess culvert replacement throughout the jurisdictions, but no culvert removals have been undertaken. The prioritization scheme will be applicable to any type of culvert regardless of ownership. Clackamas County has also developed a strategic process to address culvert replacement throughout the County.


Culverts assessed as impassable for salmon and steelhead, by ownership
N
1 0 1 2 3 Miles
1:125000
Culverts (preliminary results)
Portland (18)
Gresham (7)
Multnomah (2)
Clackamas (1)
Streams
Sub-basin boundaries
Source: Oregon Department of Fish and Wildlife Culvert Assessments;
Metro Preliminary Culvert Analysis, August 1999;
Metro RLIS Title 3 stream and street coverages;
Portland Bureau of Environmental Services Watershed Boundaries, 1999.

Condition 3: Species Interactions

The salmon and anadromous trout in Johnson Creek today are likely a genetic mix of introduced and native fish. There may also be some small populations that resemble the original native stock.

Much attention has focused on the impact of hatchery introductions into Pacific Northwest streams. Hatchery stocks may increase competition for habitat and food, and may never naturalize to their new streams. Because so little is known about the abundance and genetics of salmon and trout in Johnson Creek, it is difficult to pursue any management strategy based on relevant science. Still, augmentation with hatchery-reared populations may be a reasonable strategy to consider in the future once more knowledge is gained about salmon genetics, and habitat, water quality and flow conditions improve. This may take fifty years or more. For now, the Oregon Department of Fish and Wildlife has discontinued the release of salmon and steelhead fry, and the stocking of legal-size rainbow trout, into Johnson Creek.

Monitoring and watershed assessment

Throughout the country, organizations involved with watershed improvement have been developing tools and reporting mechanisms to describe conditions in their watersheds. These reports range from general geographic and historical portraits, to detailed evaluations of specific toxins in the water body. This report is an attempt to consolidate Johnson Creek watershed data and paint a portrait of watershed conditions today. Evaluation of future conditions in the creek will depend upon the data already collected as well as assembling new information in new ways. For example, some scientists have proposed the use of biological indices that consolidate several watershed parameters into one number. Developing such an index for Johnson Creek is discussed below along with a summation of current monitoring activities.

Fish counts

Quantitative information on the distribution of salmon and trout in Johnson Creek is recent and sporadic because it is very difficult to count fish in small streams. Counting salmon and steelhead on large river systems with dams is facilitated by fish ladders which provide the infrastructure to install fish counting equipment. Questions of life-cycle phase, sampling framework, and counting method need to be answered on small streams. For example, does one count smolts leaving the watershed as an indicator of the stream's rearing potential? Or should returning spawners be counted? Where should the monitoring take place? Will the sampling method use traps or electroshocking?

Even when questions of methodology are resolved, annual fish counts are dubious. Scientists agree it takes many years to see trends in returning fish, and then it is still difficult to know what those trends indicate. Trends could indicate an improvement in ocean conditions, failure or termination of a hatchery program, or degraded natal stream conditions. As the 1998 annual report of the Oregon Plan for Salmon and Watersheds points out, "It is not that the numbers of salmon are irrelevant. It is that they only tell a small part of the story...recovery must not only concern the quantity of salmon, but also those structural *qualities* of their populations and their ecosystems."

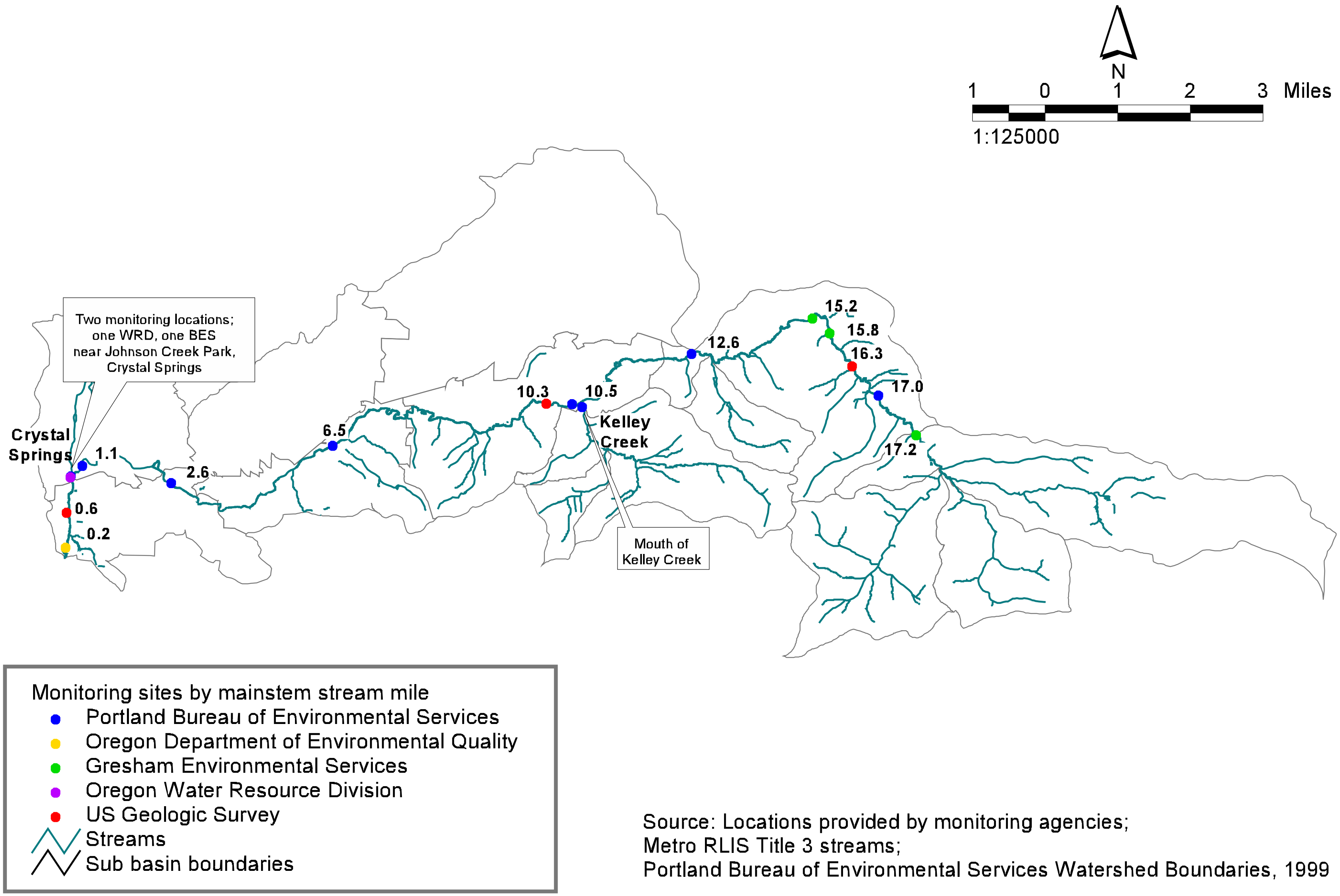
We need to continue to count fish within the parameters of good research design. But in the short term, it is those structural qualities of their ecosystem—of the Johnson Creek watershed—that will indicate how well these fish are faring in relation to the spawning and the juvenile-rearing phases of their life cycles.

