Current & Future Conditions

Summary Report

Cedar River

King County
Surface Water
Management
Everyone lives downstream.

Cedar River Current and Future Conditions

Summary Report

October 1993

King County Department of Public Works
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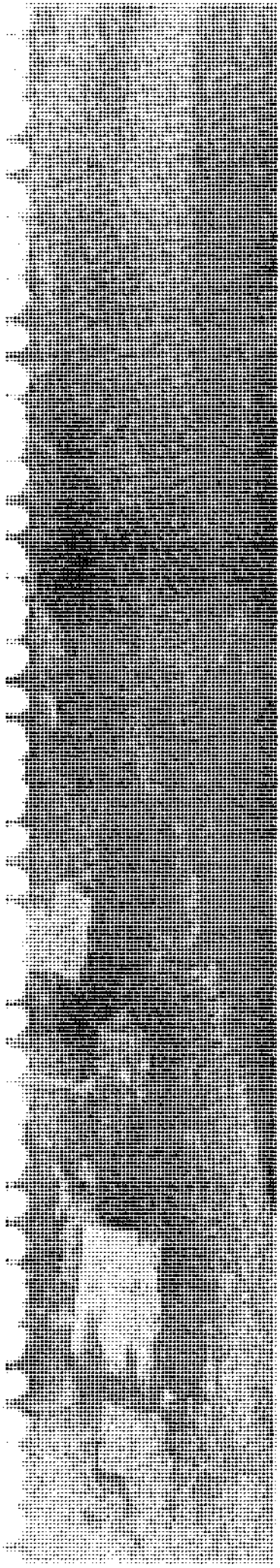

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Introduction

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Chapter 1: Introduction

1.1 INTRODUCTION

This Summary Report summarizes the Cedar River Current and Future Conditions Report (Conditions Report), a technical document. The Conditions Report provides a comprehensive assessment of the current conditions and predicts future trends in the Cedar River basin planning area. Its primary purpose is to identify significant conditions and issues to be addressed in the Cedar River Basin/Nonpoint Source Pollution Action Plan (Basin/Action Plan). The Basin/Action Plan will recommend solutions and management programs for the significant, and often interrelated, problems related to flooding, sediment erosion and deposition, water quality, and aquatic habitat.

The vision for the Basin/Action Plan is to protect, restore, and enhance the natural functions of the river and tributary systems in the Cedar River basin in order to promote human health, public safety, and environmental quality. This will be accomplished through agency and private partnerships that foster community support and ensure long term benefits for future generations. This report invites you to help create this vision, first through education and then through involvement and stewardship to shape future basin conditions.

Basin Planning Area Overview

The basin planning area encompasses approximately 66 square miles, or the lower one-third of the entire Cedar River drainage basin (*Map 1, Appendix B*). The Cedar River basin is divided into three areas: the upper basin, the middle basin, and the lower basin. The upper basin, which comprises over half of the entire Cedar River basin, is not included in the basin planning area. Most of this upper basin is owned by the City of Seattle, who manages the lands and facilities to provide water to the greater Seattle area and hydroelectric power. The middle basin includes all areas that drain into the Cedar River between the Landsburg diversion dam and Maple Valley, and the lower basin covers the area from Maple Valley to Lake Washington. The majority of the basin planning area is within unincorporated King County; only six percent of this area is within the City of Renton, the only incorporated community. Other communities in the basin planning area include Maple Valley, Fairwood, Maplewood Heights, Summit, Ravensdale (in part), and Georgetown.

A unique stream, lake, and wetland system drains the broad plateaus and steep slopes into the Cedar River valley. This extensive surface-water system includes 65 miles of mapped streams, 892 acres of inventoried wetlands, nine lakes, and 23 miles of the Cedar River within a broad floodplain. For its size, the Cedar River system has historically supported one of the largest salmon populations in the state. Healthy habitat areas, with several outstanding aquatic systems, are found in the Rock, Peterson, and Taylor Creek subbasins, with diverse and abundant

wildlife. Elk, black-tailed deer, birds, and numerous small mammals use both the basin planning area and the adjoining upper basin.

The Cedar River shoreline has been designated as a Shoreline of the State from its mouth to its headwaters and, in combination with the surrounding basin, provides a wide variety of recreational resources. Hence, these recreational resources and the natural beauty of the Cedar River basin are dependant on conservation of the surface-water system.

Cedar River Basin Planning Area Conditions Overview

During the past century, land uses in the Cedar River basin have changed dramatically from historic logging of forests and mining of coal, sand, and gravel to ever–expanding urban and semi–rural communities. More recently, the basin planning area has been subject to rapid growth pressure with the population estimated to increase to 73,250 by 2000 (a 32% increase from 1990). This development has significantly altered the Cedar River basin landscape by replacing forest cover with impervious surface areas (roads, rooftops, sidewalks, parking lots, driveways, and other constructed surfaces). The result has been an increase in pollutants and surface-water runoff, and changes in flow rates in streams and wetlands. Cedar River basin conditions not only have affected the natural environment's quality, but also have taken their toll in flood damage to structures, drinking and recreational water, and the quality of life for those who live, work, and play in this basin.

Current land development in the urbanized and lower density residential areas has substantially deforested these areas, leaving only 56 percent of the basin planning area with forest cover. Stormflows have increased dramatically from approximately 26 to 87 percent over the pre-developed forested conditions. In addition, nonpoint water pollution has escalated, well over half of the headwater wetlands have been cleared or filled, and tributaries have been piped, substantially modified, and encroached upon in the lower basin planning area.

More problematic is that the presence of one problem typically causes or intensifies other problems. For example, many fish habitats in the Cedar River system that have been significantly degraded by increased stormflows, also display problems with water pollution and, sediment erosion and deposition, leaving only remnants of the once excellent pre-development habitat and fish populations. These multiple effects are especially evident in three major fish-bearing creeks–Madsen, Molasses, and Maplewood–where the significant decline in habitat quality has nearly eliminated coho and sockeye salmon use of these creeks.

Future conditions are based on the growth estimates in community plans within the basin planning area. The total basin population in 2010 is projected to be 93,000 (a 68% increase from 1990) with approximately 12,548 new housing units. Without preventative measures, surface-water runoff and stormflows will make another significant jump from forested conditions, causing an increase in flooding, erosion and deposition, water pollution, and aquatic habitat problems. For example, tributary flooding problems and channel erosion are expected

to increase due to future development; however, flood problems are not expected to increase significantly for either the 25-year or 100-year flood along the Cedar River mainstem. In addition without preventative measures, streams, lakes, and wetlands will be increasingly subject to more nonpoint pollution due to continued urbanization. Therefore, the future quality of aquatic habitat depends on restoring damaged stream channels and wetlands and preserving existing habitat.

1.2 PLAN DEVELOPMENT

Publication of the Conditions Report and Summary Report completes the first phase of the Cedar River Basin/Action Plan: inventory of conditions, watershed characterization, and identification of significant problems. Whereas the Conditions Report includes an inventory of all known surface-water conditions in the basin planning area, the discussion of conditions focuses on the most significant among them. As such, the Conditions Report forms the basis for the issues that will be addressed in the second phase of planning–the solution phase–of the Basin/Action Plan. The Basin/Action Plan will contain the recommended solutions and management programs to address these problems.

During the solutions phase, the technical and planning team responsible for the Conditions Report will be working with the project committees; local, state, and federal agencies; and the public to develop these recommendations. Examples of Basin/Action Plan recommendations are capital facilities for detaining stormwater or enhancing fish habitat, development standards or changes in land use to reduce excessive runoff and pollutants, or programs to encourage public involvement and stewardship. The Draft Basin/Action Plan is expected to be published in mid-1994. Public comment is invited through all phases of this process, but special public meetings where the public can review, discuss, and comment on the plan will be held at this time. Throughout 1994, the Plan will be revised based on public and agency comment. Early in 1995, it is scheduled to be forwarded to the King County Council, the City of Renton, and other affected entities for adoption. The adopted Basin/Action Plan will then be implemented through capital improvement projects, development permits, and other programs administered by these agencies.

1.3 REPORT DEVELOPMENT

King County's initial effort to document surface-water conditions here was made in 1987 in the Lower Cedar River Basin Reconnaissance Report. That report assessed conditions in the only portion of the basin planning area within the Surface Water Management (SWM) Division Utility Service Area at the time, the area between the City of Renton and Maple Valley.

In King County the Cedar River basin planning area was ranked number one for nonpoint

pollution planning by King County's Watershed Ranking Committee (established by the Nonpoint Rule, Chapter 400-12, Washington Administrative Code). This ranking was due to the Cedar River's high water quality and the importance of protecting the resources. The Nonpoint Rule also established the Cedar River Watershed Management Committee in February 1991. Surface Water Management received a Centennial Clean Water Grant to fund the Cedar River Nonpoint Pollution Plan. The Action Plan was integrated into the basin planning process to form the Cedar River Basin/Nonpoint Pollution Action Plan.

Since 1990, more detailed data for the basin planning area has been collected from precipitation records, drainage complaints, hydrologic modeling, studies from local and state entities, citizen observations, reports like the King County Flood Hazard Reduction Plan, and substantial field studies. The field work entailed stream gaging of flows; habitat, erosion, and deposition surveys of the tributaries and Cedar River mainstem; stormwater and sediment sampling for water quality pollutants; an illicit stormwater hook-up survey within the City of Renton; and a groundwater and aquifer recharge study.

The Current Land Use/Land Cover Map was prepared from 1991 air-photos of the entire basin to determine the amount and location of development (*Map 3, Appendix B*). It is the basis of the hydrologic computer simulation model used to determine the current risks from stormwater discharges in the basin drainages (see *Chapter 2, section 2.5)*. The Future Land Use/Land Cover Map (*Map 4, Appendix B*) was obtained by assuming the maximum level of development allowed under current zoning by the comprehensive land-use plans for Newcastle, Soos Creek, Tahoma-Raven Heights, and the City of Renton. This map includes significant changes in future land use that have resulted from the Washington State Growth Management Act (GMA), which required the County and cities to determine the extent and outline of their future urban growth areas. Current and future stormwater discharges, generated by computer simulation, are used in the disciplinary discussions (see *Chapter 2*) to describe changes in flows with urbanization and to determine what stormwater events cause flood damage, erosion and sedimentation, and degraded aquatic habitat.

1.4 PUBLIC INVOLVEMENT

In May 1992, information gathered from field surveys and other in-house analysis was supplemented by two public open houses. These meetings, held in Renton and Maple Valley, identified citizen surface water-related concerns in the basin planning area. The technical information and the results from the open houses were used to develop this Conditions Report. When the Draft Basin/Action Plan is published, additional community meetings will be held in the basin to solicit public comment for the final plan. Public involvement and education is an important component of both the Action and Basin planning processes.

There are three committees involved in developing the Cedar River Basin/Action Plan: Watershed Management Committee (WMC), Citizen Advisory Committee (CAC), and Technical

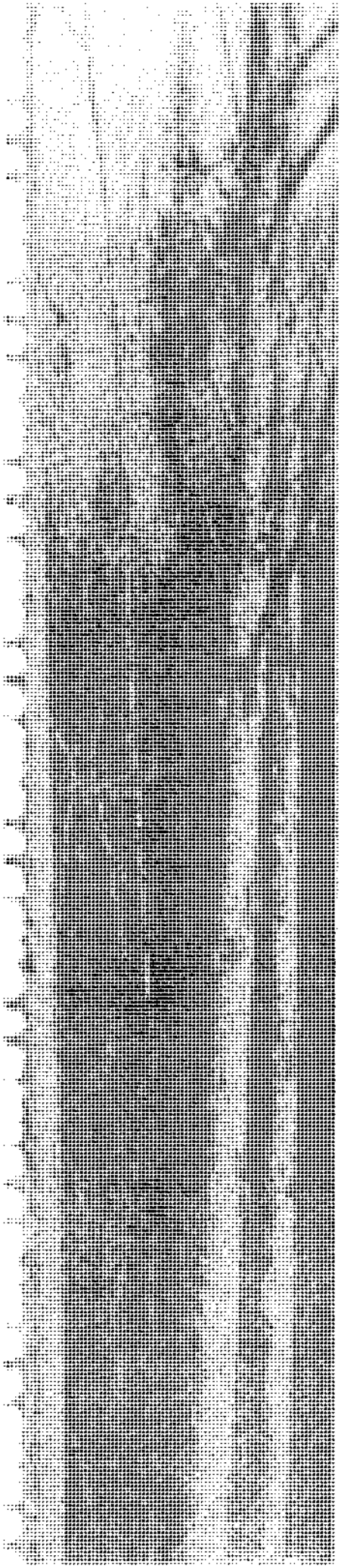
Advisory Committee (TAC). The Watershed Management Committee is a policy-making body appointed by agencies and community groups to direct development of the Basin/Action Plan. The WMC duties are to: 1) oversee plan preparation, including the work program, budget, and schedule; 2) oversee public and agency involvement in the planning process; 3) recommend the proposed Basin/Action Plan to the King County Council, the Renton and Seattle City Councils, and affected federal, state, and local agencies; 4) resolve policy conflicts that may arise; and 5) ensure that agencies with jurisdiction in the basin are aware of their responsibilities when the Basin/Action Plan is adopted.

The Watershed Management Committee represents the following agencies or organizations: the King County Surface Water Management (SWM) Division; City of Renton Planning, Public Works Department; the City of Seattle Water Department; the US Army Corps of Engineers; the King Conservation District; Washington State Departments of Fisheries, Wildlife, Natural Resources, and Transportation; the Muckleshoot Indian Tribe; representatives of area businesses, farm forestry, recreational fishing, and the environment; and the chair of the Citizens Advisory Committee.

The Citizens Advisory Committee was appointed by the Watershed Management Committee to provide a local perspective on problems and solutions throughout the planning process. CAC members, many of whom are long-time residents of the basin, represent a broad spectrum of the basin community including environmentalists, business, law, fishing, and farming. The committee's primary duty is to be a conduit between the basin community and the WMC by discussing surface-water issues with neighbors and a variety of affected interest groups in the basin. The CAC incorporates the concerns raised in these discussions into its Basin/Action Plan recommendations to the WMC. The CAC also develops and participates in public involvement activities related to the Basin/Action Plan.

The Technical Advisory Committee includes technical staff from WMC member agencies and other affected entities. The TAC makes technical recommendations to the WMC and SWM Division staff and discusses a variety of issues, including hydrologic modeling for the flooding analysis, criteria for determining significant problems, and Basin/Action Plan recommendations.

The Cedar River basin's valuable resources have drawn a high degree of interest in the basin planning process from numerous citizens, state and local agencies, and the Muckleshoot Indian Tribe. Staff and citizens recognize the importance and desirability of resolving existing drainage, flooding, erosion and deposition, habitat, and water quality problems in the basin to save public funds and resources, and reduce the likelihood of future problems. However, choices regarding future actions will be complex and difficult to make because of regulatory and social factors in addition to the physical problems. These include insufficient land-use planning and development regulations, limitations on the effectiveness of regulatory agencies, and the need for more public education and involvement. Therefore, restoring and protecting the basin's resources will require the collective commitment of all interested parties to coordinate an effective basin plan.



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CHAPTER 2: WATERSHED CHARACTERIZATION

2.1 INTRODUCTION

This chapter provides a broad overview of the physical and cultural elements that form the Cedar River basin planning area. The general description of the basin planning area, Section 2.2, begins with the physical features, followed by a brief history that provides the context for assessing current and future basin conditions. A summary of the general concepts and current and future conditions is provided in Sections 2.3 through 2.9 for the following disciplines: land use and land cover, geology, surface-water hydrology, erosion and deposition, flooding, water quality, and aquatic habitat.

Each of these disciplines defines an important element that is interrelated with other elements of the basin system. For example, a change in land use generally affects all of the other elements and can illustrate the overall problems or health of the basin system. Conversion of forest cover to urban uses or other development has substantially increased the amount of impervious surface area (roads, parking lots, roofs, sidewalks, etc.) and grass cover in the basin planning area. These land covers have increased the volume and velocity of stormwater runoff and stream flows, with related increases in erosion and deposition, flooding, habitat, and nonpoint water pollution problems. Therefore, an increase in one problem generally intensifies another. For example, stream channel erosion can scour instream habitat, pollute the water with excess sediment, or undercut streambanks causing landslides. Sediment from these sources can fill-in or "cement" spawning gravel. Deposition of the sediment can also reduce channel capacity, thereby causing or aggravating flooding problems in developed areas.

Erosion and deposition, flooding, habitat, and nonpoint water pollution problems are most severe in or surrounding the lower tributary channels and the lower Cedar River mainstem, but these conditions exist throughout the basin. In the future, areas that are currently affected by these problems, and other areas that are presently unaffected, are expected to see an increase in problems unless preventative measures can be instituted to stem stormflows and protect aquatic environments.

2.2 DESCRIPTION OF THE BASIN PLANNING AREA

Physical Overview

The Cedar River basin is located in the southeast region of the Puget Sound Lowland, curving eastward from the south end of Lake Washington to the crest of the Cascade Range (*Map 1, Appendix B*). The entire basin is within King County and drains 188 square miles. The basin

planning area, the primary focus of this report, consists of approximately 66 square miles (42,240 acres) drained by the Cedar River below the Seattle Water Department's (SWD) Landsburg Dam. Eighty percent of the upper Cedar River basin, above Landsburg Dam, is owned and maintained by the City of Seattle to protect the quality of the city's water supply.

The climate of the Cedar River basin has moderate temperatures with annual precipitation ranging from 30 to 50 inches in the basin planning area, 100 to 200 inches in the upper basin, and snowfall in the Cascades averaging 200 inches per year. Streamflows are highest during periods of high precipitation, November to February, and during high snowmelt, April to May, and are particularly high during simultaneous episodes of prolonged precipitation, warm temperatures, and snowmelt.

For planning purposes the basin planning area is divided into eight subbasins, or groups of subbasins, with similar topography, land cover, and land use: 1) Renton Reach, 2) Lower Cedar River mainstem, 3) Lower Cedar River subbasins, 4) Middle Cedar River mainstem, 5) Peterson Creek, 6) Taylor Creek, 7) Middle Cedar River subbasins, and 8) Rock Creek (*Map 2, Appendix B*). The middle subbasins, which drain into the Middle Cedar River mainstem between Landsburg and Maple Valley, are primarily forested with some low-density residential use. In contrast, the lower subbasins, which drain into the Lower Cedar River mainstem downstream of Maple Valley, contain a wider variety of land uses and land cover types, including high-density urban areas, such as the City of Renton, subdivision development on the plateaus east of Renton, and the rural community of Maple Valley, fifteen miles upstream from Renton. Detailed descriptions of the subbasins and their specific conditions are discussed in Chapter 3 of this report.

There are eight major basin tributaries flowing into the Cedar River along its twenty-one-mile course from Landsburg Dam to Lake Washington: the Walsh Lake diversion channel and Taylor (Downs), Rock, Peterson, Ginger, Molasses, Maplewood, and Madsen creeks (*Maps 17-28, Appendix B*). These creeks and numerous smaller tributaries drain the broad, flat plateaus that rise 100 to 300 feet above the Cedar River valley floor and flow over the steep bluffs, typically into narrow ravines, before reaching the Cedar River. The Cedar River flows through a fairly narrow valley from Landsburg to a mile above Maple Valley, where the valley floor broadens. Downstream from Maple Valley the river winds through the valley floor but is almost entirely constrained by revetments (rock armored banks) or steep bluffs. For the final two miles, the Cedar River flows in an artificial canal through the industrial section of the City of Renton before discharging into Lake Washington.

The basin planning area's complex drainage system includes several large lakes and wetlands. Lake Desire and Spring (Otter) Lake are on the plateau to the south of the lower Cedar River, and Walsh Lake is located in the middle basin. Lake No. 12 and Shady, Peterson, Webster, Francis, and Retreat lakes are smaller lakes located on the plateaus. The artificially created lakes in the upper basin are Chester Morse Lake, held by the Overflow Dike, and Masonry Pool, behind the Masonry Dam. There are a total of 74 inventoried Class I and II wetlands (767 acres) and many uninventoried wetlands scattered throughout the basin. Extensive wetlands

abut the shorelines of Lake Desire and Spring, Peterson, Webster, and Francis Lakes. Large wetlands are also found in the upper reaches of Taylor and Molasses Creek.

Historical Landscape and Settlement Pattern

Prior to twentieth century settlements, the Cedar River basin was densely covered with stands of cedar, fir, and hemlock trees with a thick understory of vine maple, alder, crabapple, dogwood, devil's club, hazel, salal, and wild grape. Elk, black-tailed deer, black bear, cougar, red fox, coyote, river otter, and beaver were common throughout the basin (Bodurtha, 1989).

The basin settlement pattern began its transformation from Indian settlements to the present landscape with the Georgetown to Renton railroad in 1874. This led to the incorporation of Renton in 1901. At that time the Black River was the southern outlet for Lake Washington, with the Cedar River flowing into the Black River about a mile south of the lake. Between 1911 and 1916, the Hiram Chittenden Locks were built, the water level of Lake Washington was lowered, the lower end of the Cedar River was diverted into an artificial canal ending at Lake Washington, and the Black River dried up and its channel was filled (Chrzastowski, 1983). The diversion of the Cedar River was to both reclaim land for the growing Renton community and to provide fresh water to operate the Locks.

Settlement of the lower basin was by homesteaders, coal miners, and farmers. Homesteaders, shortly after arrival in the late 1800s, cleared 40 to 80 acres or more per family for their homes. Dairy farming was also established at the turn of the century with cows grazing the valley floor in the present area of the Maplewood Golf Course and Jones Road. Coal was discovered around 1870 and, soon after, a small coal mining town was built at Cedar Mountain. Railroads built in the area for the coal towns also provided transportation for people and goods through the valley. Mining continued in this area until 1947 (Slauson, 1969).

Settlement of the valley and plateaus proceeded slowly along the railroad route due to the difficulty of travel through the thick forest. The roads of the late 1800s and early 1900s were often impassable, but early bridges were built at Renton, Elliott, and Landsburg. By 1920 a reliable road was built between Renton and Maple Valley and the Maple Valley community began to grow rapidly. Roads were built to Hobart and Black Diamond, further expanding transporration of goods, people, and services. Logging roads soon joined these major routes and the virgin forest was clearcut throughout the lower basin, opening the plateau land to development.

The upper basin (above Landsburg) was not developed because the City of Seattle purchased this area for water supply in the 1800s. In 1904, the City of Seattle built a timber crib dam on the Cedar River that transformed a natural lake (Cedar Lake) into Chester Morse Lake. This water was then piped into Seattle. Most of the land downstream from the crib dam was logged by the 1930s. This dam was replaced with the Overflow Dike in 1988. In 1916, the Masonry Dam was built forming Masonry Pool. In addition to water supply, the City of Seattle began the

operation of the Cedar Falls hydroelectric project in 1904 and it now supplies more than 8000 homes with electrical energy (Slauson, 1969).

In the 1920s settlement increased on the valley floor, despite its flood-prone nature, because of the flat open spaces and easy access to the river and the adjacent highway. Aerial photographs taken in 1936 show that the river upstream from the Renton channel was mostly unconstrained, except for a few local levees (artificially elevated riverbanks) and revetments built to protect the railroad and roads. After a large flood in 1959, King County's Department of Public Works built extensive levees and revetments, with most completed by the late 1960s. Most bends of the river between Renton and Maple Valley are now armored by levees and revetments.

The Cedar River is a very significant regional water supply. The upper basin provides 70 percent of the municipal and industrial water needs for the City of Seattle and surrounding metropolitan areas. The river provides 54 percent of Lake Washington's water supply, which is important to the operation of the Hiram Chittenden Locks for commerce, for ship passage, and to control salt water intrusion (URS, 1981). State and County agencies, and the Muckleshoot Indian Tribe, which manage fish and wildlife resources, are concerned with ensuring adequate flows in the river to maintain or enhance the habitat for anadromous (migrating) salmonids and resident fish.

2.3 LAND USE / LAND COVER

The Cedar River basin planning area has a diverse mix of land use and land cover types, ranging from urban impervious surface areas to rural forestry lands (*Map 3, Appendix B*). Major communities include the City of Renton, the only incorporated area, Maple Valley, Fairwood, Maplewood Heights, Summit, Ravensdale (in part), and Georgetown. The 1990 census population is approximately 15,400 people within the City of Renton's limits and 40,000 people in unincorporated King County, for a total basin population of approximately 55,400 in approximately 18,450 housing units (King County, 1991a).

Current Land Use

Residential, industrial, and commercial land uses are currently dispersed throughout the basin planning area. Residential uses tend to decrease in density eastward from the urban area of Renton to rural and medium-densities around Maple Valley, to forested, low-density residential areas in the middle basin. The portion of Renton within the Cedar River basin contains multi-family or high-density single-family residential uses. The high-density single-family residential pattern extends beyond Renton's city limits onto the plateaus to the east and along the lower reaches of the river, including the large subdivisions of Maplewood, Fairwood, and Maplewood Heights. About halfway between Renton and Maple Valley, residential land use on the plateaus decreases and is interspersed with a mosaic pattern of forest and grass cover. South of Lake

Desire and Cedar Mountain the residential areas become low density, primarily in forest cover, with higher residential densities surrounding the small communities of Maple Valley, Summit, Georgetown, and Retreat Lake and Lake No. 12.

Industrial and commercial land use dominates and creates expansive areas of impervious surface along the lower reach of the Cedar River in Renton. Other areas of major industrial use are located along Cedar Grove Road, including a gravel pit, the King County Cedar Hills landfill site, Cedar Grove Composting, and a Federal Environmental Protection Agency Superfund site, the Queen City landfill. Along State Route 169 there is a metal recycling business and there are several small quarries. Interspersed with rural residential uses throughout the basin planning area are small farms, small quarries, and businesses in rural homes.

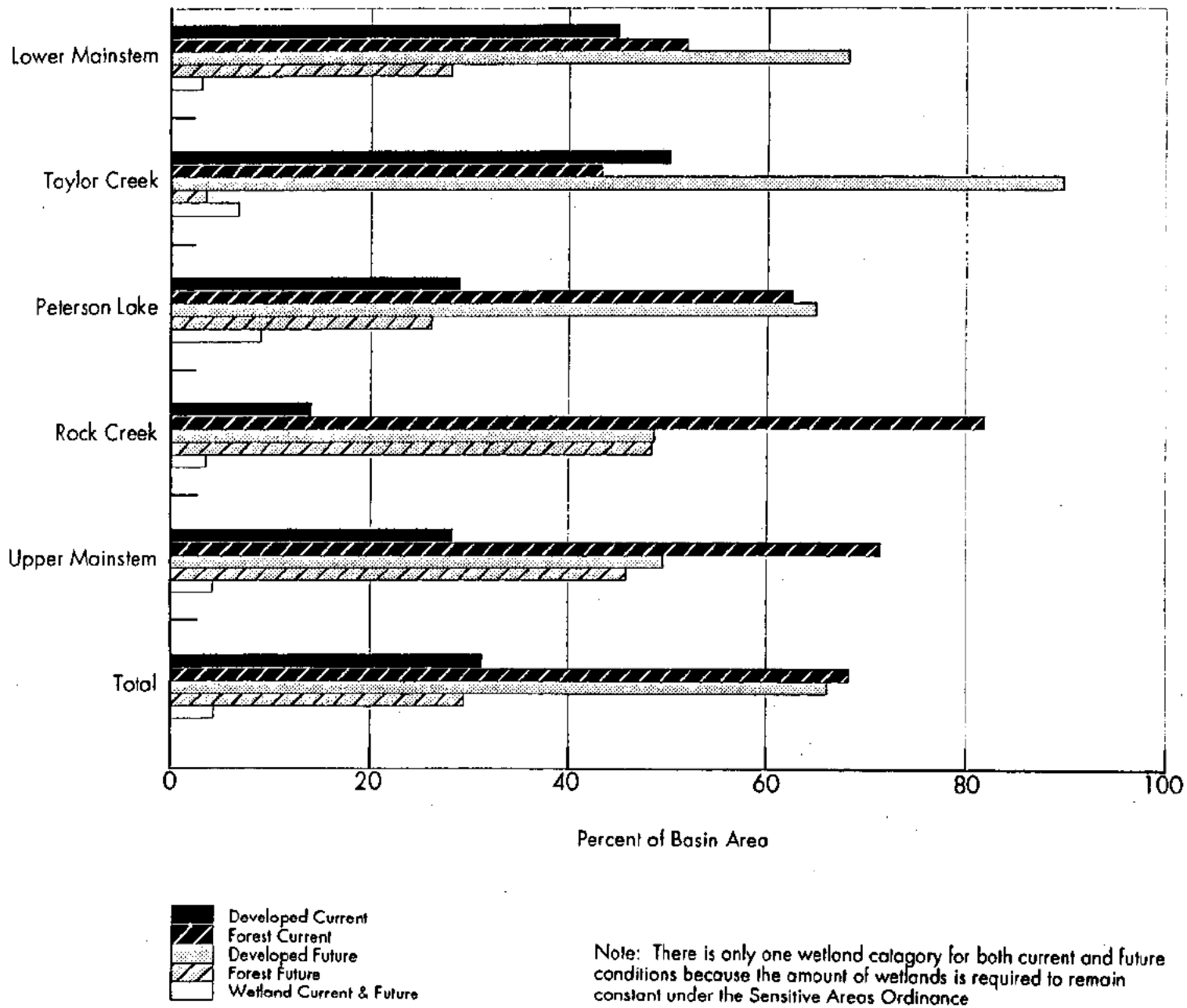
Commercial forestry is a major land use in the basin planning area upstream of Maple Valley. The City of Seattle owns extensive forest lands within the basin planning area to the south and north of the diversion dam at Landsburg. The Rock Creek subbasin is primarily private forest lands, with large sections of recent clearcut and a portion owned by the City of Kent for water supply. Below Maple Valley, the City of Seattle owns forest lands around Lake Youngs. There are also private forest lands between Francis Lake and Cedar Grove Road.

Future Land Use

Future land use in the basin planning area was mapped assuming the maximum level of development allowed under current (1992) zoning by the comprehensive land use plans for Newcastle, Soos Creek, Tahoma-Raven Heights, and the City of Renton (see Map 4 and Figure 2-1). The mapping also includes significant changes in future land use that have resulted from the Washington State Growth Management Act (GMA), which required the county and cities to determine the extent of their urban growth areas. Based on the percent of growth estimated in the above comprehensive plans, the total basin population in 2000 is projected to be 73,250 (a 32% increase from 1990) with approximately 6,000 new housing units. In 2010, the total basin population is projected to be 93,000 (a 68% increase from 1990) with 12,548 new housing units.

Most of the new housing units will be in unincorporated King County and are expected to occur on the plateaus, primarily the north plateau, within the urban growth boundary (UGB) established under the Growth Management Act (*Map 4, Appendix B*). Impervious surface areas and multi-family residential uses are anticipated to approximately double within the urban growth boundary by the year 2000. The plateaus will be almost entirely built out in single-family high-density residential uses. Only the steep knolls and bluffs above the river are expected to remain forested. Significant future areas of mixed commercial and high-density residential use will be on the plateau northeast of Renton and along the State Route 169 corridor between State Route 18 and Summit. Future industrial expansion along Cedar Grove Road will approximately double its current area of industrial land use. All of this high intensity development will add significantly to the impervious surface area that sheds stormwater and urban pollutants. Only the upper areas of the middle basin will remain as undeveloped forest.

Figure 2-1. Comparison of Current and Future Land Use/Land Cover



Note: There is only one wetland catagory for both current and future conditions because the amount of wetlands is required to remain constant under the Sensitive Areas Ordinance

In response to the Growth Management Act, the area upstream of Maplewood Heights was redesignated from high-density to low-density residential land uses. Another result of the Growth Management Act is that the Georgetown area, in the Rock Creek subbasin, is to remain rural with a small commercial center. As of this writing, the King County Council is reviewing the Briarwood area, between SE 156th and SE 183rd Streets north of the Cedar River, to determine its future residential densities.

State Shoreline Designations

The Cedar River shoreline has been designated as a Shoreline of the State from its mouth to its headwaters. To be designated a Shoreline of the State, the Washington State Department of Ecology determines that river or stream reaches have a mean annual flow greater than 20 cubic feet per second (cfs). The Shoreline Management Plans of King County and the City of Renton define two environments, "Urban" and "Conservancy," for the designated shorelines. These environment classifications, as approved by the Washington State Department of Ecology, provide a uniform basis to apply policies and land-use regulations within distinctly different shoreline areas.

The Urban designation extends upstream from the mouth of the Cedar River at Lake Washington, River Mile (RM) 0.0, to RM 2.1 on both banks and from RM 2.1 to RM 3.4 on the right bank (looking downstream) (see *Map 17, Appendix B* for river mile locations). The objective of the Urban designation is to ensure appropriate use of shorelines within urbanized areas by providing for public use, especially access to and along the water's edge, and by managing development so that it enhances and maintains shorelines for multiple urban uses. Public access to the shorelines is only on public lands.

The Conservancy environment is on the left shoreline from RM 2.1 to RM 3.4 and on both banks from RM 3.4 to the river's headwaters (see *Map 18, Appendix B* for river mile locations). The Conservancy designation consists of shoreline areas that are primarily free from intensive development. It is the most suitable designation for shorelines areas of high scenic or historical values, for areas unsuitable for development due to physical limitations, and for commercial forest lands. The objective of the Conservancy designation is to protect, conserve, and manage existing areas of irreplaceable natural or aesthetic features in essentially their native state, while providing for limited use of the shoreline at public access sites. The preferred uses are those that are non-consumptive of the physical and biological resources of the area.

According to the 1978 King County Shoreline Management Master Program Supplement, the lower reach of Rock Creek is also a Shoreline of the State, designated as Conservancy from the intersection of the County road, the railroad right-of-way, and Rock Creek (at approximately RM 0.1) downstream to its confluence with the Cedar River *(Map 28, Appendix B)*. The natural mean annual flow of Rock Creek exceeds the 20 cfs mean annual flow up to RM 1.7. However, two major diversions, only one of which is permitted, and several smaller diversions have decreased Rock Creek's mean annual flow, as measured between 1948 and 1973 by the USGS

gage at RM 0.1, to less than 20 cfs above RM 0.1.

Recreational Use

The Cedar River basin provides a wide variety of recreational resources through its system of parks, hiking, biking, and equestrian trails. In the lower and middle basin, the park and open space system is interconnected with an abundance of streams, wetlands, and lakes, as well as the Cedar River, within a green, open corridor that extends into the Cascade Range. This natural system provides active recreational opportunities, such as swimming, walking, and fishing, and passive recreational opportunities, such as picnicking, educational or scientific study, and views of the Cedar River corridor. In addition, the parks and trails serve as natural community separators (formerly termed greenbelt). The demand for recreational opportunities in the future is expected to increase while the land available for acquisition as public open space will be limited by development within the basin planning area.

The Cedar River Trail was chosen in September 1992 as the top regional pedestrian-bicycle project to receive funding. The trail is proposed to run 15 miles from Renton to Maple Valley following the river along the former railroad right-of-way. It is expected to connect existing parks located along the lower reach of the river and could provide a major link in the regional trail system proposed by King County and in the proposed and existing community trail systems of the Tahoma-Raven Heights, Soos Creek, and Newcastle community plans (King County, 1991b, 1984, 1993). Where possible, community trails provide access to natural areas and parks, as well as creating linkages between the residential areas and commercial centers. Many of the trails are on early mining, logging, or settlement roads, giving them historical significance as well as recreational value.

In addition to the Cedar River Trail, approximately 382 acres of land was acquired near Lake Desire and Spring Lake through the King County Draft Open Space Program to provide public access for open space and recreation. The wetland corridor and potential shoreline access along Lake Desire qualified the area as one of twelve sites to be acquired in the King County Open Space Plan (King County, 1988). Currently, the King County Department of Parks and Recreation is preparing a comprehensive parks plan. The plan will update the 1988 Open Space Plan and identify additional recreation and open space sites in the county. The policy portion of the plan is scheduled to be completed during the fall of 1993, while the implementation portion of the plan is expected by the end of 1993.

LAND USE KEY FINDINGS

- Current basin population is approximately 55,400 with approximately 18,450 housing units.
- Future basin population is estimated to increase to 93,000, a 68 percent increase from 1990 to 2010, with 12,548 new housing units.
- Impervious surface areas and multi-family residential uses are anticipated to approximately double within the Urban Growth Boundary by the year 2000.
- In the future, the plateaus above the valley will be almost entirely built out in single-family high-density residential and commercial uses between Renton and Maple Valley, while industrial development is expected to approximately double along Cedar Grove Road.
- The Cedar River shoreline, from its mouth to its headwaters, and Rock Creek shoreline, from River Mile 0.0 to approximately 0.1 are designated as Shoreline of the State.

2.4 GEOLOGY AND GROUNDWATER

The lower and middle Cedar River basin extends directly across the path of the great ice sheet that covered the Puget Lowland 15,000 years ago. The geology of the basin displays a variety of glacial deposits, which presently form most of the land surface in the basin, particularly the upland plateaus that flank both sides of the Cedar River valley.

The underlying bedrock topography has exerted very little influence on the modern form of the basin. The preglacial Cedar River valley was established by uplift of the Cascade Range and actually lies about two miles north of the present river course. The Cedar River has carved its present valley form almost entirely through the glacial deposits. At some locations, this downcutting has exposed several hundred feet of sediment (solid mineral or organic material transported by water, ice, or air and then deposited) that predates the last glaciation, offering many good and some rare examples of the complex sequence of deposits that underlie the Puget Lowland.

Regional History and Stratigraphy

The entire east-central Puget Lowland is underlain by Eocene-age (about 40 million years old) volcanic and sedimentary rocks many thousands of feet thick. These rock layers have been regionally folded into northwest-trending folds. This bedrock structure determined the Cedar River basin's overall form and east-west direction, but glacial and post-glacial processes have

determined the Cedar River valley's current size and location.

In the Cedar River area, Eocene rocks are exposed at the surface near Renton and Cedar Grove, and in the uplands east of Ravensdale. The sedimentary rocks have been actively mined for coal for about a century. In addition, these rocks are overlain by younger sedimentary rocks near Renton, and intruded by younger volcanic rocks east of Lake Desire.

Ice Occupation of the Basin

During the Pleistocene epoch (2 million to 10,000 years ago), glacial ice originating in British Columbia invaded the Puget Lowland several times. The most recent ice advance, named the "Vashon," shaped the present topography of the Cedar River valley 15,000 years ago. The lower and middle Cedar River basin has some of the best exposures of multiple glacial advances in the entire east-central Puget Lowland, displaying three glacial tills (nonsorted, nonlayered sediment carried or deposited by a glacier) and intervening layers of both glacial and nonglacial sediment. The uppermost till, from the Vashon ice advance, lies at or very near the ground surface of the upland plateau. Most of the valley walls of the Cedar River display a mixture of the coarse- and fine-grained sediment that renders the exposed slopes very susceptible to landslides and greatly impedes the ability of surface waters to percolate vertically to groundwater.

During the Vashon advance, ice covered the region to a depth of about 3,000 feet and deposited lodgment till (till deposited at the base of a moving glacier). Currently, lodgment till provides a low-permeability cover to underlying aquifers, reducing groundwater recharge but offering protection from surface contaminants wherever it is present at the surface.

Deglaciation and Landscape Changes

After the ice retreat, about 13,500 years ago, the Cedar River incised through a complex sequence of glacial and nonglacial deposits. This resulted in the modern form of the Cedar River valley, a 2,000-foot-wide gash through the glacial landscape and, in places, now more than 300 feet below the upland surface. High, steep valley sidewalls line both sides of the river for over 10 miles. Subsequent to that downcutting, the Cedar River has swung to and fro across the valley bottom, eroding and redepositing its modern floodplain. Steep slopes on both sides of the valley, remnants of the river's downcutting, are now the sites of not only deep and rapidly incising ravines but also some of the largest recently active landslides in all of King County.

Groundwater

Groundwater in the basin moves through the glacial deposits at different rates depending on the characteristics of the deposits. Outwash deposits (sediment deposited by meltwater streams beyond the active glacial ice), consisting of primarily sand and gravel, provide the best

opportunities for infiltration and subsurface flow. In the Cedar River basin the various outwash deposits of the last glaciation form the most common aquifers. In contrast, deposits with a higher percentage of silt and clay, notably till, offer significant resistance to flow; they are termed aquitards (moderately restrictive) or aquicludes (strongly restrictive).

Shallow aquifers over an aquiclude are "perched," because groundwater cannot move farther downward, and may discharge groundwater to form surface springs or wetlands. Aquifers at greater depth may have less direct access to surface waters, with recharge occurring only by slow percolation through overlying aquitards. Some of the groundwater supply in the basin is pumped from deep aquifers in older glacial and nonglacial deposits. These aquifers are more easily accessed from the lower elevation of the valley floor and are protected from surface contaminants because of their depth.

The primary aquifer for most of the basin is the "advance outwash" of the Vashon glacial advance. These deposits have good water yields from relatively shallow well depths. Protection of the groundwater from surface contaminants in these deposits is generally provided by overlying glacial till. In contrast, much of the City of Renton lies on a broad plain underlain by thick deposits of Vashon-age sand and gravel that was deposited as the glacier retreated from the region. These aquifers have very high yields of groundwater at minimal well depth. The absence of overlying till in this area, however, leaves this aquifer at risk from surface contaminants.

