WRI

Willamette Restoration Initiative

RESTORING THE WILLAMETTE BASIN

Strategic Issues and Challenges

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Restoring the Willamette Basin: Issues and Challenges

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This report describes environmental and social conditions in the Willamette River Basin, in terms of the Willamette Restoration Initiative's vision, mission and six goals, as of September 1999.This document is not a definitive description of the basin, but rather, a starting point for further discussion. Substantial sources of information, such as the State of the Environment Report, the Watermaster model, and the Willamette Basin Alternative Scenarios reports, will be published in the near future, and their findings will provide valuable additional information and insights. Our collective knowledge of the subjects addressed in this report thus will be continually improving; subsequent Initiative reports and strategies should reflect this improvement.

This report was commissioned to provide the WRI Board with condensed information on the Willamette Basin. Although the Board previewed early drafts, this document does not result from a formal Board approval process. Therefore, any characterizations, statements, or conclusions herein do not necessarily reflect the views of the WRI Board.

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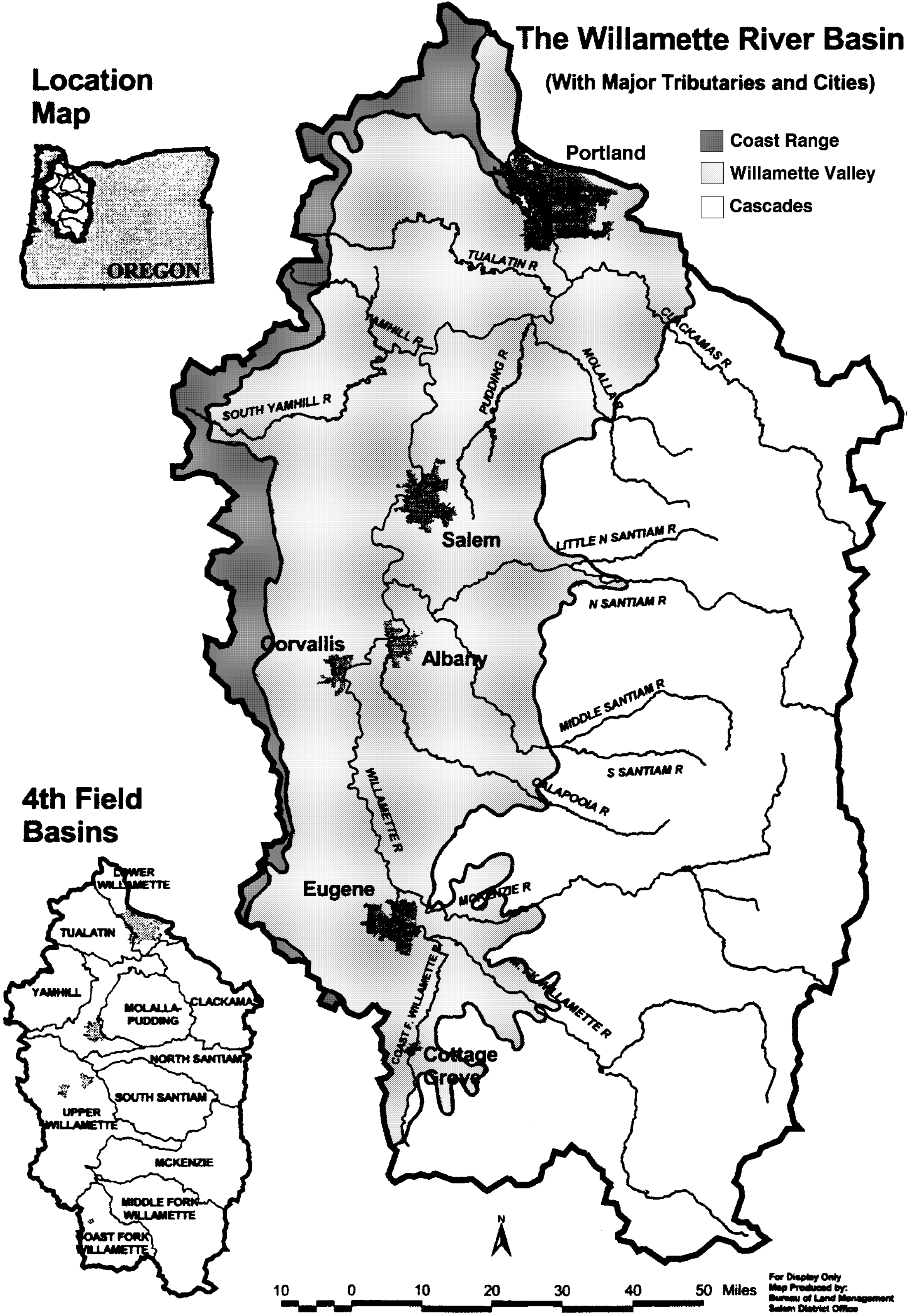
List of Acronyms

BLM	Bureau of Land Management
BMP	Best Management Practices
CREP	Conservation Reserve Enhancement Program
CWA	Clean Water Act
DEQ	(Oregon) Department of Environmental Quality
EPA	(U.S.) Environmental Protection Agency
ESA	Endangered Species Act
FEMAT	Forest Ecosystem Management Assessment Team
FWS	(U.S.) Fish and Wildlife Service
USGAO	(U.S.) General Accounting Office
IPM	Integrated Pest Management
ISG?	Independent Study Group
NAWQA	National Water Quality Assessment
NCCP	Natural Community Conservation Planning
NMFS	National Marine Fisheries Service
OBC	Oregon Business Council
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
SDWA	Safe Drinking Water Act
SWCD	Soil and Water Conservation Districts
TMDLs	Total Maximum Daily Loads
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Services
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
WLF	Willamette Livability Forum
WRI	Willamette Restoration Initiative



The Willamette River Basin

(With Major Tributaries and Cities)

For Display Only
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Bureau of Land Management
Salem District Office

I. Executive Summary

The challenges facing restoration efforts in the Willamette Basin are complex. The commitment of basin residents across all sectors will be critical to achieving the basin's ecological, economic, and social goals. Below we summarize the key issues, actions, challenges, and opportunities identified in this report.

Willamette waters are being used to the limits of their capacity. Existing water use patterns leave little available water for instream uses to support aquatic life or to maintain water quantity/quality for likely future demands. Even with innovative surface water management, groundwater will likely be utilized more extensively in the future than at present.

Water quality has improved during the past decades, but Willamette Basin waters are still impaired by high temperatures, pollution and runoff. Water temperature regimes have been changed so that they are out of synch with biological needs and exceed the tolerance of some native species. Pesticides, fertilizers and toxic pollution from agricultural and urban areas reduce water quality in basin streams and rivers. Sediment from logging, farming, industry and urban activities also reduce water quality and fish habitat.

Native habitats have been altered and reduced, adversely affecting native species. River channels, floodplains, wetlands, and surrounding uplands have been significantly changed from historic conditions, altering natural systems and habitats. Changes to natural flows of basin rivers have affected both water and habitat quality.

Affordability will be a key consideration in developing a restoration strategy. Incentives and markets that can support restoration efforts are not fully developed and need to be expanded. A combination of regulatory and non-regulatory approaches will be needed to support restoration goals.

Environmental, social and economic goals are not currently well integrated, contributing in part to the basin ecosystem's current condition. Without clear regional restoration goals, local efforts may be wasted. Institutional objectives also must support broader regional goals.

Population growth is a major challenge. As population increases in the basin, quality of life issues (e.g., affordable housing, transportation, outdoor recreation, aesthetic concerns) will become even more difficult to address. Recreation can have significant impacts on water and habitats, and these impacts will need to be addressed.

There is a strong need for public engagement in restoration activities in the basin. Without a continually engaged citizenry, the ability to sustain a healthy ecosystem will be at risk. Local capacity for meeting this challenge is lacking is some cases, and there is no unified regional framework to guide local efforts.

Existing conservation efforts are hampered by a lack of coordination and clear goals that integrate sub-regions (e.g., uplands, valley, mainstem, river mouth) and sectors (e.g., recreation, forestry, agriculture, industry, urban). There is currently no integrated information management system to support restoration, and no consistent performance measurements and standards to measure progress.

Adequate funding for restoration efforts is essential. Currently, financing for restoration is fragmented. All stakeholders must commit resources over the long term to achieve restoration goals.

Based on a review of the conditions and key needs relevant to each of the Initiative's six goals, a several possible strategies emerge repeatedly:

- Riparian buffers can help to mitigate many sources of water pollution. Criteria concerning the width and placement of riparian buffers on lands in each sector need to be clearly established, along with mechanisms for compliance.

- The acceleration and implementation of restoration plans, whether TMDLs, ESA recovery plans, HCPs or watershed management plans, will be critical for restoring the Willamette. Early development of these plans will be more cost effective than delaying action and paying for more extensive restoration at a later date.

- We cannot state this strongly enough: the multiple research, management and restoration efforts underway or planned for various parts of the basin will best achieve both individual and basin-wide goals if they are coordinated. There are four key components to achieving this synergy:

    1. Development of a basin-wide vision, plan and goals that recognize regional variation.

    2. Development of explicit mechanisms for communication to allow for the efficient and timely flow of pertinent information between groups.

    3. Implementation of comprehensive educational programs designed to reach all residents of the basin.

    4. Commitment to adequate funding necessary to carry out these steps.

The Initiative is uniquely positioned to provide the necessary components for a successful restoration strategy by providing better access to information about conditions and opportunities in the basin, supporting educational efforts to ensure basin residents understand their roles as stewards, and providing access to a diverse group of funding sources.