Water quality and flow monitoring

Data about the conditions in the Johnson Creek Watershed are limited in accessibility and scope. This is not uncommon. Much data collected about a particular condition in a water body is in response to a specific mandate or management objective, and may be limited by the technology available to measure that parameter. In the Johnson Creek watershed, the most extensive data exist on water quality and flow.

The cities of Portland and Gresham, the United States Geological Survey, the Oregon Department of Environmental Quality, and the Oregon Water Resources Division have monitoring stations in the watershed where data are regularly collected. These stations and a description of the data gathered are outlined in the Table 21 and shown on map 15. In addition to these sites, school, neighborhood and scientific groups periodically monitor specific locations in the watershed. More coordination between these agencies would better distribute monitoring throughout the creek, standardize reporting of results to facilitate data sharing, and determine a central agency for data access and distribution.

Established monitoring locations along Johnson Creek, 1999



Source: Locations provided by monitoring agencies;
Metro RLIS Title 3 streams;
Portland Bureau of Environmental Services Watershed Boundaries, 1999

Table 21. **Description of monitoring sites**

Agency / Location	Data currently collected	Frequency	Date collection began	Approx. stream mile	Notes:
DEQ - at SE 17th Ave Temperature,	Dissolved oxygen, biochemical oxygen demand, pH, total solids, ammonia and nitrate, total phosphorus, fecal coliforms.	bimonthly	1990	0.20	The Oregon Water Quality Index is computed from data taken at this site.
USGS - Milport Gauge	Water flow; temperature	hourly; summarized daily	1989; temp since 1998	0.60	
Portland BES - Crystal Springs	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	upstream from mouth of Crystal Springs	
State Water Resources Division – Crystal Springs	Water flow; temperature	daily	Gauge is expected to be fully functional January 2000	on foot bridge at Johnson Creek Park, Crystal Springs	Gauge can be expanded to gather information on other water quality parameters
Portland BES - at SE Umatilla St Bridge	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	1.10	DEQ has historical monitoring data for this location
Portland BES - Johnson Creek Blvd	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	2.60	
Portland BES - SE 92nd Ave Bridge	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	6.50	
USGS - Sycamore Gauge	Water flow; temperature	hourly; summarized daily	1940; temp since 1998	10.30	
Portland BES - SE 158th Ave Bridge	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	10.50	
Portland BES - SW Pleasant View Drive	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	12.60	
Portland BES - Kelley Creek	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	at mouth of Kelley Creek	
Gresham - SE Palmblad	Temperature, dissolved oxygen, fecal coliform, pH, conductivity.	monthly January through November	1997	15.25	
Gresham - SE Park	Temperature, dissolved oxygen, fecal coliform, pH, conductivity.	monthly January through November	1997	15.80	
USGS - Regner Road Gauge	Water flow; temperature	hourly; summarized daily	1998	16.30	
Portland BES - SE Hogan Ave Bridge	Temperature, dissolved oxygen, E.coli, pH, conductivity.	monthly July through October	1995	17.00	
Gresham—at Springwater Corridor Trail	Temperature, dissolved oxygen, fecal coliform, pH, conductivity.	monthly January through Nov.	1997	17.20	

Monitoring in the upper watershed is limited. Knowledge of temperature and flow upstream could significantly contribute to understanding how these parameters feed into the entire system. Data collected on nitrogen, phosphorous, *e.coli*, suspended sediments, temperature and flow, will also deepen understanding of the impacts of agriculture and ranching in the watershed.

Assessments of channel and riparian condition

The technical background gathered in 1993 for the Johnson Creek Resource Management plan provided some assessment of the creek's channel and riparian condition, but a complete, formal survey had not been initiated until recently. The Oregon Department of Fish and Wildlife has performed a channel assessment of Johnson Creek and some if its tributaries. The results will be final early in the year 2000, and will be extremely useful in helping prioritize riparian revegetation and restoration. The six jurisdictions in the watershed have contributed to the costs of the assessment.

Biological Monitoring

Although water chemistry parameters (such as pH, dissolved oxygen, *e.coli* content) are largely the indicators of choice to describe water bodies in the United States—perhaps by default because of the ease of measurement technology—a growing number of scientists have been looking at other in-stream indicators of watershed health. Chemical monitoring alone fails to provide information on the cumulative impacts on aquatic organisms. An alternative approach is to measure an array of attributes that when integrated provide an overall picture of the biological condition of the watershed. The basic premises are that 1) stream conditions are best described by the type of organisms living there because we can understand the system through those organisms' ecological requirements, and 2) greater complexity in species composition indicates a healthy ecosystem.

Scientists have found that the three best-documented responses to environmental stress are 1) a reduction in the number of native species, 2) change in species composition to dominance by a few opportunistic species, and 3) reduction in the average size of organisms. To understand how native species are faring in their ecosystem, scientists sample aquatic species such as fish, algae and stream insects from a disturbed stream system like Johnson Creek. The organisms found are systematically counted, compared and ranked in relation to a less disturbed stream system (commonly called a reference stream) that has similar geological, physical and environmental conditions. Subsequent samples report on whether the species "assemblage" moves closer to (stream health improves), or further away from (stream health degrades), the reference stream baseline. The states of North Carolina, Ohio, Maine and Vermont are leaders in the successful use of biological monitoring, and a substantial body of literature on this topic is developing.

Insects and algae are considered an accurate measure of stream conditions because, unlike salmon, they are not stocked or harvested, and they do not migrate from the system. The problem with this method of monitoring is that it involves much time to identify all the species collected. While volunteers can obtain the insect/algae samples fairly readily, the microscopic identification of the species in the laboratory involves many hours, and trained taxonomists to sort and identify each species. Also problematic is simply locating a reference stream to which to compare the resulting insect/algae composition.

The City of Portland is exploring the development of a *multi-metric* index for Johnson and Tryon creeks based upon algae and stream insects. *Multi-metric* means that the results of different types of monitoring data (i.e. chemical, biological, and stream hydrology) are periodically analyzed and statistically collapsed into one measurement so that scientists and lay persons alike can readily assess the general health of a watershed. The initial results of the development of Johnson Creek and Tryon Creek biological indices are not yet available, but the goal of the indices is to integrate water quality, biological and habitat data to obtain robust and complete analyses of stream conditions.

The budget for the initial, one-time sampling and development of this index is around $95,000. No consistent funding for subsequent sampling has been identified.

Such indices are not without critics. Some scientists believe that wrapping together many diverse watershed components into one value masks the importance and degree of influence each component contributes to the final result. Indeed, indices must be carefully developed so that their components can be dissected to discover the individual drivers behind an increase or decrease in the resulting watershed health index.

Regardless of how data are reported (i.e. as an index or as individual components), biological monitoring can tell us much about the results of intended improvements in Johnson Creek long before changes in salmon populations can be statistically verified. Biological monitoring is thus given a placeholder in the following Indicators section, although data are not currently available.