2.5 SURFACE WATER HYDROLOGY

Surface-water hydrology is the scientific study of the properties, distribution, and effects of water of the earth's surface. In the Cedar River basin planning area, mainstem and tributary stream flow conditions were studied using climate and stream flow records in combination with a computerized hydrologic model. The model accounts for the effects of land use and land cover on surface-water runoff characteristics and stream flow behavior, such as low flows or storm flows. In contrast, conditions discussed in Flooding Damage (Section 2.6) describe the impacts when storm flows damage property and natural resources.

The hydrologic model was used to study streamflow in fourteen major tributaries that drain the basin planning area. Additionally, flows in the mainstem were studied by adding inflow from the upper basin at Landsburg to the tributary flows and to runoff from mainstem valley areas. Modeling of forested (pre-development), current, and future conditions showed that development has and will continue to have a significant effect on tributary stream flows. In contrast, flows in the mainstem are largely determined by inflows from the 122-square-mile upper basin area. Mainstem flows are partially controlled by the City of Seattle's operation and management of the Landsburg Diversion and Masonry Dam.

Hydrologic Model and Application

The computerized hydrologic model used to analyze stream flow behavior, simulates (imitates) the hydrology of a series of land types that are distinguished from one another by topography, geology, soils, vegetation, and impervious surface areas. Ratios of these land types within a drainage area largely determine its surface runoff characteristics. Lakes and wetlands also affect runoff characteristics by storing flows and releasing them at reduced rates. The degree that peak flows are reduced depends on volumes available for flood storage in lakes and wetlands.

Soil characteristics greatly affect stormwater runoff. Till contains large percentages of silt and clay, which produce low percolation rates, and generates shallow subsurface flows and relatively high peak runoff rates. In contrast, rainfall readily infiltrates through outwash soils (sand and gravel) to the deep groundwater table and surface runoff rates from these soils are typically low or nonexistent.

Three land cover classes were used in analyzing the basin planning area stream flows: forest, grass/pasture, and impervious surface. Forested areas generate the least amount of surface runoff. Grassed areas produce more surface runoff than forested areas because surface soils are generally compacted during clearing, thus reducing infiltration capacities. Impervious surfaces consist of roads, rooftops, sidewalks, parking lots, driveways, and other constructed surfaces, and virtually all rainfall runs directly off to produce high peak flows.

Basin Planning Area Tributary Stream Flow Conditions

Hydrologic simulations of over forty-two years of stream flows were carried out under three separate development conditions: forest (predevelopment), current land use, and future land use. Forest condition simulations provide a reference base from which to measure or judge current and future hydrologic conditions in the basin. In catchments and subbasins where forest cover has been undisturbed for many decades, field observations show that streams have significantly lower flood peaks and higher baseflows, higher quality and quantity of aquatic habitat, higher water quality, and tend to be more geologically stable than catchments where forests have been cleared more recently.

Current conditions were determined for each catchment using 1991 land-use and land-cover data from aerial photographs, together with zoning, soil maps, topographic maps, and field reconnaissance.

Future conditions were modeled by assuming the maximum development levels allowed under the Growth Management Act combined with the comprehensive plans for the City of Renton, and the King County community planning areas of Newcastle, Soos Creek, and Tahoma-Raven Heights. Two future scenarios were modeled: a worst-case scenario assumes no mitigation from stormwater retention/detention (R/D) ponds in future development; the other assumes that most future development will require stormwater retention (to hold or store water) or detention

(to delay the flow of water). An estimate of the effect of detention on flood peaks was made by designing a series of typical R/D ponds. The ponds were sized such that developed 2-year and 10-year discharge levels were no higher than the pre-developed discharge levels. Land developers are generally required to install these ponds to detain the increases in surface runoff caused by replacing forest cover with less pervious grass cover or impervious surfaces.

The flood-flow behavior of the increased stream flow can be illustrated by a single number for each subbasin. This number is the 25-year stormwater discharge (Q_{25}) divided by the subbasin area and is given in units of cubic feet per second (cfs) per square mile (Table 2-1). The 25-year discharge is defined as the flow with a 1 in 25 (or 4%) chance of being equaled or exceeded in any given year. The 25-year discharge was chosen as a representative, middle value between the 2-year to 100-year flood discharges. It describes changes in flood peaks for each subbasin, with natural variations, under the four different conditions modeled: forested, current, future-unmitigated, and future-mitigated.

Forested (Predevelopment) Conditions - Under forested or "natural" conditions, human impacts associated with land development are removed from the computer model simulation and differences in streamflow characteristics among the tributaries only reflect variations in geology, soils, slopes, rainfall, the distribution of lakes, and other natural factors. Under forest conditions, the subbasins fall into three categories, depending on their relative peak runoff rates during a one in 25-year flow event. Cedar Grove, Orting Hill, Madsen, Summerfield, and Molasses produce large peak discharges (greater than 50 cubic feet per second (cfs) per square mile) because they do not have lakes to buffer flood runoff and are dominated by relatively impervious till soils. Ginger, Dorre Don, Taylor, Peterson, and Maplewood discharge moderate runoff volumes (30-50 cubic feet per second per square mile), partly because they contain lakes and wetlands that moderate the storm flows. Cedar Hills, Webster Lake, Rock Creek, and Walsh Lake produce low peak discharges (less than 30 cfs per square mile) because pervious outwash soils combined with significant surface-water storage from lakes or large ponds.

Current and Future Conditions - As forest cover diminishes from forested through current to future conditions, the subbasins exhibit an increase in "water yield," which is the average volume of precipitation that appears as stream flow. Water yield is all the water that is not consumed by vegetation or returned to the atmosphere through transpiration from plants and evaporation from lakes and ponds. Annual water yield under current conditions varies among the subbasins from 48 to 62 percent of precipitation due to differences in vegetation, soils, and the presence of lakes and ponds. Removal of forest cover accompanying urbanization has increased water yield by as much as 35 percent in some tributary subbasins. Usually these increases occur during winter storms producing increases in flood damage, erosion, sedimentation, and water quality and habitat degradation (see sections 2.6 through 2.9).

Table 2-1 Flood Peak Values for the Subbasins

	Forested cfs/mi.^{2}	Current cfs/mi.^{2}	Future Mitigated cfs/mi.^{2}	Future Unmitigated cfs/mi.^{2}
Ginger Creek	47.4	122.1	124.2	135.3
Maplewood Creek	31.4	56.5	63.4	97.8
Molasses Creek	52.9	99.2	100.9	131.2
Madsen Creek	57.3	117.6	127.4	136.2
Orting Hill	69.4	107.0	105.0	150.1
Summerfield	54.9	34.3	48.0	57.2
Cedar Grove	69.9	96.5	99.1	136.3
Cedar Hills	8.7	11.9	16.7	16.7
Webster Lake	8.6	9.7	12.9	12.9
Taylor Creek	40.4	50.1	76.7	76.7
Peterson Creek	36.9	44.5	50.3	59.6
Dorre Don	48.4	63.3	93.7	93.7
Rock Creek	23.7	27.6	46.2	48.5
Walsh Lake Ditch	17.1	17.1	17.1	17.1

The numbers below show the 25-year stormwater discharge (Q_{25}) divided by the subbasin area. The numerical values are given in units of cubic feet per second (cfs) per square mile (cfs/mi^2).

Table 2-1 can be used to compare a subbasin flood peak to another subbasin or to itself under different development conditions. Under forested conditions the Ginger Creek subbasin is estimated to produce the sixth highest flood peak discharge per square mile (47.4 cfs/mi.^{2}), yet under current conditions it produces the highest flood peak of all the subbasins (122.1 cfs/mi.^{2}). This is the direct result of the past conversion of 84 percent of the Ginger Creek subbasin area to high-density residential land use. There is very little difference between Ginger Creek's current condition flood peak (122.1 cfs/mi.^{2}) and the future condition flood peaks (124.2 cfs/mi.^{2}) because there is very little land that is left to be urbanized. The ratios for Madsen Creek show a similar pattern.

The more urbanized suhbasins in the lower part of the basin planning area (Ginger, Maplewood, Molasses, Madsen, Orting Hill and Cedar Grove) show substantial increases in their peak flows under current conditions compared to forested conditions. Summerfield subbasin's unusually low flood peaks result from a bypass pipe that diverts half the area's storm water from the creek. In the future, Maplewood, Molasses, Orting Hill, and Cedar Grove subbasins will experience substantial conversions of forest cover to more intense land uses that is expected to be mitigated by stormwater retention/detention ponds. For example, Molasses Creek has similar flood peak values for current (99.2 cfs/mi.^{2}) and future-mitigated (100.9 cfs/mi.^{2}) flood peaks. These are significantly smaller than the value (131.2 cfs/mi.^{2}) for future-unmitigated conditions.

Development has been less intense in the Cedar Hills, Webster Lake, Dorre Don, Taylor, Peterson, and Rock Creek subbasins. With the exception of Peterson, these subbasins will experience substantial future conversion of forest land to low-density residential land use. The conversion is expected to be primarily on individual parcels rather than subdivisions. Typically these parcels are not required to construct retention/detention ponds, so the flood peak values reflect that the hydrologic impacts from conversion will not be mitigated. Consequently, the values for future-mitigated and future-unmitigated conditions are similar in size and substantially larger than for current conditions. For example, residents living near Taylor Creek are experiencing flooding problems under current conditions (50.1 cfs/mi.^{2}) and simulation results suggest that future flood peaks (76.7 cfs/mi.^{2}) may increase up to 53 percent without preventative measures. Rock Creek, a large almost totally undeveloped subbasin, may experience flood peak increases up to 67 percent over current conditions without preventative measures.

Other subbasins that are most at risk for increased flood peaks are Cedar Hills, Webster Lake, and Dorre Don. In contrast, Peterson Creek subbasin will experience conversion to both high and low density residential development and thus some storm flow mitigation will occur, resulting in lower flood peak values than subbasins with only low-density development. Walsh Lake ditch only drains Walsh Lake and the surrounding area and is assumed to remain in forest cover.

Rock Creek's current and future flows are affected by two major diversions, only one of which is permitted, and several smaller diversions. One major diversion directs a significant portion of drainage from Lake No. 12 and Wetland 92 to the Green River. A field check by Surface Water Management staff in the spring of 1993 indicated that the ditch diverted approximately a third of the flow (5.0 cfs) on that day. The second major diversion of Rock Creek is made by the City of Kent at River Mile 1.7. The City of Kent has diverted water for municipal use from the site since the early 1900s. Currently, the City of Kent's diversions average approximately 26 percent of Rock Creek's mean annual flow. More importantly, current diversions represent the majority of the creek flows during the low-flow months of September and October.

Cedar River Mainstem Conditions

Both high and low mainstem flows are greatly affected by management of the upper basin for the City of Seattle's water supply. The upper basin contributes 79 percent of the total basin water yield and includes 66 percent of the land. Seattle Water Department's (SWD) diversion works above Landsburg remove an average of 191 cubic feet per second (cfs) from the river.

Estimated Effects of Seattle Water Department Facilities on Low Flows - The lowest flows in the mainstem typically occur from July through October and are greatly affected by the Seattle Water Department's operations in the upper basin. Prior to the time of Seattle Water Department's diversions, mainstem flows were significantly higher during this period.

The City of Seattle claims a water right to divert more than twice as much water as they

currently do; however, in drought years, even historical diversion rates may pose problems for downstream fish resources, water levels of Lake Washington, and operations of the Hiram Chittenden Locks. In recognition of concerns about low flows, the Seattle Water Department cooperates with interested parties including the Departments of Ecology (DOE), Fisheries (WDF), Wildlife (WDW), the Corps of Engineers (COE), and the Muckleshoot Indian Tribe to set and meet minimum "normal" (non-drought) and "critical" (drought) target instream flow levels at Renton. For example, during August the normal flow target is 130 cfs and the critical flow target is 110 cfs, approximately 15 percent lower than the normal flow target.

Estimated Effects of Seattle Water Department Facilities on High Flows - The effect of the Seattle Water Department's facilities on flood flows between Landsburg and Renton depends in large measure on how Seattle operates the facilities. In addition to providing drinking water and hydropower to the Seattle metropolitan area, under most circumstances the dams add to storage in the river system and consequently significantly reduce downstream flood discharges. During the flood season (October 1-March 31) the service spillway (overflow) gate of the Masonry Dam remains open, to pass floods up to the 100-year event. During a 100-year or larger event, emergency spillway gates may be operated at Masonry Dam to maintain safe water levels behind the dam.

Basin Planning Area Mainstem Flows - Hourly flows in the basin planning area mainstem were simulated, using a computer model, to represent forty-two years of flow records. These flows were characterized for 1) mean (average) annual flow, 2) frequency of peak annual flows (how often a stormflow of a certain size will occur), and 3) peak-flow durations (how long the peak flows will last). The average annual flow for the forty-two year period, as simulated, is approximately 668 cfs. This is within two percent of the actual average annual flow recorded at the USGS gage in Renton, suggesting that the simulations accurately represent the long term water balance of the basin.

Peak annual flow frequencies, as simulated, differ slightly from the historical record because the simulation results reflect constant land-use conditions and consistent Masonry Dam operation. The flood frequency analysis estimates the following peak flows in the Cedar River mainstem: 2-year flood = 3,800 cfs; 25-year flood = 8,000 cfs; and the 100-year flood = 11,100 cfs.

Peak flows in Renton are most often, though not always, correlated with and caused by peak flows entering the mainstem from the upper basin, above Landsburg. Generally, flows from the basin planning area tributaries cause lower, earlier flow peaks in Renton, which are followed by larger peaks from the upper basin. The typical simulated peak lag time between Landsburg and Renton is approximately five hours, with lag time decreasing with increasing flow. Flows above 3,000 cfs occur at Renton for two to three times the number of hours as at Landsburg. It appears that the typical flood wave travelling downstream from Landsburg diffuses while simultaneously it is augmented by basin planning area tributary flows. The result at Renton is a slightly higher flood peak with a significantly longer duration than the flood peak at Landsburg.

Land use changes in the basin planning area have, and will continue to have, a slight effect on

peak flows in the mainstem. Current land-use conditions affecting flows in the basin planning area tributaries have increased mainstem flood peaks by seven percent compared to pre-development, forested conditions. Future development of the basin planning area is expected to increase the contribution of tributaries to mainstem peak flows by another eight percent.

The major hydrologic effect of urbanization in the basin planning area is on the duration of the mainstem flood peak. Although tributary flood peaks are reduced by retention/detention (R/D) ponds, they are also delayed and extended in time. It is estimated that basin planning area urbanization has caused a 12 percent increase in mainstem flood flow duration from forested to current conditions for flows between 3000 and 8500 cfs. Without preventative measures, this is expected to increase an additional 15 percent in the future for a total increase of 27 percent over forested conditions.

HYDROLOGY KEY FINDINGS

Tributaries

- Water yields have substantially increased as a result of deforestation and land development, up to 35 percent in the subbasins of Molasses, Madsen, and Maplewood Creeks. Most of these increases occur during the winter storm season in the form of increased stormwater discharges.

- The City of Kent's diversion on Rock Creek causes a significant depletion of the creek's dry season flows on a yearly basis from River Mile 1.7 to the creek's confluence with the Cedar River.

- Without preventative measures, as urbanization and land development continue, the largest increases in flood peaks will occur in the basin planning area's easterly tributaries because of low-density, residential developments that do not require constructed detention facilities under existing regulation. Potentially large increases in peak flows are expected in Rock Creek, Taylor Creek, and Dorre Don and to a lesser extent in Cedar Hills and Webster Lake subbasins.

Mainstem

- The 2-year and 100-year return period peak flows at Renton are estimated to be 3,800 and 11,100 cfs respectively based on forty-two years of simulations for current basin planning area land use conditions.

- The majority of maximum flow peaks above 4000 cfs in Renton are caused by peak inflows of similar magnitude from the upper basin above Landsburg.

- Urbanization of the basin planning area tributary subbasins has caused minor increases in mainstem flood peaks but has caused larger increases in mainstem flood durations.

- While stormwater retention/detention pond mitigation in the basin planning area subbasins may have positive benefits for tributaries, it has minimal effect on mainstem flood peaks or durations.

2.6 FLOODING DAMAGE

Flooding, a natural cyclical process, occurs every few years on most natural tributary channels and in the river's floodplain. It becomes a problem only when it threatens or damages structures, roads, or other objects in the flow path. Flooding in the Cedar River basin is typically caused by the combined effects of steady rains, rising temperatures, and melting snowpack on the western slopes of the Cascade Range. Once adequate snowpack has accumulated, warm temperatures and rain can produce lowland flooding anytime from late fall through spring. The most intense precipitation occurs from November to February, and highest snowmelt takes place between April to May.

For purposes of this report, flooding becomes a significant problem when the natural event conflicts with the use of inhabited structures, natural resource functions, or transportation routes. Flooding problems in the Cedar River basin are of two forms, regional and local. Regional, large-scale flooding is associated with systemic or basinwide conditions such as high surface-water runoff, blockages from sediment deposition, channel migration, or levee failure. Regional flooding affects numerous structures and roads, causing significant damage. Local, smaller-scale flooding is also caused by high surface-water runoff and inadequate capacities in individual drainage channels, pipes, or structures. Local flooding affects a smaller area, fewer properties, and inflicts less significant damage than does regional flooding.

Generally, regional flooding is found along the Cedar River's floodplain (*Map 7, Appendix B*), with threats to public health and safety, to resource areas, to private property, and to flood control structures. Local flooding is more common in the surrounding plateau areas. In addition to direct property damage from flood waters, repeated instances of saturated ground can cause long-term effects such as foundation settlement, road damage, and environmental changes. Winter floods damage habitat by scouring stream channels, which destroys the spawning gravel and otherwise damages the environment that rearing fish need. Septic systems inundated with floodwater degrade water quality, affecting water supplies and recreational use.

Criteria for Identifying Significant Flooding Problems

Through the *King County Flood Hazard Reduction Plan* and previous SWM basin plans, a system for ranking the significance of the flooding problems has been developed. The criteria in these plans have been tailored to address the entire range of flooding problems in the basin planning area.

The following are the criteria used to prioritize these flooding problems. The flooding problems identified as significant by these criteria are noted with asterisks in *Appendix A*:

Extremely Significant - Imminent threat to human life due to swift-moving and deep water during flooding up to and including the 100-year event.

Very Significant - Frequently[1] repeated flood damage to structures occupied by humans, including single and multifamily housing; institutions such as schools, hospitals, and libraries; commercial or industrial buildings. Frequently repeated damage to, or service interruption on, arterial roads or bridges, or on roads providing sole access to occupied structures. Frequently repeated damage to Regionally Significant Resource Areas (see Section 2.9 - Aquatic Habitat).

Significant - Threat of significant[2] damage ftom less frequent flood events to structures listed under "Very Significant." Frequently repeated damage to Locally Significant Resource Areas. Threat of damage to Regionally Significant Resource Areas during less frequent events. Frequently repeated damage to areas with high recreational value.

Less Significant - Damage to areas that do not have occupied structures. Threat of damage to Locally Significant Areas ftom less frequent events. Threat of damage from less frequent events to areas with recreational value.

Flood Modeling of the Mainstem Cedar River

Data Sources - Information regarding flood damage was gathered from many local, state and federal agencies, and from the general public. Records of flooding complaints made to King County Surface Water Management (SWM) Division's Drainage Investigation and Regulation (DIR) and Facilities Maintenance (FM) Units were used throughout the study. Other contributing agencies were King County Roads Division, City of Renton Stormwater Utility, Washington State Department of Transportation (WSDOT), U.S. Army Corps of Engineers (COE) Seattle District Office, Federal Emergency Management Agency (FEMA), and City of Seattle Water Department (SWD).

The King County SWM Division staff engineers walked the portions of the mainstem protected by levees (artificially elevated portion of the riverbank) and revetments (artificially armored riverbank). Information was compiled at stream crossings, constrictions, and other locations where flooding problems were known or suspected. Photos and data sheets were compiled describing the physical configuration of each location, and this data was used to estimate the

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1 A "frequent" event is defined here as one occurring at up to a 10–year return period.

2 Significant is defined here as representing ten percent of the value of the damaged property.

flow capacity at each point studied.

Flood Model - To analyze regional flooding problems, approximately 19 miles of the Cedar River mainstem floodplain was computer modeled from its mouth at Lake Washington to Arcadia/Noble. The model used in this study computes water-surface elevations and other characteristics of the flow using stream flow data generated by the hydrologic simulation model (see Section 2.5 Hydrology) and cross-section surveys of stream reaches as input conditions for the model. The effects of bridges, culverts, weirs, levees, and dams are also computed by coding the geometry of these structures into the model. The results from the computer model are approximations of floodwater depth and of the extent of the floodplain resulting from various discharges.

Flood discharge peaks are characterized by their "return periods," such as the "25-year flood." These flows are estimated as though they occurred in an uncontrolled system. This terminology can be misleading here, however, because discharges in the mainstem of the Cedar River are strongly dependant on how the Masonry Dam is operated.

Four floods were analyzed. These were idealized for the 10-year, 25-year, and 100-year flood discharges. In addition, the November 24, 1990 flood was modeled to compare the extent of flooding and damage caused by this event to the projected effects caused by the 100-year flood. Because estimated discharge peaks on the Cedar River under future land-use conditions ranged from only a half percent to no more than eight percent greater than peaks estimated under current conditions, modeling was performed using only current condition values because future increases did not yield significant differences in the estimated size of the floodplain.

Because of differing modeling techniques and assumptions regarding land use and river discharges, there are differences between the floodplain modeled by this study and the one shown on the 1989 FEMA Flood Insurance Rate Maps. These maps determine the rates charged by federal flood insurance programs to insure properties identified as being within the 100-year floodplain.

Current Conditions

Cedar River Mainstem - The pattern of flooding problems on the mainstem is affected by historic development on the floodplain. Along the basin planning area Cedar River mainstem, between River Mile (RM) 1.6 to RM 18, there are scattered riverside homes and several areas of medium-density residential development located on narrow areas of the valley floor. Flood flows have inundated areas unprotected by levees, and have damaged or destroyed levees, roads, and residences. Developed areas along the middle mainstem, such as at Dorre Don (RM 16) and Arcadia/Noble (RM 18), experience flooding problems from both high flows and the natural migration of the river.

More than 100 residences are situated within the 10-year floodplain including those at eight

significant locations: Elliott Bridge, Cedar Grove (Rainbow Bend), Cedar Grove Road, Jan Road, Rhode (RM 13.6), the State Route 169 bridge at Maple Valley, Lower Dorre Don, and Orchard Grove. Most of these areas are subject to fast, deep flood flows and are therefore classified as "Extremely Significant Problems." An additional 47 homes are outside of the 10-year floodplain but within the 25-year floodplain; a total of nearly 300 homes are within the 100-year floodplain.

Channel capacity in the artificial Renton Reach (RM 0 to RM 1.6) has been restricted by sediment deposition that has accumulated since regular maintenance dredging was discontinued in the early 1980s. Currently, the botrom depths of the channel in some spots are as much as seven feet shallower than when dredging regularly occurred, although on average the channel is one foot shallower. During high river stages this section of the river will overtop its banks, with flood waters carrying fine sediment onto the developed floodplain. Flooding problems at the Renton Municipal Airport, the Boeing Commercial Aircraft Plant, and in portions of Renton's downtown commercial and civic areas are characterized as "Very Significant"; their economic and social impacts are among the most severe in the entire basin.

The November 24, 1990 flood of the Cedar River mainstem was very large. It was modeled for comparison to the effects of a 100-year flood and was found to be approximately the equivalent of a 100-year flood. Damage in the City of Renton was approximately $5 million and the Municipal Airport was prevented from operating. In the lower mainstem many homes were flooded with up to several feet of water. There was extensive damage to levees and roads. In the middle mainstem there was significant damage to homes from sediment and debris, and erosion of banks and roadways.

Tributaries - Tributary flooding problems in the basin planning area vary greatly depending on the amount of development and on natural characteristics such as slope, vegetation, and geology. In addition to causing property damage, floodwater from urban stormwater degrades the ecosystem by introducing sediment, nutrients, and other pollutants. Tributary flooding problems are generally caused by: 1) damaged, unmaintained, or undersized roadside ditches or culverts; 2) reduced channel capacity caused by vegetation or sediment deposition; 3) increased discharges caused by upstream development; 4) structures being built in locations such as wetlands and closed depressions, where surface drainage is naturally poor.

Development in the basin planning area has increased stormwater runoff to the point where many culverts are now too small for current flows and their associated loads of sediment or debris. The following examples meet the criteria for "Very Significant" flooding problems. In the urbanized Maplewood subbasin a culvert carrying East Fork Maplewood Creek under SE 132nd Street at 146th Avenue SE is inadequate for flows in excess of the current two-year storm. Its backed-up water regularly floods the intersection. In the Maplewood subbasin, Puget Colony Homes subdivision has experienced several instances of flooded roads and residences, and complaints that septic systems have become saturated, allowing contaminants to enter the surface water in the last ten years. These problems may have been exacerbated by filled wetlands in the neighborhood. Wetlands are unsuitable for homesites because they collect and naturally

store stormwater runoff and are therefore prone to flooding. For these and other habitat functions, wetlands are now protected under the King County Sensitive Area Ordinance (SAO). Loss of this storage from past development has contributed to higher runoff peaks, and to downstream flooding in some tributaries. The lower reach of Taylor Creek along Maxwell Road SE overtops its banks almost yearly. The resultant flooding prevents access to over a dozen homes. East and West Lake Desire Drive Southeast frequently flood preventing access to over twenty homes.

Future Conditions

Mainstem - Flood problems are not expected to increase significantly for the 25-year or 100-year flood in either the Renton Reach or along the lower or middle mainstem. Future discharges in these reaches will be similar to current conditions.

Tributaries - Future development of the Cedar River basin will result in increased and more frequent peak discharges on tributary streams. Generally, without implemented solutions, areas presently affected by floods will experience an increase in flooding, particularly in the Maplewood, Molasses, and Taylor Creek subbasins. In the Taylor Creek subbasin, flooding along Maxwell Road SE is considered "Very Significant" because it limits access to numerous homes, and it is expected to become more widespread as flood discharges increase by an anticipated 25 percent. Many areas that are presently flood-free will be affected in the future. Without implemented solutions, flooding problems are likely to develop in the Rock Creek and Dorre Don subbasins as anticipated future flood discharges increase by approximately 50 percent above their current levels. These changes will result in greater amounts of property damage, more frequent maintenance, and an increased exposure to public safety hazards.

Without action, increased flows will: 1) destabilize some stream channels that are presently stable, such as the west-fork of Taylor Creek; 2) exceed the culvert capacities at many sites; 3) increase sediment-related flood problems, particularly along Maxwell Road SE in the Taylor Creek subbasin; and 4) increase frequency and extent of flooding damage. These problems will result directly from the cumulative effects of increased development.

FLOODING DAMAGE KEY FINDINGS

- More than 100 residences are situated within the 10-year floodplain at eight locations. Most of the areas are subject to fast, deep flood flows and are therefore classified as "Extremely Significant Problems." In all, over 130 homes are within the 10-year floodplain.

- Forty-seven homes are outside of the 10-year floodplain but within the 25-year floodplain; a total of nearly 300 homes are within the 100-year floodplain.

- No significant change in mainstem flooding is anticipated in the future because future

flows are anticipated to be only slightly greater than current flows.

- Nearly all tributary flooding problems within the basin planning area are located in the flat, poorly drained headwater areas of the tributaries. With a few exceptions, most of these problems present little or no threat of immediate significant damage.

- Puget Colony Homes, on the east fork of Maplewood Creek, is subject to frequent flooding.

- In the Taylor Creek subbasin flooding along Maxwell Road SE is considered "Very Significant" because it limits access to numerous homes, and is expected to become more widespread as flood discharges increase by an anticipated 25 percent.

- Generally, without implemented solutions, areas presently affected by floods will experience increased flooding, particularly in the Maplewood, Molasses, and Taylor Creek subbasins.

- Without implemented solutions, flooding problems are likely to develop in the Rock Creek and Dorre Don subbasins as anticipated future flood discharges increase by approximately 50 percent above current amounts.

2.7 EROSION AND DEPOSITION

Erosion and sediment deposition are natural processes that shape the recently deglaciated landscape of the Cedar River basin. Low-gradient streams drain the plateaus, slowly cutting channels through the resistant, overlying glacial till. Where these streams descend the steep valley walls their velocity, and therefore their sediment transport capacity, increases. This results in erosion of the underlying, erodible glacial sediments, forming steep, V-shaped channels. Upon reaching the flat, valley floodplain of the Cedar River, the stream velocity decreases and the streams deposit most of their sediment load in alluvial fans at their mouths before entering the river.

In the basin planning area, most small tributary channels on the valley walls have extremely steep slopes, with gradients of 15 to 35 percent. The larger tributaries, such as Madsen, Maplewood, and Taylor Creeks, have lower gradients of three to ten percent, from a more active history of cutting long, deep ravines in the plateau.

Prior to land development, tributary channels were generally stable, with relatively low rates of erosion. In a stable system, small frequent floods transport most of the stream's sediment load over a period of time and larger, less frequent floods shape the channel's form. Flow increases caused by development have increased the number of large floods and these have accelerated rates of erosion in the tributaries, with adverse effects on flooding, habitat, and water quality.

In contrast, the Cedar River mainstem has downcut through the plateau over geologic time, eventually forming a broad, steep-walled valley. For thousands of years the river has meandered back and forth across its floodplain, eroding one bank and depositing the sediment on an opposite bank downstream. This process has formed the broad valley floor of the Cedar. In addition to sediment from the tributaries, the river carries sediment downstream from the basin's mountainous headwaters and from bank erosion and landslides on the mainstem.

Before 1912, the Cedar River flowed into the Black River, which drained from Lake Washington into the Green River. Since the Black River flowed out of Lake Washington with virtually no sediment load, it was probably able to transport much of the Cedar River's sediment load downstream to the Green River. After the diversion channel was built in 1912, the Cedar River deposited its sediment load in the lower two miles of the river and in Lake Washington.

The intrinsic stability of tributary channels and valley walls along the Cedar River mainstem is largely a function of slope and geology, although large woody debris and bank vegetation enhance stability and reduce erosion. In the valley walls, a variety of deposits are encountered. Glacial till and bedrock are stable and highly resistant to erosion. Glacial outwash (sand and gravel) tends to be uncohesive and easily eroded. Glaciolacustrine deposits (silt and clay glacial lake deposits) are cohesive and moderately resistant to erosion. Landslides naturally occur in the basin on slopes where impermeable clay layers block downward groundwater flow and so allow the water to pond up in the overlying deposits, favoring slope instability.

Current and Future Conditions

Tributaries - In the Cedar River basin planning area, clearing and development have significantly increased the frequency of tributary flows capable of moving sediment, such as cobbles, boulders, and large organic debris that armor the bed and form structural elements of the channel. More frequent, larger floods have increased the width and depth of the tributary channels.

In general, Molasses and Madsen Creeks and most of the other lower mainstem tributaries have experienced significant increases in flood flows (up to 250%). This is caused by development in their subbasins, accompanied by an overall increase in channel erosion. Most of the channels in the lower subbasins have downcut, with associated bank erosion causing local bank failure and landslides (Figure 2-2). In contrast, the middle mainstem tributaries have had less development, lower flow increases, and so less erosion.

Figure 2-2
Photograph of Incised Reach of Maplewood Creek

The steepest valley-side tributaries have relatively low flows but show rapid channel incision due to their steep slopes. In contrast, lower-gradient tributary channels, such as parts of Madsen Creek, have higher runoff and have formed wide, deep channels in the easily erodible sand and gravel deposits. Transport of the increased sediment load has resulted in areas of pronounced deposition farther downstream, particularly in low-gradient stream reaches on the Cedar River valley floor. Large amounts of sediment deposited by these streams have damaged structures, blocked culverts, and caused flooding, such as that seen along lower Taylor Creek.

Some stream channels, such as Rock Creek, are currently relatively stable due to small stormflow increase, and the presence of abundant large woody debris and bank vegetation. These features minimize erosion by reducing stream flow velocity and protecting the banks. Large logs within the channel trap sediment; this alters the gradient into a stable, stepped-channel profile.

Without preventative measures, future development of the basin will increase the frequency and magnitude of flows and channel erosion in the tributaries. In this region, field observations show that accelerated erosion and channel instability occur when the current 2-year flood discharge equals or exceeds the 10-year flood discharge under original, fully forested conditions. Based on this criterion, erosion problems in some currently unstable tributaries will increase under anticipated flow increases, unless preventative measures are in place, and erosion will most likely destabilize streams that are currently stable in the following subbasins: Cedar Hills, Dorre Don, Rock Creek, North Fork Taylor Creek, and Webster Lake. Future flow increases could also cause new erosion problems in small, steep streams that drain the sides of the Cedar River valley.

Cedar River Mainstem -

Effects of Human Activity Human activities in the basin have affected the erosion and sediment transport regime of the Cedar River in several ways. First, in 1902 the City of Seattle constructed a dam creating Chester Morse Lake, which has significantly reduced the size and frequency of sediment-transporting flood flows. Chester Morse Lake has probably not affected the supply of sediment to the river, since sediment from the upper basin was already trapped by the natural Cedar Lake that was replaced with the dam and artificial lake. Second, the 1912 diversion of the Cedar River from the Black River to Lake Washington removed the flow from the Black River and reduced its capacity to carry sediment. The artificial channel is now wider than upstream reaches, which reduces flow depth and hence promotes sediment deposition. Currently, the river's entire sediment load is deposited in Lake Washington and on the gently-sloping river bed near Renton, where it fills the channel and contributes to flooding. Third, revetments constructed along the riverbanks have reduced sediment input from eroding banks, channel migration, and the river's ability to store sediment in its floodplain. Finally, development and associated increased stormflows have increased the amount of sediment delivered to the river by some tributary streams.

Change in Sediment Input Sediment input to the reach of the mainstem within the basin

planning area (River Mile (RM) 0.0 to RM 21.7) can be divided into three categories based on its origin: 1) sediment from the upper basin, 2) sediment from tributary streams in the basin planning area, and 3) sediment eroded from the river banks and landslides in the basin planning area. In the upper basin, the Masonry Dam traps coarse sediment in Chester Morse Lake. In contrast, coarse sediment moves through the small diversion dam at Landsburg when the gates are opened for floods or forebay cleaning. Trapped sediment at the Landsburg diversion is probably less than five percent of the river's sediment load, estimated at 22,000 tons of suspended sediment (fine sediment carried along by the water flow) and 2200 tons of bedload sediment (coarse sediment that rolls or hops along the riverbed) per year between the Masonry Dam and Landsburg.

The 66-square-mile Cedar River basin below Landsburg would be expected to produce about 30,000 tons of suspended sediment and 3,000 tons of bedload-sized sediment per year, based on equivalent measured regions elsewhere in western Washington. Rock, Ginger, Peterson, and Molasses Creeks, and the Walsh Lake Diversion Channel, deliver a large part of their coarse sediment load to the river. Most of the remaining tributary streams within the basin planning area drop their coarse sediment load on the flat valley floor and deliver primarily sand and finer sediment to the Cedar River.

A river in equilibrium balances erosion of sediment from the river banks with deposition of sediment in gravel bars, which eventually become part of the floodplain. The natural exchange of sediment between the Cedar River and its banks has been substantially reduced by armoring the banks with revetments. Sixty-four percent of the length of the river has a revetment along at least one bank. Almost all river bends are armored by a revetment or abut bluffs of erosion-resistant glacial deposits. Sediment input from the river banks has been greatly reduced in the last 50 years, and as an apparent consequence, less sediment is now stored in gravel bars.

Changes in Channel Pattern The Cedar River has undergone major changes in its channel pattern and its ability to migrate across its floodplain since the turn of the century. These changes are from the combined effects of: 1) reduced flood flows due to the dams, 2) revetment construction, and 3) construction of the artificial channel in the Renton Reach.

An analysis of historic maps and aerial photographs indicates that the Cedar River has narrowed dramatically since 1865. The total area of the active river channel, including side channels, decreased by 350 acres (56%), from 620 acres in 1865 to 270 acres in 1989. The average channel width decreased by about 30 percent, from 250 to 170 feet, between 1865 and 1936. This change in width corresponds mostly to a change from a historic braided river pattern, with multiple channels, to a sinuous, generally single-thread pattern. These effects appear to have resulted from reduced flood flows by the upstream water supply dams, which reduced the width of single-thread channel segments by an average 36 percent.

Since 1936, the river channel has narrowed an additional 35 percent to its present average width of 110 feet, corresponding to a further loss of sediment storage sites and habitat area. River channels constantly adjust their dimensions to most efficiently transport water and sediment

load downstream. River channels also tend to become narrower during periods between major floods, but this is normally balanced by widening when banks erode during floods. In the Cedar River, this apparent permanent decrease in width is most likely explained by the construction of revetments, especially in the 1960s and early 1970s (Figure 2-3). Between 1936 and 1975 there were no major floods, which allowed vegetation to establish on former gravel bars, creating an edge resistant to erosion. The combination of revetments and tree growth have locked the river into position and now prevent widespread channel enlargement during floods.

Channel Migration The Cedar River migrates across its floodplain by moving laterally, depositing bedload sediment in a bar on one bank and eroding the opposite bank (typically the outside of a bend). A more dramatic type of migration occurs when the river abruptly switches to a new channel (avulsion). However, revetments have substantially reduced channel migration on the Cedar River since the 1960s (*Map 10, Appendix B*).

The meander belt is the area of the floodplain with obvious traces of past or present river channels. Channel changes that occurred before most revetments were built indicate that major zones of channel migration existed in the lower mainstem from the Elliott Bridge to the Taylor Creek confluence, and in the middle mainstem from Maple Valley to Dorre Don. Many homes are now located in these areas that were occupied by the river. In the artificial channel (Renton Reach, RM 0.0-1.6) migration is prevented from occurring.

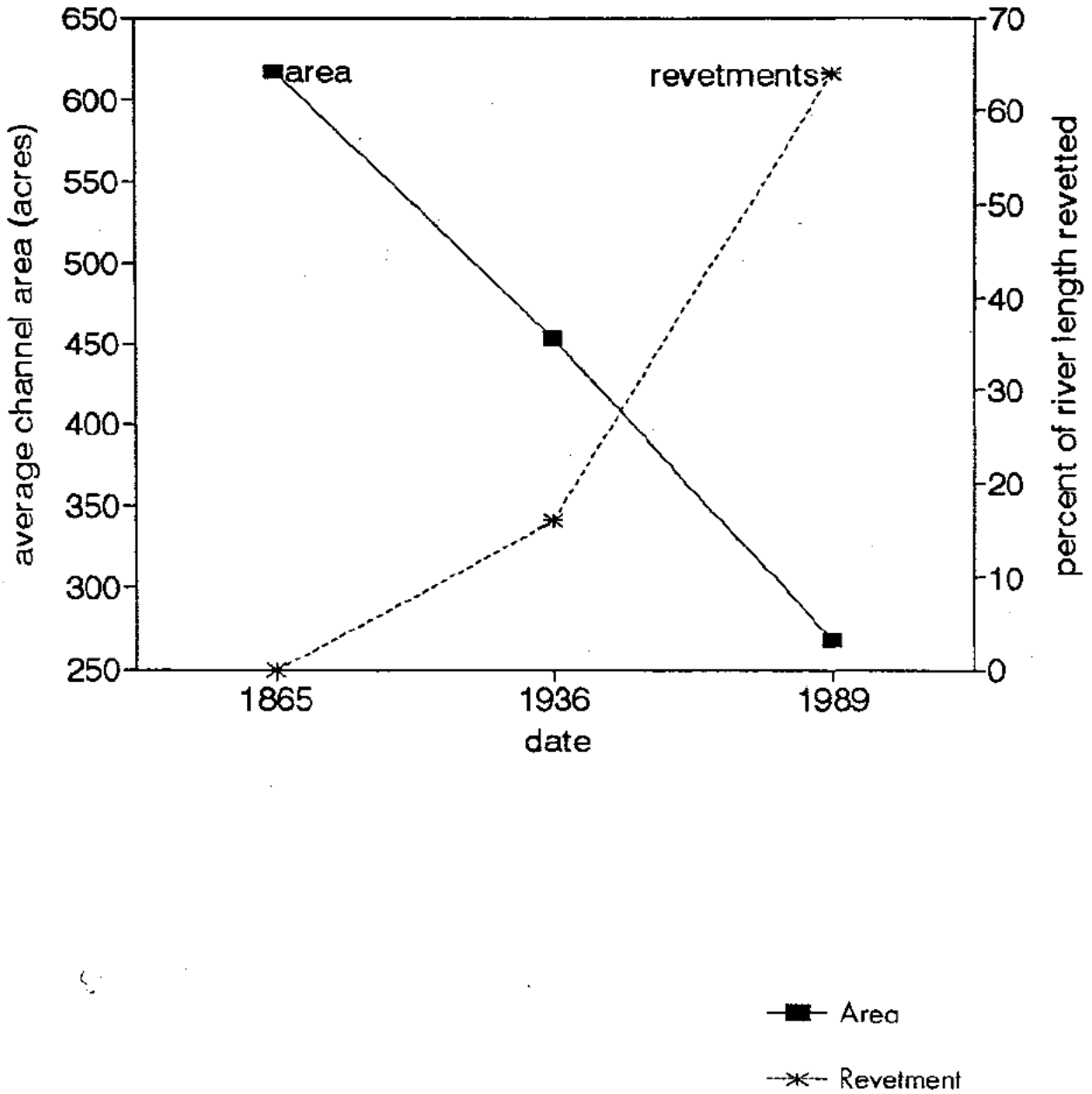
Revetments on the lower reaches of the river are extensive and future channel migration is likely to be minimal except in a few locations. Landslides from cliffs undercut by the meandering river have been significant in the past; for example in 1987, the landslide near River Mile (RM) 3.9 delivered approximately 30,000 cubic yards of mostly sandy sediment to the river (Strieby and Booth, 1992). Similar landslides could occur in the future from a few other riverside cliffs. Where revetments line both sides of the river, such as between Jones Road and RM 10, they cause higher stream velocities that can damage the revetments downstream.