II. Introduction

The Willamette Basin

The Willamette River *Basin*[*] comprises approximately 11,460 square miles, about 12 percent of the land area of Oregon. The Willamette River itself is typically the focus of the *basin*, as it is the tenth largest river in the US based on average annual flow (USACE April 1999). The Willamette is divided into 12 sub-basins, and flows approximately 187 miles from Eugene north to Portland before it joins with the Columbia River. Channel depths found throughout the river channel vary considerably depending upon location and season.

Land use in the basin is approximately 69 percent forestry, 22 percent agriculture, and eight percent urban. Conservation areas account for about one percent of the Willamette *Valley's* land; this percentage is much higher when federal *uplands* are included. A majority of the Valley's population resides in the Portland metropolitan area at the lower end of the valley, the cities of Salem, Albany and Corvallis in the middle of the valley, and the Eugene/Springfield metropolitan area at the upper end of the valley.

The Valley has provided for much economic prosperity; however, this prosperity has come at a cost to the natural systems that once flourished in the Willamette basin. Basin health has been affected in terms of water and *habitat* quality and quantity. Many *native species* have been adversely affected due to the introduction of *non-native species*, loss of habitat and habitat degradation, and contaminated waters which impede *species'* development. Increased population and development have further compounded these problems, resulting in the loss of much critical habitat and increased *pollution.*

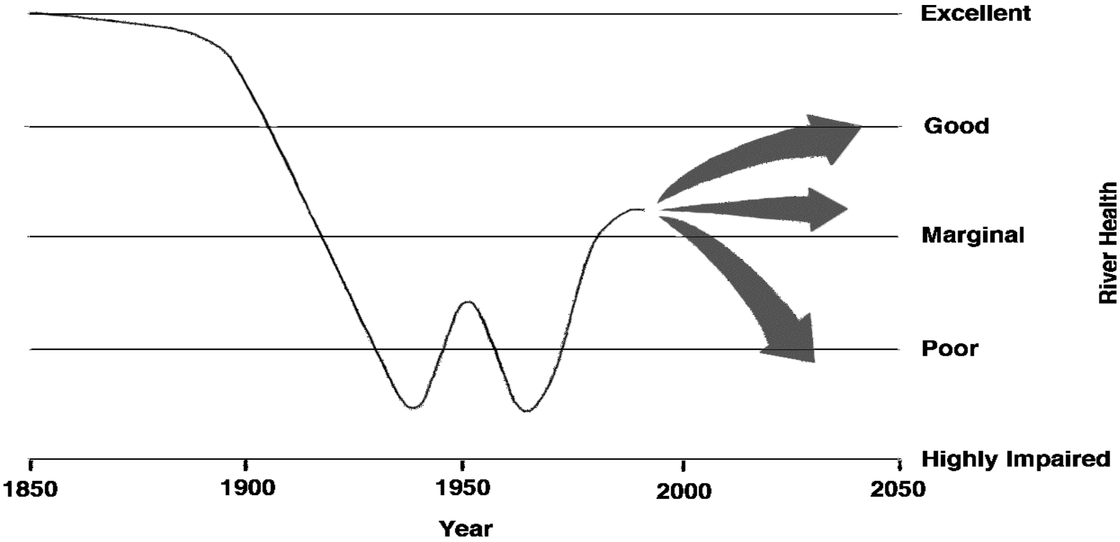

Figure 1: Past, present, and possible future health of the Willamette River, based on estimates of historic conditions, and on recent water quality, biota, and habitat studies. (Modified from Leland et al. 1997)

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[*] Italicized words in the body of this paper are defined in an appendix on page 70.

Despite continued population growth and development, some measures of *watershed* health in the basin have improved since the 1970's. It was on this hopeful note that the Willamette Restoration Initiative was launched in 1998, recognizing that formidable challenges await, but confident that Oregon's legacy of fostering both a healthy environment and a vibrant economy is prologue for the work ahead.

The Willamette Restoration Initiative

The Willamette Restoration Initiative (the Initiative) is a broad-based effort to promote, integrate and coordinate efforts to protect and restore the health of the Willamette watershed. The Initiative was established based on the recommendations of the Willamette River Basin Task Force (Task Force). The Task Force was charged by Governor Kitzhaber to examine the causes of, and potential solutions to, water quality problems in the Willamette River. The Task Force approached the issue by considering all watershed-related activities along the Willamette and its tributaries, resulting in over 100 specific recommendations (Task Force 1997). Based on the recommendations of the Task Force, the Willamette Restoration Initiative was established by Executive Order 98-18 in October 1998.

The Initiative's Board of Directors - made up of representatives from business, agriculture, agency, local governments, *watershed councils*, conservation groups, and other key leaders from around the basin - are charged to fashion and carry forward a shared vision for a revitalized watershed capable of sustaining a healthy economy. Their current mandate is to develop a Willamette Restoration Strategy, including the Willamette Basin component of the Oregon Plan for salmon and watersheds. The Initiative is to identify and promote strategies that focus on protecting fish and wildlife, and their habitat; managing *floodplains*; and enhancing water quality, all within the context of human habitation and population growth. The Initiative has not been granted any legal authority to impose or enforce the results of the Willamette Restoration Strategy. Rather, its members have committed to facilitating, convening, informing and recommending actions that will improve the health of the watershed and restore native salmon.

The Initiative will work to provide a context for *restoration* in the basin by undertaking and communicating the actions that will most effectively restore key components of a healthy watershed. "Restoration" in this case does not mean attempting to bring the basin back to conditions that existed 150 years ago. It means working to protect a number of remaining pieces of that landscape, and helping to restore some natural processes that can aid salmon recovery, improve water quality, and meet other goals of a healthy watershed. Through its efforts, the Initiative seeks to ensure that each dollar spent on basin recovery will be put toward the most strategic efforts to improve basin ecological and economic health.

The task before the Initiative is to develop a strategy for achieving the goals of clean water and healthy habitats in the Willamette Basin (Table 1). However, other societal goals – desire for a strong economy, high quality of life, shared community *stewardship*, and accountable institutions -- define the context for strategies to enhance and protect water quality and habitat. To be effective, strategies to achieve clean water and healthy habitats will need to respect and incorporate these goals.

Scope of This Paper

This paper is intended to provide a common framework for understanding the key activities and conditions that affect water quality and habitat health in the Willamette Basin. The key challenges, tradeoffs, and opportunities related to economic development and quality of life

Table 1. Initiative vision and goals.

Vision: The Willamette Basin must attain a dynamic balance between diverse human and ecological needs. Basin residents should live in healthy watersheds with functioning floodplains and habitats supporting a diversity of species. Opportunities should exist for people to interact with the wildness of a restored, healthy river system. Valley residents should be a part of a larger basin community, connected by a system of rivers and streams. That system should provide healthy aquatic life, clean drinking water, safe places for recreation, and support for a vibrant economy. Residents must accept individual and collective responsibility for this vision, and provide leaders with a mandate and the resources necessary to achieve and sustain it.

Mission: To develop a Willamette Restoration Strategy, including the Willamette Basin component of the Oregon Plan for salmon and watersheds. The Initiative is to identify and promote strategies that focus on protecting fish and wildlife and their habitat; managing floodplains; and enhancing water quality, all within the context of human habitation and population growth.

Goals:

Clean Water**:** The Willamette River and its tributaries meet or exceed standards, are clean enough for safe swimming and fishing, and offer safe and affordable drinking water sources.

Healthy Native Habitats**:** Habitats for native species are abundant and provide the natural processes necessary for self-sustaining populations.

Strong Economy**:** A robust, diverse basin economy draws continued strength from sustainable natural resource use and restoration strategies.

High Quality of Life**:** Basin residents have the opportunity for frequent interaction with healthy streams and natural settings in urban, rural, agricultural and forest lands.

Shared Community Stewardship**:** Basin citizens collectively commit to watershed stewardship by understanding their impacts on, and contributions to, watershed health and each other.

Accountable Institutions**:** Watershed health efforts by government, businesses, and local groups are managed in a cooperative, business-like way, with clear roles, measurable objectives, and specific performance measures which are carefully tracked.

are identified; implications for community stewardship and the institutional framework are also explored. To the extent possible, examples of what has worked and what has not are included. The paper does not seek to provide recommendations, but rather to provide sufficient information, drawn from the extensive body of work on the basin to date, to frame a constructive discussion of sector-specific strategies. Information gaps, ongoing studies addressing such gaps, and other sources of information forthcoming in the near term are identified where known and relevant.

This paper seeks to provide information on the current ecological conditions and critical issues related to water quality and habitats in the valley; however, neither the ecological nor the social environment of the valley are static. The most critical continuing pressure on the system - growth in population, to the tune of another 2 million people over the next 50 years - must be taken into account in designing a long-term strategy for the valley's ecological, economic, and social health.

The projected population growth in the valley will place additional pressures on the valley's human, financial, and natural resources, requiring even tougher choices between alternative uses of the resource base. Tradeoffs are inevitable, as use of a resource for one purpose may preclude its use for another. This is not to say that there are no "win-win" strategies – there are many opportunities to make progress toward clean water and healthy habitats while reaping economic benefits and improving our quality of life. However, there are also issues that will require difficult decisions.

III. The Willamette Environment

This section briefly describes how the Willamette Basin works from source to mouth, how humans have used and altered the valley's resources in the past and present, and the environmental issues that face basin stakeholders. A strategy for the basin will need to reflect the environmental variation within the region, in terms of ecosystem conditions and land use. As we describe these conditions, we will highlight key issues that an Initiative strategy will need to address.