Public Awareness

Ultimately, efforts to restore salmon populations depend upon individual understanding of the salmon's plight, and willingness to act on behalf of improved watershed conditions. As Stuart Elway, coordinator of the Seattle/Washington State Elway poll, writes "Any solution will require sustainable (consensus-level) approval from the region's citizens. Citizens will act on the basis of *their* understanding of the issue and its ramifications—not the perspective of experts and policy makers. Therefore, a big part of the job of constructing a solution will be to bring the citizens along to a comprehensive understanding of the problem, as well as the proposed solutions." Indeed, it appears that citizens may be jelling toward a consensus that urban development is a primary cause of salmon decline, as will be discussed below.

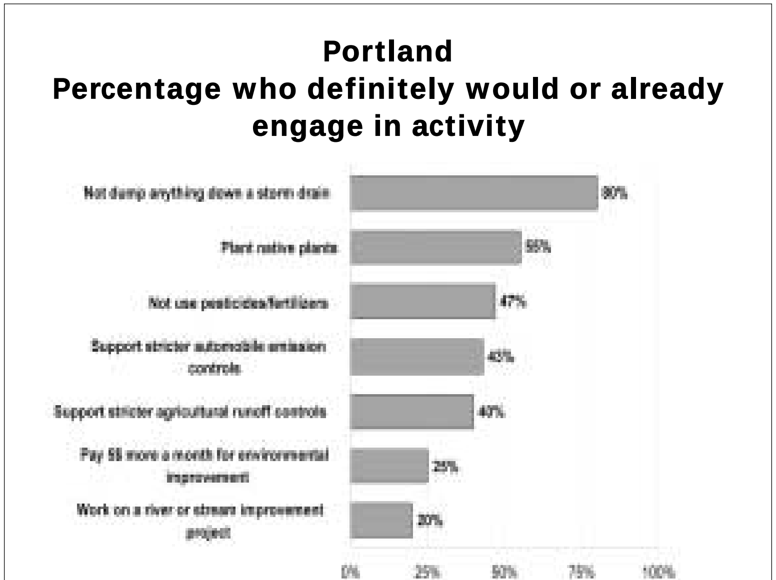
Although not a perfect science, survey research tends to be the best way to understand and measure changes in individual thought and behavior. No surveys have been conducted specific to the Johnson Creek watershed, but several surveys of note have been conducted in the Portland and Seattle areas.

Issue awareness

Salmon issues related to hydroelectric and harvest receive much attention in the headlines. A 1997 *Oregonian* poll found that the plight of salmon in the Columbia River is common knowledge among most Oregonians. In the Portland area, 88% of residents believe keeping salmon in the Columbia and Snake rivers is "very important" or "somewhat important." At a local level, a 1999 Portland Bureau of Environmental Services (BES) survey reported that 92% of Portland residents either "strongly" or "somewhat strongly" agree that native fish are an important asset to Portland. Seventy-four percent of respondents were aware that Johnson Creek existed. (Awareness rose to 81% for residents living within or in close proximity of the watershed.) Those aware of Johnson Creek rated it in low health for fish (2.4 out of 5 points, where 5 is very healthy, 1 is very unhealthy.) The majority of respondents (58%) chose "habitat problems caused by urban development" out of four possible causes (habitat problems, poor water quality, dams, and commercial fishing) as the most important cause of declining fish runs in Portland's rivers and streams.

There appears to be a general understanding of the effects of urban development on fish habitat throughout the Northwest. Forty percent of respondents to the Elway poll in Puget Sound/Seattle (May/June 1999) listed urban development and urban run-off as factors most harmful to salmon.

Chart 12



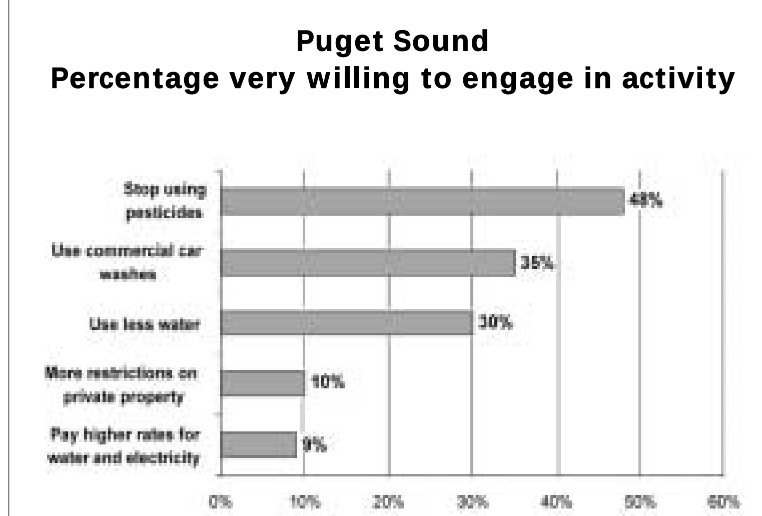
Source: Portland Bureau of Environmental Services, September 1999.

Willingness to pay for and participate in environmental improvement

Although public opinion polls appear to consistently value salmon habitat, willingness to pay for salmon restoration may be decreasing as increasing costs are perceived. The City of Portland BES study found that only 25% of respondents were willing to pay $5 more per month for environmental improvement, and only 20% have or would consider working on a stream improvement project. Activities that received greater support were planting of native plants (55%), reduction in household use of pesticides and fertilizers (47%), and support of stricter controls on agricultural runoff (40%).

Puget Sound residents polled in 1999 were similarly "very willing" to reduce pesticide use (48%). Much fewer were "very willing" to pay higher rates for water and electricity (9%), or accept more restrictions on private property (10%).

Chart 13



Source: The Elway Poll, Seattle, Washington, May-June 1999..

Prioritizing restoration efforts

How restoration efforts are framed and prioritized throughout the region will become increasingly important as more streams are impacted by water quality limitations and endangered fish listings. Since urban populations are found close to major river confluences, urban populations tend to be downstream of rural lands. This population distribution often becomes characterized as urban/rural, or downstream/upstream, antagonisms. Highly degraded urban streams like Johnson Creek often support relatively small salmon populations. In contrast, streams in upstream rural areas may have larger spawning populations, although logging, grazing and agriculture impact these streams. The strategy question that evolves from this distribution of salmon populations and degree of stream impairment is this: "Where do we put our monies and efforts?