Several revetments (RM 8.2-9.0) damaged by the 1990 flood are proposed for abandonment because they significantly contribute to flooding downstream. Eventual failure of these revetments would allow the river to meander and reoccupy old channels in the undeveloped areas of the floodplain. This would also allow sediment deposition to occur in these areas, reducing sediment deposition in the lower reaches of the Cedar River. In addition, habitat areas in the floodplain that are currently disconnected from the river by revetments would be reestablished (see Section 2.9 Aquatic Habitat).

A major channel switch (avulsion) took place in 1990 when the river switched course to a side channel next to the east valley wall between RM 10-10.5 and abandoned its old channel except during floods. The new channel alignment has directed flows against the left bank downstream, which could potentially trigger rapid bank erosion and major changes in the river course as far downstream as Upper Jones Road bridge. Between Maple Valley and Dorre Don there are fewer revetments containing the channel and the potential exists for the river to switch course into one of the numerous old channels that exist on the developed left-bank floodplain. Many

Figure 2-3. Mainstem Changes in Channel Area and Revetment Extent

This figure shows the decrease in surface area of the Cedar River (number of acres given in left hand column) between 1865 and 1989. During that same period, the dashed line shows what percentage (right hand column of numbers) of the river banks were revetted.



homes are now located in the natural floodplain areas formerly occupied by the river. A series of revetments requiring frequent maintenance has resulted to prevent the river from resuming movement across the floodplain, especially in zones of historic natural channel migration.

Sediment Transport in the Cedar River Mainstem Sediment carried by the Cedar River ranges in size from clay particles to boulders. The smaller particles (clay, silt, and fine to medium sand) are generally suspended in the water during transport. The amount of suspended sediment transported depends on the amount entering the river and generally increases with increased surface-water runoff. Most of the suspended sediment load moves all the way downstream to Lake Washington, forming a delta at the river's mouth.

The coarser part of the Cedar's sediment load (coarse sand, gravel, cobbles, and in a few locations, boulders) moves downstream as bedload, so called because the sediment grains roll, slide or bounce along the river bed. Bedload movement is slow, and it generally occurs only a few times a year when flows are large enough to mobilize the gravel pavement of the streambed. In gravel-bed rivers such as the Cedar, bedload sediment typically comprises ten percent or less of the sediment load. Bedload is very important because it forms the gravel bars and river banks that control the shape of the channel. It is the deposition of bedload, not suspended sediment, that causes the river channel to fill in or to shift laterally.

In the Cedar River, bedload transport is greatest in the middle mainstem and the lower mainstem above river mile 7. Both sediment size and the rate of transport decrease substantially between river mile 7 and river mile 2, such that downstream of river mile 2 (Renton Reach) only sand and fine gravel are carried by the slower flows. On average, over 10,000 cubic yards is transported into the Renton Reach each year; and subsequent deposition of this fine bedload sediment is a chronic problem (see Map 17, Renton Reach, for area of deposition). Approximately one-half is deposited in the canal, while the rest is deposited in the delta.

This average annual amount, however, could be exceeded if the supply of sediment from upstream were increased by recent or concurrent landsliding and a large flood. A 50-year flood, for example, would be capable of transporting the average annual sediment load in only a few days. If landslide-derived sediment were present, the amount of deposited material in the Renton Reach could be several thousand cubic yards in a single event; and this would be only a fraction of the volume of sediment transported through the reach and then deposited in the delta.

Control of most of the river's sediment sources is probably not feasible. However, the linked problems of lost channel capacity and increased flooding in the Renton Reach do not result from "excessive" sediment input into the river. Indeed, the current rates of sediment supply and transport by the Cedar River are not high by comparison to other western Washington rivers of comparable size. High levels of flood damage instead result from intensive development of the floodplain in Renton where sediment deposition once occurred naturally along the river. Most of these areas now preclude deposition because they have been occupied by flood-sensitive industrial, commercial, and residential land uses.

EROSION AND DEPOSITION KEY FINDINGS

Tributaries

- Increased stormflows from development have caused tributary channel erosion, landslides, and subsequent deposition of sediment in low gradient stream reaches on the Cedar River valley floor. Large quantities of sediment have damaged structures, blocked culverts, and caused flooding.

- The most severe erosion problems occur on tributaries that enter the Cedar River downstream from Maple Valley, particularly Madsen, Maplewood, Orting Hill, and Summerfield Creeks, and other smaller creeks that flow through high-density residential land use areas in the lower end of the basin.

- Upstream of Maple Valley erosion problems are minor due to less development, moderation of streamflow by permeable outwash soils, and generally gentler slopes.

- Without preventative measures, severe future channel erosion problems are likely to occur in five subbasins whose channels are currently stable: Cedar Hills, Dorre Don, Rock Creek, North Fork Taylor Creek, and Webster Lake.

Mainstem

- Chester Morse Dam has greatly reduced the flood flows that carry the river's sediment load. Reduced flood flows appear to be the cause of a 32-percent (80-ft) average decrease in channel width between 1865 and 1936.

- River banks have been extensively armored with revetments, which have greatly reduced bank erosion and natural channel migration areas. Revetments most likely explain post-1936 narrowing of the river channel by an additional 35 percent, to its present average width of 110 feet.

- The total area of active river channel has decreased 350 acres (56%), from 620 acres in 1865 to 270 acres in 1989. The decrease in area and complexity of the river channel has resulted in a loss of sediment storage sites and river habitat.

- A major channel switch (avulsion) at River Mile 10.1-10.5 could potentially trigger rapid bank erosion and major changes in course as far downstream as the Upper Jones Road bridge. The potential also exists for the river to switch channels between Maple Valley and Dorre Don.

- Major historic zones of channel migration are from Elliott Bridge to the Taylor Creek confluence and from Maple Valley to Dorre Don. Many homes are now located in floodplain areas formerly occupied by the river. A series of revetments requiring frequent maintenance has resulted to prevent the river from resuming movement across the floodplain.

- The movement of coarse sediment into the Renton Reach averages over 10,000 tons per year. Only one-half or less of the sediment is deposited in the Renton Reach channel; the balance adds to the delta growing into Lake Washington. New sediment sources (particularly from large landslides) could significantly increase existing rates of channel infilling; but the current rates of sediment supply and could transport by the Cedar River are not high by comparison other western Washington rivers of comparable size.

2.8 WATER QUALITY

Historically, the Cedar River basin planning area's water has been of very high quality, particularly in the mainstem due to clean water entering from the upper basin. More recently, stormwater flows and pollutants from development have increased transport and concentration of pollutants to the basin planning area's streams and lakes. Because of the relative importance of the resources and the necessity to prevent further water quality degradation, the lower Cedar River watershed was ranked number one for nonpoint pollution planning in King County by the Watershed Ranking Committee (established by the Nonpoint Rule, Chapter 400-12, Washington Administrative Code).

The Federal Clean Water Act and the Washington State Water Quality Standards protect the water quality and beneficial uses of water. Beneficial uses in the Cedar River basin include water supply (domestic, industrial, agricultural), stock watering, fish rearing, wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), commerce, and navigation. The Cedar River basin is particularly valued for the high quality of its aquatic habitat and fish resources (see Section 2.9 Aquatic Habitat).

Water Quality Definitions and Concepts

Pollutants - In general, a pollutant can be defined as any substance that degrades the quality of water and impairs a beneficial use. Sources of pollution can be natural or a result of human influences; these sources can impact either surface waters or groundwater. Examples of natural pollutants are sediments and nutrients, which are increased by human activities. Pollutants from human activity sources include chemicals, pesticides, and metals (e.g., lead, cadmium, copper, zinc) and are toxic to both human and animal life.

Sediments naturally occur in virtually all surface waters, but an excess of suspended or deposited fine sediments can be detrimental to aquatic life. Nutrients, such as phosphorus or nitrogen, are necessary for plant growth. An excess of nutrients can cause excessive aquatic plant, or algae growth (often referred to as blooms) that reduce available oxygen needed for aquatic life and impair swimming and boating. Nitrates, another nutrient, are a human health concern in drinking water and can become a problem when infiltrated into groundwater. Excess nutrient sources include failing onsite sewage disposal systems, animal wastes, sediments, and fertilizers.

Fecal coliform bacteria is found in the intestines of warm-blooded animals and is an indicator of the presence of other pathogens, and thus a potential human health concern. Fecal coliform pollution originates from failing onsite sewage disposal systems (human wastes) or animal (domestic and wildlife) waste runoff. These sources are difficult to distinguish, except through costly testing of water quality samples. Hence, the sources are usually determined by land use activities. For example, in rural areas of the Cedar River basin, animal waste is usually from animal keeping (cows/horses), but in high-density residential areas, such as Fairwood and Maplewood, failing onsite septic systems and domestic animal (dogs/cats) wastes are the most significant nonpoint sources of bacteria and nutrients.

Pollutants affect human and aquatic health based on their concentrations and duration of occurrence. Acute toxicity occurs when there are high pollutant concentrations, usually for a short period of time. Chronic toxicity occurs with continual exposure to lower pollutant concentrations.

Point Source Pollution - Point source pollution originates from a specific source, such as an outflow from an industrial waste pipe; is readily identifiable; and can be traced to a particular source, such as individual residence, business, or activity. Point source pollution can therefore be treated or controlled directly at the source.

In the basin planning area, point sources are permitted and regulated by the Department of Ecology (DOE). The DOE has issued three permits for point source discharge in the Cedar River basin. These permits contain regulations and monitoring requirements to comply with the permit.

Nonpoint Source Pollution - Nonpoint source pollution is defined as pollution not originating from a specific point, such as an industrial discharge pipe. Instead, nonpoint pollution originates from diverse and often difficult to identify sources. Most often, nonpoint pollution originates from routine daily activities, such as driving automobiles, that most people are not aware could cause a water quality problem. It is the cumulative effects of these activities that can potentially pose water quality problems.

Currently in the basin planning area, nonpoint source pollution is the main contributor to the degradation of water quality. Elevated concentrations of typical urban pollutants can be found in the tributaries, lakes or wetlands where they can harm fish, wildlife, groundwater supplies and the natural beauty of the surface-water systems. Often these pollutant concentrations are diluted when they enter the high volumes of water in the Cedar River mainstem. However, this dilution does not lessen the effects in the tributaries or in the receiving water bodies. The Cedar River contributes over 50 percent of Lake Washington's water; therefore, the quality of the Cedar River will have a direct effect on the quality of Lake Washington.

Water Quality Standards and Beneficial Uses

The State of Washington has established water quality standards to protect the beneficial uses of surface water for public health and enjoyment, and the protection and propagation of fish, shellfish, and wildlife. Surface waters are defined by classes and water quality standards are established to protect and maintain the beneficial uses for each class. Currently, the Cedar River and its tributaries are classified as Class A (excellent) from Lake Washington to the Maplewood Bridge (State Route-169 overpass, River Mile 4.1), and Class AA from Maplewood bridge to the Landsburg Dam (RM 21.7). Waters under AA classification are characterized as markedly and uniformly exceeding the requirements for all or substantially all beneficial uses. In addition, the State of Washington has established standards for groundwater quality.

Water supply is a major beneficial use in the basin. Municipal water service areas are concentrated in the more urban/residential areas of the basin, primarily within and adjacent to the Renton city limits. Private residential wells provide the remaining water supply for basin residents. The Renton aquifer is the City of Renton's only source of water; the EPA has designated it a "sole source aquifer" and have mandated additional protection measures against contamination of this resource. The City of Seattle's water facilities supply both the Soos Creek and the Cedar River Water and Sewer Districts, as well as two-third's of the Seattle metropolitan area. In the Rock Creek subbasin, the City of Kent maintains a wellfield for the production of 70 percent of the city's drinking water.

Nonpoint Pollution Sources and Water Quality Assessment

Due to the difficulty in identifying and isolating nonpoint pollution, a combination of **source identification** and **water quality assessment** (chemical analysis) has been used to determine existing and potential water quality problems. By using these methods, a comparison can be made between the identified sources and the extent of water quality degradation throughout the basin.

Nonpoint Pollution Sources - Potential nonpoint sources were identified based on the combination of land uses and human activities in the basin. Activities thought to contribute to nonpoint pollution were determined by indirect means depending on the potential source. Methods used included reviews of existing preventive programs and their effectiveness, file searches of reported problems, operational assessments of businesses and activities, and field observations.

A wide variety of activities contribute to nonpoint pollution and have been identified as sources within the basin planning area. Major nonpoint sources include forest conversion and development, urbanization, roads, onsite sewage disposal, livestock keeping activities, resource extraction and hazardous waste sites. Other potential nonpoint pollution sources are pesticide applications, underground storage tanks, small quantity hazardous waste generators, waste management, and pipelines.

Forest Conversion Forest clearing and construction activities for conversion to urban uses, are major contributors to nonpoint sediment pollution. Forest conversion significantly increases water runoff and erosion and can produce more sediment per acre than tree removal associated with clearcut or partial removal harvest. Areas that have recently experienced the most forest conversion to residential development tend to be located along the urban fringe, south and southeast of the Cedar River, within the Madsen and Peterson Creek subbasins. Areas where this trend is expected to continue are shown on the future land use map (*Map 4, Appendix B*).

Urbanization Urbanization has converted land cover from primarily forest and open space to large areas of impervious surface for residential, commercial, and industrial land use. As a result, surface-water runoff has increased in quantity, transporting an increased quantity of typical urban pollutants such as sediment, nutrients, pathogens (disease causing organisms), heavy metals, and petroleum products into the waterways. Pollutant types become more complex and variable with increasing urbanization.

In the basin planning area, stormwater from urban residential areas contains elevated levels of sediment, nutrients, fecal coliform bacteria, and metal toxicity. "Heavily polluted" (Department of Ecology guidelines) sediment due to metal concentrations were detected in the commercial core of Renton. The City of Renton is conducting a study to identify commercial activities that could be the source of these pollutants to the Cedar River.

Roads Untreated road runoff is discharged directly to streams along roadways built before current surface-water design standards. Petroleum products, heavy metals, such as copper and zinc from automotive tires and brakes, and atmospheric emissions (soot) are the common pollutants contained in this runoff. Generally, runoff from most roads in the basin contains concentrations that exceed the toxicity criteria. The acute copper toxicity standard was exceeded in approximately half of 86 stormwater samples, including instream or direct runoff samples during storm events, taken throughout the basin. Toxic concentrations occur at times in the small tributaries and could impact the localized fauna and flora.

Onsite Sewage Disposal Systems A typical onsite sewage disposal system has an average life expectancy of 20-40 years. System failures are usually due to poor soil conditions, inadequate design, inadequate construction, lack of maintenance, or incorrect use of the system. When systems fail they release effluent (discharge of waste) into groundwater, or to the ground surface where it is transported to surface water. Failing septic systems can pollute surface and groundwater with high concentrations of fecal coliform bacteria, excess nutrients, and often, household hazardous wastes or chemicals.

The Cedar River basin is currently served by three sewer districts in the urbanized areas and the remainder of the basin uses onsite sewage disposal systems. Of the 3,390 onsite sewage disposal systems evaluated in the basin planning area, repair rates were found to range from one to 22 percent, with an average estimated rate of 8.8 (SKCHD, 1991). This is much higher than the three to five percent repair rate for the entire Puget Lowland. Several neighborhoods in the basin have repair rates that far exceed the regional average. For example in the Peterson Creek

subbasin, areas surrounding Lake Desire, and Spring and Shady Lakes have reported repair rates of 15.8, 11.5, and 22.6 percent, respectively. In Maplewood Heights the average repair rate is 8.7 percent, while homes with onsite septic systems along the lower Cedar River mainstem have repair rates of 15.2 percent.

Animal-Keeping Practices Manure from animal-keeping on small noncommercial farms can become a source of water pollution. Best Management Practices (BMPs) should be used for pastures and livestock containment to minimize the pollution concerns. Livestock access to streams, lakes, or wetlands causes direct pollution from animal wastes and sediment from banks eroded by animal hooves. In addition, livestock often damages or destroys riparian vegetation that is critical in filtering polluted runoff from the adjoining pasture land.

The livestock survey of 487 farm sites in the basin planning area (*Map 14, Appendix B*) showed that farm Best Management Practices were implemented on very few sites (PSRBT, 1992). The absence of Best Management Practices along with high animal densities, proximity to water, slope, soils, and pasture condition dramatically increases the potential for chronic nonpoint pollution. These farms were rated for their pollution potential based on whether there were Best Management Practices to prevent pollution or conditions that contributed to pollution. Over 75 percent of the farms evaluated have at least some potential for contaminating surface waters. In a comparison with nine other King County watersheds, the pastures in the basin planning area were found to be in the poorest condition with the least number of Best Management Practices being used. Forty-eight percent of the identified sites were five acres or less. In general, the farms of this size had animal densities of one to three animals per acre.

Taylor Creek had the highest concentration of noncommercial farms and a low number of septic system repairs. This indicates that the fecal coliform was contributed from poor livestock keeping practices.

Recycling Facilities The basin planning area has two recycling facilities, a composting facility and a metal recycling business. The composting facility, which composts yard wastes and produces soil, is a source of pollution when nutrients and tannic acids that leach from composting piles are exposed to storm water. Metal recycling can contaminate water that contacts metals that contain oils, grease, or other pollutants. The metal recycling facility on State Route 169 is not covered from rain or contained on a drained floor, so runoff enters directly into an adjacent tributary. Best Management Practices are not being used, but these two facilities will be required to obtain a National Pollution Discharge Elimination System (NPDES) permits in the near future.

Resource Extraction Fine sediment is the most common pollutant associated with gravel mining. The basin planning area contains three gravel mining sites, but only one is active. Mining operations have significantly altered both the surface and the subsurface hydrology of the mining site. Unnamed Tributary 0316A runs through the site and carries high concentrations of sediment into Wetland 32.

Hazardous Wastes Sites In the basin planning area, Queen City Farms, near Cedar Grove Road, is a U.S. Environmental Protection Agency Superfund site on the National Priority List; PACCAR, at the mouth of the Cedar River, and the Landsburg mine are two Washington State Department of Ecology hazardous waste sites. At the Queen City Farms site, industrial wastes, including paint, petroleum products, organic solvents, and oils, were disposed of in three unlined ponds between 1955 and 1960. At the PACCAR site from 1908 to 1988, soils were contaminated with heavy metals, petroleum products, and other hazardous substances. Partial remediation has been completed; cleanup and monitoring continues on the remainder of this site. Hazardous substances were disposed of at the abandoned Landsburg coal mine between 1969 to 1971. The northern tip of the disposal area lies within 500 feet of the Cedar River and the cleanup process is still in the beginning phase.

Underground Storage Tanks (USTs) Underground storage tanks are used for the storage of petroleum and other regulated substances. The Environmental Protection Agency (EPA) has estimated that up to 25 percent of all underground storage tanks may be leaking nationwide. In the basin planning area, the Department of Ecology has identified and registered 160 commercial tanks (*Map 15, Appendix B*), concentrated in the commercial areas, most of which have been retrofitted with leak detection systems. This does not include home heating oil storage tanks in the basin that are not covered by DOE regulations.

Other Sources For many of the other potential nonpoint pollution sources there is insufficient data to determine the extent of the problem or they were found to not pose a significant water quality threat at this time. This group includes pesticides (except perhaps for herbicide applications at golf courses), small quantity hazardous waste generators, landfill operations, powerlines, and pipelines. For example, small quantity hazardous waste generators (SQHWG, *Map 15, Appendix B*) and household hazardous wastes are not regulated. The actual number within the basin is not known, but it was estimated that 211 commercial users have the potential to generate hazardous wastes.

Activities by individuals or households are often sources of water quality pollution, usually because of lack of awareness of the problems. Potential sources are excess application of pesticides or improper disposal of household hazardous wastes, such as household cleaning products, pesticides, fertilizers, paints, and automotive fluids. In addition, the number of home heating tanks (underground storage tanks) in the basin planning area are unknown and pose a growing threat to groundwater. Illegal dumping and unpermitted private landfills can leach pollutants into the ground and surface waters depending on the composition of the waste. Instances of illegal dumping can be observed throughout the basin planning area, in and along the river, in residential neighborhoods and in remote areas.

Water Quality Assessments - Water quality assessments were made by examining the chemical composition of the water and sediment samples collected from monitoring points throughout the basin. Existing conditions were assessed using historical data, ambient water (non-storm baseflow) and storm water quality sampling data, and field surveys. Data used in this assessment was collected from Metro, Department of Ecology, King County Solid Waste Division, and

Surface Water Management's stormwater monitoring programs, sediment sampling and additional sampling of identified problems in the basin.

Ambient Stream and Lake Monitoring Ambient water samples are usually taken during baseflow, or non-storm event, conditions and give an indication of the typical continuous quality of the water. Metro's primary sampling location on the Cedar River is Site A438, located at approximately River Mile 9.3 near Upper Jones Road Bridge. Site A438 meets all water quality standards for the conventional parameters such as temperature, dissolved oxygen, turbidity, and pH. Fecal coliform bacteria levels occasionally occur within the range of 200 to 300 organisms per milliliter, which exceeds the human health standard of 50 organisms per milliliter for Class AA waters.

Metal toxicity standards for lead, cadmium, copper, and zinc were calculated. Since the Cedar River's water is soft, the calculated metal toxicity standard is very low. In addition, the toxicity standard is very resrrictive. Some of the metal concentration data was recorded at an analytical detection level that is slightly higher than the calculated metal toxicity standards. Exceedences in copper and lead were indicated as potential problems, causing toxicity to aquatic life; however, it is difficult to characterize the ambient metal concentrations in the basin, because the metal detection levels are not low enough.

Lakes are often described by trophic levels, which is when excessive addition of nutrients or sediment results in increased biological production (algal blooms) and a decrease in lake volume. Human activities contribute to phosphorus (a nutrient) loadings of a lake, such as excess lawn fertilization, farm runoff, and failing septic systems.

Four lakes in the Cedar River basin were monitored as part of Metro's Freshwater Assessment Program. These are Lakes Desire, Spring, and Shady, which drain into Peterson Creek, and Lake Number 12, located in the Rock Creek subbasin. Lake Desire was rated as having poor water quality because of eutrophic levels for phosphorus, chlorophyll a, and transparency. Shady and Spring Lakes were rated good with mesotrophic levels (moderately productive), but both of these lakes were classified by DOE as having designated use impairment. Lake Number 12 was rated very good, but there has been increased plant production, indicating a problem. Restoration studies are currently being conducted for Lake Desire and Lake No. 12.

Storm Flow Monitoring Storm events will wash accumulated pollutants into the streams. The type and amount of pollutants washed off during storm events is dependant on the type and extent of land uses, the size of the storm, and the amount of time pollutants have accumulated since previous storms. By sampling storm events, "hot spots" or problem areas can be identified.

Metro sampled five high flow events between October 1989 and February 1990 at site A438. This site reflects the overall condition of the mainstem during a storm but pollutant concentrations tended to be low due to dilution by high flows. Larger intensity storms produce higher pollutant concentrations, that were twice those of total suspended solids, turbidity, fecal coliform, ammonia, nitrate, and total phosphorus measured at baseflow conditions.

King County Surface Water Management sampled twenty-one locations during five storm events in 1990 and 1991. Samples were typically taken during the initial storm flow of a storm event, or "first flush," to capture more concentrated runoff. Samples were analyzed for Metro and other parameters including metals, pH, oil and grease. The analysis showed exceedences for most of these parameters. For example, high concentrations of total suspended solids, turbidity, and total phosphorus were found at the Logan Street outfall and Maplewood Creek. Nitrates (a nutrient) were high in Maplewood Creek and all sampling sites on Taylor Creek. Fecal coliform levels exceed the standard of 50 colonies per 100 milliliter at all sites. The pH was 11.5 (caustic is pH greater than 12) at the cement batch plant stormwater outfall.

Both acute and chronic metal toxicity standards were exceeded consistently throughout the basin during storm events. Metals are toxic at extremely low concentrations in soft water; waters of the Cedar River are within the range of soft. Levels of copper were exceeded most frequently. This is of particular concern in the Cedar River basin because copper is extremely toxic to salmonids.

Sediment Samples Sediment samples can give an indication of pollution problems that may be missed in water quality samples alone. Many pollutants tend to adhere to sediment and are deposited with the sediments. These deposits provide historic records of continuous or periodic releases of pollution into the system.

Sediment chemical composition was analyzed at eighteen locations selected based on existing land use, potential for nonpoint pollutants, field reconnaissance, and stormwater quality sampling results. Most sites sampled showed sediment pollutant concentrations within the range termed "not polluted" to "moderately polluted" when compared to DOE sediment guidelines. Logan Street outfall sediments had consistent concentrations within the "heavily polluted" range, most likely from industrial and commercial activity in the area. Chemical pollutants were detected in sediments in the Renton Reach and herbicides were detected in Madsen Creek.

Level of Significance The significance of a water quality problem was determined after being analyzed in relation to many factors and their impact on functions and values (beneficial uses, such as water supply, habitat, recreation) of the water body. Each function or value is ranked for both the extent and severity of a problem. The factors used in determining the significance are then evaluated to establish the justification for the overall ranking of high, medium or low significance. Most of the water quality problems in the lower Cedar River basin and the Taylor Creek subbasin were rated as very significant (see Appendix A: Observed Conditions Summary for significance of water quality problems).

Future Water Quality Conditions

Without preventative measures, changes in land use will increase stormwater flows, and thus concentration and transport of nonpoint pollutants to the basin's streams, lakes, and wetlands.

Current pollutant concentrations - especially total suspended solids, fecal contaminants, nutrients, and metals - are expected to increase dramatically in the future with increases in urbanization and development.

There is a link between land use and the types and concentrations of pollutants that are found in the storm water runoff from different areas. The more developed land uses contribute more pollutants. Based on a comparison of estimated pollutant input, current land use and anticipated future land use pollutants are expected to increase by 30 to 100 percent without preventative measures. These pollutant increases could cause acute toxicity (death) to aquatic life because they are already high in the more urbanized catchments. In less developed areas, such as Peterson and Rock Creeks, increased pollutant levels could begin to pose a problem.

Without mitigation, Lower Cedar River Class I wetlands located in the headwaters of tributary systems will experience the most increases in pollutant inputs. Many of these headwater areas are currently less developed and, under current land use regulations, could be developed to high density residential.

WATER QUALITY KEY FINDINGS

» Cedar River is ranked as the highest priority watershed in King County for action to address nonpoint source pollution.

» Cedar River and its tributaries are classified as Class A (excellent) from Lake Washington to the Maplewood Bridge (River Mile 4.1) and Class AA from the Maplewood Bridge to the Landsburg Dam (River Mile 21.7).

» Major nonpoint pollution sources include forest conversion and development, urbanization, roads, onsite sewage disposal, agricultural activities, resource extraction, hazardous waste sites, and underground storage tanks.

» Other potential nonpoint pollution sources include small quantity hazardous waste generators, household hazardous wastes and pesticides, illegal dumping, and home underground heating tanks.

» Basin planning area average on-site sewage disposal system repair rate of 8.8 percent exceeds the regional average of 3 to 5 percent.

» Stormwater from urban residential areas contain elevated concentrations of sediment, nutrients, fecal coliform bacteria, and metal toxicity that can affect drinking water supplies, public recreation, and aquatic life.

» One Federal and two State hazardous waste sites are within the basin planning area.

- Water quality in Lake Desire is considered poor because of eutrophic conditions.

- Both acute and chronic toxicity standards for heavy metals, such as lead, copper, and zinc, were exceeded throughout the basin during storm events.

- Without preventative measures, total suspended solids, fecal contaminants, nutrients, and metals are expected to increase dramatically in the future with increases in urbanization and development.

- Without preventative measures, Lower Cedar River Class I wetlands located in the headwaters of tributary systems will experience significant increases in pollutant loadings from heavy metals and nutrients.

2.9 AQUATIC HABITAT

The basin planning area has a great diversity of aquatic environments including those of the Cedar River mainstem and valley floor, tributary streams, wetlands, lakes, and riparian (streamside) zones. These environments integrate physical, chemical, and biological influences from the surrounding landscape, and therefore are greatly affected by the nature and condition of surrounding terrestrial ecosystems. In recent decades, impacts from development have substantially reduced both the quality and quantity of aquatic habitats suitable for wild salmonids in many parts of the basin. This section discusses the relationship of the landscape to aquatic habitat, Cedar River fisheries, and stream and wetland conditions within the basin.

Aquatic habitats are primarily shaped by the interaction of water with soil and vegetation and can support an abundance of fish and wildlife species depending on their adaptability. Other important habitat factors further define natural habitats, such as food, water temperature, water quality, and cover. Different fish species require different habitat types at each stage of their life histories: spawning, rearing, overwintering, and smolt outmigration. In order to support the variety of fish native to the system it is important to maintain diverse and complex habitats, such as pools, riffles (shallow rapids), and runs, and to preserve connections between the river and the adjacent floodplain and riparian areas. For example, various shapes and sizes of pool habitats are critical in the life histories of salmonids to provide adult spawning habitat and extended freshwater rearing areas for juvenile coho salmon, steelhead trout, and cutthroat trout. Species of salmonids that enter freshwater well in advance of spawning, such as spring and summer runs of chinook salmon and steelhead trout, rely heavily on very large pools for long-term holding areas.

Wetlands, lakes, and the complex network of side-channels within the floodplain naturally provide additional habitat for salmonids and other wildlife species. Many of these environments are highly susceptible to human impact because they are closely connected with the surrounding land, or their small size or ephemeral nature makes them appear as

insignificant to fish production or other aquatic functions. As a result, they receive less regulatory attention and public concern, even though they may be critical for certain life history stages of many salmonids.

Landscape Processes and Habitat

Complex interactions among water, soil, and riparian vegetation determine the physical and biological functions of aquatic habitats. Riparian areas are transitional areas between aquatic and terrestrial environments. Although not completely sufficient in eliminating effects of development, they are vital in buffering aquatic ecosystems from a wide variety of human effects, especially the effects of pollution and flooding. They are typically the areas of greatest diversity and structural complexity of vegetation in a landscape. The best example of a structurally complex riparian system in the Cedar River basin is Rock Creek. In this subbasin, riparian vegetation buffers soil and water interactions and maintains healthy stream conditions by: 1) providing large woody debris that reduces water's energy, stores sediments, and stabilizes channels, 2) trapping what few pollutants do enter the system, 3) moderating temperature extremes, and 4) providing nutrients for the food web that supports fish and wildlife production.

Interactions among water, soil, and riparian vegetation are substantially affected by the frequency and magnitude of disturbances in the landscape, such as erosion or floods. Such disturbances are important to healthy ecosystem functioning when they occur at natural rates and magnitudes. However, land development typically affects aquatic habitat by reducing or eliminating soil and vegetation "buffers" that are important for reducing the erosive energy and pollutant loading of stormwater runoff. Disturbances may then occur at unnaturally high rates and magnitudes, overwhelming downstream areas with excess water and sediment. As a result, large woody debris is often dislodged, spawning gravels are eroded or choked with silt, and pools are filled with sediment. Such effects can be seen in the urbanized tributaries of Ginger, Molasses, and parts of Maplewood and Madsen Creeks. These changes reset an affected site's condition to that of an ecologically younger state (i.e., one with less complex flora and fauna). In many streams of the basin, the result is to make the habitat less suitable for naturally occurring coho and steelhead populations, and enable disturbance tolerant species such as cutthroat trout and sculpin to thrive.

Lakes, wetlands, and floodplains function as both important aquatic habitats and as buffers for downstream habitat. Development, through vegetation removal, grading, and filling, reduces the cleansing and storage capabilities of these features and increases stormflows, sediment input, and pollutants. As a result, both aquatic and terrestrial habitats decrease in quality, quantity, and stability.

Forests - Historically, riparian areas and uplands of the Cedar River basin were dominated by large, mature conifer (evergreen) trees, such as cedar, hemlock, and Douglas fir, rather than the mixed deciduous trees (those that lose their leaves in winter) that tend to dominate today. Both

types of trees are important, conifers play a major role in landscape functioning by forming a winter canopy to buffer the impacts of rainfall, and by providing longer-lasting large woody debris for the forest floor and in stream channels. The forest environment supports a wide variety of mammals and birds that also use the riparian areas, wetlands, and other aquatic habitats. Development has converted many areas of forest land to urban and suburban uses that increase stormwater runoff.

Cedar River Fisheries

The Cedar River basin planning area's aquatic habitats are used by seven species of anadromous and resident salmonids: sockeye, coho, and chinook salmon; and steelhead and cutthroat trout, Dolly Varden charr and mountain whitefish. A host of other fish exist in the system, including sculpins, pygmy whitefish, western brook lamprey, speckled dace, and three-spine stickleback. Many other fish species that reside primarily in Lake Washington or the river delta also use the river system. An example is longfin smelt, which make spawning and feeding forays into the river. Many of these species readily prey upon or compete with outmigrating juvenile salmonids, creating higher than typical mortality rates for salmonids produced in the Cedar River. A number of native and non-native fish species also reside in several of the basin's large lakes.

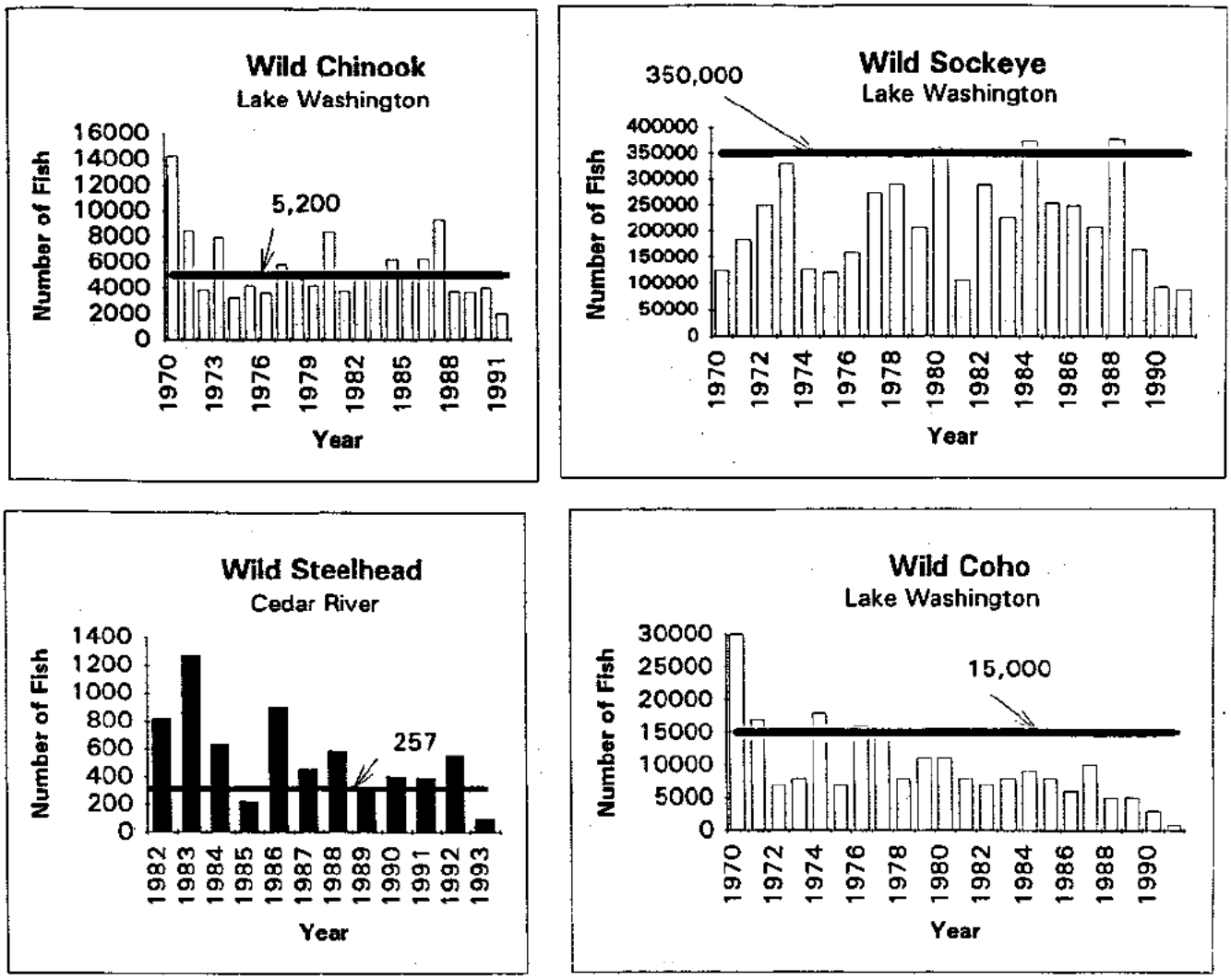
The Cedar River is a significant fishery resource in the Puget Sound basin and persists as an important producer of salmonids, despite past impacts from land-use changes in the basin. This is due to the many positive elements of the river system. These include: 1) high water quality; 2) a valley floor bedded in cobbles and gravel with relatively low amounts of fine sediment, which provides good conditions for salmon spawning and insect production; and 3) relatively stable hydrology over time.

The Cedar River is one of the few large river systems in the Puget Sound basin without a permanent hatchery; although there is an extensive history of stocking hatchery origin salmonids in the system. Unfortunately, none of the salmon or steelhead stocking programs were rigorously monitored to assess their benefits to the fishery or their effects on the wild stocks of the system.

Currently the fisheries of the Cedar River basin are managed to the extent possible for natural production of salmonids. Salmon stocks are co-managed by the Washington Department of Fisheries (WDF) and the Muckleshoot Indian Tribe (MIT). The Muckleshoot Indian Tribe and Washington Department of Wildlife (WDW) jointly manage steelhead populations.

The lowest spawning escapements on record for all species of wild anadromous salmonids returning to Lake Washington have occurred in the last few years (Figure 2-4). For some species, such as chinook, it is unclear if these low population numbers are a downward trend. In the case of sockeye, recent low numbers may be indicative of a significant decline, while low numbers of adult coho salmon suggest a major decline for this species. For example, coho

Figure 2-4 Spawning Escapement of Wild Anadromous Salmonids in the Lake Washington basin.



Chinook, coho, and sockeye estimates are for the entire Lake Washington basin (see text for estimated contribution by the Cedar River).

Horizontal lines indicate escapement goals. No data available for cutthroat trout.

spawning escapement in 1991 was only 800 fish for the entire Lake Washington basin, as compared to escapement levels averaging 13,700 and 7,700 in the 1970s and 1980s respectively. Based on available habitat, the Cedar River could be expected to contribute approximately 12 to 15 percent of overall coho production in the Lake Washington basin.

Chinook salmon have maintained steady escapement levels for the past 20 years, averaging 5,500 to 6,000 spawners per year, with approximately 40 percent contributed by the Cedar River. Steelhead trout have met escapement goals in the last twenty years but have shown recent declines attributed to sea lion predation at the Ballard Locks and habitat loss. Little is known about the life-history of cutthroat trout in the Lake Washington system, although their populations appear to be steady or even increasing.

Currently, one of the major fish management objectives for the Cedar River is sockeye production. Sockeye salmon spawning escapements have dropped from an average of 261,000 fish per year throughout the 1980s to 93,000 in 1990, and 87,000 in 1991. In a typical year, the Cedar River contributes approximately 90 percent of the total sockeye production in Lake Washington. However in 1992, unexpected low numbers of fish entered the Cedar River, while Bear and Issaquah Creeks–two of the largest tributaries to the Sammamish River–had the highest returns on record. Studies are being conducted on sockeye survival in Lake Washington in order to determine the importance of factors that could cause such a decline, such as changes in food resources, disease levels, and predator populations.

In the late 1980s, prior to the sockeye decline, artificial sockeye production facilities were proposed for the Cedar River. These facilities were to provide partial mitigation to the Muckleshoot Indian Tribe and Washington Department of Fisheries for loss of fish production from habitat above the Seattle Water Department's (SWD) water diversion dam at Landsburg, constructed in 1901. A sockeye spawning channel was to have been completed by September 1993 but has been delayed to allow completion and discussion of the above studies on the sockeye decline.

Significant Resource Areas

The Significant Resource Area (SRA) designation has been used in several basin plans to identify habitats that possess features and functions of overriding importance to fish, wildlife, water quality, or aesthetic appreciation in a particular basin. Areas not designated as significant resources will still receive protection under existing regulations, including the King County Sensitive Area Ordinance (SAO).

Regionally Significant Resource Areas (RSRAs) contribute to the resource base of the entire southern Puget Sound region by virtue of exceptional species and habitat diversity and abundance, when compared to aquatic and terrestrial systems of similar size and structure elsewhere in the region. Significant Resource Areas may also support rare, threatened or endangered species or communities.

Fourteen stream habitats in the Cedar River valley floor and selected tributary reaches of Rock, Peterson, and Taylor Creeks have been identified as Regionally Significant Resource Areas. Many of the Class I rated (i.e., unique and outstanding) wetlands, including all bogs, fens, and riparian wetlands on the mainstem, are categorized as Regionally Significant Resource Areas. The Cedar River Watershed Management Committee recognizes the regional significance of the Cedar River mainstem to the fishery resources of the Puget Sound. Designation of the Cedar River mainstem, as a Regionally Significant Resource Area from its mouth to the Landsburg Dam, is being evaluated by the Watershed Management Committee. They will determine whether it should have a separate designation that reflects both its productivity and highly managed state.