One useful way to organize our thinking about the basin is to divide it into ecoregions, which integrate landforms, soils and vegetation (Omernik and Gallant 1986). The major (Level III) ecoregions of the Willamette River Basin are the Coast Range, the Willamette Valley, and the Cascades. For this discussion, the Coast Range and the Cascades will be defined as *"uplands."* The Uplands and the Willamette Valley are fundamentally different in elevation, landforms, and vegetation, all three of which have steered each region toward different ownership patterns and landuses.

Landforms

- **Uplands**

Uplands, generally land above 500 feet elevation, are dominated at low to mid elevations by Douglas-fir/western hemlock forest, and at higher elevations in the Cascades by subalpine forests and alpine environments. Upland forests have historically provided cool, clean water to the Willamette Valley, high-quality spawning habitat for salmon, and diverse habitat for other wildlife species. Natural fire was the dominant disturbance on the landscape until the early 1900s when it was suppressed, and then replaced after World War II with clear cutting, prescribed burning, and planting crop trees on a fifty year rotation. About 60 percent of the upland is federally owned, and is managed under the Northwest Forest Plan (Tuchmann et al. 1996). The goals of this plan are complementary to those of the Willamette Restoration Initiative. Forest harvesting has been greatly reduced from former levels under this plan, and more emphasis has been placed on the habitat for fish and wildlife. The 1993 Forest Ecosystem Management Assessment Team (FEMAT) report, the scientific basis for this plan, provides the most comprehensive description of upland communities, habitats, wildlife, and ecosystem processes. About 40 percent of upland land is privately owned, and forestlands here are generally managed on a fifty-year rotation. Forest landowners must comply with the Oregon State Forest Practices Act, which limits clearcut size, mandates replanting, and requires 20-100 foot vegetation buffers depending on stream size and fish presence.

- **The Willamette Valley**

Nearly all land (96 percent) in the Willamette Valley (roughly lands below 500 feet in elevation) is privately owned and has been converted to agriculture or urban land use. Habitats in the valley can be grouped into six main types, all of which have been reduced over the past century. Significant remnants of bottomland forests, bottomland prairies, emergent *wetlands,* and open water habitats can still be found because historically they were difficult to farm or develop. Parts of these habitats are protected to varying degrees by various state and federal laws. Upland forests and foothill savannas/prairies have been eliminated with the exception of a few small parcels because they occupied land that could be easily converted for high value crops.

Water and Wildlife

The uplands (Coast and Cascade ranges) receive about 80 percent of the precipitation falling on the Willamette River Basin, and store much of this water as snow. From late winter to early summer, much of this snow melts and swells cold, faster flowing streams. Ecosystem productivity in these upland streams is relatively low, with aquatic insects gleaning much of their diet from material that falls into running water. In larger, slower tributaries, more plant material is produced in the stream itself. The *mainstem* supports a highly productive algal community that blooms as temperatures rise in the summer. Insects and some vertebrates feed on these plants, and many vertebrates, including salmonids, feed on stream-dwelling insects. The varied habitats from headwaters to mouth are home to dozens of fish, including salmon and trout, and other animals (Tetra Tech 1995).

Native salmonids in the Willamette include spring chinook, winter steelhead, cutthroat, and bulltrout. Salmon and trout from other areas in the Northwest and brook trout from the eastern US have also been “planted” in the Willamette, and compete with native fish for habitat and food (Task Force 1997). Much of the habitat for Willamette salmonids has been degraded by various land use practices or eliminated by dams. Wild salmonid populations have declined precipitously over the last century in the Willamette. This decline parallels a statewide trend that has seen Oregon salmon reduced to four percent of historical levels (Gresh et al. in press).

Salmon are not the only fish in the river. At least 61 species of fish inhabit the Willamette River Basin, nearly half of which are introduced (USGS 1997b). Many of these introduced species tolerate warmer, more polluted water, and have thrived better in the mainstem and large tributaries of the Willamette – sometimes to the detriment of salmonids. Comprehensive studies of the fish biota of the Willamette undertaken in the mid-1940's, late 1980's, and in 1992 have found that salmon are not the most abundant fish in the Willamette. There are far more northern pike minnow, crappie, bass and walleye, among others. Salmon are not the only fish in trouble, either; Oregon chub (found in the mid-mainstem and Santiam River) are endangered and a recovery plan is already in place.

Finally, salmon are not the only aquatic vertebrates in the Willamette. Many amphibians are found throughout the valley; fourteen of which are considered *at risk*. Numerous birds and mammal species are found in the basin, and many of them are at-risk species as well (Table 2). Eighteen species have been extirpated from the Willamette since 1850 (Macdonald 1999).

Table 2. List of endangered species in the Willamette River Basin. (Source: Terry Campos, The Nature Conservancy, Personal Communication)

Scientific Name	Common Name	Federal Status	State Status
Birds			
Branta canadensis leucopureia	Aleutian canada goose	Threatened	Endangered
Falco peregrinus anatum	American peregrine falcon		Endangered
Fishes			
Oregonichthy crameri	Oregon chub	Endangered	Candidate
Oncorhynchus keta	chum salmon	Endangered	Candidate
Oncorhynchus mykiss	steelhead (Upper Willamette ESU)	Endangered	Candidate
Oncorhynchus tshawystcha	steelhead (Lower Columbia ESU)	Endangered	Candidate
Oncorhynchus tshawystcha	chinook (Upper Willamette ESU)	Endangered	Candidate
Salvetinus confluentus	chinook (Lower Willamette ESU)	Endangered	Candidate
		Endangered	Candidate
	bull trout		
Mammal			
Canis lupus	gray wolf	Threatened	Endangered
Odocoileus virginianus leucurus	Columbian white-tailed deer	Endangered	Vulnerable
Invertebrates			
Icaricia icarioides fenderi	Fender's blue butterfly	Proposed*	
Plants			
Castilleja levisecta	golden indian-paintbrush	Threatened	Endangered
Delphinium leucophaeum	white rock larkspur	SOC**	Endangered
Delphinium pavonaceum	peacock larkspur	SOC	Endangered
Erigeron decumbens var decumbens	Willamette Valley daisy	Proposed	Endangered
Lomatium bradshawii	Bradshaw's lomatium	Endangered	Endangered

*** Proposed endangered**
**** Species of Concern**

Human Uses: Pre- and Post-Settlement

The Willamette Valley has long been the home of the Calapooia Tribe in the valley, and the Clackamas Tribe below Willamette Falls. Pre-European contact human population in the valley is estimated to have been 13,500 or 2.5 people/mi^2 (1/km^2) (Hulse 1998). Significant changes in the valley had already taken place by the 1830's. Hudson Bay Company trappers had trapped virtually all of the beaver out of the valley. European diseases, and conflicts between the Calapooia and the settlers, native populations by between 80-96 percent. By the 1850's, vegetation patterns established by fire management practices of the Calapooia started to change, with grasslands and savannas being invaded by woody vegetation (Boyd 1999).

To support this growing population, land was plowed and drained, and trees were cut for firewood, fuel, and houses. The Willamette River's side channels and tributaries were simplified and shortened to improve transportation and commerce. The wettest prairie habitats were mostly grazed and hayed in the late 1800's and early 1900's. The main period of conversion of *riparian*, wet meadow, and *wetland* habitats occurred after World War II (Macdonald 1999). The advent of flood control, irrigation systems, and development of crops suitable for clay soils, enabled farmers to develop bottomlands more intensively. Most riparian stands along the Willamette River, originally ranging from 1 to 7 miles wide, have shrunk to only a few hundred feet, depending on width of the floodplain (Benner and Sedell 1997). Many streams now have only a thin strip of vegetation one or two tree lengths in width, and others have had all of the riparian forest removed (Hulse 1998). Other habitats were almost entirely converted to human uses, notably native prairie grasslands and oak savannas.

Urban development in the valley followed agriculture. Ninety-six percent of Oregon's population resided in Portland in the 1850s. By the 1930's there were twenty-one incorporated cities in the Willamette Valley, and the majority of the valley had a low human population density (< 37/mi^2) (Macdonald 1999; Hulse 1998). By the 1990's, there were over 70 incorporated cities, and population density throughout most of the valley exceed 37/mi^2. In the Metro region, there are an estimated total of 8,840 structures in or close to the floodplain, and approximately 1,080 household units were built in or close to the floodplain between 1992 and 1995 (Metro 1997).

From 1850 to 1900, much of the Willamette River was channelized and dredged for navigation. The intensity of the activity decreased as the river's importance for navigation declined. Structural measures, such as reservoirs and revetments, constructed in the basin to regulate tributary flows and support navigation have modified the hydrologic regime of the Willamette Basin. Beginning in the early 1940's, the Corps of Engineers constructed multi-purpose storage reservoirs which provide approximately 2.3 million *acre feet* of flood control storage in the basin. Construction of wing dams, revetments and removal of woody debris were common methods used to protect navigation, control flooding and to establish farmland along the river (Metro 1997). These dams provide some significant benefits: in the flood of 1996, Corps dams were able to reduce peak flood levels in downtown Portland by two feet, preventing additional major damages. Similar benefits were noted in Salem, resulting in a savings of more than $3.2 billion dollars in damages throughout the region (USACE April 1999). However, these approaches have not eliminated flooding in the Willamette River valley.

In summary, the Willamette River Basin is complicated. We have described the basin with broad brush strokes. It is not merely a few ecoregions, but dozens of plant and animal communities composed of thousands of species on a myriad of soil types, on a continuum of slope positions and elevations. Human uses of the Willamette River Basin during the past 150 years have eliminated or simplified habitats, and have also added a layer of complexity.