Chart 14

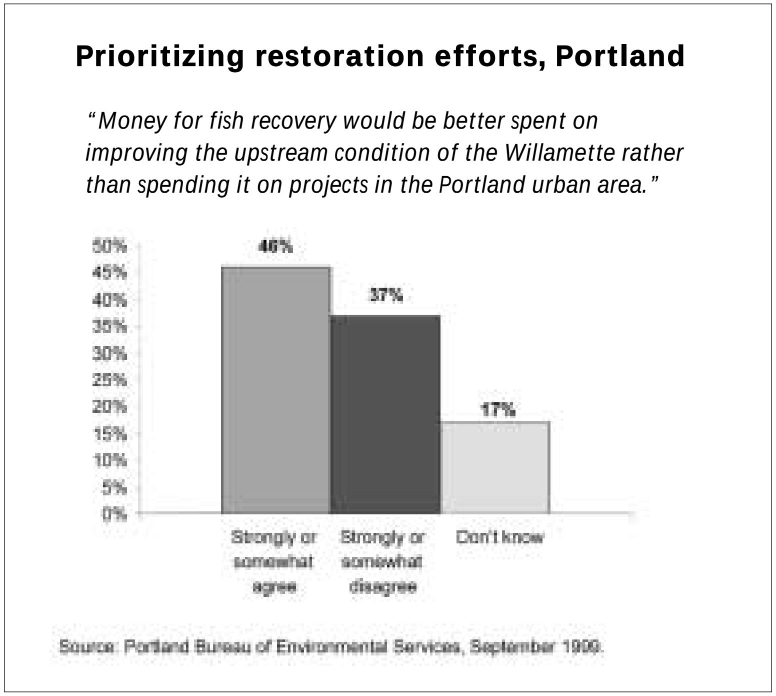
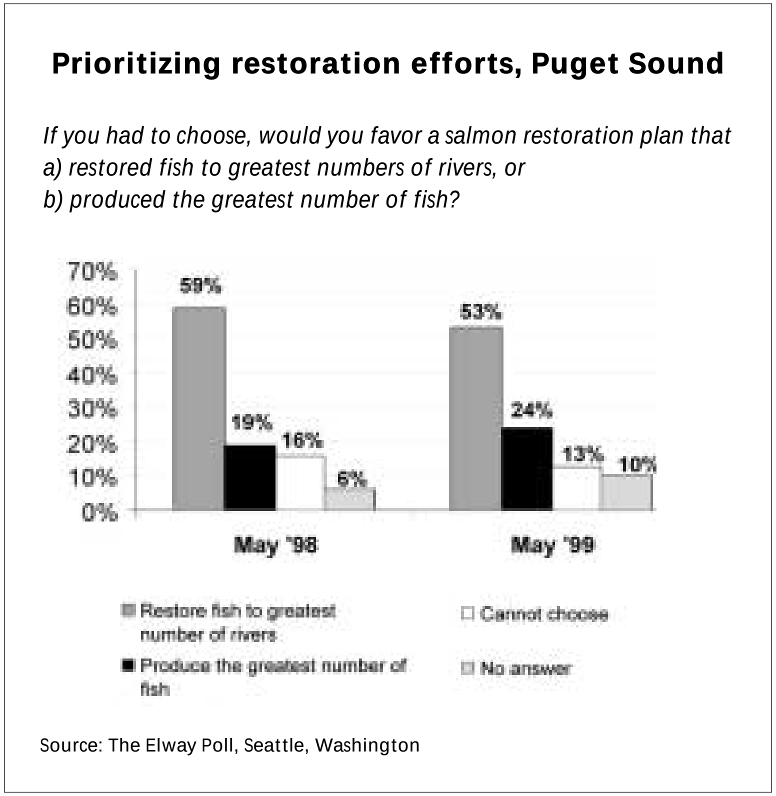


Chart 15



Do we envision salmon recovery as restoring the greatest numbers of fish, even if this means allowing some streams to stay degraded and the possible loss of the genetic resources of the salmon populations that inhabit those streams?" Further, to the extent that Endangered Species Act regulations will allow, do we depend on hatchery fish to increase the number of fish?

In the Seattle area, public opinion on the question of "restoring the greatest number of fish versus the greatest number of river environments" favors healthier rivers at the possible risk of less fish. The Elway poll has been the only local poll to phrase this question so aptly to Puget Sound residents. By a 2 to 1 margin (down from 3 to 1 in 1998), respondents strongly favor a restoration plan that would restore the greatest number of rivers.

The BES survey approached this issue with a different question. It asked Portlanders if “Money for fish recovery would be better spent on improving upstream conditions of the Willamette River rather than spending it on projects in the Portland urban area.” A solid upstream/downstream preference is not apparent in the survey responses. Forty-six percent of respondents either “strongly” or “somewhat strongly” agreed with the statement, 37% “strongly” or “somewhat strongly” disagreed, and 17% did not know.

Salmon and Watershed Indicators

The reliance on hatchery programs to supplement diminishing salmon runs, coupled with technology that could be readily placed at dams to count returning fish, established returning salmon counts, or "escapements" (those fish that escape being caught and return to spawn), as an indicator of the fitness of salmon populations. Today it is generally recognized that these counts tell only part of the story of how well salmon populations are faring, and are often clouded by extraneous environmental and technical factors. Among these complications are fluctuations in ocean conditions that may create wide variance in returning fish from year to year, and the number of hatchery reared fish in the system. While many hatchery-produced fish are marked (their adipose fine is clipped), several stocks are not. This makes it difficult to determine how well a particular native salmon or trout run is faring. Further, fish counts occur primarily on major rivers; fish data are not consistently collected on the tributaries that feed these rivers. For these reasons, escapement counts are not a conclusive indicator of salmon health.

Chart 16

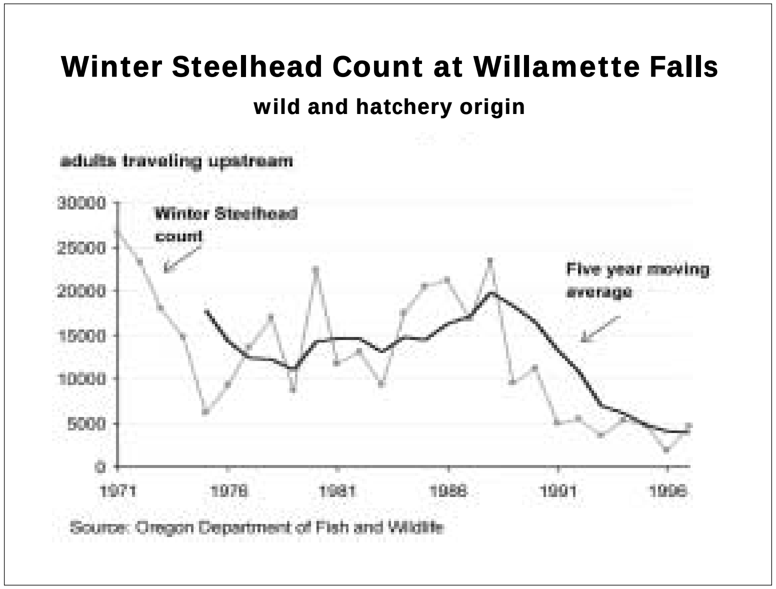


Chart 16 shows historical counts (1971 through 1997) of winter steelhead at the Willamette Falls fishway in Oregon City. The runs counted consist of wild, naturalized and hatchery steelhead.

Escapement counts need to be understood in context of supporting environmental conditions, such as ocean and freshwater habitat. As stated in the Oregon Plan for Salmon and Watersheds Annual Report "Long-term indicators are needed to track whether habitat conditions are improving and whether salmon populations are showing signs of increasing phenotypic diversity." "Phenotypic diversity" refers to the observed behavioral adaptations to local environmental conditions, such as the timing of seaward migration in relation to the stream's flow patterns. The following indicators focus on the freshwater habitat conditions supportive to salmon. Phenotypic diversity of salmon in Johnson Creek is near impossible to describe but is probably low given the low abundance of salmon in the watershed.

Of the following suggested indicators, only three—water temperature, water flow and riparian habitat—have measurement protocols in place.

SUMMER INSTREAM WATER TEMPERATURE

Indicator: Percentage of water temperature samples above 64°F (each year) grouped by reach.

Rationale: Water temperature has been identified as a limiting or unfavorable factor for salmon; DEQ has set 64°F as a regulated standard for salmon bearing streams.