Locally Significant Resource Areas (LSRAs) also contribute to the resource base of the region, but to a lesser extent in terms of both habitat abundance and diversity compared to Regionally Significant Resource Areas. Locally Significant Resource Areas are significant within a particular basin, and provide important plant and animal habitat. Locally Significant Resource Areas have been identified on reaches of Maplewood, Molasses, Madsen, and Taylor Creeks, and unnamed Tributary 0316/0316A, and the Walsh Lake Diversion Ditch. A number of Class 2 wetlands that are within stream corridors have been assigned the same Significant Resource Areas designations as the adjoining streams. These streams and wetlands are critical in maintaining fish and wildlife habitat, water quality, and stormflow attenuation in these systems.

(See Appendix A, Observed Conditions Summary for a complete listing of Significant Resource Areas).

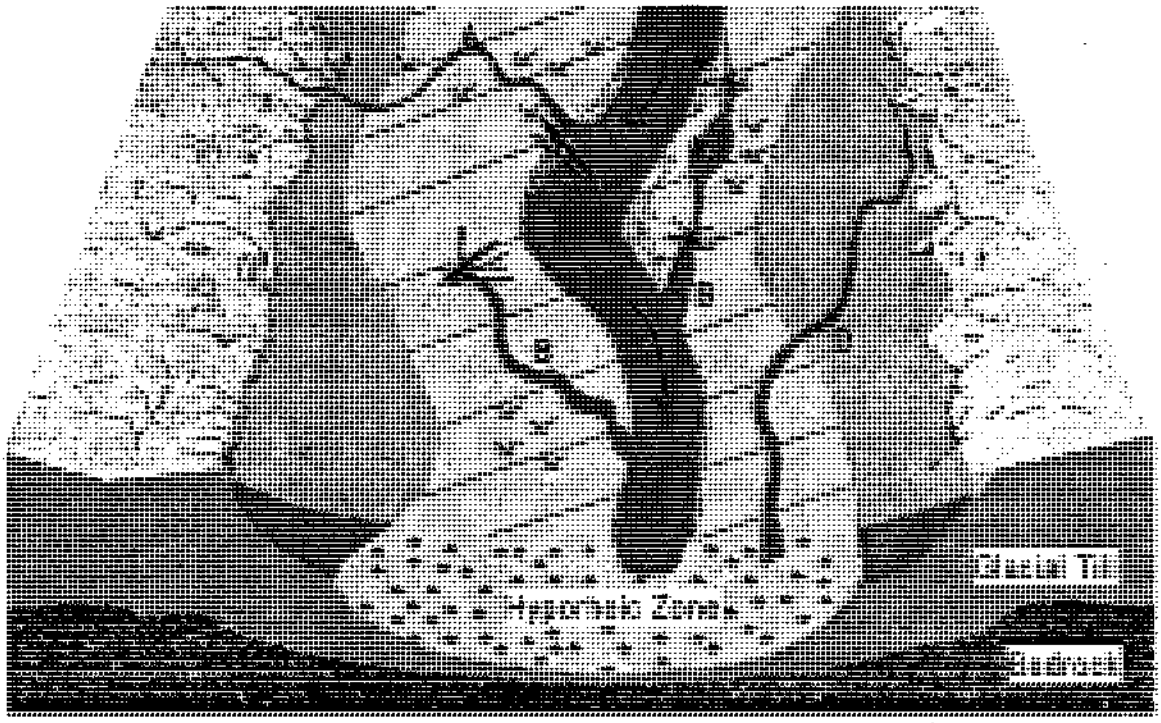
Mainstem Habitat Conditions

The aquatic habitat in the basin planning area Cedar River mainstem consists of three major interactive elements: in-channel habitat, valley floor or floodplain habitat, and subsurface or hyporheic habitat (Figure 2-5). Much of the 21 miles of mainstem aquatic habitat has been dramatically altered by human activities, such as Seattle Water Department's water supply dams, land development, levees, revetments, and removal of large woody debris. Fish habitat in the mainstem has been reduced by approximately 56 percent in the last 80 years due to these water diversion and flood control activities. Once a highly braided river channel, the Cedar River is now mainly a single-thread channel, with dramatically reduced channel complexity and connection with its floodplain and surrounding landscape (See Section 2.7 Erosion and Deposition).

In-Channel Habitat - Near Cedar Mountain, between River Mile (RM) 9.6 and 10.7, the river interacts naturally with the adjacent floodplain and riparian vegetation. As a result, large woody debris accumulations have developed along the banks and a complex river braiding pattern exists. The 1993 Executive Proposed King County Flood Hazard Reduction Plan has recommended abandoning or setting back levees at several similar sites to reduce flood hazards and allow improvement in the overall health of the river/riparian ecosystem.

Figure 2-5 Mainstem Habitat

These are the elements that contribute to healthy, stable, and diverse habitats capable of supporting most all salmonid species during their fresh-water life stage.



- Wood Debris
- A Tributary
- B Side Channel
- C Pond
- D Wall Bosed Tributary
- Floodploin
- Wet Soil

Flood control facilities and maintenance measures, such as levees, revetments, and removal of large woody debris, have created smooth and hardened banks that accelerate water movement. While this facilitates flood water conveyance, they also reduce in-channel habitat complexity. Levees confine most of the flows to the active channel along much of the river. This creates relatively high habitat instability because the energy of floodwater is not reduced by interaction with large woody debris or the floodplain. As a result, gravel (including spawning gravel that contains maturing salmonid eggs) may be more often scoured (dislodged), lowering the river's salmonid productivity. Revetments also limit the available spawning gravel supply, since armored banks prevent the river from either depositing gravel or reaching gravel sources (See also Section 2.7 Erosion and Deposition).

Revetments and large woody debris removal on the basin planning area mainstem result in channel conditions that favor the formation of relatively low complexity riffle (shallow rapids) and glide (slow, smooth, shallow run) habitats. In addition to removal of in-channel large woody debris, up to two-thirds of the large trees have been removed from the mainstem riparian zone, especially along revetments. This has further degraded the habitat value of many pools and extensive river reaches by eliminating overhanging woody vegetation, which provides cover and food, and moderates water temperature.

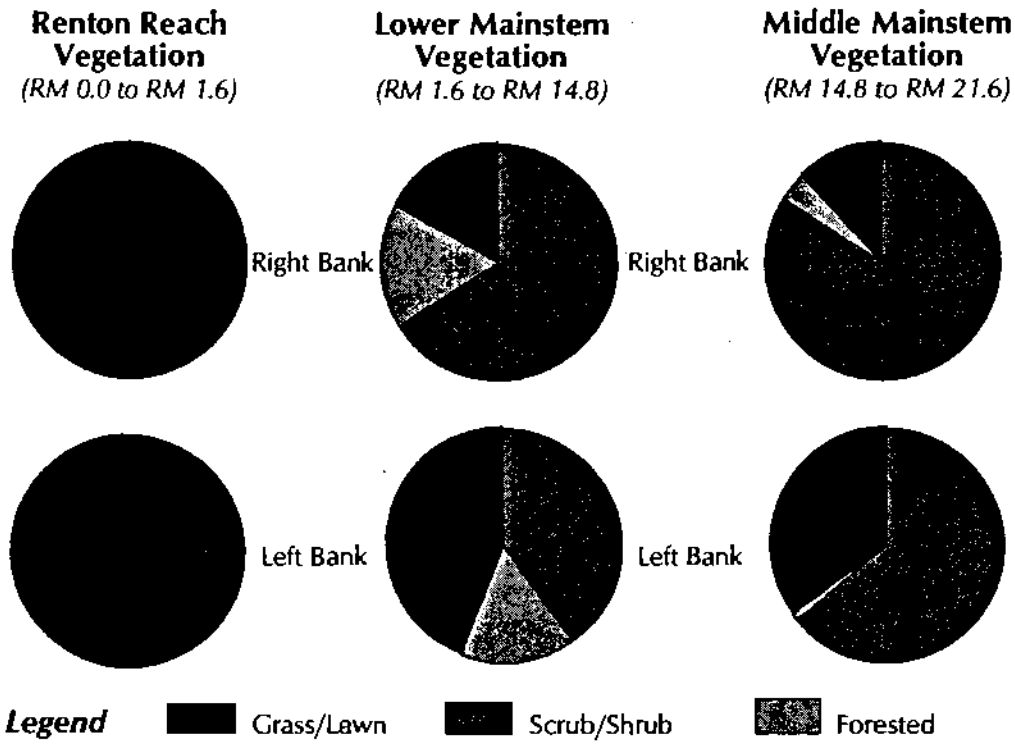
Most of the lower mainstem river (RM 1.6 to RM 14.8) is confined by levees and revetments and contains low volumes of large woody debris. There are approximately 70 percent fewer large pools than would be expected if the river were not armored and flows were not diverted and controlled (Figure 2-6). The Renton Reach (RM 0.0 to RM 1.6) is essentially one long riffle with little internal complexity. In contrast, a few relatively unmodified reaches of the middle mainstem (RM 14.8 to RM 21.2) exhibit very good habitat, except for small areas of floodplain encroachment by development in the Dorre Don and Arcadia/Noble area. The majority of large pools also occur at the base of high bluffs in the middle mainstem.

Valley Floor/ Floodplain Habitats - The Cedar River valley floor, or floodplain, contains diverse aquatic habitats outside of the mainstem channel. These include the mouths of tributaries, riparian wetlands, wall-based ponds, and side channels fed by springs, groundwater, or high flows from the mainstem (see Figure 2-5). Many of these habitats are formed in swales or channels left by past river migrations. In many instances they are small, highly complex habitats out of the direct influence of mainstem flood flows, while others are important in routing flood waters across the valley floor. These areas typically comprise some of the most productive riverine salmonid habitats in the Pacific Northwest, and as such, are considered significant habitats along the Cedar River mainstem.

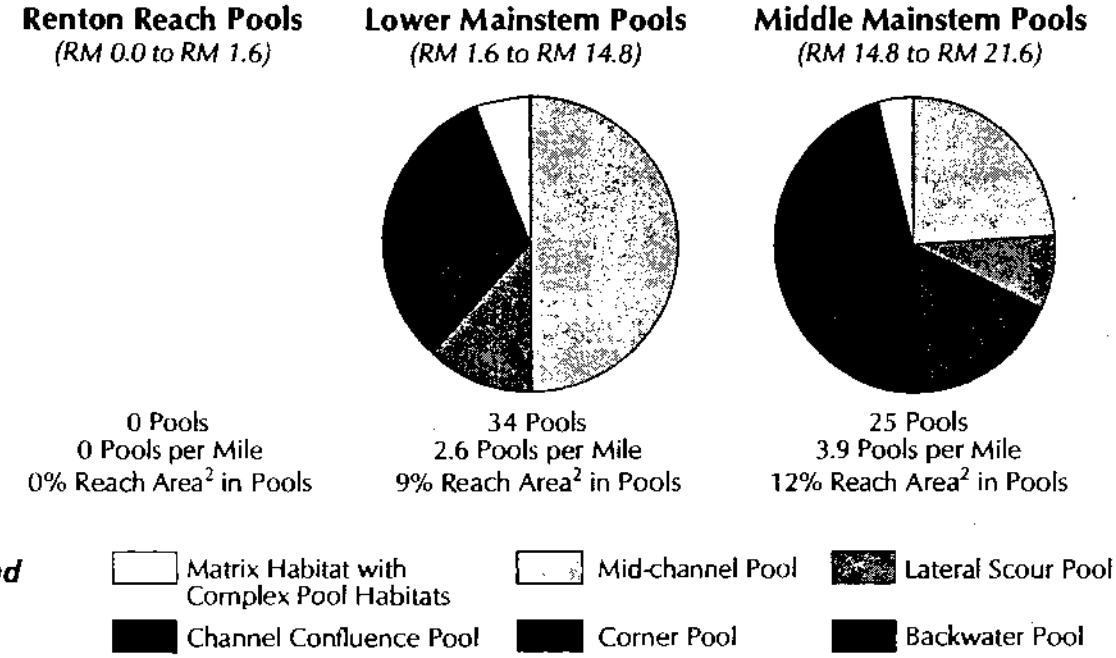
A survey of Cedar River valley floor habitats indicated that access from the mainstem Cedar River to side-channels limits fish use in nine of 68 identified sites, while lack of large woody debris or poor riparian conditions are problems at 37 additional sites. Other problems that may limit salmonid use in these habitats include seasonally low surface water, localized development impacts, flood control structures, and site instability due to flooding.

Figure 2.6

Riparian Vegetation Conditions
Cedar River Mainstem below Landsburg



Summary of Large Pool[1] Habitat Types
Cedar River Mainstem Below Landsburg



[1]Large Pools > one channel width in length [2]Average pool length is estimated 150 feet

Several large valley floor wetlands are Regionally Significant Resources Areas. Notable among them is Wetland 6, Cavanaugh Pond, which combine 14 acres of open water, forested, scrub-shrub, and emergent wetland habitat. Its most unique feature is its large expanse of exceptionally high quality salmonid spawning, rearing and refuge habitat.

Subsurface or Hyporheic Habitats - The hyporheic zone of the Cedar River mainstem is an unseen but significant portion of the river, providing complex linkages between the river and adjacent valley floor habitats. It consists of subsurface interstitial habitat (spaces between large gravel) and water that underlies the riverbed and its bordering riparian zone (see Figure 2-5). The subsurface water of the hyporheic zone interacts with the overlying surface water and the underlying groundwater.

This zone is important in regulating nutrient cycling in the river that influences the productivity of fish and other biotic organisms. It accomplishes this by providing habitat for benthic (bottom dwelling) invertebrates (mostly insects) and fish, and by maintaining biological and physical connections between the river and the riparian zone.

Although the Cedar River hyporheic zone has not been delineated or considered in past development actions, it appears that this portion of the riverine ecosystem remains relatively healthy, except for a probable reduction in size due to water diversions. In the future, water extraction, flow regulation, septic systems, land clearing, and many other human activities that occur in the floodplain will continue to affect the quantity and quality of water in the hyporheic zone.

Lake and Wetland Habitat Conditions

Lakes and wetlands are critical elements of the Cedar River basin. They provide habitat for a variety of flora and fauna, and many other valuable ecological functions, such as flood storage, water quality purification, and groundwater exchange. By acting as storage areas during rainstorms, wetlands help protect the Cedar River mainstem and its tributaries from excessive peak flows, erosion, and scouring. They also provide a source of sustained stream flow during hot, dry periods in summer and early fall. Many of these systems have been altered by past development, although a number of larger wetlands remain in surprisingly good condition.

Nine major lakes and numerous small ponds occur in the basin. All of the lakes in the basin planning area, except for Walsh and Webster Lakes, have been extensively altered by development, and a few of the lakes also have moderate to severe water quality problems.

Wetlands are defined as transitional areas between land and water that are typically saturated or inundated by surface or shallow groundwater for a significant part of the year. Prolonged saturation of these areas results in the formation of soils with distinctive characteristics and communities of plants adapted to life in wet growing conditions. Both the planning area and portions of the Cedar River watershed above Landsburg Dam contain an unusual array of peat

wetlands, which can be broadly divided into two categories, bogs and fens. The bogs and fens within the planning area have developed from aquatic ecosystems such as lakes or ponds that have filled with woody vegetation. Fens differ from bogs in that they receive water that has passed through mineral soil, whereas bogs receive water only from precipitation. Lower Cedar River Wetland 28 (Spring Lake) contains one of the largest fens in western King County.

Eighty-three wetlands covering a total of 892 acres in the basin planning area have been identified and classified in the King County Wetlands Inventory. However, the basin planning area contains dozens of other wetlands that have not yet been inventoried. The basin's wetlands include some of the largest bogs in western King County; as well as many marshes (emergent plant types: cattails, water lily), forested swamps (dominated by trees and shrubs), scrub/shrub wetlands, riparian systems, and shallow water areas near many of the lakes and ponds. Most of the basin planning area's Class I and large Class 2 wetlands are complex mosaics of several of these habitat types and are considered to be either Locally or Regionally Significant Resource Areas depending on their functions and values. Thirty-five percent of the basin planning area's wetlands are Class I. Many of the Class 2 wetlands are located in riparian areas (e.g., along streams and the mainstem), reflecting a high degree of interconnectedness among streams and wetlands in the basin. Detailed criteria for wetland classes may be found in *Appendix C: Glossary* and the King County Wetlands Inventory.

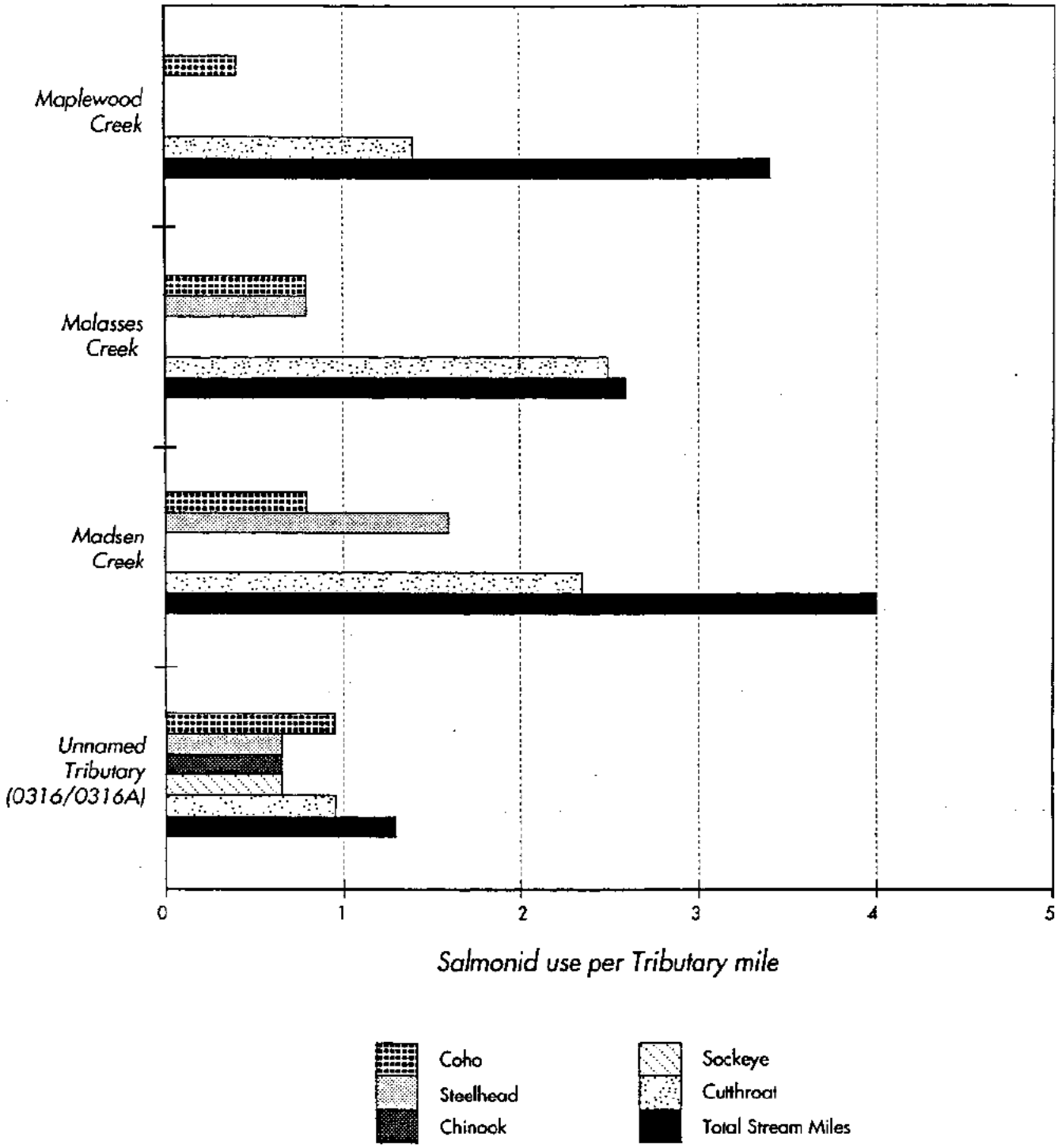
Wetlands, as well as lakes and streams, are currently protected by the 1990 King County Sensitive Areas Ordinance, which restricts development in and near wetlands and requires mitigation for unavoidable impacts by public and private development. In spite of this law, wetland encroachment continues; when small wetlands, or portions of larger wetlands, are drained or filled.

Current wetland conditions in the basin planning area indicate that a high proportion of the wetlands identified in the inventory have undergone some degree of buffer removal, clearing, drainage, or filling since the inventory was first conducted in 1983. For example, two of the basin planning area's fifteen Class I wetlands have been converted to stormwater retention/detention facilities, which was permitted in the past but is currently prohibited under the Sensitive Area Ordinance. In the urbanized areas of the basin, many wetlands have been partially or completely disconnected from previously interconnected aquatic and upland habitats. Isolation of wetlands from upland areas and from other elements of the hydrologic system by urban development usually leads to species loss or replacement with other, less desirable species. The uninventoried wetlands in the basin are particularly vulnerable to damage and destruction due to permitted and unpermitted land use activities.

Tributary Habitat Conditions

There are nine major fish-bearing tributaries in the Cedar River basin: Maplewood, Madsen, Molasses, Taylor, Peterson, and Rock Creeks, unnamed tributaries 0316A and 0336, and the Walsh Lake Diversion Ditch. These tributaries comprise approximately 29 stream miles, of which some 18 miles are available to anadromous (sea-run) fish (Figure 2-7 and 2-8). The Cedar

Figure 2-7 Extent of Salmonid Use in Tributaries of the Cedar River



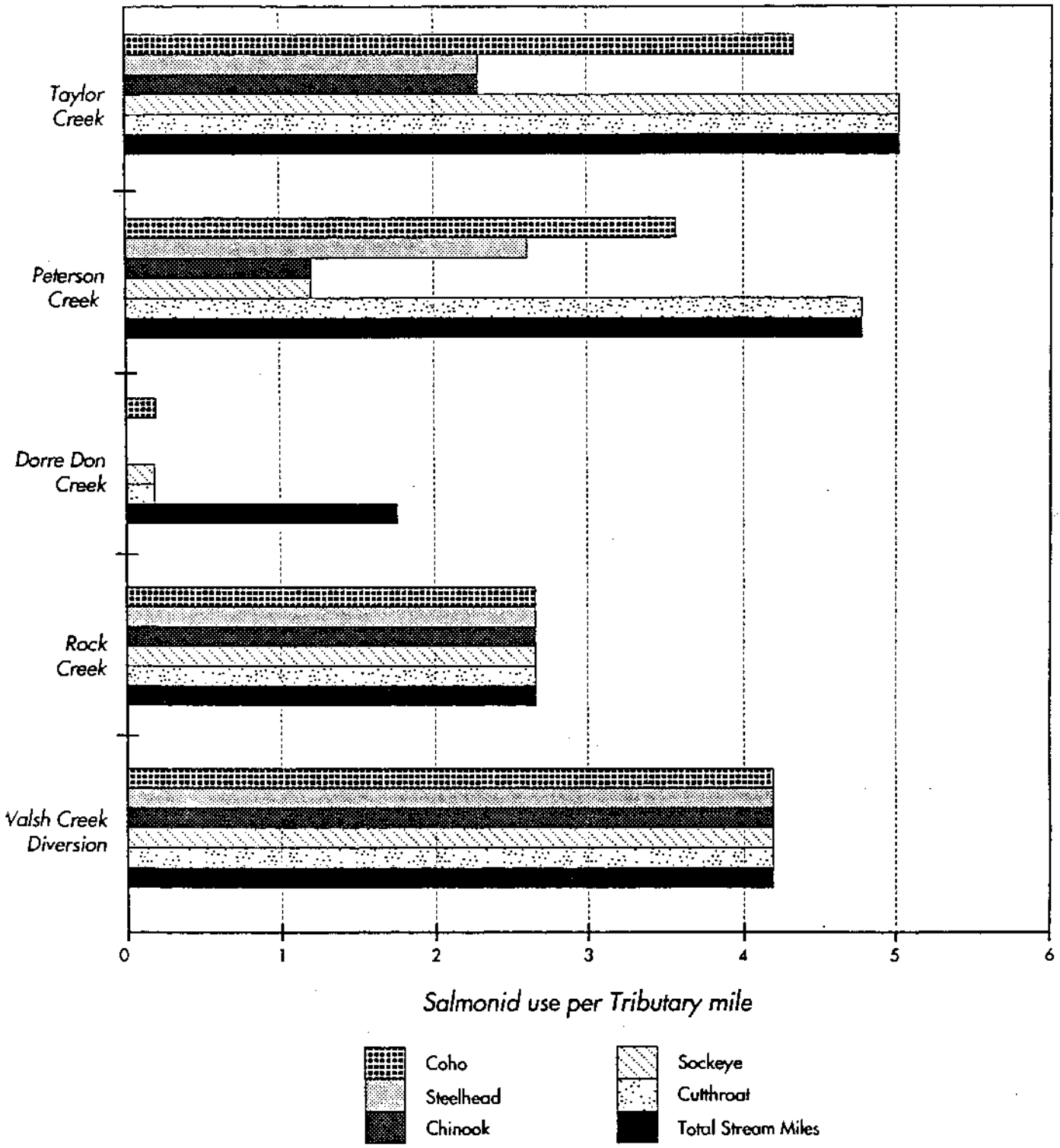
River tributaries drain high, broad plateaus and descend through ravines of varying steepness to the valley floor. Historically, coho salmon, and steelhead and cutthroat trout were limited in their use of these streams only by low flows and steep gradients, but access is now blocked in many reaches by culverts and reduced summer flows. In addition to the above species, sockeye and chinook use many of the low-gradient reaches of the larger tributaries, such as Taylor, Peterson, and Rock Creeks.

Tributary habitat in the Cedar River basin has been extensively impacted by changes in stormwater hydrology, and sediment erosion and deposition. This is due to urban development primarily in upstream plateau areas and reductions in the structural complexity of stream channels and riparian areas. Other impacts result from the water quality effects of gravel mining, failing septic systems, and large scale composting and metal recycling facilities. Examples of urbanization impacts are seen in Madsen, Molasses, and Maplewood Creeks. Upper reaches of these tributaries are highly fragmented by road and drainage networks in subdivisions. Downstream ravine reaches are typically affected by polluted urban runoff, high sediment loads, and low buffering capacity caused by low quantities of large woody debris and immature riparian vegetation. Long riffles and shallow pools tend to dominate the habitats in these systems. While coho and steelhead maybe unable to survive in these changed conditions, cutthroat trout are present, and ofren abundant, throughout these triburaries, even in the highly degraded habitats of upper Molasses and Madsen Creeks.

In contrast with the degraded habitat of the urbanized tributaries, the middle subbasin tributaries, such as Peterson, Taylor, and Rock Creeks, generally have good to excellent areas of aquatic habitat. Impacts similar to urban development exist, including increased stormflows, cleared riparian and wetland vegetation, removed large woody debris; but water quality problems tend to be caused more by failing septic systems and animal keeping. Rock Creek, one of the outstanding streams in King County, is threatened by development encroachment, and water withdrawal by the City of Kent, which maintains a system of wells near the Summit-Landsburg road crossing (RM 1.7). Water withdrawals in Rock Creek during the late summer and early fall months are removing approximately 75 percent of the stream's baseflow and limit migration of chinook and sockeye salmon.

Without preventative measures in the future, stormflows on both Rock Creek and Taylor Creek will most likely increase under current land-use regulations causing habitat degradation from scouring in steeper reaches and fine sediment deposition in the lower reaches. Peterson Creek, in contrast, flows through an extensive complex of lakes and wetlands that can help protect it from encroachment by future development.

Figure 2-8 Extent of Salmonid Use in Tributaries of the Cedar River



AQUATIC HABITAT KEY FINDINGS

- Landscape-level changes in the past century have significantly altered the quantity, quality, and stability of many salmonid habitats in the Cedar River basin.

- The lowest spawning escapements on record for all species of wild anadromous salmonids returning to Lake Washington have occurred in the last few years.

- Fish habitat in the Cedar River mainstem has been reduced by approximately 56 percent in the last 80 years due to water diversion and flood control structures.

- Flood control structures and maintenance measures, such as levees, revetments, and removal of large woody debris, have created a hydraulically smooth channel with hardened banks. This has disconnected the river from its floodplain, reduced habitat complexity, and limited the supply of spawning gravel.

- There are 70 percent fewer large pools in the Cedar River mainstem than would be expected under unmanaged conditions.

- An extensive network of at least 68 individual habitats including side channels, riparian wetlands, and wall-based tributaries, are currently distributed throughout the Cedar River valley floor but are under-utilized due to levees and revetments built for flood control.

- The Cedar River basin has an unusually high diversity of wetland resources, including the Spring Lake Wetland, one of the largest fens in western King County.

- A high proportion of the 892 acres of inventoried wetlands have undergone some degree of buffer removal, clearing, drainage or filling since the King County Wetland Inventory was conducted in 1983.

- Permitted and unpermitted damage has occurred to dozens of uninventoried wetlands that exist in the basin planning area due to development impacts.

- Three major fish bearing tributaries, Madsen, Molasses, and Maplewood Creeks, have been severely affected by urbanization.

- Much of the mainstem of Taylor Creek is suffering early signs of habitat degradation due to immature (small, sparse vegetation) riparian areas and low amounts of large woody debris.

- Water withdrawals in Rock Creek during the late summer and early fall months are removing approximately 75 percent of the stream's baseflow and limit migration of chinook and sockeye salmon.

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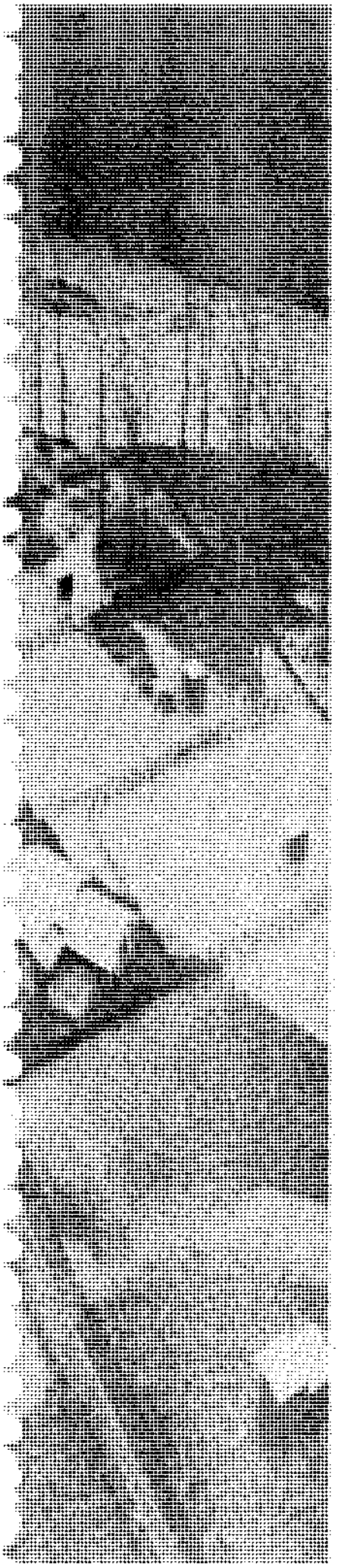

Chapter 3

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Chapter 3: Current and Future Conditions by Subbasin

3.1 INTRODUCTION

This chapter describes the conditions associated with flooding, habitat, water quality, and erosion and sediment deposition in each of the eight subbasins of the Cedar River. These subbasins are characterized by unique natural features and land-use patterns. Of the eight subbasins, three are reaches of the mainstem and the remaining five are tributaries, or groups of tributaries, to the Cedar River (*Map 2, Appendix B*). Although this chapter covers the more significant conditions, a full list of conditions observed in the basin planning area can be found in *Appendix A*. For details on the cause and effects of the conditions discussed, refer to Chapter 2.

Among these subbasins there is a remarkable range of conditions from almost entirely developed in the Renton Reach, which is dominated by commercial and industrial uses, to nearly pristine in the Rock Creek subbasin. From the mouth of the river, at the south end of Lake Washington, to the I-405 bridge comprises the *Renton Reach*–this reach could be referred to as river mile (RM) 0.0-1.6. River miles are marked for the mainstem and tributaries on the maps in this report. Moving upstream, the *Lower Cedar River mainstem* (RM 1.6-16.2) is the next subbasin and consists of the mainstem channel. The *Lower Cedar River subbasin* includes 16 tributaries and several unnumbered channels that drain to the Cedar River from the north and from the south. The *Middle Cedar River mainstem* spans from Maple Valley to Landsburg (RM 16.2-21.7). Subbasins that drain into the river along this reach include the *Peterson Creek subbasin*, draining four lakes and their associated wetlands and numerous small tributaries, the *Taylor Creek subbasin*, which includes Taylor Creek as well as its tributaries, and the *Middle Cedar River subbasin*, which includes Tributary 0336 and the Walsh Lake Diversion Ditch. Farthest upstream is the *Rock Creek subbasin*, in the southeastern section of the basin planning area.

3.2 RENTON REACH

Introduction

The Renton Reach (RM 0.0-1.6) is a gently sloping area extending from I-405 to the mouth of the Cedar River at Lake Washington (*Map 17, Appendix B*). The Cedar River was diverted in 1912 into the south end of Lake Washington, away from the now dry Black River. This armored diversion channel extended the Cedar River one mile north to Lake Washington and also straightened and armored a mile-long reach of existing river channel. The Renton Reach is the most intensively developed part of the Cedar River basin planning area. Near the mouth of

the river, expansive areas of impervious surfaces dominate the landscape including the Boeing Commercial Aircraft plant and the Renton Municipal Airport, numerous roads and highways, and Renton's commercial core as well as high-density residential areas. There are only small pockets of mature vegetation. The most apparent surface-water problem in this subbasin is repeated flooding in Renton, primarily caused by high discharges that enter a region where the floodplain has been intensively developed and where sediment accumulations decrease the channel's capacity. Water quality, however, is also a significant concern in this reach.

Flooding

Along the lowest mile of the Cedar River, where the Renton Municipal Airport borders the left bank and the Boeing Commercial Aircraft plant flanks the right, several elements combine to influence flooding. The most significant of these is the loss of a floodplain to industrial land uses. In addition, the channel here has reduced capacity caused by sediment deposition within it.

Under current conditions, the Municipal Airport is the location most prone to flooding; the southern one-quarter of the airport is within the 25-year floodplain. As additional sediment build-up further reduces the conveyance capacity of the channel, future 25- and 100-year floods are expected to increase the extent of flooding in this reach.

Erosion and Sediment Deposition

Because this is a nearly flat reach, sediment carried from the collective headwaters of the river and its tributaries settles out here. Sediment is continually deposited in the downstream two miles of the river and in the delta at the river's mouth in Lake Washington. Periodic dredging of sediment from the channel and delta was discontinued in about 1982. The sediment build-up since then has severely reduced the maximum flow that the channel can convey without causing flooding in Renton. The channel does not currently migrate in this armored reach, although prior to 1916 the rate of channel shifting was probably very high.

Water Quality

The commercial and industrial areas of the Renton Reach are significant sources of nonpoint pollution. During storm events, the Logan Street outfall consistently contributes extremely high levels of heavy metals (e.g., copper, lead, zinc), suspended solids, turbidity, total phosphorus, and fecal coliform bacteria. Sediments at this outfall are within the range of "highly polluted."

The lower portion of the Renton Reach receives runoff from airports and other commercial and industrial facilities. The stormwater discharges contain concentrations of phosphorus and fecal coliform bacteria (likely from the abundant water fowl) and even higher levels of heavy metals.

In addition, volatile organics and PCBs have been detected in the sediments at outfalls within this reach. These pollutants can be attributed to commercial activities.

Aquatic Habitat

Despite its limitations, this entirely artificial reach serves as a migration route for many fish species and is used for spawning and rearing by sockeye, chinook, and coho salmon, and steelhead and cutthroat trout, as well as long fin smelt. Urban and industrial uses, however, have permanently limited the quality and number of habitat sites along this reach.

3.3 LOWER CEDAR RIVER MAINSTEM

Introduction

The Lower Cedar River mainstem (River Mile 1.6-16.2) spans more than 14 miles of the river from I-405 to Maple Valley and includes the immediately adjacent valley floor (*Map 18, Appendix B*). Significant land-use features along this reach include the Maplewood Golf Course, two parks, and numerous residential areas. There are also scattered commercial, industrial, and high-density residential land uses, particularly near the Maple Valley community.

Most of the development in the Cedar River valley outside of Renton is located along this portion of the narrow floodplain, which forms the valley floor. Structures have been placed in commonly flooded areas, and floodplain development is likely to continue, particularly near I-405 on the downstream end and near Maple Valley on the upstream end. Flooding in undeveloped areas of the floodplain goes unnoticed now, but will be a problem if homes and businesses are built in these areas.

Flooding

This reach experiences the most significant flooding problems in the basin planning area. Many structures, most of them residences and roads, have been placed in the natural floodplain along the valley floor, where the river has historically meandered between the valley walls.

In a number of cases, homes along this reach are protected from river meandering and high flows by revetments and levees. However, significant flooding problems along this reach often occur where levees are insufficient to contain the high flows.

In the vicinity of the Elliot Bridge levee (RM 5.0), five houses are within the 10-year floodplain, two more are within the 25-year floodplain, and a total of 12 houses are within the 100-year floodplain. Along the reach upstream from the Elliot Bridge (RM 5.3-6.5), there are 20 homes

along the armored banks that are within the 25-year floodplain and a total of 45 homes are within the 100-year floodplain. Farther upstream, an armored river bend (RM 11.2) is likely to be overtopped during the 10-year flow, flooding four homes and 55 mobile homes, in addition to damaging county roads. Another 15 houses (RM 11.4-12.2) are likely to be flooded by the 10-year event. Between RM 13.0 and 14.7 there are 11 houses within the 10-year floodplain, 22 within the 25-year floodplain, and nearly 50 within the 100-year floodplain.

Neither the severity nor the frequency of flooding in this reach is expected to increase significantly in the future. This reflects the minor contribution to peak flows from the Cedar River's tributaries, and the very large contribution made by the Seattle Water Department's watershed. Because no significant development will take place inside the watershed boundary, no increase is expected in the future. The incidence of problematic flooding, however, could increase if more structures are placed in the path of high flows.

Erosion and Sediment Deposition

The most apparent erosion problem in the Lower Cedar River mainstem is caused by the unstable slopes in the Maplewood area. In 1987, a large landslide (RM 3.9) delivered about 30,000 cubic yards of sediment to the river, and severe erosion of the landslide is still occurring. Renewed landsliding is likely at RM 3.9 and is possible at an older failure at RM 4.5. Increased runoff from upslope developments may in some cases contribute to the failure of these marginally stable slopes. Sediment from landslides in this area moves rapidly downstream and deposits in the delta or channel in Renton, contributing to the flooding problems there.

Channel migration has been largely halted by revetments, which armor one side or the other of over 70 percent of this reach. Presently, the most significant remaining channel migration occurs in the Cedar Mountain area (RM 10.0-10.5). In this reach, the river switched course into a channel next to the east valley wall in 1990, abandoning its old channel except during high flows.

Water Quality

Although concentrations of nonpoint pollution are generally fairly low in the mainstem due to dilution, recommended levels for many pollutants were exceeded during the higher intensity storms. In addition, extremely high pHs of 11.9 and 11.3 were measured in the runoff from a cement batch plant, which is now obtaining state permits to manage this discharge.

Aquatic Habitat

Levees and revetments along the banks of this part of the Cedar River have limited the formation of pools and have disconnected the river from potential habitats in the floodplain.

For example, in two areas (RM 3.9 and RM 13.9), revetments built to prevent catastrophic landsliding have also changed the recruitment of sediment and limited the formation of deep pools. Before the revetments, these landslides likely contributed spawning gravels to the river, although the site at RM 3.9 may have also added even greater quantities of fine sediments that reduce the quality of spawning downstream.

In addition to three Locally Significant Resource Areas (LSRAs; see *Chapter 2, section 2.9*) in the valley along the Lower Cedar River mainstem, nine Regionally Significant Resource Areas (RSRAs) have been identified, two of which are associated with wetlands. There are six wetlands along this reach: Wetlands 6, 37, 103, and 132 are RSRAs, and Wetlands 105 and 118 are LSRAs.

Wetland 6, also known as Cavenaugh Pond, is the only Class 1 wetland on the Cedar River valley floor. The 14-acre pond, located between RM 6.4 and 6.85, provides a large expanse of exceptionally high quality salmonid spawning, rearing, and refuge habitat. Because this is King County open space land it is likely to remain a stable habitat, but sediment deposition where a small tributary enters the pond is a concern.

Wetlands 103 (RM 7.3-7.6) and 37 (RM 8.3-9.1) both provide possible flood refuge for salmonids in addition to the typical wetland functions of water quality protection and flood attenuation. Two Class 2 wetlands (Wetland 105 at RM 10.5 and Wetland 132 at 13.4) each provide over-wintering habitat for juvenile salmonids, despite the presence of trash throughout Wetland 105 and logging and clearing of several thousand square feet of Wetland 132 and its buffer. Extensive clearing and grading in Wetland 118 has limited its water quality, wildlife habitat and flood attenuation function.

3.4 LOWER CEDAR RIVER SUBBASINS

Introduction

This subbasin drains over 7,000 acres of the plateau and valley floor between I-405 and Maple Valley (*Maps 18-24, Appendix B*). The tributaries in this area include Ginger, Maplewood, Molasses, and Madsen creeks, as well as numerous smaller channels. Most of these streams have their headwaters in the plateaus above the Cedar River, where much of the urban development lies.