IV. The Natural Environment

In light of the basin's complex history, the multiple challenges, and numerous existing efforts, the Initiative seeks to advance an integrated, comprehensive approach to achieve its vision and goals. The Initiative's vision that the Willamette Basin must attain a dynamic balance between diverse human and ecological needs has given rise to six goals (see Table 1).

In this section we take a closer look at the Initiative's clean water and healthy native habitat goals. What does each really say? What issues emerge as especially challenging or important? How will we know when we have achieved these goals? What are the likely actions that policy makers, agencies, researchers, business sectors and citizens may want to take to address each goal?

CLEAN WATER

Goal: The Willamette River and its tributaries meet or exceed standards, are clean enough for safe swimming and fishing, and offer safe and affordable drinking water sources.

Water quality improved in the Willamette Valley as *point sources* came under regulation in the early 1970s. However, recent studies have found that much of the Willamette mainstem is still water quality limited for temperature, bacteria, fish deformities, and dissolved oxygen (Larson et al. 1997). Nutrient and pesticide conditions in basin waters are typical of concentrations elsewhere in the United States, as are concentrations of organochlorine pesticides and PCBs in streambed sediment and fish tissue. Trace element concentrations in *sediments* were generally lower than national averages. But with an increasing population, with more industry, and with a trend toward more intensive agriculture, non-point source pollution has become the major challenge.

Most of the mainstem Willamette exceeds standards for toxics, biological criteria, bacteria, and temperature.

The Initiative's goal of "clean water" includes several components, each of which contain individual challenges. Assuming we agree on these components, we need to be able to measure our progress toward them. The goal of "meeting or exceeding" state and federal clean water standards seems relatively straightforward and should provide for measurable criteria. But it's not that simple.

Setting standards and measuring compliance is complex. The Clean Water Act (CWA) requires states to set physical (e.g. temperature, flow) chemical (e.g. pH) and biological (e.g. macroinvertebrate and fish abundance and diversity) standards to make waters swimmable and fishable. The Safe Drinking Water Act sets national standards for drinking water focusing on micro-organisms(e.g. fecal coliform), inorganics (e.g., nitrates, metals), and organics (volatile organics, petroleum compounds, pesticides) (Table 3).

Table 3. List of pollutants for which standards are applied in Oregon and their significance in the Willamette Basin. (Source: Task Force 1997)

Stream Temperatures	State adopted standards are exceeded in many segments throughout the basin, causing fish mortality.
Dissolved Oxygen	Standard levels are not met in some sections of the river, especially during summer months, potentially jeopardizing fish.
Fecal Coliform	Can cause human illness; found in elevated levels at numerous sites throughout the basin, especially during winter storms. Concentration increases from upstream to downstream.
Suspended Solids (erosion)	Damages stream habitats. Agriculture and urban sites are the greatest contributors; approximately 90 percent of the annual surface runoff occurring in tributaries is during major winter and spring storm events.
Nutrients	Includes nitrogen and phosphorous from fertilizers, human and animal waste, and other organic matter that enters streams during rainy seasons and concentrates during low flow periods.
Toxic Organic Chemicals	Includes pesticides and other compounds found in stream segments throughout the basin, especially in agricultural lands. Some pesticides are believed to cause cancer and other serious health problems.
Trace Metals	Includes lead and mercury which can affect human health, and zinc and copper which can affect aquatic species health. Most enter waterways in urban areas, and are found in the basin.

Oregon's Department of Environmental Quality (DEQ), in consultation with the U.S. Environmental Protection Agency (EPA) is responsible for setting CWA standards, for reporting waters that fail to meet these standards (via a 303d list), and for developing implementation plans (using Total Maximum Daily Loads goals) for water that falls short.

Currently, there are over 144 out of 531 water body segments in the basin on the 303d list that exceed standards for *toxics*, bacteria, dissolved oxygen, temperature, flow, aquatic weeds and algae, and pH (Figure 2). Most of the mainstem Willamette exceeds standards for mercury, biological criteria, bacteria, and temperature (DEQ, 1998). Only the Tualatin has an implemented TMDL for phosphorous and ammonia. TMDLs for dioxin have been developed for the mainstem, the Tualatin, the Yamhill, Ricreall Creek, the Coast Fork, the Pudding, and Columbia Slough.

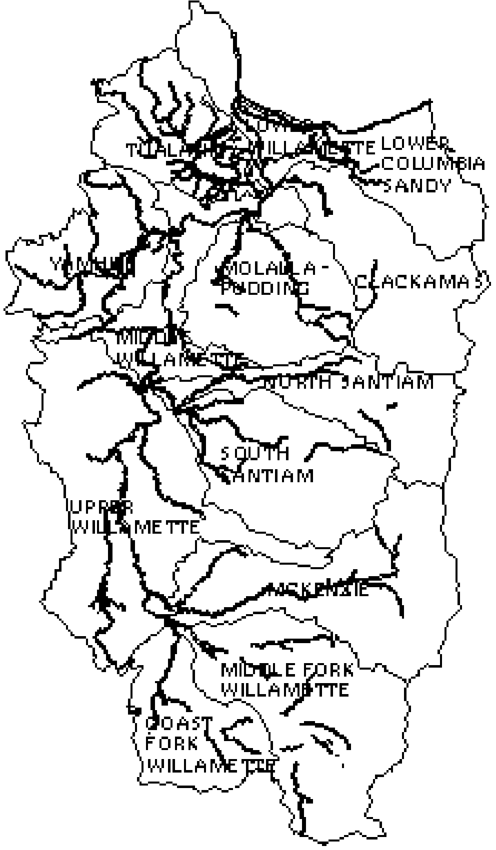

Figure 2: 303d listed streams in the Willamette River Basin, Oregon. (Source: Modified from DEQ 1998)

"Water quality standards" sounds like a hard and fast term, but in fact the CWA provides for considerable flexibility in setting standards, so that standards can be tailored to ecosystem and economic conditions and to changes in these conditions. For example, temperature standards for cold Cascade streams are different than those for the warmer mainstem Willamette. Furthermore, current DEQ standards under the CWA allow certain portions of the Willamette (such as pollution mixing zones) to be unsafe for swimming or fishing. This concept can potentially be applied "in time" as well as "in space" (e.g., does the Willamette have to be 'swimmable' in February?).

"Affordability" is explicitly noted as a consideration in the drinking water component of the Initiative's clean water goal, and in developing a strategy it will be important to make sure that limited financial resources are applied to the greatest effect in achieving safe drinking water throughout the basin.

- **Basin Conditions and Considerations**

The Willamette *floodplain* has been dammed, diked, drained, filled, and confined to the point that it no longer functions as a healthy ecosystem with the capacity to support native fish and wildlife, absorb and reduce the impact of flooding, and filter contaminants.

Some streams and rivers in the basin have high temperatures and insufficient flows during summer months, which adversely impact aquatic species such as salmon and steelhead (Task Force 1997). Low flows also reduce the ability of the river to dilute contaminants, the presence of which may lead to dangers for both aquatic species and humans. Such contaminants are often found with great frequency in the basin as a result of *erosion* from agricultural, industrial, urban and forested lands.

Health of the Willamette River:

- **Upper reach has good health**
- **Salem Reach has marginal health**
- **Newberg Pool has marginal to poor health**
- **Tidal reach (downtown Portland) has poor health**

Some flows for many streams and rivers in the basin may have historically been low during the summer and fall; however, recent developments may have exacerbated these low flows to an unacceptable level.

There are admittedly several factors impeding the goal of clean water in the basin, many of which are enhanced by one another, and thus must be solved in an integrated fashion. To restore the basin's water quality, the Initiative will have to address four key, interrelated issues: water availability, temperature, erosion, and pollutants.

Main Clean Water Issues:

- **Water Availability is limited for a variety of reasons**
- **Temperature regimes are outside the natural tolerances of native species**
- **Erosion from urban and agricultural lands carries sediments to the river**
- **Pollutants from non-point sources are a major problem**
- **Pollution from non-point sources has been reduced but requires continued attention**

Water Availability

When we talk about availability, we're talking about water quantity, flow levels, storage, and accessibility. Several major sectors use large quantities of water, including agriculture, industry, and municipalities. Some use more surface water, some more ground water (Figure 3). As more people move to the Willamette Basin, these sectors are likely to use even more water. The problem is that most of that water is already spoken for under Oregon's system of water rights, a majority of which is allocated for out-of-stream uses (e.g., irrigation, drinking water, etc.). In addition, the timing and amount of flow of Willamette basin water is the fundamental driver for temperature and erosion, while also affecting pollutant levels.