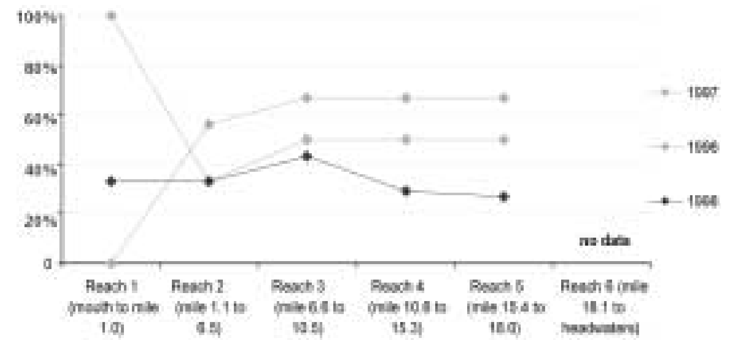
Data sources: Water quality data from DEQ, USGS, Gresham and Portland.

Data notes: Water temperature data are analyzed by reach. Because the number of samples taken in each reach varies (see table below chart), the results are clouded by the frequency of sampling. For example, very high or low percentages may occur because only one or two sample data are available. There is no temperature sampling above river mile 18.0.

Frequency of reporting: Annually.

Chart 17

Percentage of samples that exceeded 64 degrees Fahrenheit, by reach Johnson Creek 1996 through 1998



Source: Portland and Gresham Environmental Services, USGS, DEQ

Year	Reach 1 N=	Reach 2 N=	Reach 3 N=	Reach 4 N=	Reach 5 N=	Reach 6 N=
1996	1	4	4	4	4	no data
1997	1	5	3	3	3	no data
1998	6	3	7	7	11	no data

MINIMUM INSTREAM FLOW

Indicator: Percentage of days each year that the average daily instream-flow fails to meet Oregon Department of Fish and Wildlife recommended instream flows for Salmon, as measured at three different flow gauges.

Rationale: Sufficient instream flow is critical during fry and juvenile development. ODFW's recommended instream flows are often **not** met during the months of July through September.

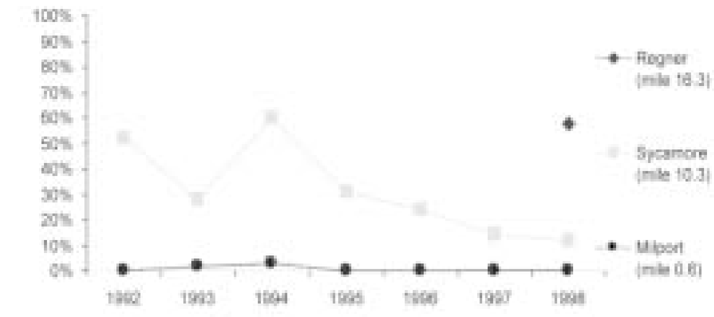
Data sources: Average daily flow measured by USGS at three mainstem gauging stations.

Data notes: Trend begins at 1992 for Sycamore and Milport gauges; 1998 for Regner Road gauge.

Frequency of reporting: Annually.

Chart 18

Percentage of daily instream flows that failed to meet instream flow recommendations*



* Instream flow recommendations are the Oregon Department of Fish and Wildlife instream water rights for Johnson Creek mainstem

RIPARIAN HABITAT

Indicator: Quantity and quality of riparian habitat, scored from 1 (little or no) to 4 (well-vegetated and extending beyond immediate area).

Rationale: Riparian habitat is essential to maintaining a broad set of biological and hydrological functions. This measure will also help determine if restoration projects and setback requirements are effective.

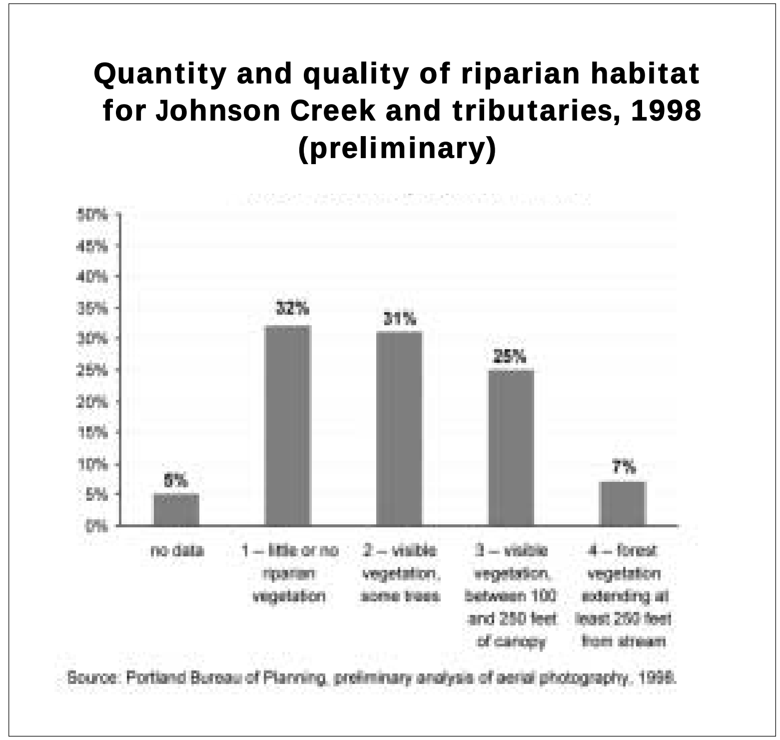
Data sources: Aerial photography interpretation by Portland Bureau of Planning / Endangered Species Act "PEP" team.

Data notes: All categories are important to understanding riparian habitat along the creek. Increases in higher numbers (scores 3 and 4) are desirable; increases in lower numbers (1 and 2) are undesirable.

Frequency of reporting: Every two years, or as aerial photography is available. Only one year's data is available for this indicator.

This indicator could also be enhanced with a measure of restoration work performed along the creek such as miles of linear stream bank planted.

Chart 19



MIGRATORY FISH PASSAGE —

preliminary data not shown

Indicator: Miles of mainstem and tributaries without passage barriers as measured from the confluence at the Willamette River.

Rationale: Understanding the sequence of culverts from confluence to headwaters is critical to determining the types of habitat salmon have access to, and for planning instream and riparian restoration projects.

Data sources: Culvert assessments and culvert replacement / repair records. GIS stream coverage.

Data notes: "Impassable" culverts must be checked against culvert inventories and fish observations. This check will ensure that **1)** all known culverts were assessed and **2)** that culverts assessed as impassable correlate with fish observations (i.e. if anadromous fish have been recently seen above a culvert assessed as impassable, the culvert may not be 100% impassable, but still pose a problem to migrating fish).

Frequency of reporting: Unknown. Depends on frequency of assessment surveys and repair activities.

Number of culverts repaired and replaced will also enhance this indicator although by itself is not an indicator of salmon passage throughout the creek.

INDEX OF BIOLOGICAL INTEGRITY (IBI) —

no data

Indicator: Score of biological integrity for Johnson Creek mainstem and tributaries.

Rationale: Assemblages of resident aquatic organisms such as algae and stream insects respond quickly to environmental stresses, such as sediment, toxins and water temperature. As such, an index of biological integrity assesses many components of the stream system simultaneously. The Index can be deconstructed to understand declines or improvements in the score. The Index may also point to problematic stream sections.