This part of the Cedar River basin planning area has a residential character, with subdivisions, mini-malls, schools, and industrial areas. Currently, 33 percent of the land here is in high-density residential and commercial uses, 12 percent is in low-density residential, and 55 percent is forested (*Map 3, Appendix B*). If this area were to be developed to the maximum allowed under current zoning, high-density residential would increase to 52 percent, low-density residential would increase to 16 percent, and only 32 percent would remain forested (*Map 4, Appendix B*). In other words, nearly half of the forested area could be replaced by commercial

and residential development.

Peak flows are not expected to increase significantly for the tributaries near Renton, but for those nearer Maple Valley, such as Tributaries 0311 and 0316, the conversion of forested land to impervious surfaces could result in stormflow increases of up to 40 percent as these currently less developed areas build out. The increase in peak flows here will likely cause erosion of the stream channels where they flow through steep, wooded ravines cut into the walls of the Cedar River valley. This, in turn, will likely result in degraded habitat, destabilized streambanks, and delivery of large sediment loads to the streams. Sediment deposited in the lower reaches of tributary streams tends to augment flooding problems in this reach.

Flooding

The Lower Cedar River subbasin has the most severe tributary flooding in the Cedar River basin planning area. The most significant flooding occurs on Maplewood Creek (Tributaries 0302 and 0303), Molasses Creek (Tributary 0304), and unnamed Tributary 0313.

Flooding damage occurs in the Puget Colony Homes subdivision for flows larger than the two-year storm because the pipes that carry the east fork of Maplewood Creek (Tributary 0303, River Mile 0.4-0.8) through the subdivision are too small for these flows. The flooding that results has covered roads and damaged homes. In addition, there have been complaints that when flooding occurs, septic systems become saturated, allowing contaminants to enter the surface water.

At RM 0.4 on Tributary 0303A (a tributary to the east fork of Maplewood Creek), a culvert carrying this small tributary under SE 132nd Street is too small to carry flows greater than the 2-year storm. Its backed up water regularly floods the SE 132nd Street/146th Avenue SE intersection, prevents access to homes on the east, and enters the catchment of the Orting Hill Tributary (Tributary 0307).

There are two significant flooding problems on Molasses Creek, which drains the Fairwood area. The first (Tributary 0304, RM 1.8) occurs at approximately the 5-year flow, when SE 180th Street floods, preventing access to residences. The second problem (Tributary 0304, RM 2.0) occurs in a sag where 140th Avenue SE crosses over Wetland 22 just north of the Carriage Crest Elementary School. Currently, the road and nearby properties flood almost annually. In the future, flows will probably be significantly higher as the currently undeveloped surrounding area builds out, causing deeper and more frequent flooding.

Flooding has also damaged a mobile home park along unnamed Tributary 0313 (RM 0.2). Erosion from upstream has delivered sediment to this site where it fills in the channel, reducing channel capacity and forcing water to overflow the streambanks.

Erosion and Sediment Deposition

The most widespread erosion problems in the Cedar River basin planning area can be found in the catchments in the highly developed, lower end of the valley, particularly along Maplewood (Tributary 0302), Molasses (Tributary 0304), and Madsen (Tributary 0305) creeks. These tributaries drain densely developed areas in the uplands and flow down the erodible sedimentary material of the Cedar River valley walls. The eroded sediment is carried to the flatter valley floor below, where the streams slow down, allowing the sediment to settle out. This deposited sediment fills in channels, augmenting local flooding on the valley floor. As development increases, so will stormwater flows, causing tributary channels to become wider and deeper. This can undermine slopes and can lead to subsequent landslides, as is currently the case in Madsen Creek, and can further contribute sediment to the lower gradient reaches.

The west fork of Madsen Creek (Tributary 0306), which joins Madsen Creek (Tributary 0305) at RM 1.5, has experienced severe erosion. Natural gas lines originally buried under the streambed are now suspended 6 to 15 feet in the air and have been abandoned, and a METRO sewer line also buried there has been exposed and damaged at numerous locations.

Without preventative measures, future development not only will accelerate all of these problems but also will be likely to induce erosion in presently stable channels. Channels that have been identified as likely to become problem areas with future development are Unnamed Tributaries 0316B and 0317, as well as some unnumbered steep small channels throughout the eastern part of this area.

Water Quality

Stormwater sampling indicates that urbanization in the Lower Cedar River subbasin is impacting the water quality in Maplewood Creek (Tributary 0302), Madsen Creek (Tributary 0305), Orting Hills (Tributary 0307), Cedar Hills (Tributary 0316A), and at the unnumbered old King County Shop tributary. Modeling based on current land-use indicates that nonpoint pollution problems are also likely to be present in Ginger Creek (Tributary 0300), Molasses Creek (Tributary 0304), and Cedar Grove (Tributaries 0308-0310).

In particular, Maplewood Creek bacteria and nutrient concentrations exceed recommended levels and standards. The septic failure rates, coupled with poor livestock waste management practices, indicate that contamination results from both human and animal wastes. Currently there are extremely significant levels of nonpoint pollution in this tributary, which, according to modeling results, will increase in the future without preventative measures.

In Madsen Creek (Tributary 0305) water quality has been impacted by nonpoint pollution associated with development, including herbicides applied by the golf course and by residents. In addition, there is a potential for failure of the METRO sewer line, which runs beside the creek.

High concentrations of nutrients and fecal coliform bacteria were found in the Orting Hills tributary (Tributary 0307), which seem to be associated with the high rate of septic tank failure in this catchment. The nonpoint pollution concentrations, which exceed acute and chronic toxicity standards, result from urbanization and will increase with future development unless preventative measures are instituted.

There are several activities in the Cedar Hills catchment (Tributary 0316A) that may contribute to nonpoint pollution. The traffic to and from the Cedar Hills landfill contributes to copper, lead, and zinc levels; runoff from nearby gravel mining activities contributes to high sediment loads; and stormwater carries extremely high concentrations of nutrients and organic matter from a composting facility. The Queen City Farms Federal Superfund site is also located within this catchment and includes the area surrounding Wetland 13.

Aquatic Habitat

Generally, the best tributary habitat in the Lower Cedar River subbasin can be found in the ravines that carry the streams from the plateaus to the valley floor. Unfortunately, in cases such as Maplewood Creek, some reaches have been blocked or culverted, reducing the accessibility or value of habitat. On the plateaus, much of the stream and wetland habitat has been fragmented and degraded by extensive development, but in the ravines that carry the tributaries to the valley below, there are a number of locally significant resource areas (LSRAs) including reaches of Maplewood (Tributary 0302), Molasses (Tributary 0304), and Madsen (Tributaries 0305 and 0306) creeks.

In its lower reaches, where Maplewood Creek flows through a golf course (RM 0.0-0.5), the streamsides are groomed and provide little streamside vegetation to provide shelter, shade, and food for fish. Even so, coho salmon have been known to migrate through an 800-foot culvert to spawn in this reach in recent years. Upstream from the golf course, two sediment ponds block migrating fish that would benefit from use of the upstream reaches. These ponds were installed to trap sediment that is carried down from the highly developed upland areas. Erosion and deposition of sediment also degrades habitat farther upstream on the mainstem of Maplewood Creek (RM 1.0-1.4) and along the east fork (Tributary 0303). For both stream channels, habitat on top of the plateau is highly fragmented and degraded by development activities.

Wetland 150, in the headwaters of the east fork of Maplewood Creek (Tributary 0303), has lost much of its flood storage and biofiltration potential due to incremental filling of nearly half of the original wetland. This is likely a factor in the downstream flooding problems at Puget Colony Homes and severe erosion of Maplewood Creek as it descends to the valley floor.

In the lower reach of Molasses Creek (Tributary 0304), habitat has been degraded in the vicinity of a commercial gravel pit, but farther upstream it flows through a deep, wooded ravine with overhanging streamside vegetation, large conifer trees, and large woody debris that provides good

habitat. Salmon passage is blocked at RM 0.8 by a long culvert, although cutthroat trout exist upstream.

Wetland 2, in the middle reach of Molasses Creek, and two Class I wetlands upstream (Wetlands 22 and 23) provide valuable flood storage. In addition, Wetland 22 provides habitat for cutthroat trout, though it has been severely impacted by development. Wetland 23 contains Labrador tea, which indicates bog characteristics. Although less impact has occurred here than in Wetland 22, it is slated to be encircled by development, resulting in a likely loss of natural flood storage which could add to existing erosion and flooding problems downstream.

Madsen Creek (Tributaries 0305 and 0306) was once a major spawning and rearing habitat for coho salmon and steelhead trout, but only cutthroat trout and occasional steelhead are found there now. In the lower reaches of Madsen Creek (RM 0.0-0.8) fine sediment has buried spawning gravels. In the middle reaches, a sediment pond and a high- flow bypass channel block and trap fish. Upstream, in the steeper reaches, ravine habitat has been degraded by placement and maintenance of a METRO sewer line and by sediment from the west fork of Madsen Creek (Tributary 0306).

The west fork Madsen Creek has also experienced the most severe habitat degradation in the entire basin, due to channel incision of up to 15 feet and landsliding near its confluence with the east fork (Tributary 0305). This reach was initially disturbed when gas and sewer pipelines were buried under the creek bed. In an attempt to protect these facilities, the banks were armored with rock and large woody debris was removed, reducing the quality of the habitat.

There are three wetlands associated with Madsen Creek. Wetland 25 received a Class 1 rating because it supports an uncommon bog plant community (Labrador tea and hemlock). Although the hemlocks there seem to be healthy, filling and buffer removal have greatly reduced the overall size, species diversity, and habitat value of the wetland. Wetland 18 is a riparian wetland that was converted to a retention/detention facility during development of the Fairwood subdivision in the 1970s. It may be considered for enhancement during a King County SWM capital improvement project to stabilize downstream areas of Madsen Creek. Wetland 16, a 14-acre, Class 1 system, is presently in good condition and also supports Labrador tea. Unfortunately, it is at risk from development and is likely to undergo significant increases in lead, phosphorus, and total suspended solids concentrations.

Six other wetlands in the Lower Cedar River subbasin also provide significant habitat, water quality, and natural flood storage in the basin; three of these (Wetlands 13, 33,and 36) are Class 1 wetlands, and the other three (Wetlands 31, 32, and 39) are Class 2 systems,.

3.5 MIDDLE CEDAR RIVER MAINSTEM

Introduction

The Middle Cedar River mainstem is almost six miles long (River Mile 16.2-21.7), extending from Maple Valley to Landsburg (*Map 25, Appendix B*). Over geologic time, the river has eroded a channel through the glacial sediments typical of the Puget Sound Lowland and has meandered back and forth across the valley floor to establish a floodplain between the bluffs that rise above the river.

This subbasin is dominated by forests but also contains some low-density residential areas, especially near Maple Valley. Although present zoning would allow over one third of the forests adjacent to the mainstem to be converted to low-density residential areas, the lack of roads along this reach may deter significant future development along the river.

Flooding Damage

This reach is a more confined, steeper channel than below Maple Valley and does not have the broader floodplain of the Lower Cedar River reach. The flooding problems in this reach are primarily caused by placement of houses and roads in the natural floodplain of the Cedar River.

In the Dorre Don area (RM 16.4), county roads and over twenty houses have been repeatedly damaged and access to many homes has been blocked by flooding over the levee. For events larger than the 10-year flood, a levee in the Orchard Grove area (RM 17.1) is overtopped, damaging homes behind the levee. Overtopped levees have also caused flooding, erosion, and deposition of eroded material above RM 18.1, damaging properties and homes in this area as well.

Erosion and Sediment Deposition

The steep bluffs downstream from Landsburg tend to be fairly stable and so erode only slowly. This is due to a combination of the geologic material of the valley sides and revetments that have been constructed on one bank or the other along nearly 50 percent of the length of this reach. The gradual erosion of these bluffs provide the river with gravel suitable for spawning without much risk of severe bluff retreat.

Before the revetments were constructed there was a zone of rapid channel migration between Maple Valley and Dorre Don. In fact, the river flowed across what is now the lower Dorre Don neighborhood in 1865, and there were once numerous channels where there is only one active channel today. Although revetments at least partially armor the outsides of every bend in this reach, many of the old channels still exist on the nearly-undeveloped left bank floodplain, and the river could conceivably switch course into one of these old channels during a large flood.

Water Quality

Water quality in the Middle Cedar River mainstem is considered excellentupsstream of this reach is the City of Seattle watershed, which is managed to provide high quality drinking water. Nonpoint pollutants are contributed towards the lower end of this subbasin as the land use becomes more residential.

Aquatic Habitat

Above Maple Valley, the Cedar River is more rural than the Lower Cedar River mainstem, and the historic habitats have not been as radically modified due to floodplain development. There are two reaches (RM 15.8-17.9 and RM 18.2-18.8) where floodplain and riparian conditions have been degraded by floodplain development. Several bluffs along this reach, especially in the vicinity of the mouth of the Walsh Lake Diversion Ditch, are important sources of spawning gravel.

Wetland 83, about one-half mile south of RM 21.8, contains a dense mat of Sphagnum, Labrador tea, and hemlock, and attracts numerous wildlife species. Clearing and development have occurred along the edges of this wetland and are likely to continue.

Wetlands 69 and 80 are small Class 2 systems near RM 20.0 that provide important wildlife habitat. Wetland 69 is directly connected to the mainstem through a culvert under the Cedar River trail. With structural alterations, Wetland 80 could become a over-wintering habitat for juvenile fish. Both wetlands are likely to be impacted by future development.

3.6 PETERSON CREEK SUBBASIN

Introduction

The Peterson Creek subbasin drains over 4,000 acres of rolling hills between the communities of Fairwood and Maple Valley (*Map 26, Appendix B*). Most of this subbasin is on the flat, poorly drained plateau south of the Cedar River valley, but in its lower reach Peterson Creek drops down steep slopes to meet the Cedar River. This subbasin includes the mainstem of Peterson Creek (Tributary 0328), numerous small tributaries (Tributaries 0329 through 0334), and a network of four lakes (Peterson Lake, Spring Lake, Shady Lake, and Lake Desire), all of which are associated with extensive wetlands.

Currently, two percent of the land in this subbasin is in high-density residential uses, 26 percent is in low-density uses, and 71 percent is forested (*Map 3, Appendix B*). If this area were to be developed to the maximum allowed under current zoning, high-density residential would increase to 20 percent, low-density residential would increase to 44 percent, and 35 percent

remain forested (*Map 4, Appendix B*). Almost ten percent of the undeveloped land is in wetlands, giving this area the highest percentage of wetlands in the Cedar River basin planning area. These wetlands provide valuable fish and wildlife habitat as well as natural flood storage. Under present zoning, almost half of the undeveloped areas could be replaced by both high- and low-density residential uses. In spite of this, the increase in peak flood flows is expected to be only about 12 percent, one of the lowest increases in the basin planning area. This is due to the water-storage capabilities of the wetlands. Even these relatively low increases of flows, however, will likely accelerate erosion in the lower reaches of Peterson Creek, which contain some of the best fish habitat in the basin planning area.

Flooding

The flat, upland areas of this subbasin are characterized by numerous wetlands and lakes. These natural water-storage areas are underlain by deep peat deposits, which retard drainage during the most severe storm events. When roads and buildings are built in or near these wetlands, minor flooding commonly results. Artificial systems intended to drain these areas are not always entirely effectiveas is the case around Spring Lake, where drainage systems periodically plug with debris or silt.

The most serious flooding in this subbasin occurs in the headwaters of Peterson Creek (Tributary 0328B) along East and North Lake Desire Drive SW. The road, which is underlain by peat, was built in Wetland 15 and appears to be sinking.

Erosion and Sediment Deposition

On the steep reach of Peterson Creek between the Cedar River and the plateau (RM 0.2-0.6), there have been numerous landslides on the ravine walls and severe stream-channel erosion. Although landsliding and erosion are natural processes in this type of setting, they may have been accelerated by increased flows from development. The material that is eroded from these areas introduces a high sediment load to Peterson Creek and provides some coarse sediment to the Cedar River. In addition to sediment from the mainstem, several of the short tributaries that enter Peterson Creek from the north contribute fine sediment to the system during storms. Although future flows may accelerate these problems, this erosion and subsequent sediment deposition are not expected to pose a significant threat to public safety or the environment.

Water Quality

In addition to nonpoint pollution found at the confluence of Peterson Creek (Tributary 0328) with the Cedar River, the lakes and wetlands in this subbasin are experiencing varying levels of eutrophication. Lake Desire is considered to have poor water quality and Shady Lake and Spring Lake have been classified by DOE as being designated use impaired. Modeling indicates

that future development will generate increases in nonpoint pollution in the creeks, lakes, and wetlands of this system, including Wetlands 14 and 15 (upstream from the already eutrophic Lake Desire) and Wetland 28 (Spring Lake).

Aquatic Habitat

Habitat in the Peterson Creek system is buffered from existing development by an extensive lake and wetland network. As a result of this buffering and relatively light development, this system has good to excellent habitat and is used by all salmon species native to the Cedar River.

The first half mile from the confluence with the Cedar River cuts through a steep ravine, containing excellent habitat. In this reach, large, old trees not only provide stream-side shade and shelter but also contribute large woody debris to the stream. Landsliding is common along this reach but not always to the detriment of the habitat. For example, when the ravine sides fail they take the trees along with the soil. The trees that fall into the stream provide shelter and habitat diversity for salmon and trout. The reach from RM 0.0 to 1.2 is a Regionally Significant Resource Area, even though there is little large woody debris in some areas.

The reach of stream below Peterson Lake (RM 1.2-1.6) is a Locally Significant Resource Area. Salmon and trout use the reach even though the streambank has been artificially straightened. Despite past modifications, tbe banks are well vegetated with small trees. Another locally significant resource area lies upstream from Peterson Lake, where Peterson Creek (RM 2.0-2.4) has been channelized, streamsides have been trampled by farm animals, and the channel has been damaged by operation of heavy equipment in the stream.

Four major wetlands in the Peterson Creek subbasin have been designated as Regionally Significant Resource Areas. Wetland 14 in the headwaters is a 43-acre, Class 1 system, 37 acres of which have been significantly altered by peat mining that ended in the late 1980s. The remaining six acres contain typical bog species, including hemlock, Labrador tea, cranberry, and Sphagnum mosses. In addition to the excavating, clearing, and filling associated with mining, the wetland suffers from increased volumes of runoff from a residential subdivision upstream. Despite these impacts, Wetland 14 provides valuable flood storage and habitat for wildlife species, such as great blue heron, migratory waterfowl, and occasional deer, coyote, river otter, and bear. Conditions will likely remain stable unless future development significantly alters water levels in the wetland.

Wetland 15, a 17-acre, Class 1 system at the north end of Lake Desire, has been impacted by past logging and the impoundment of water behind Lake Desire Road, which floods frequently during winter storms. Water quality in the lake and the integrity of the wetland are at risk if areas near the lake are allowed to build out under current zoning.

Wetland 28 is an 83-acre, Class 1 system that includes Spring Lake. Sixty-eight acres of the wetland near the southeast shoreline comprise an extraordinarily high quality

Sphagnum/Labrador tea fen and hemlock swamp. Wetland 28 is the most pristine wetland examined within the basin planning area. Unfortunately, large areas adjacent to the wetland could be cleared and filled for homesites, roads, and utility lines. Without preventative measures, development around the lake could adversely affect the fragile biochemical balance that enables this system to exist.

Wetland 42 includes Peterson Lake, which supports salmon and a variety of warmwater species. This wetland has been affected by Petrovitsky Road SE and the Lake Youngs pipeline, which bisect the wetland. In the future, widening of the road and commercial development could further degrade this wetland unless effective mitigation measures are in place.

3.7 TAYLOR (DOWNS) CREEK SUBBASIN

Introduction

The Taylor Creek subbasin drains over 3,300 acres of gently rolling hills northeast of Maple Valley (*Map 27, Appendix B*). The mainstem of Taylor Creek (Tributary 0320), which parallels Maxwell Road SE and turns north along State Route 18, is joined by one large stream (unnamed Tributary 0321) and numerous smaller ones.

Currently, two percent of the land in here is in high-density residential uses, 49 percent is in low-density residential, and 49 percent is forested (*Map 3, Appendix B*). If this area were to be developed to the maximum allowed under present zoning, high-density residential would increase to five percent, low-density residential would nearly double to 85 percent, and only ten percent would remain forested (*Map 4, Appendix B*), so nearly all of the forested land would be converted to low-density land uses. These changes would increase peak flood flows by about 53 percent.

Presently, the most significant problem in this subbasin is flooding on the valley floor, which is exacerbated by sediment eroded from upstream. Without mitigation, future increases in runoff from development will likely result in increased severity and frequency of the flooding.

Flooding

Flooding can occur as often as yearly in the Cedar River floodplain along Maxwell Road SE (River Mile 0.4-0.8), preventing access to several homes and saturating the surrounding soil. This flooding is partly due to a culvert under State Route 18 (RM 1.2) that is inadequate to convey even moderately high flows. The excess water floods the shoulder of Maxwell Road SW and picks up sediment before flowing back into the stream channel, where the sediment is deposited.

If the box culvert is improved by the Washington State Department of Transportation as planned, flooding at the State Route 18 crossing will be reduced, but flows to the Maxwell Road reach (RM 0.4-0.8) will increase. Regardless, flooding along Maxwell Road SE is likely to occur more frequently due to increased flows caused by future development.

Erosion and Sediment Deposition

Because Taylor Creek is a low-gradient stream with relatively little development, it currently has few severe problems associated with erosion and sediment deposition. There is, however, some erosion in the steeper reaches (RM 1.2-1.6), which will likely increase due to future development under present zoning. The eroded sediment is carried to the valley floor where it fills the channel (RM 0.4-0.8), decreasing channel capacity and worsening flooding along Maxwell Road SE.

Tributaries 0321 and 0322 are presently stable but, without controls, they will likely begin to erode with future development. The eroded sediment could deposit in lower Taylor Creek, aggravating flooding problems there.

Water Quality

Nonpoint pollution in this subbasin is primarily from State Route 18, so expansion of that road could increase the pollutant loading of metals, oils, and grease to the Taylor Creek system without water quality controls. In addition to the road-related pollutants, fecal coliform levels are among the highest in the basin. It is likely that these levels are from animal waste; septic repair rates are within the regional average, but the Taylor Creek drainage has the highest concentration of small noncommercial livestock-keeping farms in the basin.

Aquatic Habitat

Taylor Creek is a major spawning and rearing stream for migrating salmon in the Cedar River basin planning area. The relatively young, but thick, stream-side vegetation, and boulders in the steeper stream reaches, provide good riparian and instream habitat. Moreover, if existing vegetation is allowed to mature, stream habitat in this system will improve. If not, the habitat could easily deteriorate.

Although impacts from State Route 18 are light because of existing buffers between the channel and the roadway, the maintenance that is done to reduce flooding where the stream is carried under the highway may explain the lack of large woody debris and streamside vegetation in at least one reach of the stream (RM 1.25-2.4).

Unnamed Tributary 0321 is a large tributary that joins Taylor Creek upstream from the

confluence with the Cedar River. Its lower reaches have been affected by animal-keeping activities, but from RM 0.2 to 0.8 it is in excellent condition and is a Regionally Significant Resource Area. Above this reach, the headwaters of Tributary 0321 are affected by agriculture, rural development, and roads.

Wetlands 49, 50,and 52 are large Class 2 systems in the headwaters of Taylor Creek, all of which have been impacted by some degree of clearing. Wetlands 49 and 50 are both affected by State Route 18 and will be further impacted by future widening of the highway without controls.

Two additional Class 2 wetlands in the Taylor Creek system, Wetlands 73 and 133, have been impacted by development, grazing, and invasion by blackberries. As is the case with other headwater wetlands in this subbasin, existing forested areas will likely be converted to low-density single-family residences and non-commercial farms without formal drainage facilities. Increased stormwater runoff volumes, summer drying, and nonpoint pollution are likely to affect these wetlands in the future.

3.8 MIDDLE CEDAR RIVER SUBBASIN

Introduction

This subbasin drains over 5,000 acres of mostly forested, rolling hills and include both the Walsh Lake Diversion Ditch and unnamed Tributary 0336 (*Map 25, Appendix B*). The diversion ditch was constructed by the Seattle Water Department in the 1920s to divert poor quality water away from the Seattle supply intake below Landsburg.

Currently, over two-thirds of this subbasin is forested and most of the remainder is in low-density residential uses. The land uses here consist of four percent high-density residential uses, 19 percent low-density residential, and 77 percent forest (*Map 3, Appendix B*). If this area were to be developed to the maximum allowed under current zoning, high-density residential would increase to nine percent, low-density residential would increase to 40 percent, and 51 percent would remain forested (*Map 4, Appendix B*). Although most of the area that drains into the Walsh Lake Diversion Ditch will remain forested, 30 percent of the forested land draining into Unnamed Tributary 0336 could be converted to low-density residential uses. This conversion, in addition to conversion of some areas to high-density uses, could cause increases in peak flood flows of 48 percent.

Flooding

There is some minor flooding in the unnamed Tributary 0336 subbasin, both on the plateau and in the river valley, all occurring where streams flow through culverts under roads. Although this type of road flooding is fairly common in this subbasin, particularly along Dorre Don Way

SE, it does not pose a threat to public safety, but significant flooding does occur in the Dorre Don area due to flows from the mainstem of the Cedar River.

Erosion and Sediment Deposition

The banks of unnamed Tributary 0336 are generally stable and vegetated, but some minor erosion occurs in the steeper reaches as the channel drops from the plateau to the river valley where sediment deposits in a wedge-shaped accumulation, called an alluvial fan. As flows increase due to future development, severe erosion in the steeper reaches will likely add sediment to the fan, which could aggravate local flooding unless preventative steps are taken.

Where the Walsh Lake Diversion Ditch flows down the valley wall, the stream has cut deeply into the glacial sediment over which it flows, forming a canyon. Material from the eroded canyon has also formed a large alluvial fan near the confluence with the Cedar River and has delivered high volumes of coarse sediment to the mainstem. Considering that the canyon is still actively eroding 70 years after the construction of the channel, it is likely that erosion will continue for some time.

Water Quality

There are elevated levels of nutrients and bacteria in unnamed Tributary 0336, which seem to be associated to numerous failing septic systems.

In the Walsh Lake Diversion Ditch, one out of the three samples taken showed metals that exceeded standards, and fecal coliform standards were marginally exceeded in two of the samples. These are not excessive and could be due to wildlife contributions from within the Seattle watershed. According to modeling, pollutant loadings are expected to increase slightly, the most significant increase being phosphorus due to future conversion from forest to low-density residences around Wetland 64.

Aquatic Habitat

Habitat in the two drainages in this subbasin are quite different. Unnamed Tributary 0336 is dry for most of the year above the Cedar River valley floor, so it has limited habitat value, although migrating salmon do use the valley floor reach seasonally for spawning and for shelter during winter storms. Trout are found up to RM 0.8, even in reaches that are seasonally dry. In the headwaters, Wetland 77 provides natural flood storage and water quality protection for lower reaches of the stream.

Because it is a recently created artificial channel, the Walsh Lake Diversion Ditch is a geologically young system and its habitat is still evolving. The stream is still in the process of

eroding its channel, leaving bare areas along the banks as a result of landsliding. Thick underbrush and deciduous trees blanket more stable bank areas and, in places, there is good habitat where large woody debris has fallen into the channel from above. This young system shows promise of becoming an increasingly valuable habitat as it matures. However, fish access near its mouth can be blocked during low flows because the stream soaks into the permeable gravels of the alluvial fan.

Although extensive clearing has occurred along the south half of Wetland 64, the upper end of the wetland is in very good condition and provides significant habitat for migratory waterfowl and other animals.

3.9 ROCK CREEK SUBBASIN

Introduction

The Rock Creek subbasin, which drains over 7,000 acres in the southeast corner of the basin planning area (*Map 28, Appendix B*), is the least disturbed and most pristine of the five tributary subbasins. Both Rock Creek (Tributary 0338) and its south fork (Tributary 0339) occupy gently-sloping channels, though the creek channel steepens where it flows down the valley wall to the Cedar River.

Currently, the majority of land is forested though there are a few small concentrations of residential and commercial development in this subbasin with a scattering of rural land use. This pattern is reflected by the percentages of different land uses in the subbasin. Two percent is currently in high-density residential uses, 12 percent is in low-density residential, and 86 percent of the subbasin is forested (*Map 3, Appendix B*). If this area were to be developed to the maximum allowed under current zoning, high-density residential would increase to seven percent, low-density residential would increase to 42 percent, and 51 percent would remain forested (*Map 4, Appendix B*). This conversion of forest cover would increase the peak flood flows by as much as 68 percent, which could cause flooding and erosion problems and degrade the water quality and habitat of the Rock Creek subbasin unless effective preventative measures are in place.

Flooding

Flooding is generally neither common nor serious in this subbasin. This is due not only to the low intensity of development but also because the outwash soils here are very permeable and allow water to soak into the ground rather than accumulate on the surface. If, however, future development causes increased flows as expected, the relatively minor flooding of roads in this subbasin will increase and could become significant without preventative measures. In addition, future flooding is likely to occur where the stream flows through culverts under SE 248th Street

and under the Summit-Landsburg Road.

Erosion and Sediment Deposition

There is currently very little erosion or subsequent sediment deposition in this subbasin. This is partly due to its limited development but also because low-gradient, heavily vegetated streams do not experience the severe erosion that occurs in steep or poorly vegetated stream channels. Even with future development, further erosion problems are unlikely on the low-gradient reaches of Rock Creek and its tributaries. However, the steeper reaches, which carry Rock Creek down the valley wall to the Cedar River, experience more energetic flows that can transport more sediment. Although presently stable, severe erosion of these reaches is likely in the future as a result of future development unless these flows are controlled.

Water Quality

Water quality in Rock Creek is thought to be very good, although few data are available for this subbasin. It is still quite rural here and the low-intensity land uses have had relatively little impact on the water quality. Only low levels of nonpoint pollution were found and septic failure rates are among the lowest in the basin, although the latter are likely to increase as these fairly new systems age.

Most of the existing forestry operations within the basin planning area are located in Rock Creek. Currently, most of the acreage is in the early stages of regrowth. Future harvest in 30 to 50 years will require controls to prevent excessive sediment loading of the natural drainage system.

Nonpoint pollution is likely to increase as the subbasin builds out. Because the development will be low density, which does not require mitigation, these increases could be significant. In addition, phosphorus loadings in Wetland 82 are predicted to increase significantly. These increases in pollutant loads may jeopardize the quality of drinking water supplies that are withdrawn from Rock Creek by the City of Kent at RM 1.7.

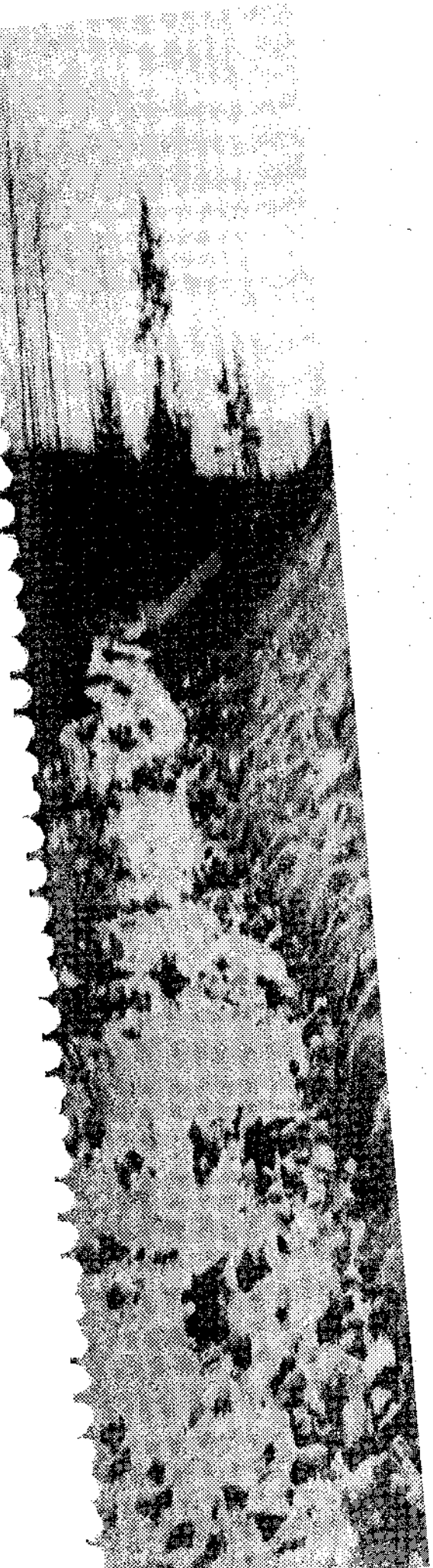
Aquatic Habitat

Rock Creek, which contains some of the best habitat in the basin and perhaps in the entire Lake Washington basin, is an important stream for all salmonid species found in the Cedar River basin planning area. The minimal development here has left much of the streamside vegetation in place to reach maturity. This tributary exhibits some excellent examples of how large woody debris provides channel stability and a variety of stream habitats. Because of the high-quality of habitat in this subbasin, the reach of Rock Creek from River Mile 0.0 to 2.5 has been designated a Regionally Significant Resource Area.

Currently, the most notable habitat concern in the Rock Creek subbasin is the City of Kent's permitted water withdrawal, which can lower flows to the extent that chinook and sockeye salmon cannot migrate upstream to spawn in autumn. These low flows are further aggravated by a diversion of water from Lake No. 12 away from Rock Creek into the Green River. In addition, there is a reach upstream (RM 0.3-0.8) where large woody debris is scarce, and near the headwaters (RM 2.5-2.65) the streambanks have been trampled by livestock and cleared of riparian vegetation. Because Rock Creek is expected to experience one of the highest increases in flows of all the subbasins, and because the streamsides are not protected from development by the steep banks common to streams elsewhere in the basin planning area, it is likely that increases in both flows and development will degrade habitat in this subbasin.

There are four large wetlands along Rock Creek. The system around Lake No. 12 consists of Wetlands 91 and 92, which field inspection reveals to be one 134-acre wetland. Three quarters of the shoreline of Lake No. 12 is bordered by residential yards but the east end is fringed by cattails and dense shrubs and trees. This shallow, eutrophic lake is prone to algal blooms and Eurasian milfoil growth in the summer. Future projections for this lake are mixed: as reforested areas mature, conditions will improve, but these improvements may be offset by the effects of increased development. Wetlands 93 and 94 downstream from Lake 12, have both been affected by logging, but as in the case of Lake No. 12, conditions will improve as reforested areas mature.

There are also two large, isolated wetlands in this subbasin, Wetlands 82 and 87. Although Wetland 82 (Hidden Lake) has been affected by clearing and off-road vehicles, it provides good habitat for warmwater fish and a variety of birds, amphibians, and mammals. Wetland 87 is generally well protected from intrusion by dense vegetation except in the southeast corner where horses have grazed and trash has been dumped.



Appendix A

Observed Conditions Summary

Appendix A

Cedar River Basin Observed Conditions Summary

RENTON REACH (RM 0.0 TO RM 1.6)			
River Mile	River Bank	Subject	Description
0.0-1.6		SED **	Current: Sediment deposited in the channel raises the river bed, which reduces channel capacity and causes more frequent flooding. The channel was last dredged prior to 1982. Future: Sediment will continue to deposit in the channel due to its low gradient.
0.0-1.6		HABITAT	Current: Habitat degraded by fine sediment deposition, poorly developed riparian area, and low habitat complexity. Future: As sediment accumulates, spawning habitat quality will be reduced.
0.0-1.6		FLOOD **	Operations at Renton Municipal Airport are impacted by the 5-year flood. During the November 1990 flood, the basements of City Hall and the Carco Theater received minor damage, and the Municipal Airport was prevented from operating. This problem will probably get worse as the channel continues to receive sediment.
0.1		WATER QUALITY *	Cedar River Park drainage ditch; Sampling site CR1, S1: Stormwater: Cu, Pb & Zn exceeded acute and chronic toxic levels. FC levels of 380-1800 org/100 ml. Sediment: Detected several semivolatiles at an outfall.
1.0		WATER QUALITY *	Outfall; Sampling site S3: Sediment: Detected several semivolatiles.
1.1		WATER QUALITY **	Logan Avenue Bridge; Sampling site CR2, S4: Stormwater: Cu, Pb & Zn exceeded acute and chronic toxic levels. FC levels of 2500 org/100 ml. TP exceeded recommended levels. Sediment: Levels of TP, FOG & %volatiles are in the "Heavily Polluted" range; Cu levels are 36 times, Pb levels are 176 times & Zn levels are 18 times the DOE guidelines for "Heavily Polluted."
1.5		WATER QUALITY	Bronson Way Bridge; Sampling site CR3, O438: Stormwater: FC levels of 60-1840 org/100 ml. All other below standards or recommended levels.
1.6		WATER QUALITY **	I-405 Outfall (& Renton urban areas); Sampling site CR4, S5: Stormwater: TSS, Turb & TP exceed recommended levels. Cu, Pb & Zn exceed acute and chronic toxic levels. FC levels of 1400-4600 org/100 ml. Sediments: Cu, Pb & Zn in "Moderately Polluted" range (DOE guidelines).

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LOWER CEDAR RIVER MAINSTEM (RM 1.6 TO 16.2)			
River Mile	River Bank	Subject	Description
Entire Length		HABITAT	Current: Habitat in this reach is extensively affected by dikes and revetments and by degraded riparian conditions.
Entire Length		WATER QUALITY **	Septic tank failure rates (15.4, 13.8, 16.5%) indicate a likely water quality problem.
1.6-2.2		SED	Current: Sediment deposited in the channel raises the river bed, which reduces channel area and causes more frequent flooding. The channel was last dredged prior to 1982. Future: Sediment will continue to deposit in the channel due to its low gradient.
2.0	Right Bank	WATER QUALITY *	Stoneway R/D Outfall; Sampling site CR5, S6: Stormwater: pH levels of 11.3 and 11.9. Hardness was high, which reduced the metal toxicity levels. FC levels of 10-1200 org/100 ml.
2.0	Right Bank	FLOOD	Ten percent of the Stoneway Gravel processing site is inundated by the 25-year flood. About a third of the site is within the 100-year floodplain.
2.2	Right Bank	FLOOD *	The 100-year flood damages two apartment buildings, affecting an unknown number of units.
2.9		WATER QUALITY	Mainstem Wooden Bridge; Sampling site CR6, S7: Stormwater: TP & TSS above recommended levels. FC levels of 140-400 org/ ml. Sediment: 2,4,5-T (pesticide) detected at just above the detection limit.
3.5-4.2	Right and Left Banks	HABITAT	Current: No large woody riparian vegetation due to development on the right bank and a slide on th left bank, which is a potential source of sediment.
3.5-4.2	Right Bank	FLOOD	The HEC-2 model indicates none of the homes in Maplewood are within the 100-year floodplain. Several homes were reportedly threatened by the November 1990 flood.
3.9	Left Bank	SED *	Current: A revetment was constructed at the toe of this steep, slide-prone hillside in 1972 to prevent further undermining of the slope by the river. The hillside remains unstable, however, due to natural geologic conditions and runoff from upslope developments. The most recent failure, in 1987, released approximately 30,000 cubic yards of mostly sandy sediment into the river. Severe surface erosion of the landslide is still occurring, caused largely by subsurface flow. Future: Repairs to the slide have not adequately controlled subsurface drainage. Renewed landsliding is likely and could involve fill materials placed at the toe of the slide as well as the original hillside. (See also Lower Cedar River Subbasins, unnumbered channel at Cedar RM 3.9, left bank.)
4.2-5.0	Left Bank	FLOOD	A portion of the eastern part of the City of Renton's Maplewood Golf Course facility is within the 10-year floodplain; a small additional amount is within the 100-year floodplain. This area was flooded during the November 1990 storm, but suffered no major damage. The foundation of the eastern abutment of the abandoned railroad bridge at RM 4.2 was partly exposed, and the nearby bank suffered damage to its protecting rock. (See also Lower Mainstem Subbasins, Maplewood Creek: Tributaries 0302, 0303, and 0303A.)

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Right and Left Bank designations are assuming the observer is facing downstream.