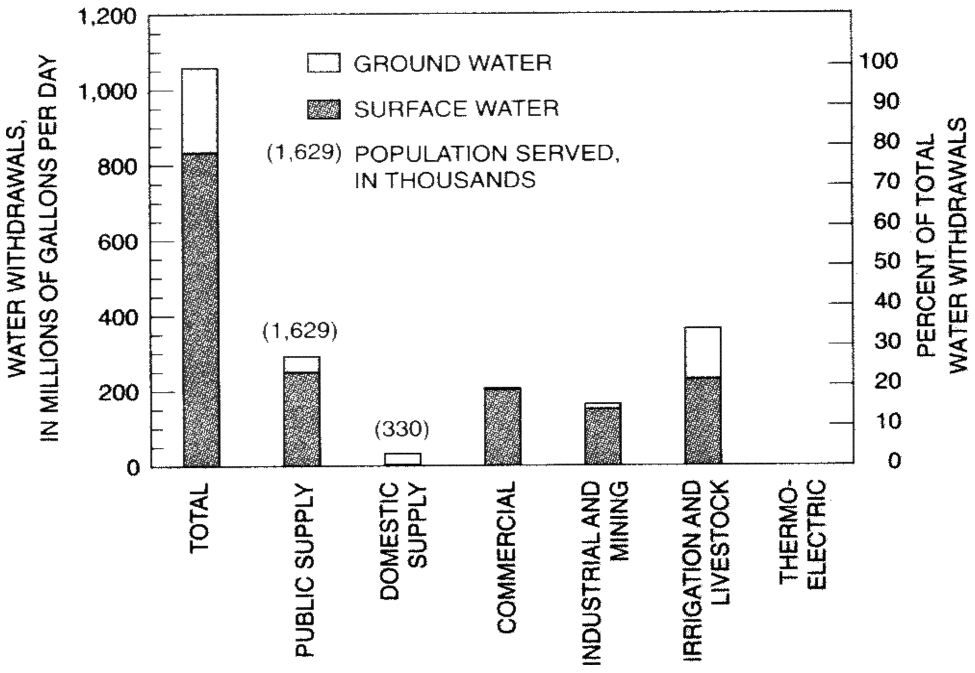

Figure 3. Estimated water withdrawals in 1990. Most were from surface water; irrigation was the largest single use. (Source: USGS 1998a)

To start at the beginning, the Willamette River Basin receives over 40 million acre feet of rain and snow per year. About half that (23 million acre feet) flows past Sauvie Island in an average year. The difference between rainfall and what flows into the Columbia is mainly due to evaporation, transpiration and storage as ground water. People directly consume a few million acre feet, not a huge percentage of the basin's total flow. One would think that there is plenty of water in the basin, but there is not. As with many other things, timing is everything.

Unlike many other places in the United States, the Willamette River Basin gets ninety percent of its precipitation from October through April; only two percent falls in July and August. Much of this winter precipitation is stored as snow, and melts from late winter through early summer. The Willamette and its Cascade tributaries flow high and fast during this time with typical maximum flows of nearly 300,000 cfs at Portland. But by July-September, the Willamette's flow at Salem is only 2500 cfs compared to an average of 18,000 cfs. This summer low-flow condition can be even more severe in Willamette tributaries, which have widely different flow regimes depending whether they originate at high or low elevation, and in the Cascades or Coast Range (Figure 4).

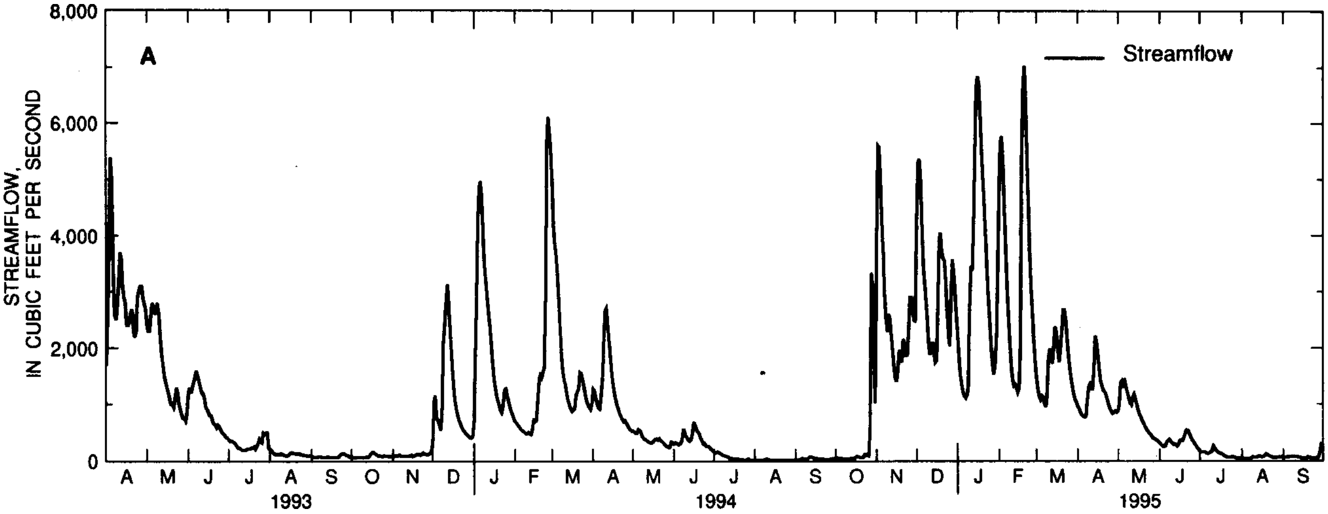

Figure 4: Seasonal variability of stream flow, Pudding River at Aurora, Oregon, April 1993 through September 1995. (Source: USGS 1998b)

This low-flow period occurs just when society's demands for irrigation, residential watering, and recreation are greatest. The natural flow of the Willamette River in summer cannot meet society's needs without removing so much water that habitat and wildlife would be harmed. On the other hand, natural high flows result in severe spring and winter floods. These floods are concentrated in many of the places we have built cities and established farms in Willamette floodplains.

Now add one more complication: the Willamette River Basin rarely has an average water year, or an average water month (Figure 5). This makes allocating the water to different users difficult.

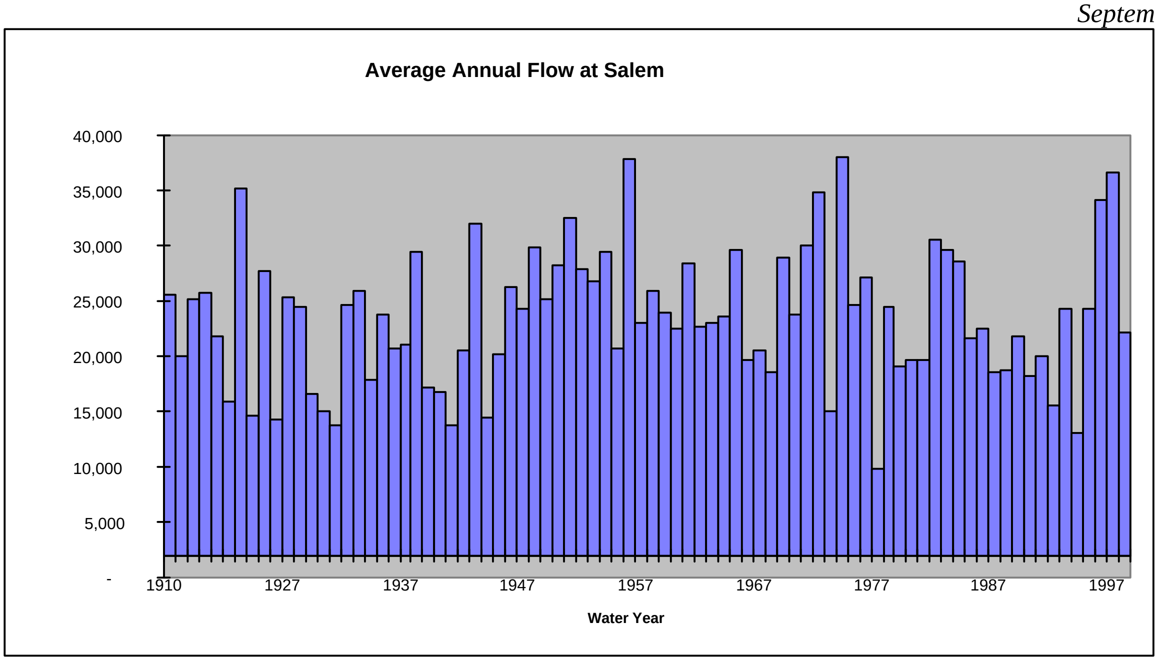

Figure 5: Average annual flow of Willamette River at Salem, Oregon. (Source: USGS 1995)

We have patched together some solutions over the years. To even out the flow, we store water behind hundreds of dams. Some 371 dams in the basin store about 2.7 million acre feet of water. The Corps of Engineers alone stores 2.3 million acre feet behind eleven major dams. About 1.64 million acre feet of Corps of Engineers water are available for use in the basin, with most of that earmarked for irrigation. However, only 50,000 acre feet of the Corps of Engineers waters have been purchased by irrigators; the eventual purchase and allocation of the remaining 1.59 million acre feet will be a key driver for future Willamette River Basin water management. Basin residents also draw considerable *groundwater* from wells; agriculture is the biggest groundwater user. Assuming more people move to the valley, and assuming municipal, and industrial uses grow, we'll need more water.

High winter and spring flows are held back by dams, then released in the summer and fall. So the Corps of Engineers takes the edge off the big winter floods, and provides a minimum flow (4000 cfs at Albany, 6500 cfs at Salem) during the summer when natural flows can be quite low. The 250-350,000 acre feet required for this "flow augmentation" keeps water in the river to enhance water quality, wildlife, and recreation, and for pumping water out to irrigators, industry, and municipalities (Leland et al. 1997). These minimum flows were initially authorized as flow augmentation for navigation. While benefits to other purposes, such as water quality and fish were recognized, they were secondary considerations. Today, water quality and fish are far more important considerations than navigation, and efforts have been adjusted accordingly.

Our solutions have come at a price. The unruly flow of the Willamette is precisely what created the diverse and productive habitats from tributaries to mouth. Seasonal floods bring pulses of sediment, *nutrients*, and debris; floods also carve out new habitats or renew established ones - wetlands and side channels - which provide refuges for wildlife. Much of the habitat has been physically eliminated, and we have regulated the Willamette and its tributaries so that the current river system can maintain only what little habitat is left; the Willamette, as currently regulated, cannot do much work to enhance or restore habitat.