Data sources: Portland State University, under contract with Portland Bureau of Environmental Services, is developing indices for Johnson and Tryon Creeks. **Continued funding for this indicator has not been obtained.**

Data notes: Although the stream samples can be collected easily, identification of the aquatic organisms takes much time and expertise.

Frequency of reporting: Dependent on labor and funding. The Index may be constructed so that parameters are measured in alternate years.

JUVENILE SALMON COUNTS — *no data*

Indicator: Numbers of juvenile steelhead counted annually in Johnson Creek and tributary sampling.

Rationale: Although salmon counts may take many years to statistically verify population trends, these counts need to be performed so that we can relate watershed efforts back to this keystone indicator. Salmon counts can also help us understand the spatial distribution of salmon in the creek.

Data sources: A sampling methodology for Johnson Creek has not been developed.

Frequency of reporting: Unknown.

Strategies toward recovery

Due to the complexity of watershed and salmon recovery issues, it is difficult to assign priorities to recovery strategies. What should be underscored is that salmon recovery requires long-term vision accompanied by inter-jurisdictional cooperation and funding strategies that support comprehensive watershed planning and restoration. Principal to planning efforts is the development of a comprehensive vision for the watershed that integrates environmental objectives rather than mitigates the impact of development on the watershed's natural components.

The priority action-areas outlined in Appendix A of the Johnson Creek Memorandum of Understanding (May 1999) provide a solid foundation for making coordinated improvements in the watershed. The Policymakers Committee should continue to ensure that these action-areas are assigned to lead implementing-agencies. The Policymakers Committee should also seek recommendations for new action-areas to be added to the list when others are completed. In addition, a fair-share funding formula amongst the jurisdictions could help distribute costs for activities such as land acquisition, stormwater management projects, and monitoring. Funding could be allocated on a land-area or stream mile basis with weighting that accounts for impacts from denser populations and downstream effects from upper watershed activities.

The following strategies are grouped into five themes: water quality, water quantity, stream habitat, monitoring, and public awareness.

Water quality protection – temperature

- Local adoption of Metro's Title 3 (and in the near future Goal 5) codifies protection of streambank resources. Adequate enforcement of Title 3, and streambank revegetation are necessary to prevent further water temperature increases.
- Sufficient resources should be dedicated to the development of the Agricultural Water Quality Management Plan under SB 1010. At this time, it is unclear how this volunteer effort will be initiated and supported. The East Multnomah County Soil and Water Conservation District should consider seeking grant funds and/or contributions from the local jurisdictions to support the Plan's development.
- Because agricultural lands outside of Metro's jurisdiction are exempt from Title 3, local jurisdictions should provide input to the development of streambank protection measures included in the SB 1010 Agricultural Water Quality Management Plan.
- Small water detentions, whether for irrigation or stormwater control, should be identified and evaluated for their potential releases of warm water to the stream.
- Local jurisdictions should also consider developing conservation easements for private properties adjacent to the stream.

Water quality protection – sediment and pollutants

- All jurisdictions should make implementation and enforcement of erosion control regulations a top priority. This includes evaluating the adequacy of enforcement staff and increasing staff as necessary. Monies for increased enforcement may come from increased permit fees and/or increased financial penalties for erosion control non-compliance, as state statutes allow.
- Develop better measures for contractor monitoring and reporting on the effectiveness of erosion control devices. For example, installing an erosion control device and requiring contractors to monitor the turbidity of run-off would enable them to evaluate their erosion control practices on a regular basis. This may be accomplished by requiring that construction firms designate a "code compliance liaison" who consults and periodically reports to local inspectors.
- Jurisdictions should consider including in their erosion control ordinances specific time periods for clearing and grading activities. This way erosion-causing activities are avoided when potential run-off to the stream is greatest.
- Jurisdictions should continue to educate the public on pollution prevention and the relationship between non-point pollution and stream health.

Water quantity – summer low flows

- The Oregon Water Resources Division (OWRD) should dedicate staff resources to developing and documenting an accurate understanding of the amount of water diverted from the creek. This effort should include assessing and quantifying which water rights are truly active, canceling non-active rights, and estimating (and shutting-off) illegal diversions.
- The OWRD should also consider requiring that all water diversions be metered, so water users do not inadvertently pull a greater "instantaneous" flow from the creek than it can sustain.
- The OWRD should also engage in a watershed-wide educational campaign in partnership with the Oregon Water Trust and Oregon Department of Fish and Wildlife about the benefits of instream water rights.
- These strategies may require additional funding of OWRD. Additional OWRD staff could be funded in part through a funding partnership of the jurisdictions.

Water quantity – winter high flows

- For new and re-development, detention structures should be viewed as a last resort technique for stormwater management. Focus should be placed on design elements that retain or mimic natural features for processing stormwater.
- Plans for new development, including former urban reserves 4 and 5, should be performed on a sub-watershed basis, minimize disturbance of the natural or existing landscape, and emphasize natural drainage and strict impervious limits. For example, plans for new development in a suburb of Vancouver, British Columbia, Canada incorporate natural drainage features that infiltrate all stormwater within the community's boundaries.
- Current detention facilities should be evaluated for their effectiveness in holding back and attenuating the volume of water generated in a typical storm. If the facilities are found deficient, they should be supplemented with additional stormwater management techniques.
- Minimizing the impact of stormwater outfalls should be given greater consideration in watershed planning. Existing outfalls should be evaluated for removal or directed through vegetated-buffers or constructed wetlands before reaching the creek.
- Local jurisdictions should require a permit or consultation to remove deciduous or evergreen trees with a caliper greater than 5 inches. Substantial fines for tree cutting without a permit should be imposed. If trees must be cut, strict mitigation requirements should apply.

Stream habitat, including fish passage

- Make instream improvements, restore streambanks, and acquire flood-prone and other areas identified as good or potential salmon habitat.
- Develop a comprehensive inventory and prioritization of upland, riparian and instream sites for restoration, as noted in the Johnson Creek Memorandum's Appendix A. Part of this inventory has been completed as part of the Johnson Creek Revegetation Program. A lead agency should be identified to complete this work.
- The Inter-jurisdictional Committee should ensure that it also reviews the smaller proposed watershed restoration projects and grant requests to help align projects with watershed needs and opportunities.
- In order to track restoration progress in the watershed, information about restoration projects, such as location, types of improvements made, participants in the process, and parties responsible for maintenance, should be collected by a lead organization. The Johnson Creek Watershed Council, with appropriate funding, may be best suited to this task.
- Ensure that all restoration projects are properly maintained, such as watering, weeding, and replanting, for several years after installation.
- Develop a long-term funding source to acquire the identified key acquisition target areas when they become available. Applications for state and federal funding should be coordinated among the jurisdictions, with demonstrated connections to the protection of people, property and wildlife (e.g. flood hazard areas). A watershed-based bond initiative or local environmental tax district might be considered to raise funds for land acquisition and restoration.
- The jurisdictions should continue to pursue flood management and restoration activities that reconnect floodplain with the active channel, and pursue FEMA funds for those activities. This involves discussions with FEMA to obtain greater funding for pre-disaster mitigation.
- Fish passage considerations must be incorporated into restoration inventory and prioritization. Local jurisdictions may wish to consider using either the Clackamas County ranking system for culvert replacement or the one that the City of Portland ESA team is developing.
- Maintenance schedules for existing culverts should be considered comprehensively.
- Repair or replacement of locally owned culverts should be considered in the cost of road improvements, rather than as additional expenditures.