4.4-5.0	Right Bank	SED *	In this reach, the river flows at or near the base of a slide-prone hillside. In 1968 a revetment was constructed at the toe of a large landslide between RM 4.9 and 5.0. Although no major slides have occurred in several decades, there is continued minor sliding and erosion. Future: River migration could potentially undercut the hillside and cause a major landslide; this is most likely at RM 4.4-4.6.
5.0	Left Bank	FLOOD ***	Two homes located on the left bank of the Cedar River and three on the right immediately downstream of the Elliot (Lower Jones Road) Bridge are within the 10-year floodplain and are subject to deep, fast flows during the 100-year event. Upstream of the bridge, there are 2 homes in the 25-year floodplain and a total of 7 in the 100-year floodplain. There are additional homes that are sufficiently elevated, but their access would be blocked by the 100-year flood.
5.3-6.5	Right Bank	FLOOD **	Twenty homes located on the right bank of the river and Jones Road are within the 25-year floodplain. A total of 45 homes are within the 100-year floodplain. Some have experienced ground subsidence, washouts, and the loss of bank armoring. Flood flows have eroded the rubble and concrete levees, and have overtopped and damaged Jones Road, beyond.
6.8	Right Bank	HABITAT *	Current: A wall-based tributary (approximately 0.25 miles in length) with salmon use has been impacted by development in the floodplain. Future: Local development threatens an existing natural channel and spring area.
6.8	Right Bank	FLOOD *	There is one home downstream from and opposite the Riverbend Mobile Home park that is at risk of flooding during the 100-year flood.
7.0	Left Bank	FLOOD	The November 1990 flood washed out the levee protecting this facility, undermining twelve mobile homes. The owner of the park has rebuilt the revetment.
7.4	Right Bank	FLOOD *	Two homes, apparently above the 100-year flood stage, were severely damaged by flood flows when the existing levee was overtopped and eroded during the November 1990 flood.
8.4 *Wetland 37 RSRA*		HABITAT *	Wetland and buffer filling in Wetland 37 at a King County construction staging area.
9.2		WATER QUALITY	Jones Road Bridge; Sampling site A438: METRO ambient sampling point. Data inconclusive but indicate possible metal toxicity during baseflow.
9.4 *RSRA from 9.6-10.7*	Right Bank	SED	Current: This is a chronic slide area; bedrock at the toe of the slope prevents massive landsliding. Future: Periodic sliding is likely, but the contribution of sediment will probably be relatively small compared to other landslides on the river.
10.6 *wetland 105 LSRA*		HABITAT *	Scattered garbage and localized trash dumping in Wetland 105.
10.6 *RSRA from 9.6-10.7*	Left Bank	FLOOD *	The river makes a 90 degree bend to the left downstream of the Rainbow Bend Mobile Home park. The 6 homes located within the bend are within the 100-year floodplain; all were damaged during the November 1990 flood.
11.2	Right Bank	FLOOD ***	Four permanent houses and 55 mobile homes are within the 10-year floodplain and are subject to deep, fast flows during the 100-year event. Flows have repeatedly overtopped and damaged the levee, causing significant damage to county roads and to numerous private residences. Flooding also prevents access to many residences.

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Right and Left Bank designations are assuming the observer is facing downstream.

11.3	Right Bank	WATER QUALITY *	Metal recycling facility.
11.4-12.2	Left Bank	FLOOD ***	The area between Cedar Grove Road's intersection with SR-169 and RM 12.2 floods during the 10-year. 15 homes and are subject to deep, fast flows during the 100-year event.
11.5 *this is an RSRA*	Left Bank	HABITAT	This wall-based tributary ("McDaniels Channel") is affected by grazing, but the impact is not severe.
11.6-11.8	Right Bank	SED	Current: The river flows against an unvegetated bluff of glacial sediments, which has eroded back through shallow landslides at average rates of up to 20 feet per decade since 1936. Future: Erosion will continue.
12.3	Right Bank	SED	Upstream left bank levees at RM 12.5 help direct flows into an eroding cliff with periodic landslides.
12.4	Left Bank	FLOOD *	This is a very tight bend in the river; momentum of the water has repeatedly caused overtopping of this levee and damage to roads and homes. Thirty homes are within the 100-year floodplain; 12 homes are inaccessible during the 25-year flood.
12.9	Right and Left Banks	HABITAT *	Current: A percolation side-channel (0.3 miles in length) has an artificial barrier to fish at the mouth. Habitat is affected by heavy equipment crossing the channel.
13.0	Right Bank	FLOOD ***	Flood flows leave the channel above Jan Road (SE 197th Place), damage residences and roadways with flooding and scour, then return to the mainstem at RM 12.1. There is one home within the 10-year floodplain, which is subject to deep, fast flows during the 100-year event. There are 3 homes within the 25-year floodplain, and 7 within the 100-year floodplain. Access is prevented to several homes during the 25-year event.
13.6 *Wetland 132 LSRA*		HABITAT **	Wetland and buffer clearing in Wetland 132.
13.6	Left Bank	FLOOD ***	Two homes are located within the 10-year floodplain and are subject to deep, fast flows during the 100-year event. 3 homes within the 25-year floodplain, and 21 are within the 100-year floodplain. Several residences and two roads were damaged by water and deposited sediment during the November 1990 flood.
13.8-14.7	Right and Left Banks	FLOOD ***	The SR-169 and SR-18 bridges may be restricting flows, raising the backwater elevations in portions of this area. There are 9 homes located in the 10-year floodplain, two of which are and are subject to deep, fast flows during the 100-year event. 16 homes are within the 25-year floodplain, and 21 are within the 100-year floodplain.
14.2-14.3	Left Bank	SED	Intermittent sloughing of valley wall where undercut by the river.
14.9 *this is an RSRA*	Left Bank	HABITAT	This extensive wall-based tributary is lightly affected by development and landscaping efforts.
15.7-15.9 *this is an RSRA*	Right Bank	HABITAT	This year-round side-channel is confined by development but is otherwise healthy.
15.8	Left Bank	FLOOD	The Coleman-Lotto levee suffered erosion during the November 1990 flood, but no serious damage resulted.
15.9 *this is an RSRA*	Left Bank	HABITAT	This percolation side-channel has low LWD levels and some runoff from pastures.

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Right and Left Bank designations are assuming the observer is facing downstream.

LOWER CEDAR RIVER SUBBASINS			
Tributary	River Mile	Subject	Description
0300A Ginger Creek	Entire Length	WATER QUALITY **	Comparison of land-use based modeling (for TSS, TP, and Pb) and monitored water-quality data from other catchments indicates that a water quality problem is likely to exist.
	0.0	HABITAT	Culvert is a partial barrier to approximately 0.2 miles of potential coho and trout habitat.
	0.2-0.4, 0.45-0.6	SED	Current: At these locations there is minor streamside landsliding and channel incision and widening that becomes severe between RM 0.2 and 0.3. Future: Relatively small future flow increases are predicted so the channel should eventually stabilize.
	1.3-1.6	FLOOD	Current: Localized poor drainage, yard flooding, basement dampness. Future: This condition is likely to continue.
0302 Maplewood Creek	Entire Length	WATER QUALITY **	Septic tank failure rates (15.4, 13.8, 16.5%) indicate a likely water quality problem.
	0.0-0.5	HABITAT	Current: Habitat is affected along the golf course and by an 800' culvert under SR-169 and an old railroad grade; there is also a complete fish blockage at RM 0.5 caused by sediment ponds used to protect the golf course. Future: The City of Renton is debating the creation of a low-flow channel and high-flow by-pass channel.
	0.2	FLOOD *	Current: Concrete culvert under SR-169 is now adequate for about the 50-year flow. Future: Approximately the 2-year storm will cause flooding under future unmitigated scenario, flooding the Maplewood Golf Course and possibly SR-169.
	0.2-0.4	FLOOD	Current: The Maplewood Golf Course floods during large storms, possibly due to an inadequate culvert parallel to the driveway and sediment in the channel. Future: These flows are projected to increase significantly, so this problem will only get worse. The City of Renton is planning to enhance the sediment ponds. As a separate project, they are also planning to add a low-flow (habitat) channel to divert some flows from the lowest reach of Maplewood Creek (RM 0.2) to the north, away from the driveway.
	0.3	WATER QUALITY **	Maplewood Golf Course; Sampling site CR7, S8: Stormwater: TSS, Turb, TP, NO3&NO2-N above recommended levels. FC levels of 420-3200 org/100 ml. Sediment: Dicamba (pesticide) detected.
	0.5, 0.6 *LSRA from 0.5-1.1*	SED	Current: Existing ponds are sometimes inadequate to trap the significant sediment load from upstream. The subsequent siltation of the channel downstream aggravates flooding. Future: The sediment load is likely to increase in response to flow increases from future development.
	0.55 *LSRA from 0.5-1.1*	SED	Current: Erosion and downcutting of a right-bank channel delivers fine-grained sediment to Maplewood Creek. Future: Continued fine sediment source.

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0302 (cont)	0.7 *LSRA from 0.5-1.1*	SED	Current: A small gully on the right bank is fed by culvert outfall and flow from springs. Future: The gully will continue to grow upstream, contributing to future sediment production.
	0.9-1.2 *LSRA from 0.5-1.1*	SED *	Current: Slow-moving landslides in glaciolacustrine deposits undercut by the stream are a chronic source of fine-grained sediment. Future: Not only is this condition likely to continue, but future flow increases could accelerate landslide movement by causing channel incision in this reach.
	0.95 *LSRA from 0.5-1.1*	SED *	Current: A large left-bank gully, fed by a culvert outfall, has deposited sediment in a fan in the creek. Future: The gully will continue to grow, contributing to future sediment production.
	0.95	WATER QUALITY **	Maplewood Creek: Sampling site 7A Stormwater: Extremely high TSS, Turb & TP levels. Cu, Pb & Zn above acute and chronic levels.
	1.0-1.4 *LSRA from 0.5-1.1*	HABITAT *	Current: Sediment deposition from gullies created by daylighted culverts and channel erosion are severely affecting habitat; trash, especially old tires and appliances in stream; low amounts of effective LWD in channel. Future: No change.
	1.05 *LSRA from 0.5-1.1*	SED *	Current: A large, right-bank ravine has eroded below the outfall of a culvert that overhangs a 40-foot-high scarp. The eroded material has collected to form a small sediment fan at the mouth of the ravine. Future: Erosion is likely to continue, but at a reduced rate.
	1.2	SED	Current: Left-bank landslide at culvert outfall. Future: Continued minor sediment production.
	1.25-1.4	SED *	Current: In this reach there is severe channel incision and bank erosion in outwash sand. Future: Future flow increases will worsen this condition.
0303 East Fork Maplewood Creek	0.0-0.2 *LSRA from 0.0-0.2*	HABITAT *	Current: Good habitat is threatened by channel erosion and sediment deposition Future: Sediment from upstream erosion will threaten this reach.
	0.2-0.4	SED *	Current: In this reach there is severe channel widening and incision in outwash sand and silt. Future: The affected area is likely to extend upstream through knickpoint migration; future flow increases would worsen this condition.
	0.2-0.6	HABITAT	Current: Heavy erosion of the stream channel degrades local habitat and exacerbates downstream habitat problems. Future: Problems will worsen as flows increase due to urbanization.
	0.4-0.8	FLOOD/ WATER QUALITY **	Current: The pipes that carry the creek through Puget Colony Homes are inadequate for storms above a two-year intensity. Yards and homes are damaged, roads are repeatedly flooded, and there are complaints that septic systems become saturated, allowing contaminants to enter the surface water. Future: There will likely be large increases in flows from upstream that will cause flooding and septic system failures to occur more frequently. Unfortunately, improved conveyance through Puget Colony would cause an increase in erosion downstream.
	0.6-1.2	HABITAT	Continued fragmentation of stream channels and wetlands by urban development will degrade local habitat and exacerbate downstream habitat problems.

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0303 (cont)	1.0-1.2	HABITAT *	Extensive wetland and buffer clearing, filling, and trash-dumping in Wetland 150 has reduced this wetland's natural flood storage, water quality, and habitat functions, thereby impacting a downstream RSRA.
0303A	0.4	FLOOD **	Current: A culvert carrying this small tributary under SE 132nd Street is inadequate for flows in excess of the two-year storm. Its backed up water regularly floods the SE 132nd Street /146th Avenue SE intersection, prevents access to homes on the east, and enters the Tributary 0307 catchment. Future: Flooding will increase with development; increasing the capacity of this crossing will add some flow in Tributary 0303 and contribute somewhat to the erosion there.
unnumbered channel Cedar RM 3.9, Left Bank		SED	Current: Runoff from this gully may have triggered a large landslide into the Cedar River in 1987. (See Lower Cedar River Mainstem, RM 3.9) Future: Continued erosion of the gully will occur, adding sediment to the landslide deposit and further destabilizing this naturally unstable slope. Revetment and sediment control structures have been built at the foot of the slide area to reduce sediment delivery to the Cedar River.
0304 Molasses Creek	Entire Length	WATER QUALITY **	Comparison of land-use based modeling (for TSS, TP, and Pb) and monitored water-quality data from other catchments indicates that a water quality problem is likely to exist.
	0.0-0.2	HABITAT *	Poor habitat (low quality riffle area, low LWD levels) in vicinity of gravel pit operations.
	0.2-0.8 *LSRA from 0.2-0.8*	SED *	In the future, severe channel incision could occur in this reach if flows increase.
	0.6 *LSRA from 0.2-0.8*	SED	Current: There is a gully and a landslide scar in the power-line corridor. Future: Continued minor erosion is likely as the slide scar ravels.
	0.65-0.8 *LSRA from 0.2-0.8*	HABITAT	Trash in stream; at RM 0.8 there is a blockage to fish passage where a culvert outfall is stranded above the streambed.
	0.8	SED	Current: There is erosion of the left bank at a culvert outfall. Several shallow landslides on ravine walls have now revegetated. Future: Continued minor erosion is likely.
	0.8-2.0 *Wetlands 2, 22, and 23 LSRA*	HABITAT	Current: Stream habitat is fragmented by culverts and channelization. Future: Habitat and buffering provided by Wetlands 2, 22, and 23 will protect the channel. Water quality may have an affect on the existing fish population.
	1.0	FLOOD *	Current: During 25-year and larger storms, water ponds between 132nd and 133rd Place SE, in an inadequately-sized detention area behind an access road in the SWD right-of-way south of SE Fairwood Blvd. Of two houses built lower than subdivision requirements, one suffered flood damage and another is threatened. Future: Projected increases in flows would make this problem worse.
	1.8	FLOOD **	Current: SE 180th Street floods at approximately the 5-year flow, preventing access to residences. Future: Flows will increase, making road flooding and access problems more frequent.

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0304 (cont)	2.0 *Wetland 22 LSRA*	FLOOD **	Current: The 140th Ave SE crossing spans Wetland 22, at RM 2.2. The low point in this arterial and the surrounding properties experience flooding almost annually. This crossing has a capacity of 26 cfs, or about a 5-year storm. Future: Most of the area above where 140th Ave SE crosses Wetland 22 is currently undeveloped, so future flows will probably be significantly higher, causing deeper and more frequent flooding.
	2.0 *Wetland 22 LSRA*	HABITAT *	Class 1-rated Wetland 22 has been converted into an R/D pond for a subdivision. The pond access road causes chronic buffer impacts and is a conduit for trash dumping. Thick brown foamy water was observed in Molasses Creek near the pond outlet.
	2.4 *Wetland 23 LSRA*	HABITAT	Filling near outlet of Class 1-rated Wetland 23. Future: This wetland will be encircled by a 77-unit subdivision.
0304A	0.2	HABITAT *	Extensive filling, grading, and debris dumping in Wetland 2 south of Petrovitsky Road.
0305 Madsen Creek	0.0-0.8	SED	Current: Fine sediment has been deposited in the channel, significantly reducing its capacity; the capacity of the sediment pond at RM 0.8 was exceeded in 1990.
	0.0-0.8	HABITAT *	Current: An artificial "low-flow" channel here provides low habitat value. Also, fine sediment moves through poorly functioning sediment pond at RM 0.8, and a high-flow by-pass channel traps fish. Future: Habitat will continue to function poorly.
	0.8 *LSRA from 0.8-2.15*	WATER QUALITY **	Madsen Creek (upstream from sediment pond); Sampling site CR9, S10: Stormwater: TSS, Turb, & TP exceeded recommended levels. Cu & Zn exceeded acute and chronic toxicity. FC levels of 520-6800 org/ ml. Sediment: No pollutants detected.
	0.8-2.15 *LSRA from 0.8-2.15*	HABITAT/ WQ *	Current: Ravine habitat above and below the confluance with Tributary 0306 has been affected by management activities associated with the METRO sewer line. Future: Habitat recovery from landslide on Tributary 0306 may be impaired by activities associated with METRO sewer line and ravine stabilization efforts.
	0.85-1.5 *LSRA from 0.8-2.15*	SED/WQ	Current: This channel reach is generally stable, although local bank erosion has exposed a METRO sewer line in a few places.
	1.5 *LSRA from 0.8-2.15*	WATER QUALITY *	Madsen Creek; Sampling site S11: Sediment: 2,4-D (pesticide) detected at 66 ug/kg, 7 times the detection limit.
	1.5-1.6 *LSRA from 0.8-2.15*	SED *	Current: There is downcutting and bank erosion in this reach.
	1.6, 1.8 *LSRA from 0.8-2.15*	SED	Current: Logjams on the east fork of Madsen Creek trap sediment and prevent incision from progressing upstream. Future: Removal or failure of these logjams would lead to rapid erosion and downcutting.
	1.85-2.1 *LSRA from 0.8-2.15*	SED *	Current: There is active widening and incision of the channel. Three recent landslides on the right bank may have been caused by disturbance from the sewer-line road. Future: Continued erosion is likely. However, the road crossing at RM 2.15 (162nd Ave. SE) will prevent erosion upstream of that point.

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0305 (cont)	2.15	HABITAT	Culvert under 162nd Ave SE is a complete barrier; cutthroat trout exist upstream.
	2.15-2.5	HABITAT	Current: Habitat fragmented and constrained by development; some localized reaches provide good habitat for trout. Future: Habitat will be degraded if Wetland 16 is further affected by development.
	2.6 *Wetland 16 RSRA*	HABITAT/ WQ **	Dredging and filling near the outlet of Class-1 rated Wetland 16. Water quality modelling indicates this wetland will undergo the highest percentage increase in future pollutant loads of any SRA wetland in the basin.
0306 West Fork Madsen Creek	0.0-0.1 *LSRA from 0.0-0.25*	SED/WQ **	Current: Over 15 feet of downcutting have occurred here, with associated landsliding and channel widening, which has left gas lines suspended in the air and has damaged a METRO sewer line.
	0.0-0.2 *LSRA from 0.0-0.25*	HABITAT *	Current: Habitat degraded by erosion from high flows and sewer and pipeline failure; impassable culvert (Fairwood Blvd.) at golf course at RM 0.2. Future: Habitat will be degraded by active incision and by efforts to stabilize the channel.
	0.1-0.2 *LSRA from 0.0-0.25*	SED *	Current: Here the channel is much narrower than downstream, with active incision and minor landsliding. Future: Further incision and substantial widening are likely as the channel adjusts to past changes.
	0.2-1.0 *LSRA from 0.0-0.25*	HABITAT	Current: Habitat fragmented and constrained by development; some localized reaches provide good habitat for trout. Future: No changes anticipated.
	0.3-0.45	SED	Current: Downcutting and widening have occurred in till. Future: Slow channel enlargement will continue to occur.
	0.7	HABITAT *	Extensive filling has severely reduced Wetland 18's natural flood storage, water quality, and habitat functions, resulting in a loss of buffering of a downstream LSRA. One half acre of the wetland and riparian zone was recently cleared as a neighborhood beautification project.
	1.3	HABITAT	Approximately 60% of Class-1 rated Wetland 25 and the entire buffer were eliminated during construction of homes and a subdivision R/D pond.
0306A		HABITAT	Habitat fragmented by golf course and development.
0307 Orting Hill	Entire Length	WATER QUALITY **	Septic tank failure rates (13.1%) indicate a likely water quality problem.
	0.0-0.2	HABITAT	Stream confined to long culvert blocking upstream passage.
	0.2	WATER QUALITY **	Jones Road Trib.; Sampling site CR8, S12: Stormwater: TSS, Turb, TP & NO2&NO3-N exceeded recommended levels. Acute and chronic levels of Cu & Zn. FC levels of 420-9600 org/100 ml. Sediment: No pollutants detected.
	0.2	SED	Current: In the past, a catch basin filled with sediment and plugged a culvert during major floods. Future: Inlet replacement and a bank stabilization project under construction upstream may reduce sediment problems. (See RM 0.4-0.0.5, below.)
	0.3	HABITAT	A culvert under a private driveway is a potential barrier.

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0307 (cont)	0.4-0.5	SED	Current: Bank erosion and discharge from daylight culverts have caused streamside landslides. Future: A left bank stabilization project currently under construction will protect some of the affected streambanks, but future flow increases could initiate channel incision and additional streamside landslides on the right bank.
	0.4-0.5	HABITAT	Current: Habitat is impacted by culvert failure of Orting Hill Road and past road management activities. Future: A channel stabilization effort by the County will increase quantity and stability of pool habitats.
	0.5-0.7	HABITAT	Current: There is very good habitat in forested park setting; an upstream channel is culverted under a large development.
0308, 0309, & 0310	Entire Length	WATER QUALITY **	Comparison of land-use based modeling (for TSS, TP, and Pb) and monitored water-quality data from other catchments indicates that a water quality problem is likely to exist.
		SED	Current: These channels are generally stable upstream from Jones Road, with some widening and only minor incision, with the exception of a short section of 0309 at RM 0.2. Future: If unmitigated, future flow increases could result in severe downcutting and erosion of steep reaches.
0309	0.2	SED	Current: There is a 100-foot-long, severely eroding channel with a headcut. Future: The headcut will progress upstream and threaten the SE 143rd St. road crossing, 60 feet upstream.
	0.8	FLOOD	The crossing under 175th Avenue SE appears to be undersized, causing nuisance flooding.
0310	0.1	FLOOD/ SED	Current: The channel here fills with sediment and changes course with larger flows, causing flooding of yards and possibly threatening homes. Future: No increase in flows, and therefore no increase in flooding, is expected.
0311 Summer-field	0.2-0.55	SED	Current: Sediment deposition problems at the mouth of the ravine have led to construction of a sediment basin. A debris flow occurred on this steep channel in 1990. The channel is deeply incised, with widespread bank slides and erosion. The major part of the flow has since been tightlined to the valley floor, bypassing the ravine. Future: Ravine walls should eventually stabilize.
0313	0.15-0.45	FLOOD/ SED *	Current: This channel has severe incision, bank erosion, and landsliding. Sediment deposition at the mouth of the ravine contributes to flood damage at a mobile home park. A debris flow reportedly occurred on this channel in the 1930s. Future: Continuous, severe sediment production is likely and could worsen if flows increase with future development.
0314	0.2-0.4	SED	Current: Channels are deeply incised and there is bank erosion on both the mainstem and 0314B. 0314A is stable except near its mouth, where a headcut is progressing upstream; riprap controls erosion at the downstream end of mainstem 0314. Future: Erosion is likely to continue on the mainstem and 0314B. The headcut on 0314A is likely to move upstream and could potentially destabilize a 600-foot-long reach of channel.
0315B	0.1	SED	Current: There is bank erosion and channel incision in one fork of this stream, with a sediment fan below.

*** Extremely Significant
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0316	Entire length *LSRA from 0.0-0.3*	HABITAT/ WQ *	Current: Water quality and quantity of this wall-based tributary is affected by the Stoneway Gravel Mine at the headwaters. Rainbow Bend Trailer Park confines habitat along the valley floor. This tributary flows into an RSRA Future: Unmitigated work by Stoneway will continue to threaten habitat. There is much potential for habitat improvement of this site.
0316A	0.0-0.2 *LSRA from 0.0-0.45*	HABITAT *	Current: The Stoneway Gravel Mine and the Cedar Grove Composting Facility are affecting water and habitat quantity and quality of the stream, including a downstream LSRA Future: No change is expected.
		WATER QUALITY **	Cedar Grove Road.;Sampling site CR10, S13: Stormwater: Elevated TSS, Turb & TP levels. Cu exceeded acute and chronic toxicity. FC levels of 28-2800 org/100 ml.
		WATER QUALITY **	Cedar Grove Road, Runoff diversion.; Sampling site S13: Sediment: No pollutants detected.
		WATER QUALITY **	Cedar Grove Road Culvert. Stormwater sample showed high levels of TP (1030 ug/l), NO3+NO2 (3690 ug/l), Turb (340 NTU), & TSS (295 mg/l).
		WATER QUALITY **	Stoneway Gracvel. Channel connects process pond water with 0316A, contributing extremely high levels of very fine sediment.
		WATER QUALITY **	Cedar Grove Composting Facility. Stormwater sample from below the outfall showed extremely high levels of TP (6740 ug/l), NO3+NO2 (2530 ug/l), Turb (250 NTU), & TSS (257 mg/l). Background sample levels below recommended level; however, background pH was 4.6.
		SED	Current: There is severe gully erosion where the channel passes through disturbed quarry soils.
	0.1-0.4 *LSRA from 0.0-0.45*	SED	Current: The channel is generally stable, but the slope has been rocked in locations where the creek is close to Cedar Grove Road to protect bank erosion. Future: Flow increases are likely to cause channel incision, which could potentially undermine Cedar Grove Road.
	0.6-0.7	HABITAT	The stream bank has been denuded of vegetation, thereby impacting salmonid habitat.
	0.7-1.2	HABITAT	Wetlands 31, 32, and Tributary 0316A have been affected by high nutrients and turbidity in runoff from the Cedar Grove Composting Facility and the Stoneway Gravel Mine and by past channelization of the stream. The north buffer of Wetland 32 has been impacted by livestock grazing and soil compaction. These impacts have severely reduce the ability of these wetlands and the segment of Tributary 0316A connecting them to support salmonids. Revegetation has been started by the landowner.
	Isolated Habitat *Wetland 13 LSRA*	HABITAT/ WQ **	Part of the buffer of Class 1-rated Wetland 13 was removed during gravel mining. The wetland has also been impacted by toxic waste disposal within an EPA Superfund Cleanup Site and by clearing of the south buffer during gravel mining.

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unnumbered channel Cedar RM 8.0, Left Bank	0.0	WATER QUALITY	Old King County Shop Ditch; Sampling site CR11: Stormwater: TSS, Turb & TP exceeded recommended levels. Cu, Pb, & Zn were at acute toxicity levels.
		SED	Current: There is a wide, incised, severely eroding channel with a large sediment fan at the mouth of the ravine. Future: Continued erosion is likely
unnumbered channel Cedar RM 8.8, Right Bank		SED	Current: The side-slopes of the ravine were destabilized by sewer-line construction in 1991, resulting in landslides and bank erosion. Future: Not likely to change
0317	0.15-0.25	SED	Current: This small stream is presently stable. Future: Projected flow increases are likely to cause severe channel incision in this short, steep reach of the stream.
	0.2	FLOOD	Current: 21" concrete pipe under Maxwell Road SE backs up and floods partially during high flows. Future: This problem will probably increase in frequency as flows increase with development.
	0.8-1.2	HABITAT	This stream infiltrates within a former gravel mine that is currently a demolition debris landfill.
	1.9 *Wetland 36* *LSRA*	HABITAT *	There has been extensive buffer removal and ditching around Francis Lake (Class 1-rated Wetland 36). Portions of the wetland and buffer are grazed.
	Isolated Habitat	HABITAT	Filling and clearing has occurred within Wetland 39.
0334A	0.1-0.4	SED	Current: In 1990, there was damage from a debris flow, which deposited sediment at the mouth of this ravine. Runoff has since been diverted from the ravine and tightlined to the valley floor. Future: The ravine will revegetate and stabilize now that the runoff source has been removed.
unnumbered channel Cedar RM 10.5, Left Bank		SED	Current: In 1990, there was erosion of this steep ravine and sediment deposition at the mouth, reportedly caused by failure of an R/D pond.
unnumbered channel Cedar RM 11.0, Left Bank		SED	Current: Sediment deposition problems were reported at the mouth of this steep ravine in 1986, but no problems have been reported recently.

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MIDDLE CEDAR RIVER MAINSTEM (RM 16.2 to RM 21.7)			
River Mile	River Bank	Subject	Description
Entire Reach		HABITAT	Development along riverbanks is creating localized habitat problems associated with bank hardening and vegetation removal.
16.3-16.4	Right Bank	HABITAT	This percolation side channel habitat is degraded by lack of riparian habitat due to levee construction.
16.4	Right Bank	FLOOD ***	County roads and 23 homes are within the 10-year and are subject to deep, fast flows during the 100-year event. Flooding can also prevent access to many of the homes. (See "Upper Mainstem Tributaries 0336 & 0337 - Dorre Don" for a description of minor flooding where Trib 0336 crosses Lower Dorre Don Way.)
17.0	Left Bank	SED	At this bend, the river flows against a slowly-eroding bluff of glacial sediments.
17.1	Right Bank	FLOOD ***	There are two homes located in the 10-year floodplain, seven in the 25-year floodplain, and a total of 13 in the 100-year floodplain. The 100-year flood blocks access to 14 homes.
17.4-17.5	Right Bank	SED	A large, slow-moving landslide is a chronic source of silt to the river. Future: Movement will likely continue.
17.5-17.8 *these are RSRAs*	Left Bank	HABITAT **	Current: Two side-channel habitats have been affected by lack of LWD and possible regulation of flows by residents. Future: Habitat will continue to be degraded by landowners.
17.7-20.2 *this in an RSRA*	Right and Left Banks	SED	The river flows against slowly-eroding bluffs of gravelly glacial sediment at the outsides of these bends. Because erosion of these bluffs provides spawning-sized gravel to the river, this reach is an RSRA.
17.9	Left Bank	HABITAT /WQ *	Current: This off-channel pond is blocked by a railroad culvert. Habitat has been affected by landowner landscaping and horses. Future: This is a potential SRA. Water quality and habitat will continue to degrade as landowner increases landscaping effort.
18.1 *this is an RSRA*	Left Bank	HABITAT	Current: This off-channel pond at the mouth of Rock Creek lacks access for fish in Rock Creek. Future: Potential SRA.
18.1-19.0	Right and Left Banks	FLOOD *	This reach, composed of several bends in the river, includes four areas of potential flooding problems. Nine homes are located within the 25-year floodplain, and 24 are within the 100-year floodplain.
18.3 *this is an LSRA*	Left Bank	HABITAT *	Residents have disturbed a wall-based tributary in this LSRA.
19-0 *this is an RSRA*	Left Bank	HABITAT	This side channel lacks LWD and structural diversity.
19.7	Left Bank	HABITAT *	Current: A wall-based tributary is being modified by land clearing and has fish access blocked by railroad. Future: This is a potential SRA. Habitat will degrade if development activities continue.

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Right and Left Bank designations are assuming the observer is facing downstream.

19.7 *this is an RSRA*	Left Bank	HABITAT	This percolation side channel lacks LWD and coniferous riparian zone.
20.6 *Wetland 69 RSRA*	Right Bank	HABITAT **	Low flows prevent fish access to outstanding oxbow lake (Wetland 69).
21.3		WATER QUALITY	Landsburg Dam; Sampling site CR14, S18 Stormwater: Water quality very good, all parameters well below Class AA standards. (One of three samples exceeded acute copper and chronic lead standards.)
21.6 *Wetland 83 RSRA*	Left Bank valley floor	HABITAT **	The south buffer of Class 1-rated Wetland 83 has been cleared within a power line right-of-way. The west buffer is a grazed pasture. Recent clearing, filling, grading, and debris deposition has occurred along the northeast and southwest edges.

*** Extremely Significant
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Right and Left Bank designations are assuming the observer is facing downstream.

PETERSON CREEK SUBBASIN			
Tributary	River Mile	Subject	Description
0328 Peterson Creek	Entire Length	WATER QUALITY **	Septic tank failure rates at Spring Lake (11.5%) indicate a likely water quality problem.
	0.0 *RSRA from 0.0-1.2*	WATER QUALITY *	Peterson Creek; Sampling site CR13, S16, C438: Stormwater: Cu exceeded acute toxicity limits in 2 of 3 samples. FC levels of 60-300 org/ ml.
	0.2-0.6 *RSRA from 0.0-1.2*	SED *	Current: The banks of this reach are naturally prone to landslides, which were occurring here even prior to development. Future: Landsliding and severe bank erosion are likely to continue.
	0.5-1.2 *RSRA from 0.0-1.2*	HABITAT *	Current: Habitat is of relatively low complexity and is moderately scoured and eroded due to lack of significant accumulations of LWD. Future: Habitat should improve gradually as LWD accumulates in the channel.
	0.6-0.9 *RSRA from 0.0-1.2*	SED *	Current: There is moderate channel incision and widening, with bank erosion worsening downstream. Future: Future flow increases could increase erosion rates.
	1.2-1.6 *LSRA from 1.2-2.6*	HABITAT *	Current: This stream is extensively channelized below Peterson Lake; the banks are well vegetated with small alders and low vegetation but the channel is low in complexity and lacking in LWD. Future: Limited improvement will occur as the channel ages.
	1.9 *Wetland 42 RSRA*	HABITAT *	Filling and buffer removal has occurred in an uninventoried segment of Wetland 42 near the Lake Youngs pipeline.
	2.0-2.2 *LSRA from 1.2-2.6*	HABITAT *	Current: Habitat is of low complexity; channelized appearance. Future: No change is expected.
	2.2-2.4 *LSRA from 1.2-2.6*	HABITAT *	Current: Stream banks and instream habitat have been affected by operation of heavy equipment in the stream, overgrazing, and clearing of riparian vegetation in a pasture area.
	2.6	FLOOD	SWM has received numerous complaints regarding the adequacy of drainage systems around Spring Lake. These small systems periodically plug with debris or silt. Future: No change is expected.
	2.7 *Wetland 28 RSRA*	HABITAT *	A portion of Sphagnum mat of Class 1-rated Wetland 28 is disintegrating.
0328B	Entire Length	WATER QUALITY **	Septic tank failure rates at Lake Desire (15.8%) indicate a likely water quality problem.
	1.0 *RSRA from 0.0-2.2*	WATER QUALITY *	Lake Desire exibits signs of eutrophication.

*** Extremely Significant
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(cont) 0328B	1.3 *Wetland 15 RSRA*	HABITAT *	Localized clearing and filling near the south end of Class 1-rated Wetland 15.
	1.5-1.7 *RSRA from 0.0-2.2*	FLOOD **	Current: Frequent flooding of East Lake Desire Drive SE and North Lake Desire Drive SE. Caused by 1) road subsidence due to incompetent subgrade, and 2) periodic rises in lake water surface due to inadequate maintenance of the lake's outlet pipe at RM 1.0. Access to several homes is blocked. Future: No significant changes expected.
	2.3 *Wetland 14*	HABITAT *	Bog (Wetland 14) extensively altered by peat farming and filling.
	Headwaters	HABITAT	Extensive filling and buffer removal has fragmented habitat of Wetland 102.
0328C	Entire Length	WATER QUALITY **	Septic tank failure rates at Shady Lake (22.6%) indicate a likely water quality problem.
0330, 0331, 0333		SED	Current: There is incision and gullying of small channels tributary to Peterson Creek; part of 0331 gully has been rocked to control further erosion.

*** Extremely Significant
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TAYLOR (DOWNS) CREEK SUBBASIN			
Tributary	River Mile	Subject	Description
0320 Taylor Creek	Entire Subbasin	WATER QUALITY **	Poor animal keeping practices have degraded water quality in this subbasin.
	0.1	HABITAT	Wetland 132 has been cleared along the south end and partially excavated along the north end (in Taylor Creek).
	0.4	WATER QUALITY **	Taylor Creek, Maxwell Road; Sampling site CR12, S15 Stormwater: NO3+NO2- N exceeded recommended levels. FC levels of 52-3960 org/100 ml.
	0.4-0.8	FLOOD **	Current: This reach floods almost yearly, flooding a sole access road and preventing access to several homes. Saturated soils resulting from the flooding have reportedly caused some foundations to settle and crack. Future: This condition will worsen with future development and with improvement to a box culvert that now limits flows (see flooding on Trib 0320, RM 1.2).
	0.4-0.8	SED **	Current: Sediment deposition has reduced channel capacity and increased flooding of Maxwell Road. Most of this material appears to have been deposited during failure of a culvert at SR-18. Future: The amount of sediment deposited in this reach will increase if future flow increases cause more upstream channel erosion.
	0.4-1.2	HABITAT	Current: Habitat has been affected by channelization associated with Maxwell Road, noncommercial farms, and residential development.
	1.2 *LSRA from 1.2-3.2*	FLOOD *	Current: A concrete box culvert under SR-18 has only about a 20-year capacity. Larger flows flood a tavern parking lot, picking up material that is then deposited downstream (see flooding on Trib 0320, RM 0.4-0.8). Future: If WSDOT improves or enlarges this culvert as planned, this flooding problem will be reduced, but downstream flows will be higher (see RM 0.4-0.8).
	1.2-1.6 *LSRA from 1.2-3.2*	SED *	Current: Although this channel is generally stable, there is some local bank erosion and minor downcutting. Future: Future flow increases could destabilize the channel and cause incision.
	1.25-2.4 *LSRA from 1.2-3.2*	HABITAT *	Current: Habitat is relatively low complexity and moderately scoured and eroded due to lack of significant accumulations of LWD. Future: Habitat will improve as riparian areas mature and LWD accumulates in the channel.
	1.7	WATER QUALITY **	Taylor Creek; Sampling site CR15: Stormwater: TP & NO3+NO2-N exceeded recommended levels. FC levels of 800-2980 org/100 ml. Cu exceeded acute and chronic toxicity limits.
	1.7	WATER QUALITY **	SR-18 Drainage; Sampling site CR16: Stormwater: TSS, TP & NO3+NO2-N exceeded recommended levels. FC levels of 10-180 org/100 ml. Cu, Pb & Zn exceeded toxic limits periodically.
	2.4-3.2 *LSRA from 1.2-3.2*	HABITAT *	Current: There is good habitat with localized impacts from rural residences. Future: High threat from increased rural development pressures.

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(cont) 0320	Headwaters	HABITAT	Wetland 133 has severe grazing impacts: many dead and drying trees and a large expanse of muddy soil.
	Headwaters	HABITAT	Several acres of Wetland 49 and its buffer were recently logged.
0321	0.0-0.2	HABITAT /WQ	Current: Noncommercial farm activity is eroding banks. Future: No change is expected.
	0.2-0.5 *RSRA from 0.2-0.8*	SED	Current: This channel is generally stable. Future: Future flow increases may destabilize the channel.
	0.2-0.8 *RSRA from 0.2-0.8*	HABITAT *	Current: Habitat is in near pristine conditions. Future: Habitat will degrade if not protected.
	Headwaters	HABITAT *	A downstream RSRA is threatened by noncommercial farms, channelization along roads, and rural residential landscaping.
0322	0.0-0.2	SED	Current: This channel is generally stable. Future: Future flow increases may destabilize the channel.
0323	Headwaters	HABITAT *	A downstream RSRA is threatened by noncommercial farms, channelization along roads, and rural residential landscaping.
0323A	Headwaters	HABITAT *	A downstream RSRA is threatened by noncommercial farms, channelization along roads, and rural residential landscaping.
0326	0.0-0.7 *this is an LSRA*	HABITAT *	Current: There is good habitat with localized impacts from rural residences. Future: High threat from increased rural development pressures.
	2.6 *LSRA from 1.2-3.2*	WATER QUALITY **	Upper Taylor Creek; Sampling site CR17, S17: Stormwater: TP & NO3+NO2-N exceeded recommended levels. FC levels of 920-2610 org/100 ml. One sample exceeded toxic levels for Cu & Zn.

*** Extremely Significant
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MIDDLE CEDAR RIVER SUBBASINS			
Tributary	River Mile	Subject	Description
0336 Dorre Don	0.0	FLOOD	Current: Lower Dorre Don Way and nearby properties flood at about the 5-year flow. The culvert carrying the stream under the road is old and undersized, but enlarging it may not significantly increase its capacity for larger storms because the flooding may be due to backwater effects from the Cedar rather than inlet capacity; egress is still possible during these events. Future: As flows increase this problem will occur more frequently.
	0.0-0.17	HABITAT	The stream is channelized through a residential area in the floodplain. There is an impassable culvert at RM 0.17; the stream is dry for most of the year above the culvert.
	0.1	WATER QUALITY **	Dorre Don Way Trib.; Sampling site CR18: Stormwater: TSS, TP & NO3+NO2-N exceeded recommended levels. FC levels of 240-1540 org/ ml. Cu & Zn acute toxicity limits exceed.
	0.25-0.75	SED	Current: Some channel enlargement has occurred, with scattered zones of bank erosion. Future: Possible channel erosion is likely under future flow conditions, with concurrent sediment deposition problems downstream from RM 0.2.
	0.3	FLOOD	Current: 48" CMP under SE 244th Street in poor condition. Although water backs up behind it, there is no damage from flooding at the present, but there is erosion on the downstream side. Future: The capacity of this crossing may be inadequate for storms larger than 5-year future unmitigated, or 10-year future mitigated.
0336A	1.0	FLOOD *	Current: 18" concrete culvert is undersized, causing arterial flooding of SE 224th Street during larger storms. Future: This condition is likely to worsen.
0337	0.0-0.1	FLOOD	Current: Many complaints of ,poor drainage and minor flooding during larger storms. Future: Condition will gradually worsen as development increases.
	0.1	FLOOD	Current: 24" CMP under SE 255th Street has about a 10-year capacity. Future: May cause road-flooding problems frequently in the future.
0341 Walsh Lake Diversion Channel	0.0-0.2 *LSRA from 0.0-4.0*	HABITAT *	Current: At low flows, fish access is frequently blocked because the stream soaks into the permeable gravels of the sediment fan. Future: Increase in surficial water at low flows is possible as the streambed accumulates silts.
	0.0-0.6 *LSRA from 0.0-4.0*	HABITAT	Current: Habitat still evolving since construction of diversion; opportunity for increasing rate of habitat formation exists. Future: Gradual improvement as LWD accumulates and riparian areas mature.
	0.2-0.5 *LSRA from 0.0-4.0*	SED *	Current: Severe downcutting and channel widening has occurred since this channel was constructed in the 1920s--the ravine has 30-40-foot high banks with numerous bank failures. Sediment from the ravine has formed a fan downstream from RM 0.2. Future: Continued erosion is likely.
	0.5-0.65 *LSRA from 0.0-4.0*	SED	Current: Downcutting here is less severe; the 6- to 10-foot-high banks have partially stabilized. Future: Continued erosion is likely.