Water temperature and flow regimes have been changed so that they are out of synch with biological needs and may exceed the tolerance of organisms.

Temperature

Land use practices, such as altering flow regimes, as well as forestry, agriculture and development, have affected river temperature. For example, we have reduced winter and spring floods which may have been important in recharging an extensive open water and subsurface aquatic network. Today, we store this cold winter flood water behind dams, deliver it in mainstem channels, withdraw it for various purposes, and return much of it to the river at higher than natural temperatures. On the other hand, waters immediately downstream from large dams are cooler in the late spring and summer and warmer in the late fall and winter.

Dam construction in the basin has altered seasonal water temperatures downstream of dams, with negative impacts on both ecosystem and fish health.

The overarching problem however, is that much of the Willamette's waters are too warm, especially during the summer. There are several likely causes resulting in this temperature increase. Much of the streamside vegetation in the Willamette basin has been reduced or eliminated. These riparian forests historically provided shading for the river and its tributaries, resulting in lower water temperatures associated with decreased exposure to the sun. Forest practices in uplands have resulted in warmer water flowing into the valley. For example, improper harvesting and road building can increase peak flows, which lead to wider, shallower stream channels, and result in warmer water.

These cumulative practices have resulted in higher water temperatures, which can have numeroous negative effects. Salmonids can't physiologically tolerate temperatures above 70 degrees (Groot and Margolis 1991). They also behave differently at higher temperatures. Under existing conditions, cooler water temperatures in the late spring and summer (in the tributaries below dams) impede upstream migration of spring Chinook salmon and growth of native trout, including bull trout. Warmer fall/winter temperatures accelerate egg incubation and fry emergence of spring Chinook, subjecting fry to unfavorable conditions such as high flows and scarce food, leading to poor survival (USACE 1995). Warmer water increases the fish's metabolism so that migration, spawning, hatching, and rearing timing is thrown off, which puts salmonids out of phase with key resources they need to complete their life cycle. Warmer temperatures can also increase the fish's vulnerability to disease and parasites. Higher summer water temperatures also have serious ecosystem effects for other species. All metabolic processes go faster at higher temperatures. Nutrients are taken up faster by aquatic organisms, requiring more oxygen consumption by these organisms. This depletion in oxygen can be harmful to many native species.

Vegetated streamside *buffer* widths ranging from 50 to 100 feet have been cited as effective in controlling stream temperatures (Castelle and Johnson 1997). A 100-foot vegetated buffer for logging operations has been found to maintain water temperatures within 1°C of their former average temperature (Lynch et al. 1985), and are generally thought to provide a similar level of shading as that of an old-growth stand. These results point to promising opportunities for buffers in the maintenance of water temperatures. However, most work on the effects of riparian shading on temperature has been conducted in forestry applications, with less attention to agricultural and urban areas.

Erosion

Erosion is a natural component of streams. However, major disruptions such as timber harvests, agricultural activities and urbanization serve as significant clean water stressors. Factors such as steep slopes and unstable soils increase the rate of erosion. Erosion deposits fine sediment that covers up spawning beds, and it carries nutrients from fertilizers to the water. Dams also have changed erosion processes in the Willamette by trapping sediment; however, this sediment appears to have been replaced by increased erosion downstream of dams. The *suspended sediment* particles of downstream erosion are smaller than “pre-dam” particles – this smaller particle size may be important, as nutrients and toxic constituents are transported more easily in fine sediment flows (USGS 1998a).

Urban sites in the basin contribute the greatest amount of suspended sediment to the river on a *per acre basis*.

In the Willamette River Basin, urban, agricultural and forestry sectors have all contributed to erosion and sedimentation (Figure 6). Urban sites in the basin contribute the greatest amount of suspended sediment to the river on a per acre basis (USGAO 1998). The amount of suspended sediment transported by the Willamette River as it enters the Portland Harbor varies seasonally, with the highest levels recorded after major storms or during the spring snowmelt.

The majority of this sediment comes from storm water runoff, sewage treatment facilities and industrial sources. Approximately 75 percent of the original shoreline in urban areas has been lost to channelization for navigation and increased development area, resulting in the modification of the once widely braided river into a single channel (Task Force 1997). In addition, the erosive power of the Willamette River has increased because of the concentration of flows into a single channel. This has contributed to increased bank erosion and more widespread loss of riparian vegetation during flood events (USACE 1999a).

Construction activities also contribute significantly to sedimentation -- without proper controls at construction sites, sediment loads can reach 35-45 tons per acre per year. Erosion from roads is another major source of sediment (USGAO 1998). Impervious surfaces result in increased surface erosion, higher and faster storm flows in streams, and increased channel erosion. This typically results in elevated sediment levels for urban streams (Wahl et al. 1997); urban storm water runoff also carries pollutants directly to streams, bypassing the natural filtration that would occur by passage through soil.

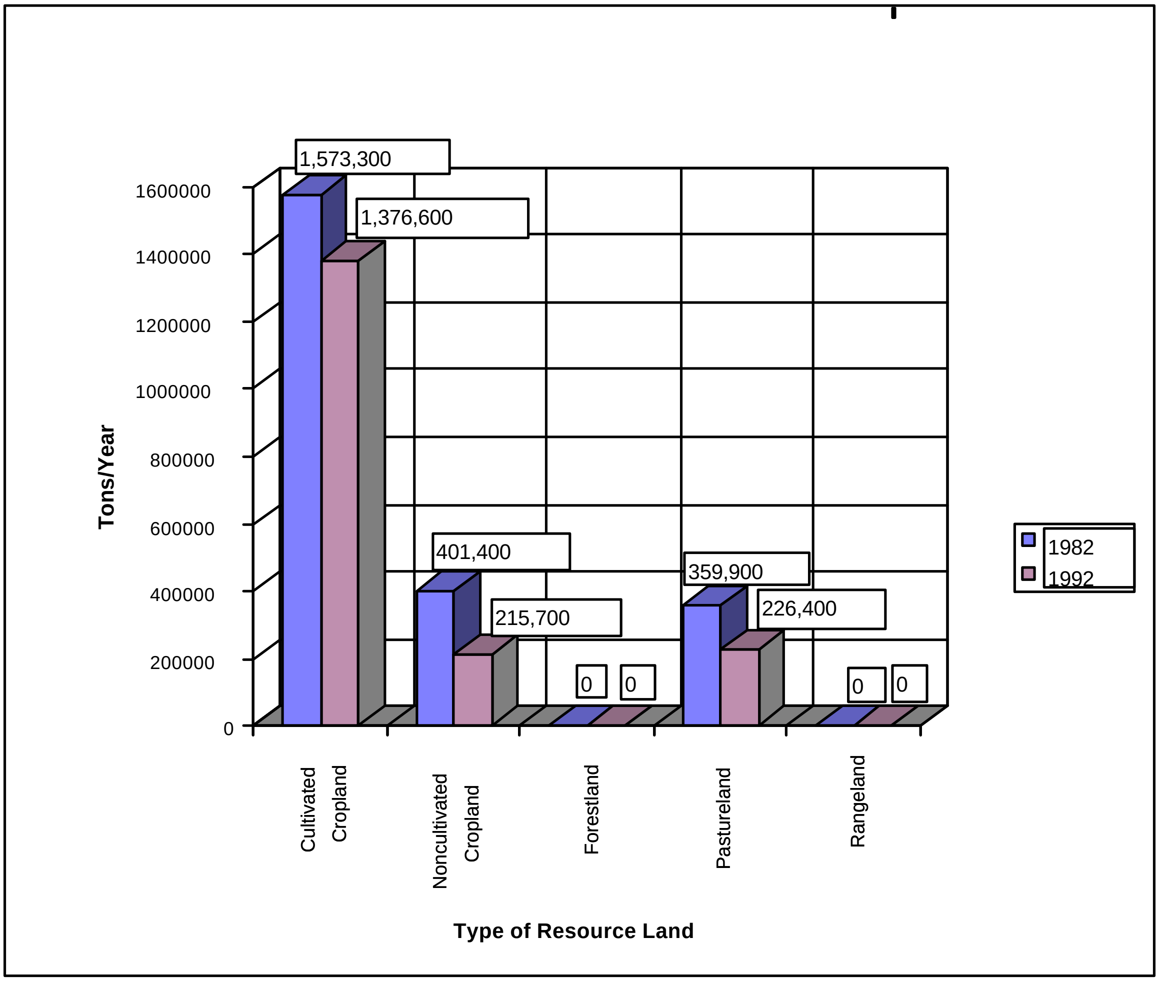

Figure 6: Sill and rill water erosion, tons lost estimates for the Willamette Basin. Estimated for non-federal lands only. No urban data for sill and rill water erosion was available, however the urban sites contribute the greatest amount of suspended sediment to the river on a per acre basis. (Source: Catherine Darby, USDA - National Resources Inventory)

A 1997 study commissioned by Governor Kitzhaber found that agriculture contributes more sediment to the river than any other activity in the basin (note: this is in contrast to a *per acre* basis, as agricultural lands consume more land in the valley than urban sites). An estimated 1.8 million tons of soil are lost each year from erosion on agricultural lands in the basin (USGAO 1998). The loss of vegetation in riparian areas is particularly significant, as vegetated riparian zones provide vital functions for water and habitat health, reducing nutrient concentration in streams (Lowrance et al. 1994), as well as regulating the micro-climate of stream-riparian ecosystems (Castelle et al. 1994).