Monitoring

- The Inter-Jurisdictional Committee should develop a fair-share formula so that all jurisdictions participate in funding instream-monitoring efforts.
- Monitoring could be better coordinated among the agencies that have monitoring gauges or stations in place. This includes:
    1) A coordinated quality control and quality assurance process for data collection
    2) Better spatial distribution of monitoring stations on the mainstem, including the addition of monitoring stations in the headwater areas
    3) A centralized database system, such as EPA's *STORET* database, for consistent data reporting and storage.

- Biological criteria should be considered in monitoring. If the initial results of the trial index of biological integrity (being developed in partnership between the City of Portland and Portland State University) are valid and meaningful, the six jurisdictions should evaluate the application of this methodology to the entire watershed.
- Spawning surveys and juvenile fish inventories should be performed consistently. To ensure mainstem and tributary locations are surveyed and timed in accordance with steelhead, cutthroat, chinook and coho life cycles, appropriate staffing should be dedicated to these surveys by the Oregon Department of Fish and Wildlife. Local jurisdictions and property owners should be enlisted in these efforts as well.
- The Inter-jurisdictional Committee, DEQ and USGS should consider supporting a university research project that studies the relationship between land-use, mitigation practices and sediment load. Such a study will help inform the local jurisdictions on how well stricter erosion controls are working, and what types of activities generate the most sediment. These studies could also look at the types of pollutants attached to sediment in order to determine where pollution prevention efforts should be focused.

Public awareness / education

- Local jurisdictions and the Johnson Creek Watershed Council should continue and expand watershed based educational campaigns around pollution prevention, the importance of the urban tree canopy, and the watershed itself.
- Consider a Biennial instead of the Annual Johnson Creek Summit, to reduce the burden on staff resources in preparation. In interim years, a short publication documenting watershed policy, programs and annual accomplishments could be distributed to prior attendees of the Summit.
- The Johnson Creek Watershed Council should consider developing a “watershed watcher” program that trains residents on how to identify violations of water quality and development regulations, spot illegal water diversions and discharges, and how to report suspected violations to the appropriate agencies. This sort of program would strengthen the enforcement capacity of local jurisdictions.

Memorandum of Understanding for the Johnson Creek Watershed

Appendix A: Project and Policy Issues List — May 9, 1999

1. Coordinate funding with COE, FEMA, and the Johnson Creek Watershed Jurisdictions to complete the floodplain delineation study. (Lead: City of Portland with Interjurisdictional Committee support)

2. Recommend and support legislative changes to forestry and agricultural practices within mostly urban watersheds to prevent erosion and control sedimentation and to implement best management practices (BMP's) to improve water quality throughout the Watershed. (Lead: unidentified. Interjurisdictional Committee will provide technical support on BMP development.)

3. Obtain direct or in-kind funding to coordinate, develop, and implement Project Impact within the Watershed. (Lead: City of Portland and Multnomah County)

4. In cooperation with appropriate local, State, and Federal agencies, fund and conduct a watershed-wide restoration site inventory project to prioritize public and private sites along Johnson Creek and its tributaries for riparian area planting and restoration projects. (Lead: unidentified. JCWC, Interjurisdictional Committee, and Metro will provide technical support.)

5. Work together to identify key properties for acquisition within the 100 year flood plain of Johnson Creek on a willing seller basis and to obtain annual funding through local, State, and Federal agencies to purchase the identified properties in order to reduce flood damage, improve water quality, and enhance fish and wildlife habitat. (Lead: City of Portland)

6. Each party will adopt stream-side buffer requirements and flood plain balanced cut and fill regulations for the Johnson Creek Watershed based on Metro's Title 3 Model ordinance which will adequately protect water quality and reduce flood damage impacts. (Lead: Local jurisdictions)

7. Work cooperatively to ensure that the Oregon State Legislature develops and passes implementing legislation for the recently passed Measure 66 (15% of Oregon Lottery Funds for State Parks and fish & wildlife habitat restoration). (Lead: JCWC)

8. Work cooperatively to ensure that the Oregon State Legislature provides adequate ongoing funding for Watershed Councils in general and the Johnson Creek Watershed Council specifically. (Lead: JCWC)

9. Participate jointly and cooperatively in the planning, organization, and hosting of the second Johnson Creek Watershed Summit. (Lead: Summit Steering Committee with support from Interjurisdictional Committee)

10. Commit to fund, coordinate, and develop land use plans for the urban reserve areas in the Watershed which will properly address and protect fish & wildlife habitat and recreational opportunities of the Creek and its tributaries. This will include model standards for development which are “watershed friendly”. (Lead: Local jurisdictions and Metro with Interjurisdictional Committee developing model standards)

11. Develop a mechanism to coordinate various planning efforts in the watershed and ensure, where applicable, the incorporation of the following principles:

a. flood damage reduction
b. appropriate land development: encourage development outside the flood plain, adequate riparian buffers, erosion control, and storm water quality and quantity controls
c. fish and wildlife enhancement and Endangered Species Act (ESA) considerations
d. pollution prevention for all activities

(Lead: Local jurisdictions with coordination through Interjurisdictional Committee)

12. Implement specific action items contained in the May, 1995 Johnson Creek Resources Management Plan and revise as necessary. (Lead: Local jurisdictions with support from JCWC, Interjurisdictional Committee, and Metro)

13. Obtain direct funding or in-kind contributions for the Johnson Creek Summit Coordinator position. (Lead: Local jurisdictions)

Glossary of Selected Terms

Adapted from StreamNet: http://www.streamnet.org/ff/Glossary/

Alevin — The developmental life stage of young salmonids and trout that are between the egg and fry stage. The alevin has not absorbed its yolk sac and has not emerged from the spawning gravel.

Canopy — A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. This term may also include leaves, branches and vegetation that are above water and provide shade and cover for fish and wildlife.

Cobble — Substrate particles that are smaller than boulders and are generally 64-256 mm in diameter. Can be further classified as small and large cobble. Commonly used by salmon in the construction of a redd.

Confluence — The stream or body of water formed by the junction of two or more streams or rivers.

Corridor — A defined tract of land, usually linear, through which a species must travel to reach habitat suitable for reproduction and other life-sustaining needs.

Cover — Vegetation used by wildlife for protection from predators, or to mitigate weather conditions, or to reproduce. May also refer to protective shading provided by vegetation.

Dissolved Oxygen (DO) — The amount of free (not chemically combined) oxygen dissolved in water, usually expressed in milligrams per liter.

Diversion — The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.

Eddy — A circular current of water, usually resulting from an obstruction.

Embryo — The early stages of development before an organism becomes self-supporting.

Emergence — The process during which fry leave their gravel spawning nest and enter the water column.

Endangered species — Any species of plant or animal defined through the Endangered Species Act as being in danger of extinction throughout all or a significant portion or its range, and published in the Federal Register.

Endangered Species Act (ESA) — A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Enhancement — Emphasis on improving the value of particular aspects of water and related land resources.