*** Extremely Significant
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(cont) 0341	1.1 *LSRA from 0.0-4.0*	WATER QUALITY	Walah Lake Diversion; Sampling site CR19 Stormwater: Cu & Zn exceeded acute toxicity limits in 1 of 3 samples.
	Headwaters *Wetland 64 LSRA*	HABITAT *	Class 1-rated Wetland 64 has been converted to an R/D pond for a subdivision. Extensive buffer clearing has occurred along the south half of the wetland.
	Headwaters *Wetland 82 LSRA*	HABITAT *	Approximately 50% of the buffer of Wetland 82 (Hidden Lake) has been logged.

*** Extremely Significant
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ROCK CREEK SUBBASIN			
Tributary	River Mile	Subject	Description
0338 Rock Creek	0.0-0.8 *RSRA from 0.0-2.5*	SED *	Current: No erosion/sediment problems observed. Future: As flows increase, severe channel erosion is likely to occur between RM 0.2 and 0.8. Sediment deposition is likely between RM 0.0 and 0.2, reducing channel capacity and potentially causing flooding.
	0.0-1.7 *RSRA from 0.0-2.5*	HABITAT **	Low flows may not meet instream standards and needs of spawning and rearing fish due to the City of Kent's water withdrawal.
	0.2 *RSRA from 0.0-2.5*	FLOOD	Current: Railroad tie box culvert under SE 248th Street is at capacity at 5-year flow. Future: As flows increase, this situation would occur more frequently.
	0.3-0.8 *RSRA from 0.0-2.5*	HABITAT *	LWD accumulations are lacking.
	1.4 *RSRA from 0.0-2.5*	FLOOD	Current: Three 36" culverts under Summit-Landsburg Road are at capacity during a 10-year flow, at which point the road may flood. Future: As flows increase, this situation would occur more frequently.
	2.5-2.65	HABITAT *	Streambank clearing and light erosion associated with residences and noncommercial farms, affecting a downstream RSRA.
	2.6	FLOOD	36" CMP under 262nd Avenue SE is probably flooding at about 2-year flow, though there are no complaints on record Future: This condition will worsen as flows increase.
	2.8	FLOOD	Current: Two 30" concrete pipes under the Kent-Kangley Road have a combined capacity of about a 25-year storm, at which flow the road would probably flood. Future: This problem will become more frequent.
	3.1	FLOOD	Current: Two 36" culverts under 268th Avenue SE should provide 10-year capacity, though a neighbor complains of annual flooding, possibly due to poor maintenance of this and downstream crossings. Future: Future unmitigated flow estimates put this crossing at a 2-year capacity.
	3.2-3.4 *Wetland 94 LSRA*	HABITAT *	The buffer of Wetland 94 has been completely logged. Vegetation has been removed within a power line right-of-way that crosses the wetland.
	Headwaters *Wetland 92 LSRA*	HABITAT *	Installation of a communications line within Wetland 92 and its buffer has modified habitat structure and hydrology. Future installation of a water pipeline in the wetland could severely damage this wetland's habitat, water quality, and hydrology.
	Headwaters *Wetland 91 LSRA*	HABITAT *	Wetland vegetation has been removed in back yards along 75% of the shoreline of Lake No. 12 (Wetland 91).
	Outlet from Retreat Lake	WATER QUALITY	Retreat Lake; Sampling site CR20: Stormwater: Acute Cu toxicity in 1 of 3 samples taken. All other parameters are below recommended levels.

*** Extremely Significant
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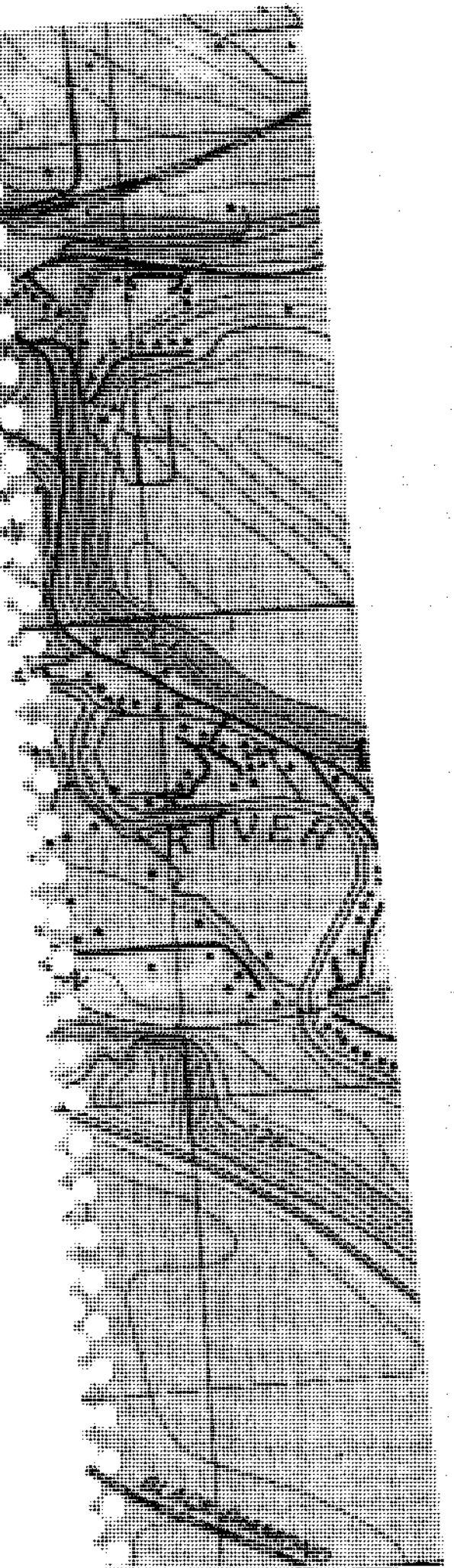


Appendix B

Cedar River Basin Maps

Map 1 Cedar River Basin and Location
Map 2 Subbasin Boundaries
Map 3 Current Land Use/Land Cover
Map 4 Future Land Use/Land Cover
Map 7 Generalized Floodplain-Cedar River Basin
Map 10 Revetment Location and Meander Belt of the Lower and Middle Cedar River Since 1865
Map 14 Farm Locations, 1992
Map 15 Small Quantity Hazardous Waste Generators and Underground Storage Tanks
Map 17 Renton Reach Subbasin Conditions
Map 18 Lower Cedar River Mainstem Conditions

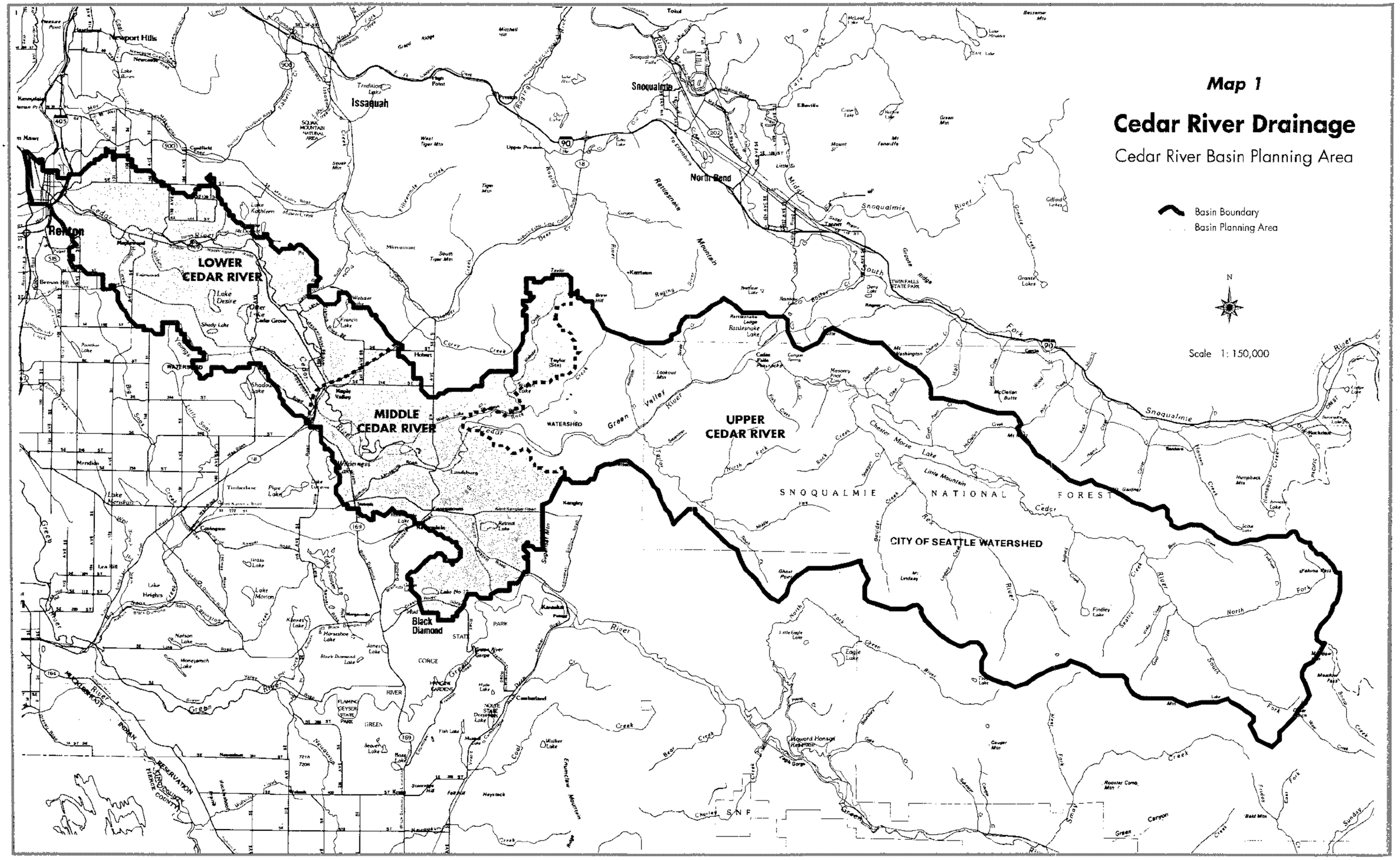
Lower Cedar River Subbasins
Map 19 Ginger Creek Subbasin Conditions
Map 20 Maplewood and Orting Hills Subbasin Conditions
Map 21 Molasses Creek Subbasin Conditions
Map 22 Madsen Creek and Summerfield Subbasin Conditions
Map 23 Cedar Grove Subbasin Conditions
Map 24 Cedar Hills and Webster Lake Subbasin Conditions

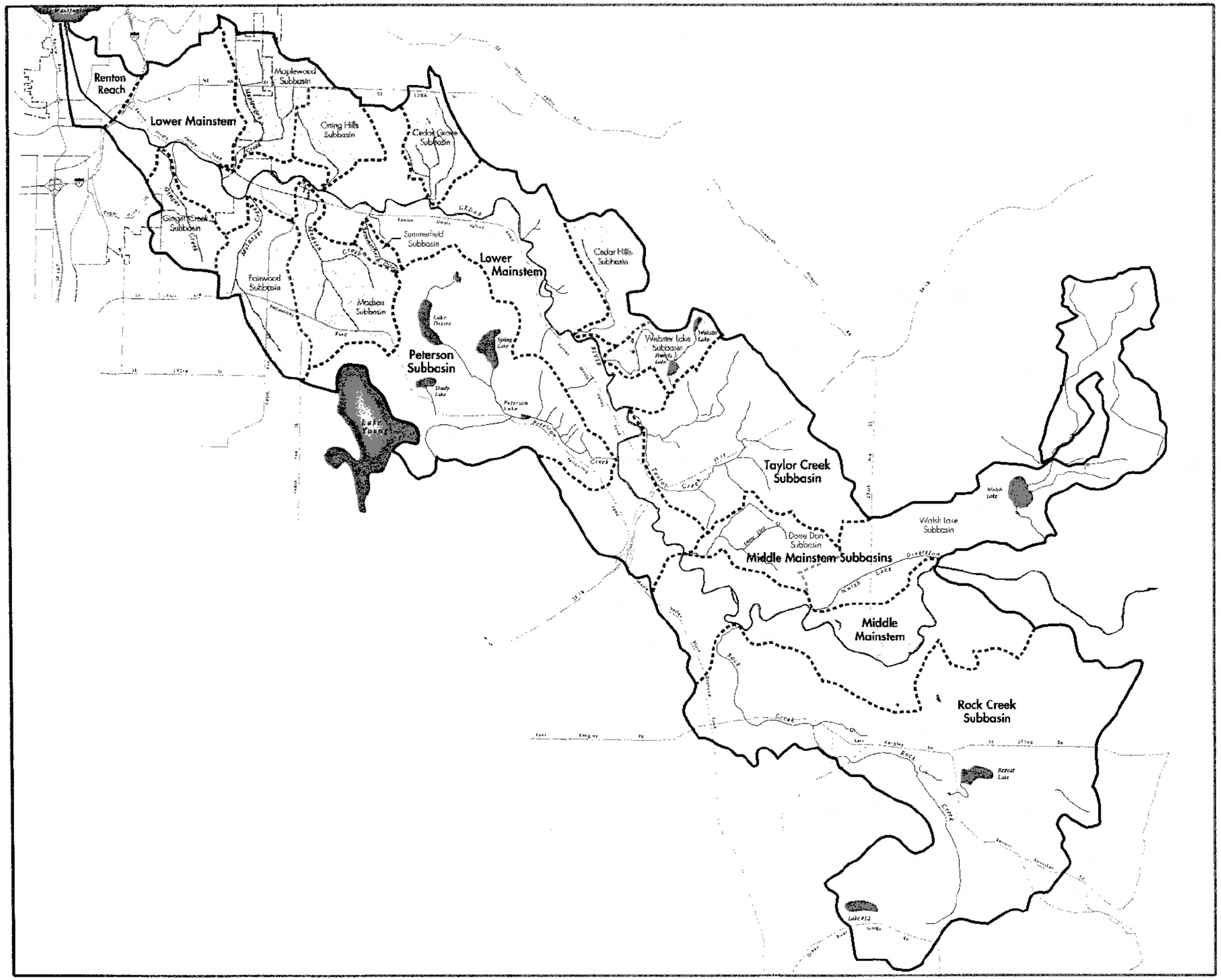
Map 25 Middle Cedar River Mainstem and Subbasins Conditions
Map 26 Peterson Creek Subbasin Conditions
Map 27 Taylor Creek Subbasin Conditions
Map 28 Rock Creek Subbasin Conditions

Selected Cedar River Wetland Locations

Wetland #	Subbasin (map#)	Approximate Location
37	Lower Mainstem (#18)	SR169 & SE Jones Road
105	Lower Mainstem	McDonald Grove Road (near Cedar Grove Rd)
132	Lower Mainstem	Maxwell Rd SE & SE 196th St
2	Molasses Creek (#21)	SE Petroivitsky Rd & 132nd Pl SE
22	Molasses Creek	SE 190th St & 145th Ave SE
23	Molasses Creek	140th Ave SE & SE 183rd St
16	Madsen Creek (#21)	Directly North of Petrovitsky Park
13	Cedar Hills (#24)	Just west of Cedar Hills Landfill
36	Webster Lake (#24)	Lake Francis (SE Lake Fransic Road)
69	Middle Mainstem (#25)	About 1/2 mile downstream from Landsberg
83	Middle Mainstem	About 1/2 mile south of Landsberg on E side of Issaquah-Ravensdale Road
14	Peterson Creek (#26)	148th Ave SE & SE 170th St
15	Peterson Creek	Extends 1/3 mile north end of Lake Desire
28	Peterson Creek	Surrounding south and west ends of Spring Lake
42	Peterson Creek	Peterson Lake and areas west
64	Middle Subbasins (#25)	SE 224th St & about 290th Ave SE
82	Rock Creek (#28)	About 1 mile East-Southeast of Landsberg
91	Rock Creek	Lake No. 12 (north side of Green River Gorge Road 1 mile east of Black Diamond)
92	Rock Creek	Extends 2/3 mile east of Lake No. 12
94	Rock Creek	About 1 mile south of Retreat Lake (also south of Retreat-Kaniskat Road)

MAPS


Map 1
Cedar River Drainage
Cedar River Basin Planning Area
Basin Boundary
Basin Planning Area
N
Scale 1: 150,000
LOWER CEDAR RIVER
MIDDLE CEDAR RIVER
UPPER CEDAR RIVER
SNOQUALMIE NATIONAL FOREST
CITY OF SEATTLE WATERSHED
Renton
Issaquah
Snoqualmie
North Bend
Black Diamond
Newport Hills
Lake Desire
Lake Sammamish
Lake Meridian
Lake Kathleen
Rattlesnake Mountain
Rattlesnake Lake
Masonry Pool
Howard Hanson Reservoir
Green River
Cedar River
Snoqualmie River
Tiger Mtn
West Tiger Mtn
South Tiger Mtn
Taylor
Webster
Hobart
Maple Valley
Landsburg
Kanaskat
Cumberland
Kent
Auburn
Enumclaw
Mt Washington
Chester Morse Lake
Little Mountain
Mt Lindsay
Ghost Point
Eagle Lake
Findley Lake
Humpback Mts
Bessemer Mtn
Green Mtn
Mt Fenwicke
Mount St
Granite Lakes
Gifford Lakes
Grouse Ridge
TWIN FALLS STATE PARK
Masonry Pool
Rattlesnake Ledge
Cedar Falls Picnic Area
McClellan Butte
Lookout Mtn
Green Valley
Taylor (Sta)
Brew Hill
Carey Creek
Webster Hill
Francis Lake
Shady Lake
Shadow Lake
Panther Lake
Cedar Grove
Deer Lake
Yoman
WATERSHED
Big Soos
Little Soos
Mendian
Timberlane
Pipe Lake
Lake Meridian
Coalington
Lea Hill
Lake Heights
Lake Morton
Kennys Lake
Nelson Lake
Moneymarth Lake
Black Diamond Lake
Horseshoe Lake
Jones Lake
Lake No
Mud
Green River Gorge
HANGING GARDENS
Hyde Lake
FLAMING GEYSER STATE PARK
GREEN RIVER GORGE
STATE PARK
Fish Lake
Beaver Lake
Boss Lake
Walker Lake
Retreat Lake
Kanaskat Palmer
Ravensdale
Maple Valley
Black Diamond
Nasonville
Stevens Hill
Fairfield
Haystack
Enumclaw Mountain
Coal Creek
Bear Creek
Chester
Green Canyon
Rooster Comb Mtn
Bald Mtn
Sunday Creek
Cougar Mtn
Little Eagle Lake
Tolt Lake
Meadow Pass
Snoqualmie Pass
Humpback Creek
Old Rockdale
Lake Mondale
Lake Lake
Tradition Lake
Mitchell Hill
Grand Ridge
Tiger Mtn
Squak Mountain Natural Area
Newcastle
Lake Burien
Kennydale
Cedar River Watershed
Indian Reservation
Muckleshoot
Pierce County
King County
S N F



Map 2

Subbasin Boundaries

Cedar River Basin Planning Area

- Stream
- Lake/River
- Basin Boundary
- Subbasin Boundary
- Renton City Boundary
- Lower Mainstem Subbasins

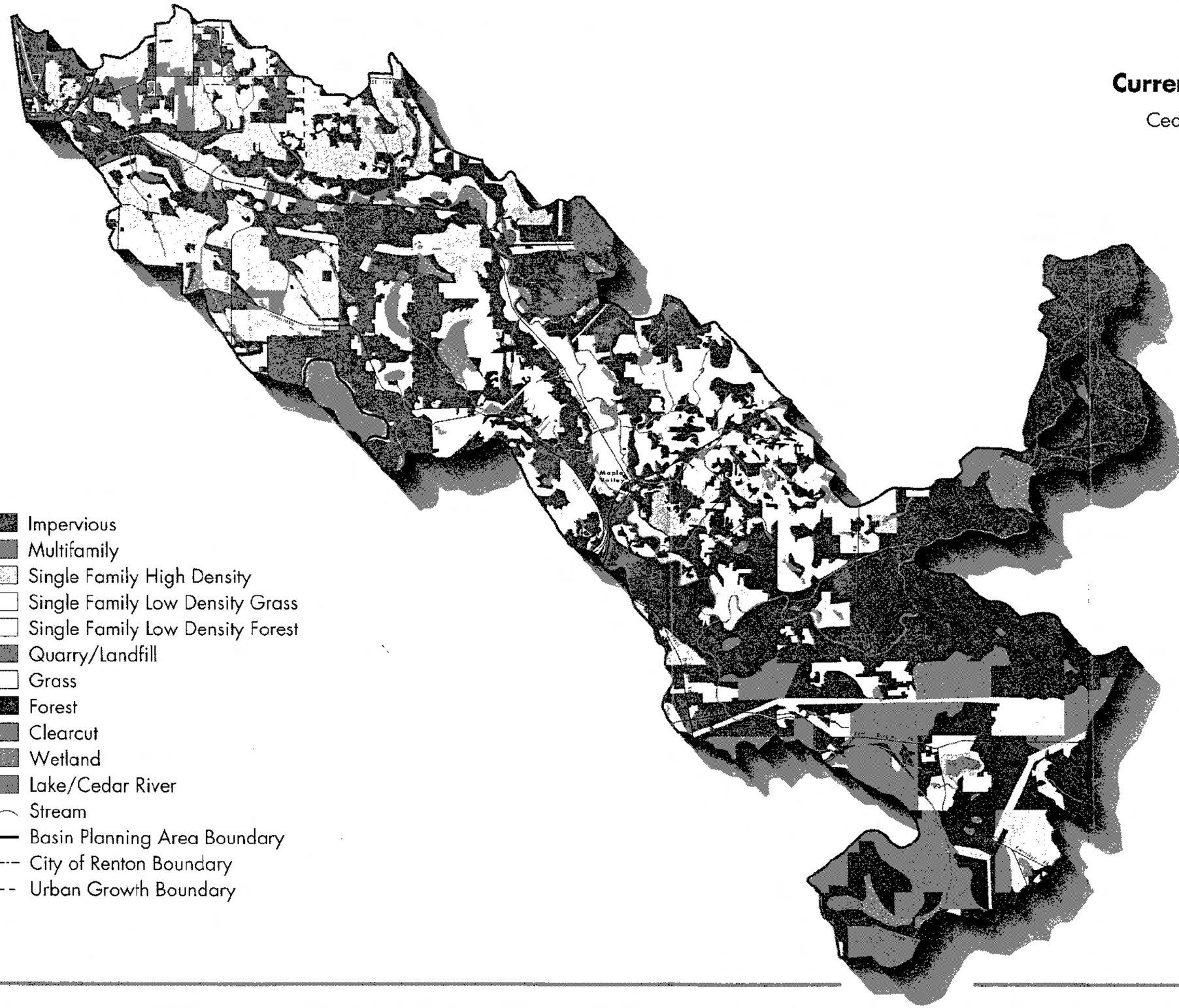
N

0 1 2 Miles

Map 3

Current Land Use/Land Cover

Cedar River Basin Planning Area

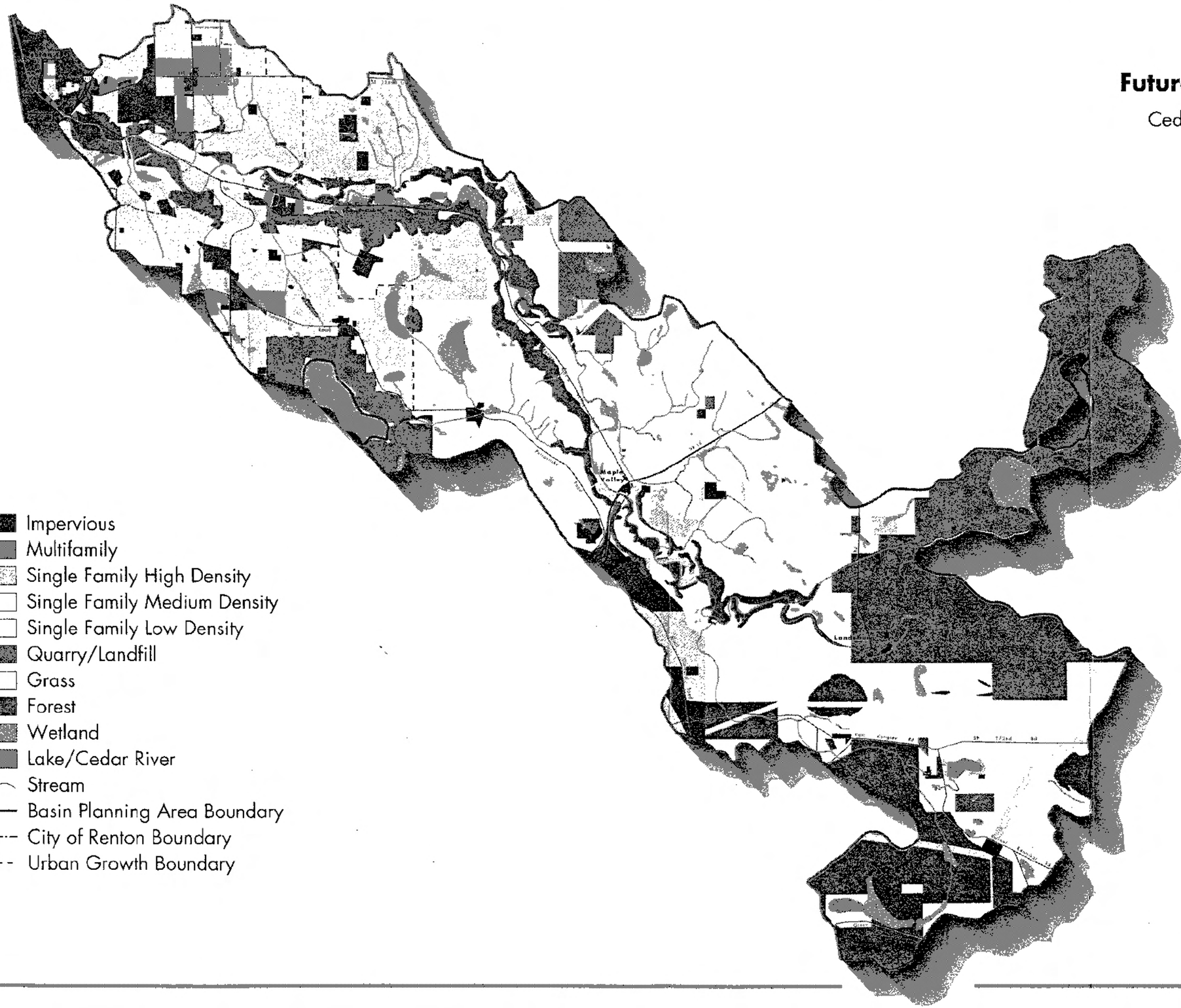


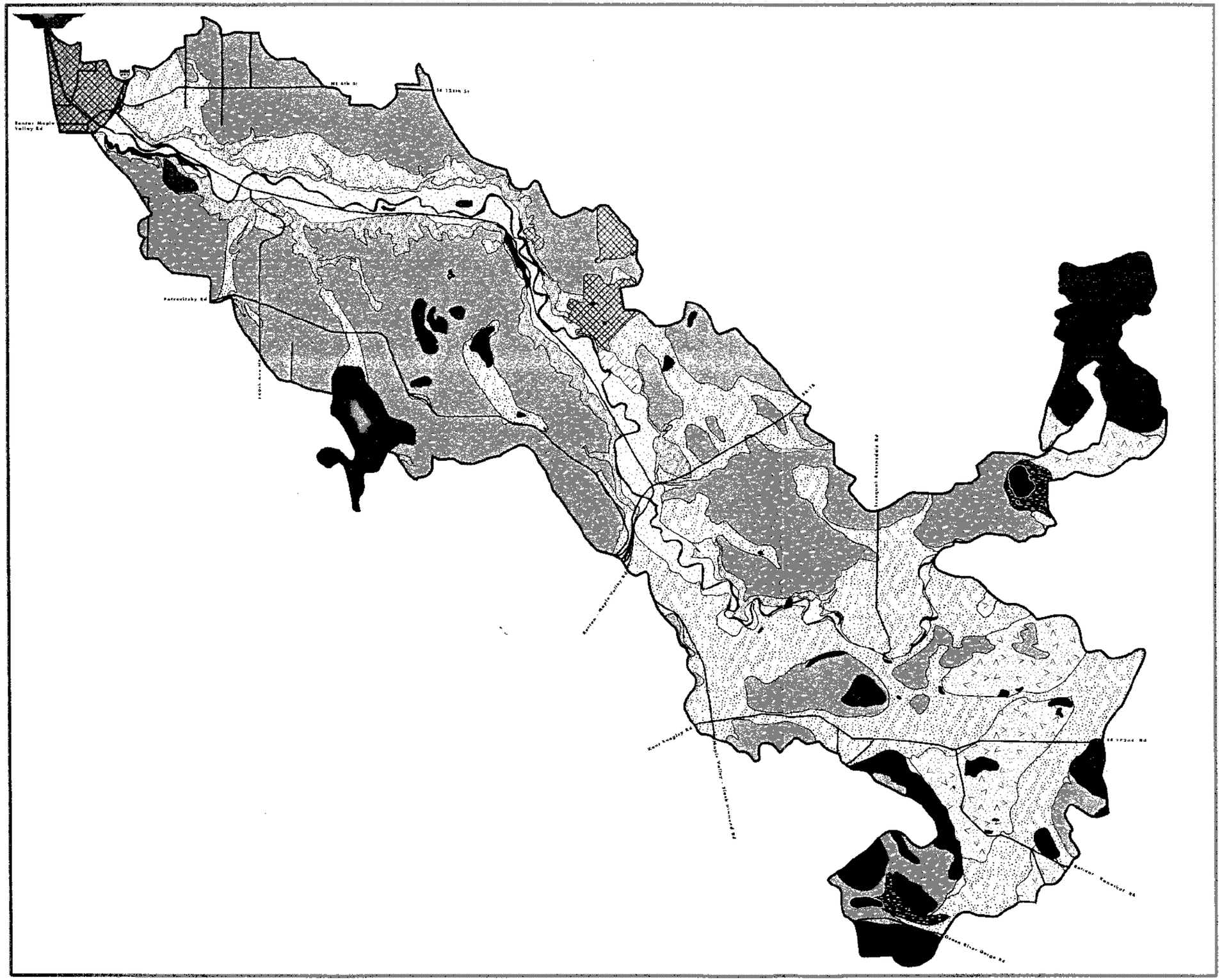
- Impervious
- Multifamily
- Single Family High Density
- Single Family Low Density Grass
- Single Family Low Density Forest
- Quarry/Landfill
- Grass
- Forest
- Clearcut
- Wetland
- Lake/Cedar River
- Stream
- Basin Planning Area Boundary
- City of Renton Boundary
- Urban Growth Boundary

Map 4

Future Land Use/Land Cover

Cedar River Basin Planning Area





Map 5

Geology

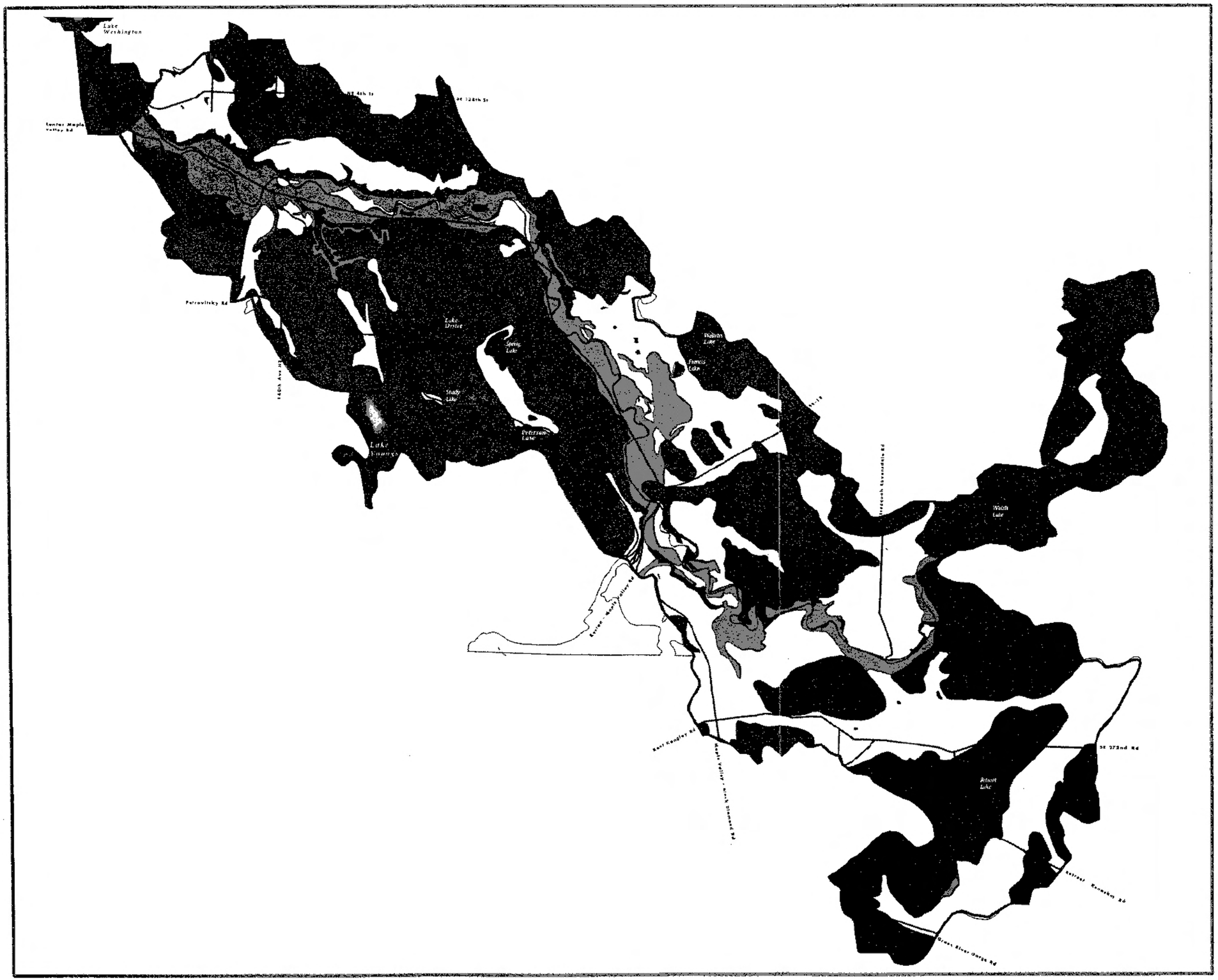
Cedar River Basin Planning Area

- Basin Boundary
- Cedar River/Lake
- Wetland (Qw)
- Modified
- Landslide (Qls, Qmw)
- Alluvium (Qyal, Qf)
- Older Alluvium (Qoal)
- Recessional Outwash (Qvr)
- Ice Contact (Qvi)
- Till (Qvt)
- Advance Outwash & Older Deposits (Qva, Qpf)
- Bedrock (Ti, Ts, Tp, br)

(Symbols in parentheses refer to unit description in text)

N

0 1 2 Miles



Map 6

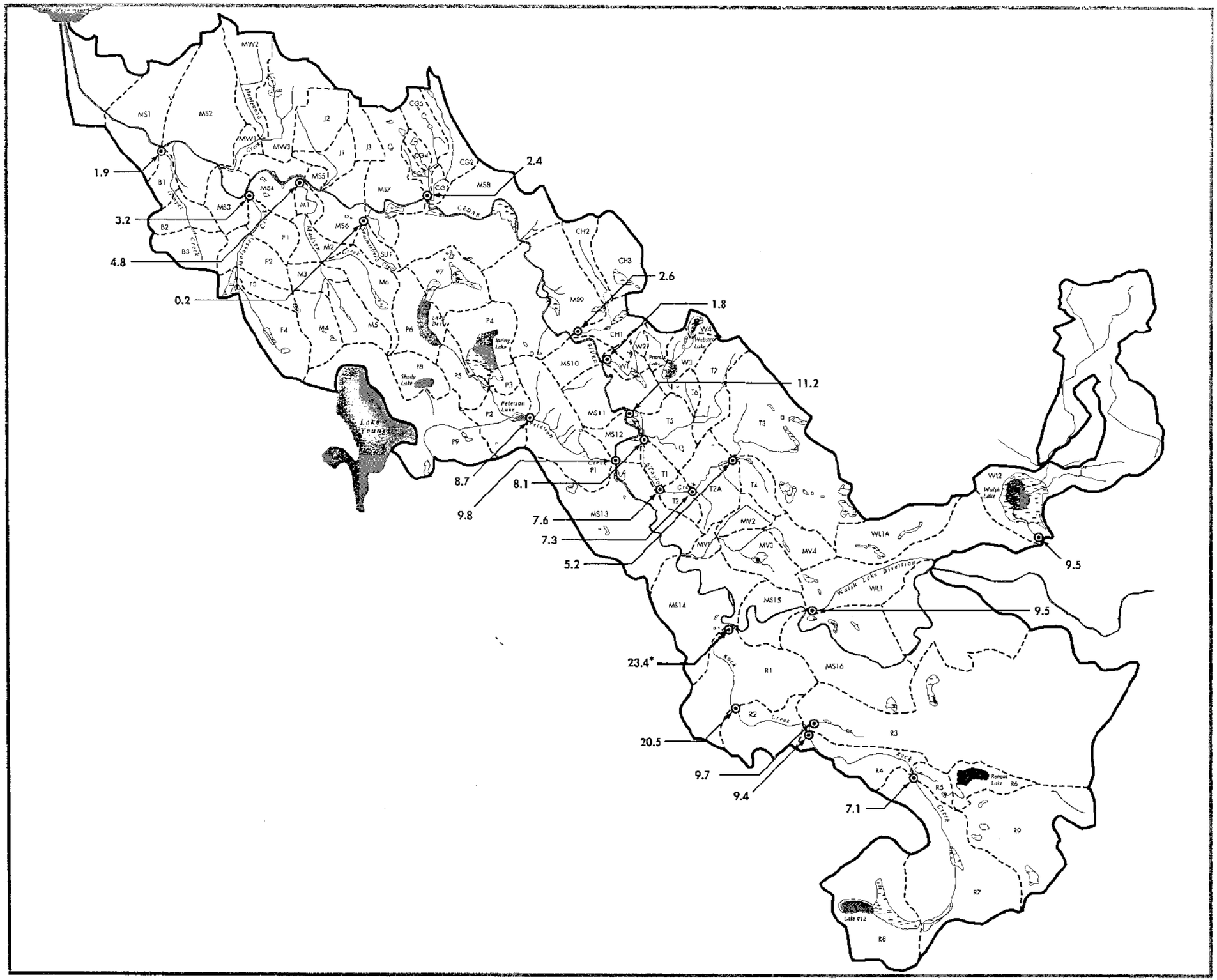
Recharge Areas

Cedar River Basin Planning Area

- Basin Boundary
- Cedar River/Lake
- High Recharge
- Moderate Recharge
- Low Recharge