Agriculture contributes more sediment to the river, *overall*, than any other activity.

Forest practices in the Willamette Basin can contribute to erosion, particularly when Best Management Practices (BMPs) are not used. For example, improper ground-based logging practices can compact the soil and create ruts that channel sediment into streams (USGAO 1998). Forest practices and regulations have steadily improved through the years, but the results of old practices are still an issue. For example, forest roads constructed prior to the 1970s have been found to be a major contributor of sediment to streams. Improperly stabilized logging roads can yield more than 350 tons of sediment per acre of road surface per year (Kundell and Rasmussen 1995). Vegetation along streams, and large woody debris within the stream, was often removed during timber harvesting, resulting in increased water velocity, allowing streams to carry more sediment and resulting in more severe stream bank erosion.

Maintaining riparian buffers is critical to stream protection, as forested buffers trap sediments and decrease pollution, provide temperature control and inputs of large woody debris and other organic matter necessary for aquatic organisms (Wenger 1999; Table 4). The width required for riparian buffers to be most effective in controlling erosion is a matter of significant debate. Suggested riparian buffers range from 20-foot partial harvest strips to a full tree-length or more (400+ feet, Castelle et al. 1994; Johnson and Ryba 1992). Most stream ecologists agree that buffer size should be tailored to stream characteristics and site-specific goals. Buffers are generally widest on federal lands where standards are set by the Northwest Forest Plan, narrower on private forest lands where standards are set by the Oregon Department of Forestry, and highly variable on agricultural and urban lands. Overall, buffers tend to decrease with increasing urbanization (Moy et al. 1997).

Table 4. Functions of riparian vegetation as they relate to aquatic ecosystems

	Riparian Vegetation	
Site	**Component**	**Function**
Above ground Above channel	Canopy and stems	• Shade - controls temperature and instream photosynthetic productivity • Source of large and fine plant detritus • Source of terrestrial insects
In channel	Large debris derived from riparian vegetation	• Control routing of water and sediment • Shape habitat - pools, riffles, cover • Substrate for biological activity
Streambanks	Roots	• Increase bank stability • Create overhanging banks-cover
Floodplain	Streams and low-lying canopy	• Retard movement of sediment, water and floated organic debris in flood flows

Pollutants

Many waterways in the Willamette Basin fail to meet Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) water quality standards due to the presence of pesticides, heavy metals, dioxins and other pollutants (Task Force 1997). These pollutants originate from both point (industrial and municipal waste) and nonpoint (agriculture, forestry, urban activities, etc.) sources.

Point and nonpoint sources of pollution are regulated by DEQ under a permit system to ensure protection of human health and the environment. Few Total Maximum Daily Loads (TMDLs) have been implemented in the Willamette Basin to date; accelerated TMDL implementation could have a significant impact on reducing pollutants in the river.

As a result of the progress that has been made in addressing point source pollution statewide, about 70 to 80 percent of the pollutants entering the basin today do so via *nonpoint sources* (USGS 1997b). A 1993 DEQ statewide study found that agriculture accounted for 39 percent of all nonpoint water pollution, forestry 17 percent, boating 14 percent and urban runoff 12 percent – a diverse range of sources that underlines the need to involve all sectors in addressing the problem (USGAO 1998). The types and amounts of compounds found in runoff are often correlated with land use patterns: fertilizers and pesticides are found frequently in agricultural and urban settings, and nutrients are found in areas with human and animal waste.

People contribute to chemical pollution in the basin, but natural and seasonal factors also influence pollution levels in various ways. Nutrient and pesticide concentrations vary considerably from season to season, as well as among regions with different geographic and hydrological conditions. Natural features (such as geology and soils) and land-management practices (such as storm water drains, tile drainage and irrigation) can influence the movement of chemicals over both land and water, emphasizing the role local and regional practices can have on water quality.

Nutrients

Nutrients, which include both nitrogen and phosphorous, are necessary for life. Elevated nutrient levels, however, can threaten the survival of many aquatic species. Elevated nutrient levles are found at numerous sites in the basin. The most common sources of nitrogen and phosphorous contamination are fertilizers in agricultural fields, waste from concentrated animal feeding operations, septic drainage fields, leaking sewer pipes and urban lawn fertilizer application. As of 1996, the amount of nitrogen from fertilizer and manure that eventually entered the Willamette River was not known. A 1991-95 USGS water quality study found that only two of the 51 streams sampled in the Willamette Basin exceeded safe nitrate levels for drinking water (USGS 1998a). In general, elevated nitrate concentrations have been associated with the larger populations and increased industrial and agricultural activities of the northern part of the basin (Table 5).

Table 5. Estimated unit loads (kilograms/hectare/year) for land use classes in the Willamette Basin (Task Force classification). (Source: Tetra Tech 1995)

	Total Nitrogen	*Total Phosphorous*
Forest	3	0.5
Forest/Grazing	4	0.6
Rangeland	5	0.7
Cropland, Dry	6	1.3
Cropland, Irrigated	10	1.9

Cropland, Potential	5	0.7
Urban	8	3

The highest nutrient concentrations in the basin are found in agricultural and urban areas, while the lowest nutrient concentrations are generally found in forested areas (USGS 1998b). The higher concentrations in agricultural areas reflect the long period of time over which agricultural lands receive fertilizer applications. Applications sometimes contain phosphorus and nitrogen at concentrations exceeding those required for maximum crop production (Cramer et al. 1985).

Highest nutrient concentrations in streams and rivers are found in agricultural areas; lowest nutrient concentrations are found in forested areas.

Nitrogen and phosphorous are primary nutrients necessary for plant growth; however, large inputs of nitrogen into waterways can cause eutrophication, the excessive growth of aquatic plants, particularly algae. These blooms of algae die off, and algal remnants settle into interstitial gravel space depriving salmon eggs the necessary conditions to complete their life cycle. In addition, algae may deplete dissolved oxygen and increase pH, resulting in fish mortality (Meehan 1991). Nitrogen contamination can have adverse effects on human population as well: nitrate in drinking water can cause methemoglobinemia (blue baby syndrome) in children (USGS 1996b).

Phosphorous also can have deleterious effects. A 1991-94 USGS study found that 45 percent of streams sampled in the Willamette Basin exceeded EPA standards for total phosphorus. Sixty-eight percent of these streams drained predominantly agricultural lands (USGS 1998a). However, caution should be exercised here as the study contained only a limited set of sample sites and did not sample all of the streams in the basin. Furthermore, background levels of phosphorous in the Willamette Basin are not precisely known.

45 percent of streams sampled by USGS in the Willamette Basin exceeded EPA standards for total phosphorous.

Riparian buffers are an effective way to reduce the spread of nitrogen and phosphorous to waterways. Riparian buffers of 66-98 feet can remove nearly 100 percent of nitrate (Fennesy and Cronk 1997). Riparian *buffer strips* can prevent nitrogen from reaching waterways through uptake by vegetation or through denitrification, the conversion of nitrate into nitrogen gas by anaerobic microorganisms. Denitrification represents a removal of nitrogen from the riparian ecosystem, and occurs at high levels in wetlands.

Once applied to soil, phosphorous may be taken up by vegetation, adsorbed into soil or organic matter, precipitated with metals, or released into the stream (Lowrance 1998). Forested or grass buffers can help reduce or prevent the introduction of phosphorous into streams. Vegetated buffers can remove excess nutrients from runoff and overland flow by filtering water, via plant uptake in some agricultural settings, and microbial activity. It is clear that buffers may play a pivotal role in combating nutrient pollution, as forested vegetated buffers have been found to absorb 89 percent nitrogen and 80 percent phosphorous (Peterjohn and Correll 1984). These buffers may also prove to be economically beneficial, as retaining phosphorous and nitrogen on site may result in reduced fertilizer applications on crops and lawns.

Pesticides

The 1993-95 USGS/National Water Quality Assessment (NAWQA) study found that pesticide concentrations in the basin exceeded maximum contaminant levels for drinking water and water-quality criteria for chronic toxicity for the protection of freshwater aquatic life. The largest number of exceedences was generally associated with agricultural land use. Forested sites have shown decreased pesticide concentrations in recent years. Overall analyses concluded that nutrient and pesticide conditions in Basin streams were typical of concentrations in streams from other NAWQA study sites around the country (USACE 1999).

Approximately 4.5 billion pounds of pesticides are used annually in the basin [in agricultural and urban settings].

Pesticide use in the basin is greatest in urban and agricultural settings. Approximately 4.5 billion pounds of pesticides are used annually in the basin to control weeds, insects and other pests in agricultural and urban settings (Rinehold and Witt 92). Some pesticides are found at relatively uniform frequencies throughout the valley; however, with few exceptions, maximum concentrations were found in the northern valley (USGS 1996a).

Soils in the basin are characterized by a high clay and organic matter content. In such soils, pesticides attach easily to organic matter; this increases the transportation of pesticides to waterways in areas with high erosion rates.

Agricultural lands appear to be contributing the greatest amount of pesticides *in total* to the river compared to urban, mixed-use and forested sites (USGS 1996a). Grass seed pesticides were applied in the largest volume in the basin due to the large area covered by grass seed crops. The increase in the number of nurseries operated in the basin in recent years has resulted in an increase in chemical use from 1,000 to as much as 18,000 pounds statewide as well (USGS 1996a).