Erosion — Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Estuary — A coastal body of water that is semi-enclosed, openly connected with the ocean, and mixes with freshwater.

Floodplain — Land that gets covered with water as a result of the flooding of a nearby stream. Similarly, level lowland bordering a stream or river onto which the flow spreads at flood stage.

Floodplain (100-year) — The area adjacent to a stream that is on average inundated once a century.

Flow — The amount of water passing a particular point in a stream or river, usually expressed in cubic-feet per second (cfs).

Food chain — Organisms that are interrelated in their feeding habits, each feeding upon organisms that are lower in the chain and in turn being fed on by organisms higher in the chain.

Fry — A stage of development in young salmon or trout. During this stage the fry is usually less than one year old, has absorbed its yolk sac, is rearing in the stream, and is between the alevin and parr stage of development.

Genetic diversity — The array of genetic traits that exists within a population which enables it to adapt to changing conditions.

Habitat — The local environment in which an organism normally lives and grows.

Habitat diversity — The number of different types of habitat within a given area.

Homing — The ability of a salmon or steelhead to correctly identify and return to their natal stream, following maturation at sea.

Hyporheic zone — The area under the stream channel and floodplain that contributes nutrients to the stream.

Impact — A spatial or temporal change in the environment caused by human activity.

Indicator — An organism, species, or community that shows the presence of certain environmental conditions.

Instantaneous flows — The velocity of a volume of water at a particular point in time.

Jack salmon — A young male salmon that matures precociously (earlier than other fish in its age-class).

Juvenile — Fish from one year of age until sexual maturity.

Large woody debris — Pieces of wood larger than 10 feet long and 6 inches in diameter in a stream channel.

Limiting factor — A requirement such a food, cover or spawning gravel that is in shortest supply with respect to all resources necessary to sustain life and thus "limits" the size or retards production of a fish population.

Mainstem — The principle channel of a drainage system into which other smaller streams or rivers flow.

Minimum flow level — The level of stream flow sufficient to support fish and other aquatic life, to minimize pollution, or to maintain other instream uses such as recreation and navigation.

Natal stream — Stream of birth.

Naturalization — The process by which introduced fish successfully establish a naturally spawning population.

Nonpoint source pollution — Pollution that does not originate from a clear or discrete source.

Outfall — The mouth of a drain or sewer.

Parr — The developmental life stage of salmon and trout between alevin and smolt, when the young have developed parr marks and are actively feeding in fresh water.

Parr marks — Distinctive vertical bars on the sides of young salmonids.

Passage — The movement of migratory fish through, around, or over dams, reservoirs and other obstructions in a stream or river.

Peak flow — Refers to a specific period of time when the discharge of a stream or river is at its highest point.

Physiological — Pertaining to the functions and vital processes of living organisms and the organs within them.

Pollutant — Something that pollutes, especially a waste material that contaminates air, soil, or water. Similarly, any solute or cause of change in physical properties that renders water unfit for a given use.

Pool — A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Pool/riffle ratio — The ratio of 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. Used to describe fish habitat rearing quality.

Pre-smolt — A juvenile salmon or steelhead that has not yet reached the physiological state known as a smolt.

Predation — Hunting and killing another animal for food.

Productivity — A measure of the capacity of a biological system. Also used as a measure of the efficiency with which a biological system converts energy into growth and production.

Rearing — Refers to the amount of time that juvenile fish spend feeding in nursery areas of rivers, lakes, streams and estuaries before migration.

Rearing habitat — Areas in rivers or streams where juvenile salmon and trout find food and shelter to live and grow.

Recovery — Action that is necessary to reduce or resolve the threats that caused a species to be listed as threatened or endangered.

Redd — A nest of fish eggs covered with gravel.

Redd Counts — A spawning female salmon prepares a series of nests, called a redd, in suitable areas of streams. Redd counts are used to compare the relative magnitude of spawning activity between years.

Resident species — Species of fish which spend their entire lives in freshwater.

Restoration — The renewing or repairing of a natural system so that its functions and qualities are comparable to its original, unaltered state.

Riffle — A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders.

Riparian habitat — The aquatic and terrestrial habitat adjacent to streams, lakes, estuaries, or other waterways.

Riparian vegetation — The plants that grow rooted in the water table of a nearby wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, or meadow.

Riprap — Usually refers to rocks or concrete structures used to stabilize stream banks from erosion.

Run (in stream or river) — A reach of stream characterized by fast flowing, low turbulence water.

Run (of fish) — A group of fish of the same species that migrate together up a stream to spawn, usually associated with the seasons, e.g., fall, spring, summer, and winter runs. Members of a run interbreed, and may be genetically distinguishable from other individuals of the same species.

Runoff — Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.

Salmonid — Fish of the family Salmonidae, that includes salmon and steelhead.

Sediment — The organic material that is transported and deposited by wind and water.

Smolt — Refers to the salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.

Smoltification — Refers to the physiological changes anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.

Spawn — The act of reproduction of fishes. The mixing of the sperm of a male fish and the eggs of a female fish.

Spawning surveys — Spawning surveys utilize counts of redds and fish carcasses to estimate spawning activity and identify habitat being used by spawning fish. Annual surveys can be used to compare the relative magnitude of spawning activity between years.

Species — A group of closely related individuals that can interbreed and produce fertile offspring.

Steelhead — The anadromous form of the species Oncorhynchus mykiss. Anadromous fish spend their early life history in fresh water, then migrate to salt water, where they may spend up to several years before returning to fresh water to spawn. Rainbow trout is the non-anadromous form of Oncorhynchus mykiss.

Stream — A general term for a body of flowing water. A natural water course containing water at least part of the year.

Stream Channel — The bed where a natural stream of water runs or may run; the long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.

Stream reach — An individual stream segment that has beginning and ending points. Reach end points are normally designated where a tributary confluence changes the channel character.

Streambank erosion — The wearing away of streambanks by flowing water.

Streambank stabilization — Natural geological tendency for a stream to mold its banks to conform with the channel of least resistance to flow. Also the lining of streambanks with rock or riprap to control erosion.

Streambed — The channel through which a natural stream of water runs or used to run, as a dry streambed.

Streamflow — The rate at which water passes a given point in a stream or river, usually expressed in cubic feet per second (cfs).

Substrate — The composition of a streambed, including either mineral or organic materials.

Trend — A statistical term referring to the direction or rate of increase or decrease in time series data when random fluctuations of individual members are disregarded. Similarly, a unidirectional increasing or decreasing change in the average value of a variable.

Tributary — A stream that flows into another stream, river, or lake.

Turbidity — The term “turbid” is applied to waters containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted.

Urban runoff — Storm water from city streets and gutters, that usually contains pollutants and organic wastes, and flows into sewer systems and receiving waters.

Water rights — Priority claims to water. In western States, water rights are based on the principle of prior-appropriation, or “first in time, first in right.” This means that older claims take precedence over newer ones.

Watershed — An area of land that drains to a specific stream.

Watershed management — The analysis, protection, development or maintenance of the land, vegetation and water resources of a watershed for the conservation of its resources and the benefit of its residents.

Watershed restoration — Improving current conditions of watersheds to restore degraded fish habitat and provide long-term protection to aquatic and riparian resources.

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