Riparian buffers decrease pesticide pollution from overland flow to waterways, as many pesticides are broken down within buffer zone soils (Figure 7). Buffers also reduce the danger of drift. Vegetated buffers can slow the flow of runoff and allow it to percolate into the ground. The soil then releases this water into streams and wetlands over an extended period of time, resulting in stabilization of water levels during winter and summer. Greater buffer widths increase the retention time for chemicals in the buffer soils, as well as providing more sites for binding metals. Cover cropping may also be used to minimize weed seed germination, and thus reduce the amount of pesticides needed to control weed populations.

The DEQ 1996 Phase III study found that five compounds - carbaryl, diazinon, dichlobenil, prometon, and tebuthiuron - had significantly higher ($p<.05$) concentrations at urban sites than agricultural sites in the Willamette Basin (USGS 1996a). This suggests that urban pesticide use needs to be curbed and monitored more carefully.

Urban areas in the Willamette Basin have the most violations of water quality standards (mainly for dissolved oxygen and bacteria) for the protection of aquatic life and the protection of human health in the basin. These violations can be linked to pesticide usage, as well as discharges from sewage treatment facilities and industrial sewage.

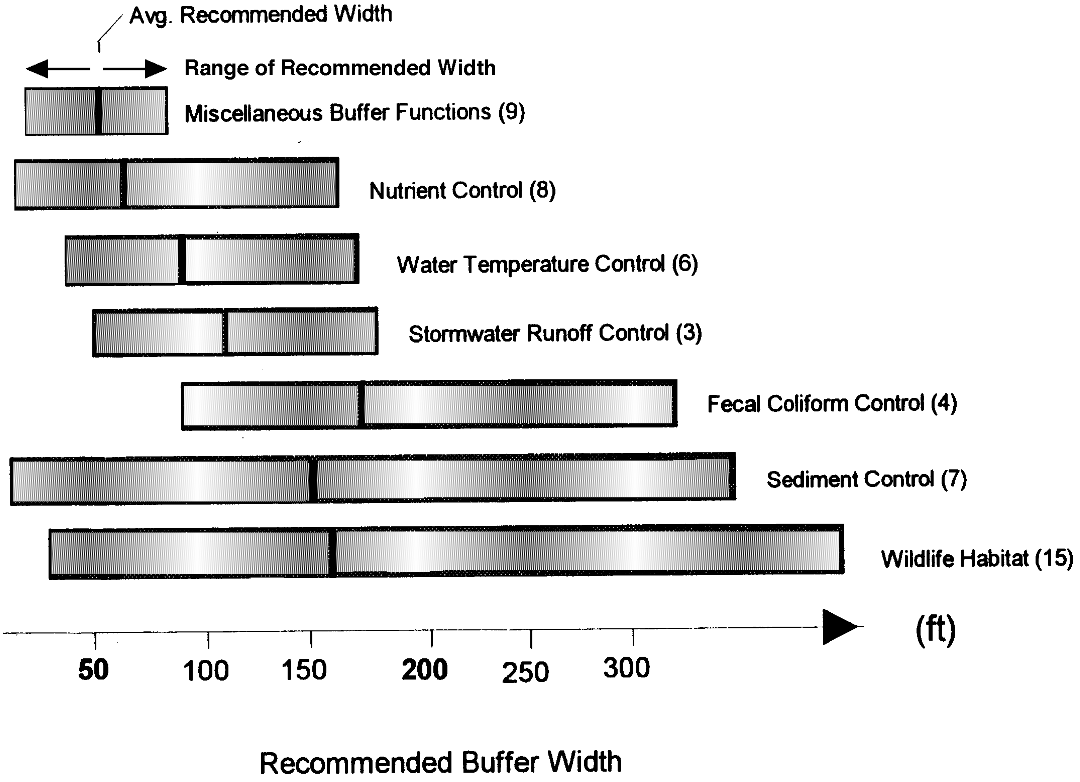

Figure 7: The role of vegetated buffers in providing water quality and habitat benefits has been the subject of much debate and many studies. Bars show range and average buffer widths for different functions from a review of published literature. Number of studies is in parentheses (Modified from Metro 1997)

Herbicides account for 70 percent of total national use of pesticides, and are found with greater frequency and in higher concentrations in streams draining agricultural areas (USGS 1997b). Herbicides are detected at twice the rate of insecticides in both agricultural and urban streams; however, insecticides are generally more toxic to aquatic life and concentrations frequently exceed federal standards (USGS 1998a). Insecticides are found at higher frequencies and concentrations in urban area streams.

Toxics

Industrial organic compounds, such as dioxin and furan, can be particularly harmful to fish, wildlife and humans due to their potential toxicity. Dioxins and furans are not deliberately manufactured, but are inadvertently produced as by-products from chemical reactions. They are commonly found in waterways with inputs from waste incineration (products are found in smoke from incineration practices and then returned to the water after reaching their peak toxicity) and effluent discharge from pulp and paper mills that use chlorine bleaching (USGS 1998a).

Dioxins and furans have been detected in streambed sediments and aquatic-tissue samples throughout the basin, but the highest concentrations are noted downstream from *point sources*.

Fish from the industrial harbor of Portland contain significantly greater concentrations of dioxins and furans than those at up-river sites (DEQ 1997). The highest concentrations were found at sites with high industrial or urban inputs, with a very high potential toxicity for mammalian life. At most agricultural and forested sites, dioxin and furan concentrations in bed sediment were similar to those reported worldwide and are thought to be background concentrations due to atmospheric deposition (USGS 1998c).

Highest concentrations of dioxins and furans found at sites with industrial or urban inputs.

Lead concentrations exceeded guidelines for protection of aquatic life from trace element concentrations in bed sediment at nine sites in the basin, six of which were urban sites (Environment of Canada 1995). Zinc concentrations exceeded guidelines at a majority of urban sample sites in the basin (USGS 1996a). Common sources of lead and zinc in urban environments include batteries, dyes, and paints. Mercury concentrations in bed sediment were generally higher in urban areas than in forested or agricultural areas, with the greatest concentrations in bed sediment found downstream from an abandoned mercury mine. Mercury found in fish tissue is harmful for human consumption.

Areas for Inquiry and Action

There is limited knowledge concerning such important processes as hydrologic interplay between groundwater and surface water, historic temperatures, and the proportional causes of temperature increases. It is also difficult to identify exact sources of erosion and nonpoint source pollution. Society currently assumes that Willamette Basin waters can assimilate some level of its excess erosion, nutrients, fertilizers, pesticides and toxins, even though we know these compounds have deleterious effects on ecological and human health. The Willamette is out of compliance with state standards for several chemicals, yet within state standards for many other compounds. However, it is unclear if these standards will be sufficient over the long-term.

Even less is known about the effects that addressing these issues will have on natural and human attributes in the Willamette. For example, what will be the most effective actions for reducing water temperatures? Should we: Ensure vegetation buffers for all stream banks? Allow more winter/spring flooding? Reduce warm water inputs from industry, agriculture and municipalities? Install temperature control facilities in dams? What are the most viable options for reducing erosion in the basin? Increased riparian buffer zones? Changes in farming practices? Urban runoff controls? Dam operation modifications?

It is not yet known how to restore the river’s historic, natural functions on a large scale, without also restoring flooding and the highly braided, complex stream system. Will it be sufficient to restore some of the rivers’ ecosystem functions on a more limited basis? Can we do this while minimizing impacts on floodplain residents?

Various stakeholders will need to address these issues in the near future. They need better information to forecast these actions, and they need robust monitoring of management practices to tell them what works and what doesn’t. However, just because we don’t have *all* the answers, doesn’t mean we shouldn’t do anything. There are viable options for action.

Several critical issues (water availability, water temperatures, erosion/sedimentation, and pollution) discussed in this section suggest a number of key needs relevant to the Initiative's clean water goal. These needs in turn, suggest numerous possible strategies. These issues, needs and possible strategies are summarized in Table 6.

Table 6. Clean Water Matrix

Goal	Setting	Needs	Possible Strategies
The Willamette River and its tributaries meet or exceed standards, are clean enough for safe swimming and fishing, and offer safe and affordable drinking waters sources.	• <u>Water Availability</u> is limited in absolute amount and quality. Most water allocated is allocated to out of stream uses.	• Meet water demands for commercial, agricultural, residential and instream uses.	• Mimic natural, seasonal flows through water releases and reconnecting the river and floodplain. • Acquire water rights from willing partners. • Identify and implement water conservation and distribution practices. • Ensure sustainable sources of clean groundwater.
	• <u>Water Temperatures</u> in the Willamette are high, especially in the summer, leading to the reduction and fragmentation of usable habitat.	• Need to reduce temperature for much of the Willamette. • Need to bring water downstream of dams closer to natural seasonal variation.	• Accelerate implementation of TMDLs. • Ensure adequate vegetation buffers for shading. • Ensure BMPs are used to avoid channel modification. • Restore degraded, shallow channels. • Reduce temperature of water returns. • Install and monitor the effectivness of downstream temperature control devices in major reservoirs.
	• <u>Erosion/Sedimentation</u> from various sectors leaving many deposits which carry pollutants to the river and cover up spawning beds.	• Reduce sedimentation from upland and riparian sources.	• Use BMPs in forestry, agriculture and urban development. • Ensure adequate riparian buffers to filter sediments and stabilize streambanks.
	• <u>Pollutants</u> such as nutrients, pesticides and toxics impair the Willamette's water quality.	• Need to reduce pollution, especially nonpoint sources, and filter pollutants out before they reach the water.	• Accelerate implementation of TMDLs. • Ensure vegetative buffers are adequate for filtration of pollutants. • Investigate alternatives to toxics and implement incentives and regulations for reducing pollutants (e.g., IMP, crops that use fewer chemicals).