N

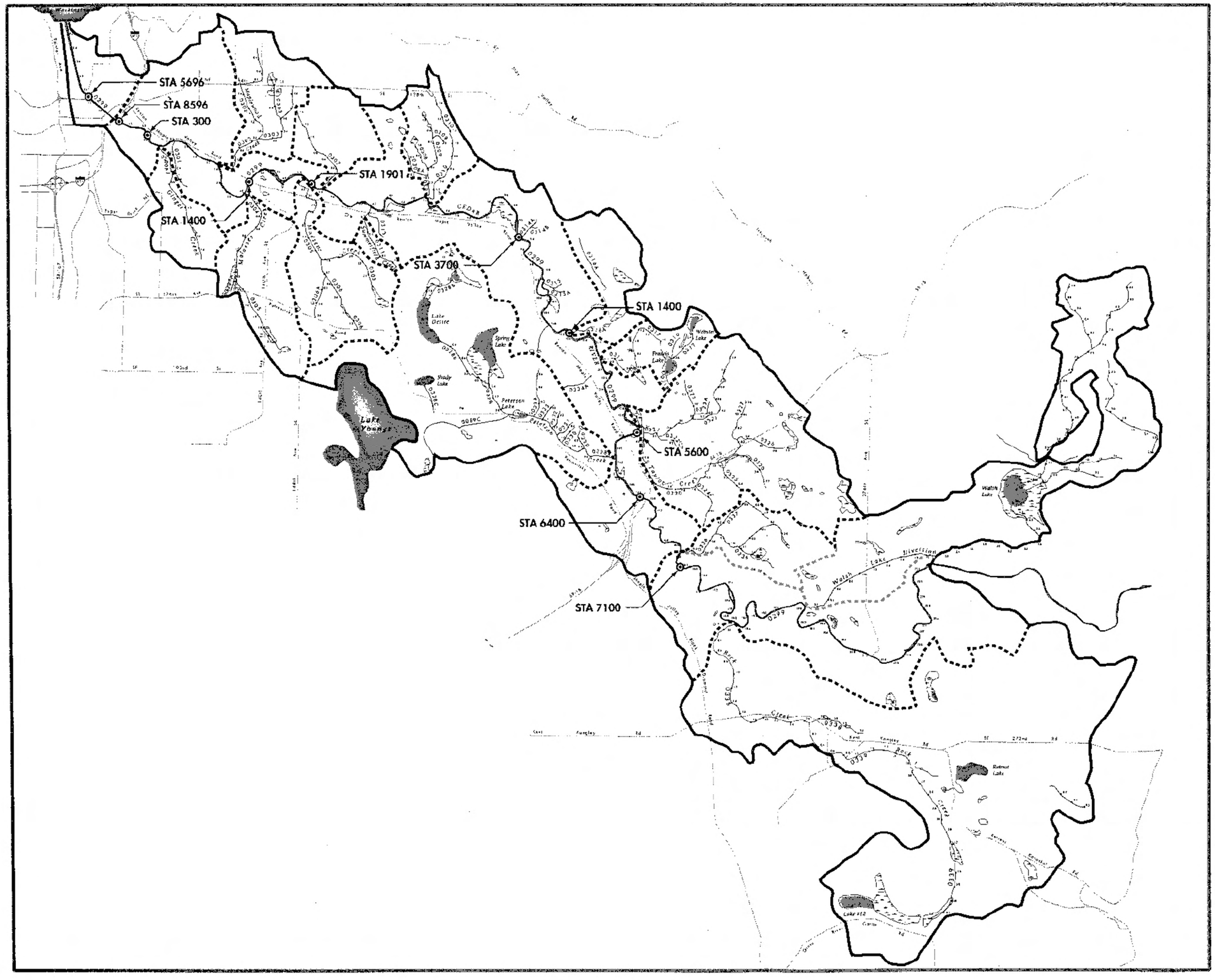
0 1 2 Miles



Map 7

Mean Annual Flows

Cedar River Basin Planning Area



Map 8

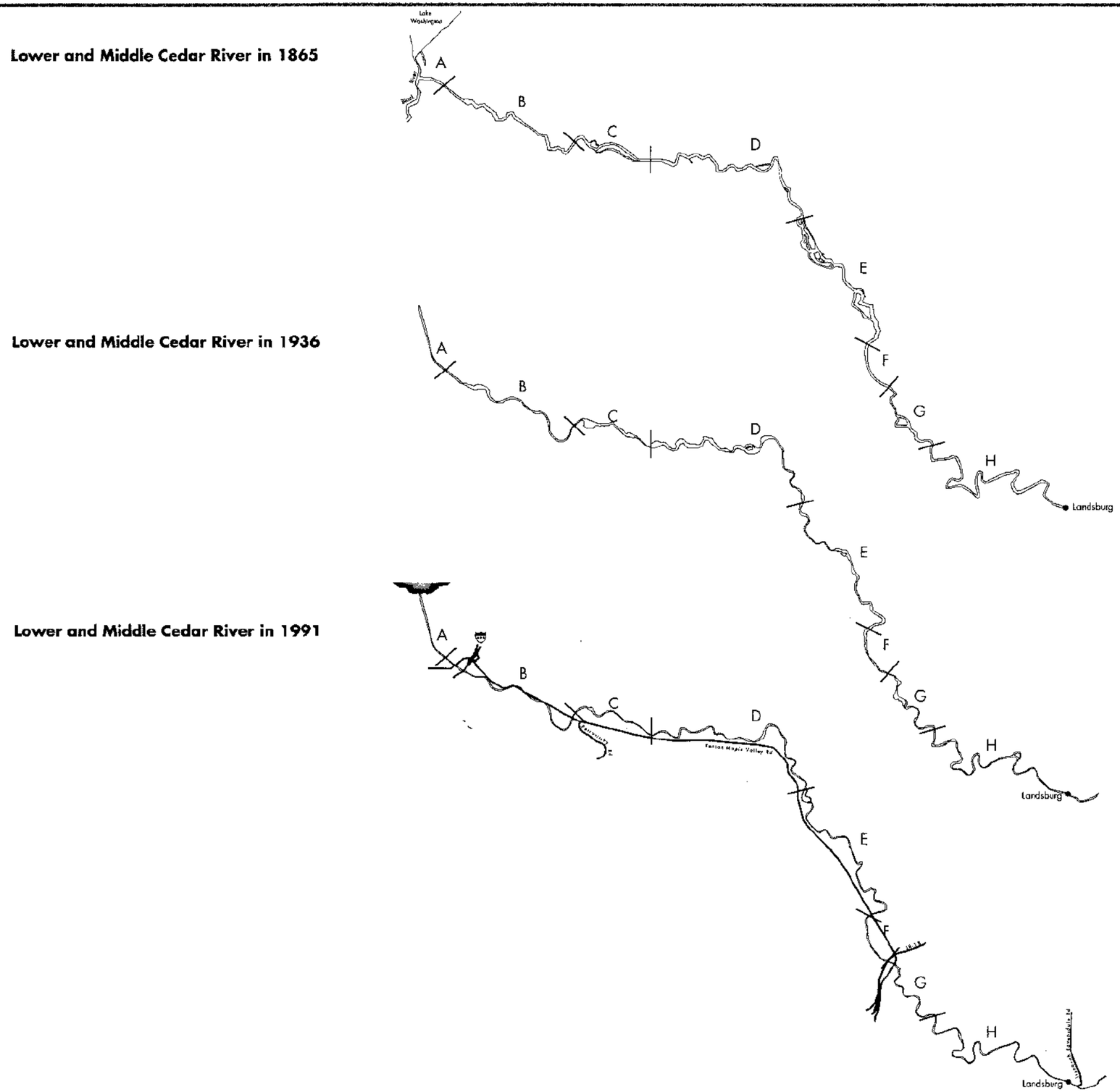
Locations of Selected HEC-2 Cross Sections

Cedar River Basin Planning Area

- Stream and Stream Number
- Lake/River
- Stream Mile
- Wetland
- Basin Boundary
- Subbasin Boundary

N

0 1 2 Miles



Map 9

Changes in Lower and Middle Cedar River Channel Pattern

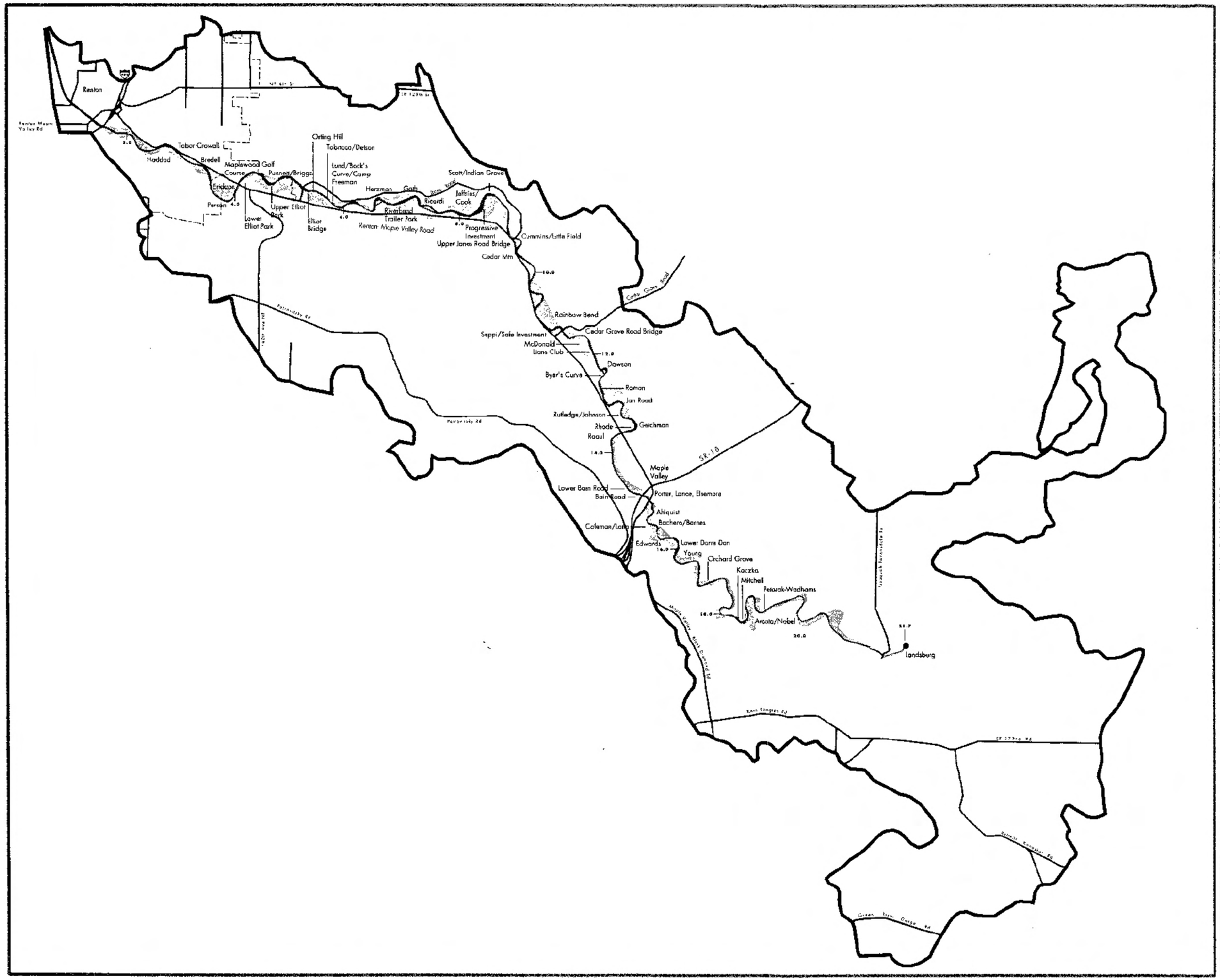
Cedar River Basin Planning Area

Cedar River

D Referenced Stream Reaches

N

0 1 2 Miles



Map 10

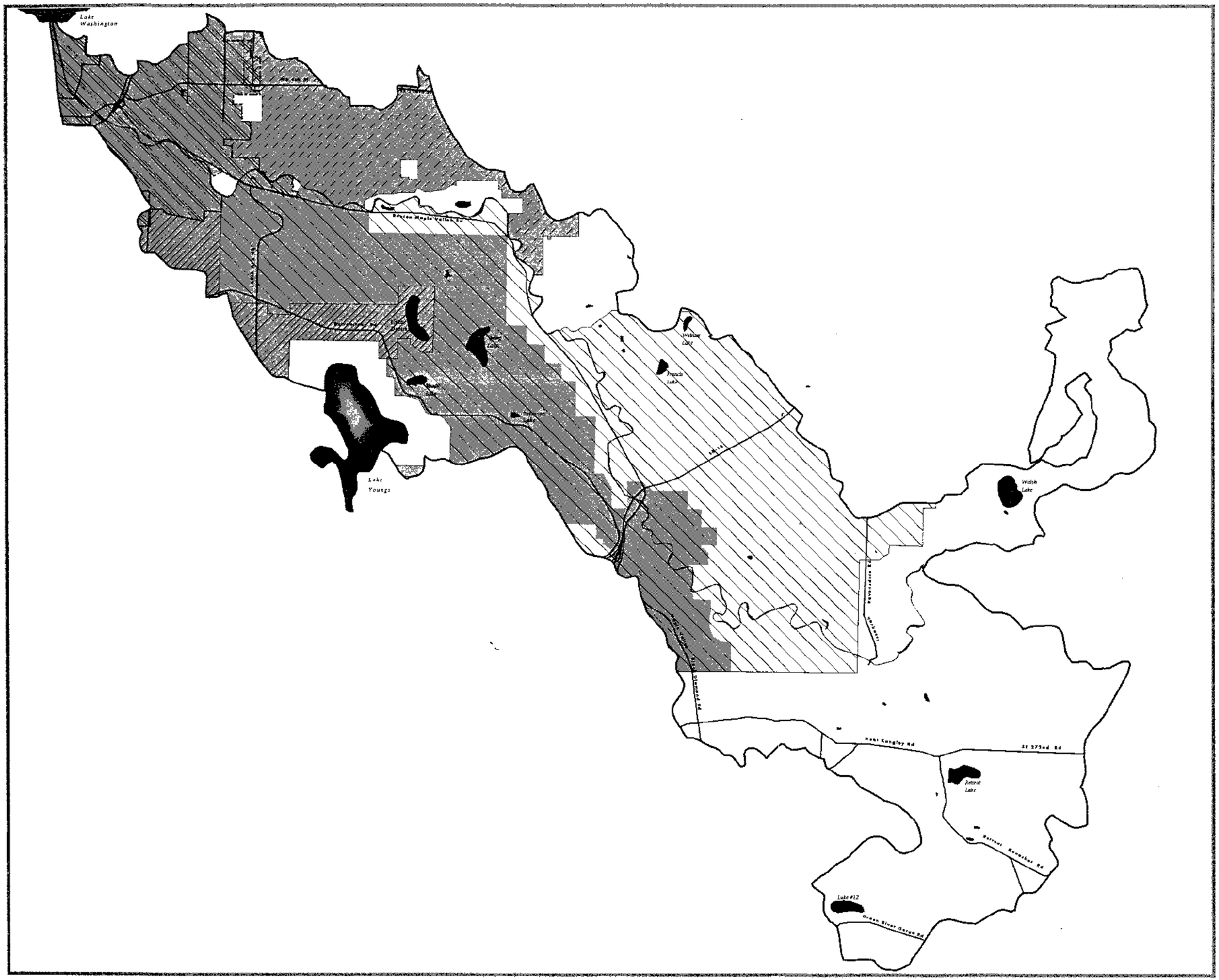
Revetment Location & Meander Belt of the Lower & Middle Cedar River since 1865

Cedar River Basin Planning Area

- Basin Boundary
- Cedar River
- 2.0 River Mile
- River Migration Zone
- Revetment
- Lund Revetment Name
- City of Renton Boundary

N

0 1 2 Miles



Map 11

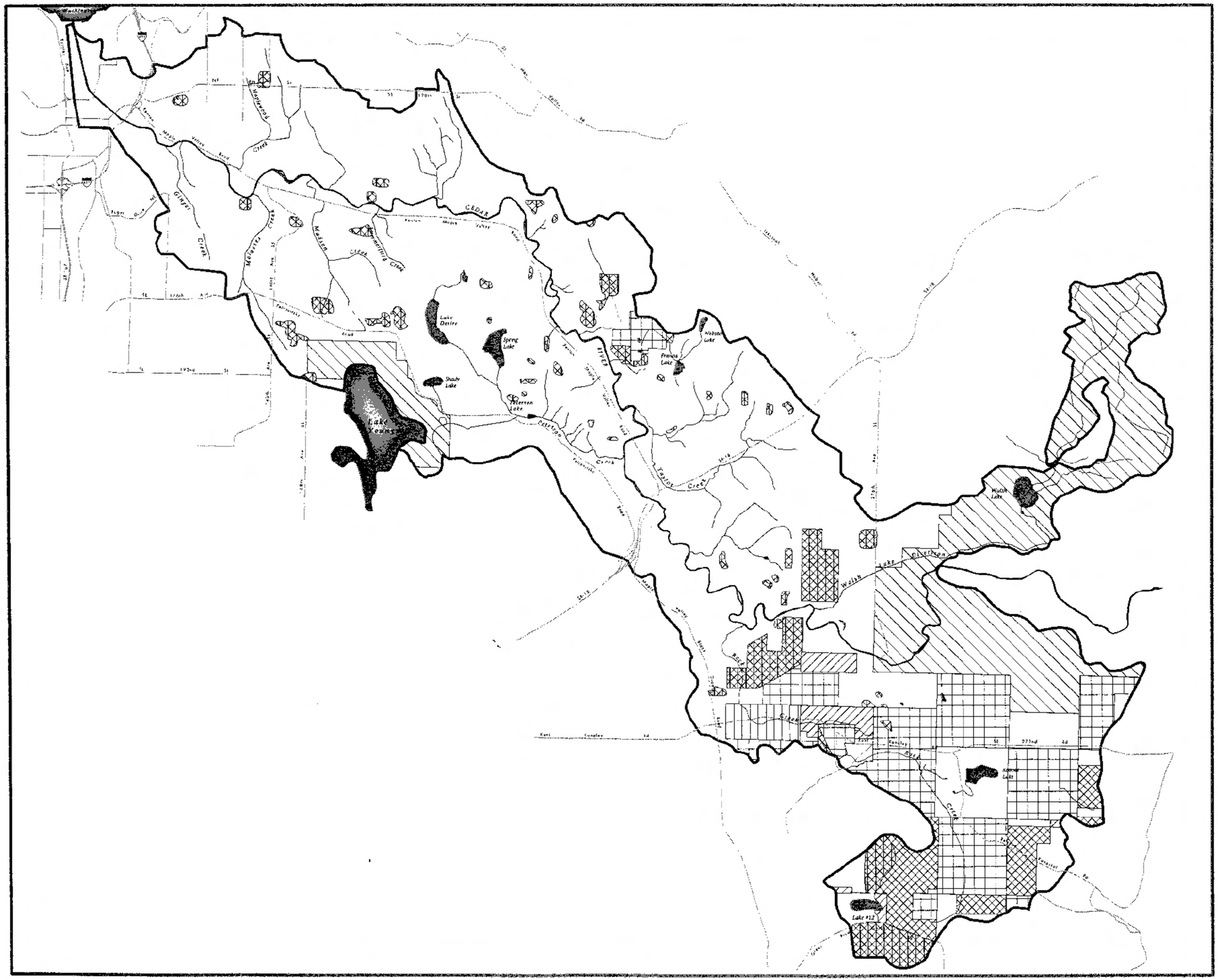
Water Supply by Water Districts

Cedar River Basin Planning Area

- Basin Boundary
- Cedar River/Lake
- Existing Water Service Areas
- City of Renton Boundary
- City of Renton Planning Area
- Water District No. 90 Planning Area
- Cedar River Water & Sewer Dist. Planning Area
- Soos Creek Water & Sewer Dist. Planning Area

N

0 1 2 Miles



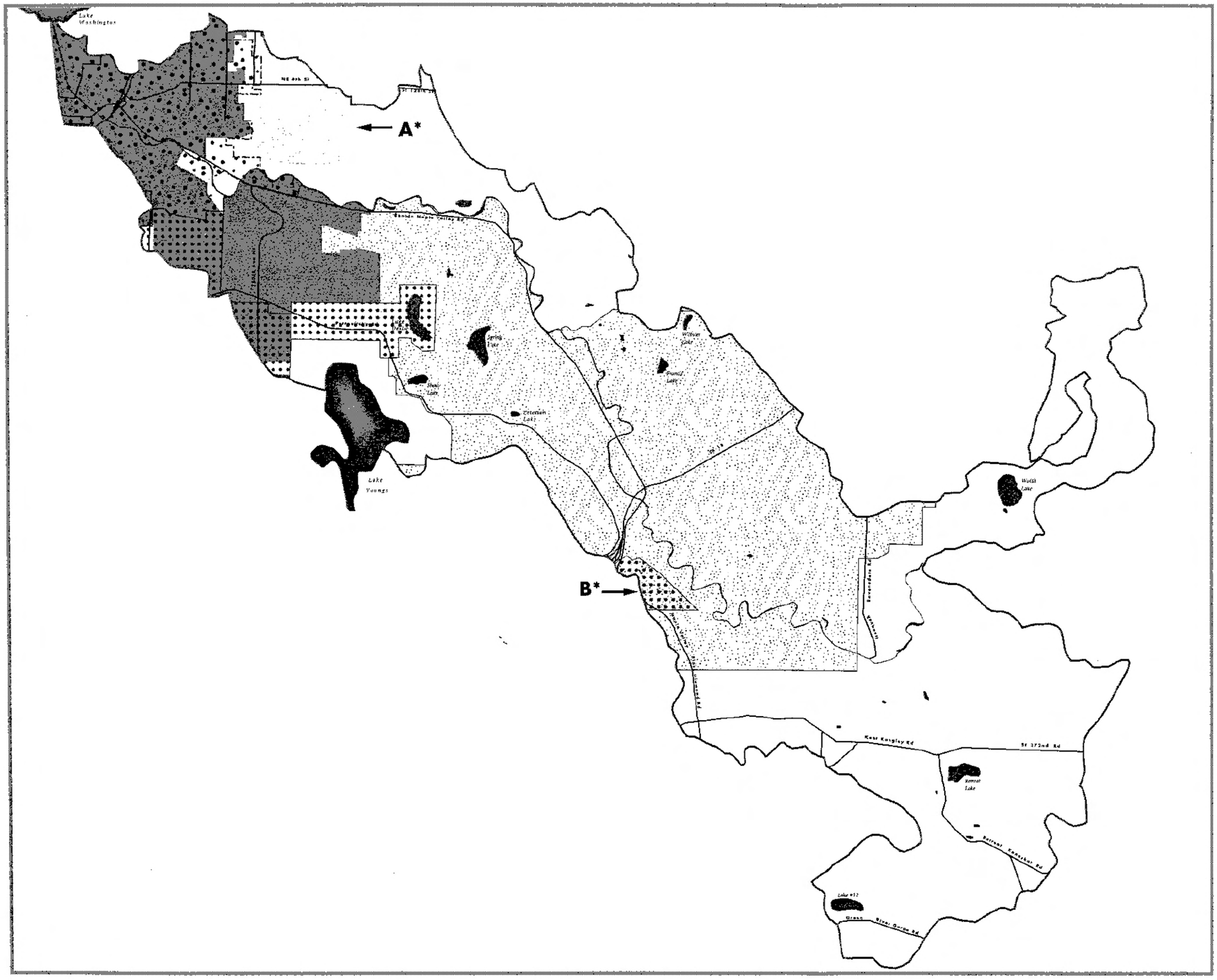
Map 12

Forest Reference, 1992

Cedar River Basin Planning Area

- Stream
- Lake/River
- Basin Boundary
- Plum Creek
- City of Seattle
- Weyerhauser
- Palmer Coking Company
- City of Kent
- Clearings (1985-1989)

USDA Puget Sound Cooperative
River Basin Team



Map 13

Sewer Service Areas

Cedar River Basin Planning Area

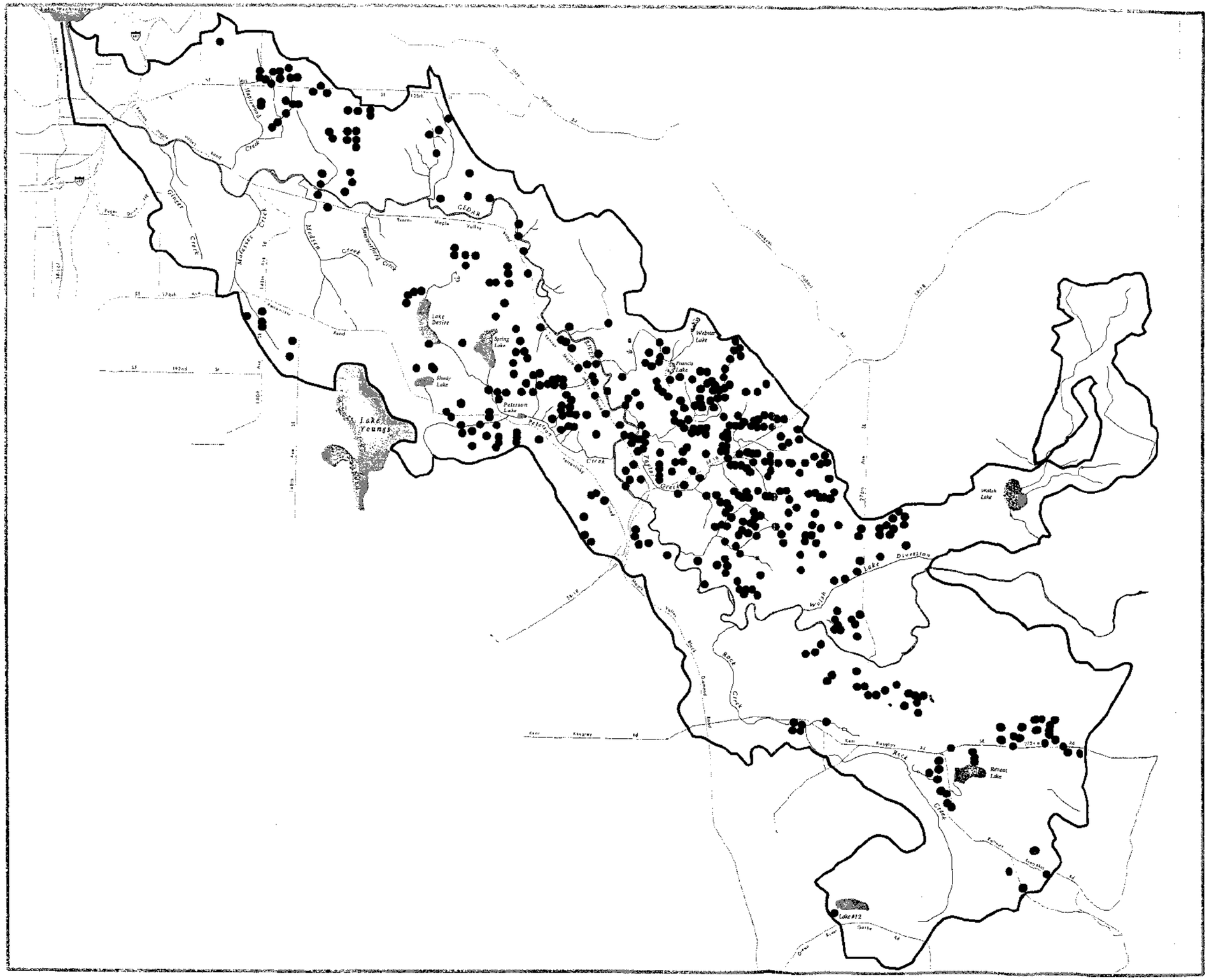
- Basin Boundary
- Cedar River/Lake
- Existing Sewer Service
- Proposed Expansion of Sewer Service
- City of Renton Boundary
- City of Renton Sewer Planning Area
- Cedar River Water & Sewer Dist. PLanning Area
- Soos Creek Water & Sewer Dist. Planning Area

A* Proposed expansion of sewer service by the City of Renton.

B* Proposed sewer service in area B would be serviced by the Soos Creek Water & Sewer District.

N

0 1 2 Miles



Map 14

Livestock-keeping Locations, 1992

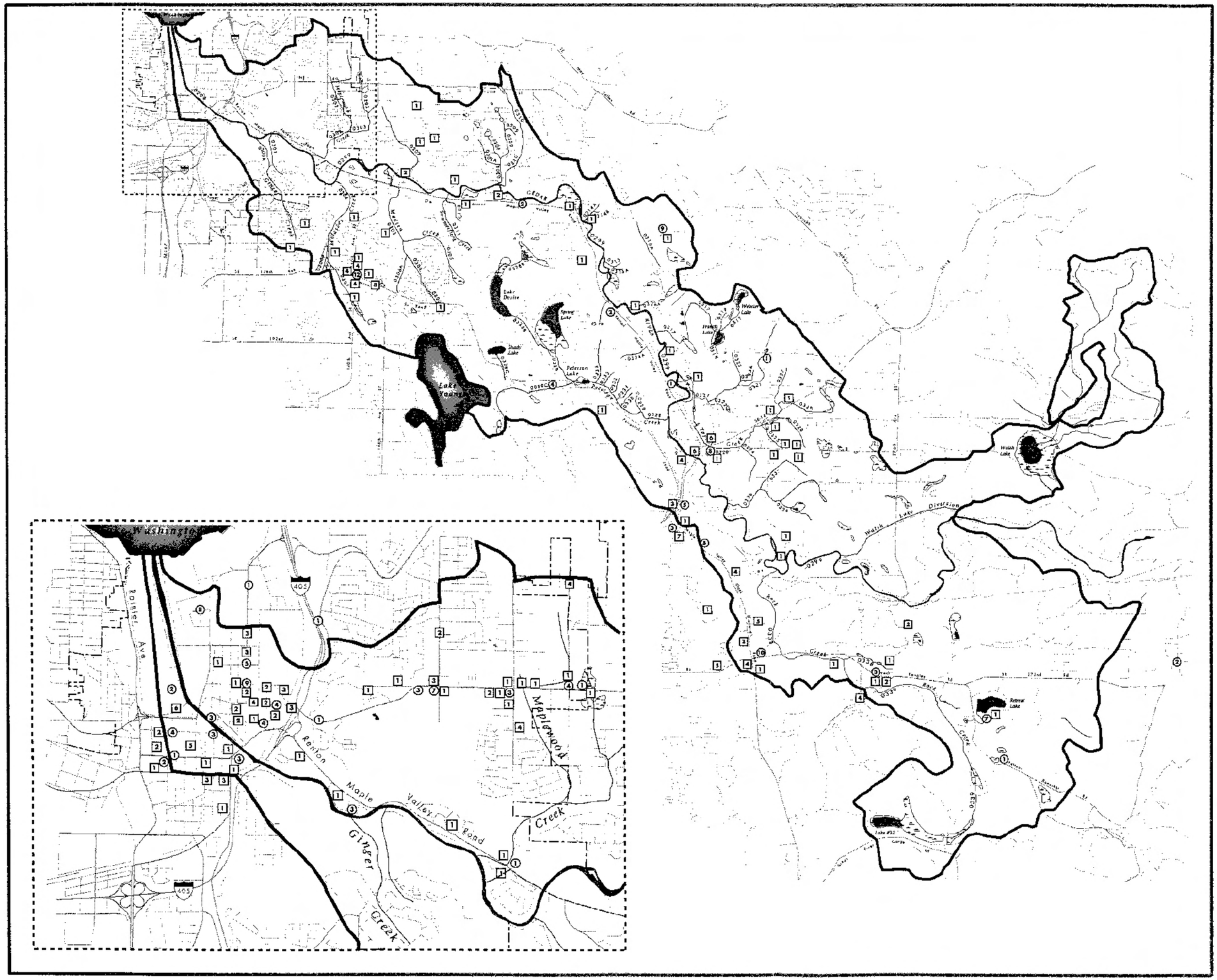
Cedar River Basin Planning Area

Stream
Lake/River
Basin Boundary
Livestock-keeping Location

USDA Puget Sound Cooperative
River Basin Team

N

0 1 2 Miles



Map 15

Small Quantity Hazardous Waste Generators & Underground Storage Tanks

Cedar River Basin Planning Area

- 0299 Stream & Stream Number
- Lake/River
- Wetland
- Basin Boundary
- Renton City Boundary
- (7) Location & Number of Underground Storage Tanks
- [1] Location & Number of Small Quantity Hazardous Waste Generators

Survey Completed in 1991

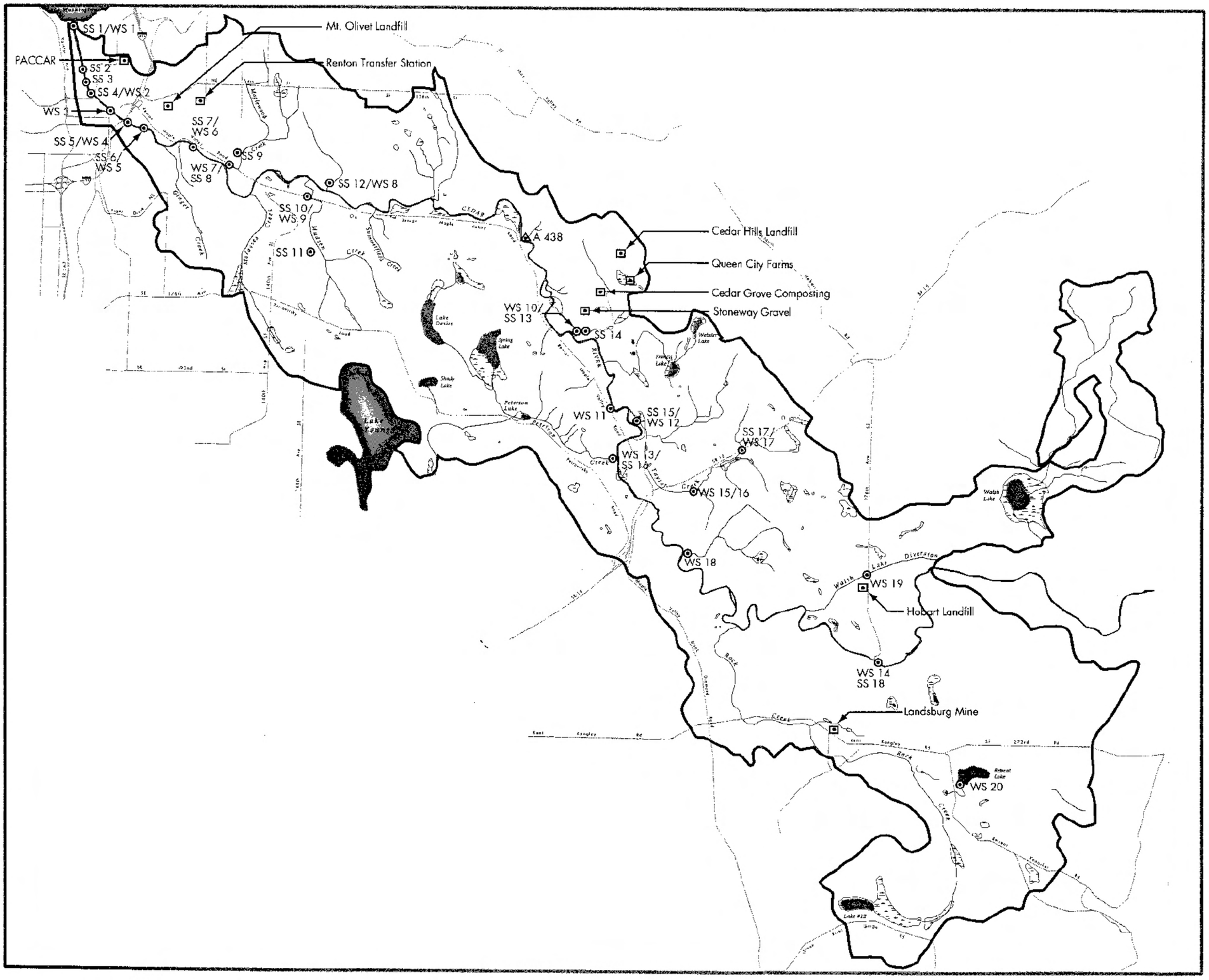
N

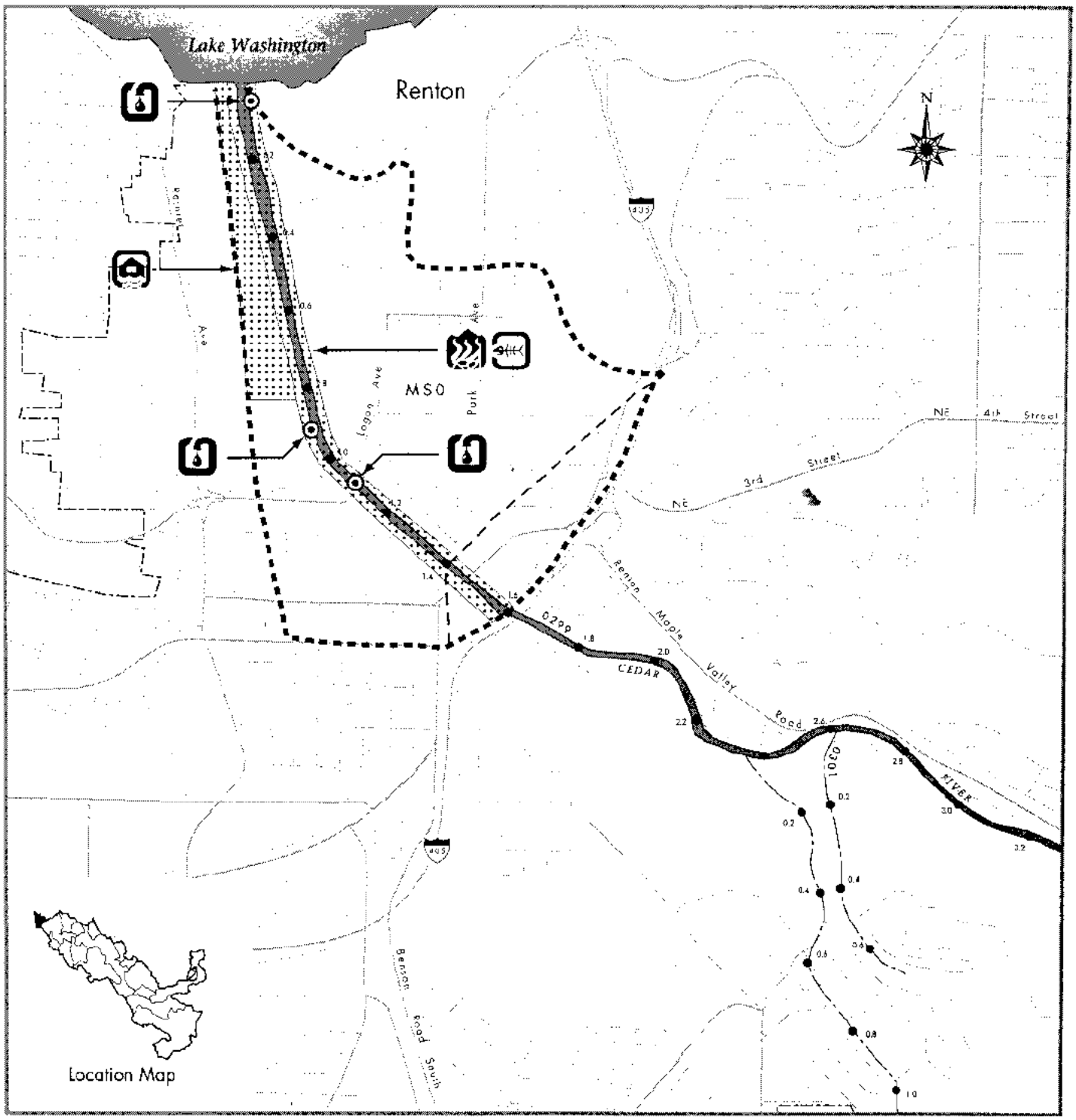
0 1 2 Miles

Map 16

Sampling and Site Locations

Cedar River Basin Planning Area





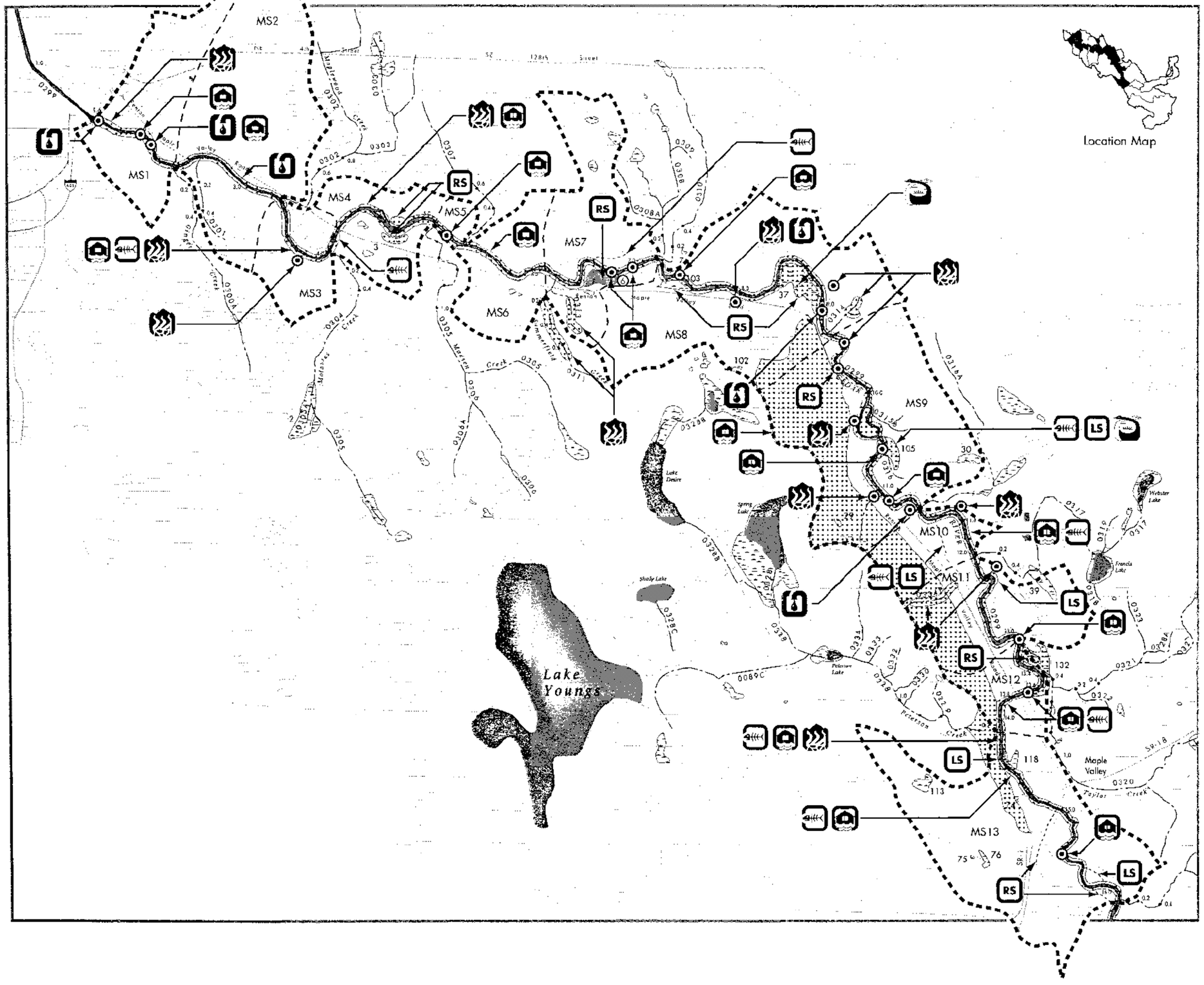
Renton Reach Subbasin Conditions

Map 17

Cedar River Basin Planning Area

- 0299 Stream & Stream Number
- Lake/River
- 3.6 Stream Mile
- Wetland
- Subbasin Boundary
- Catchment Boundary
- MS0 Catchment Number
- Renton City Boundary
- Problem Location/Area
- Stream Habitat Problem
- Erosion/Sedimentation
- Flooding
- Areawide Nonpoint Water Quality Problem

0 ¼ ½ Mile



Map 18

Lower Cedar River Mainstem Conditions

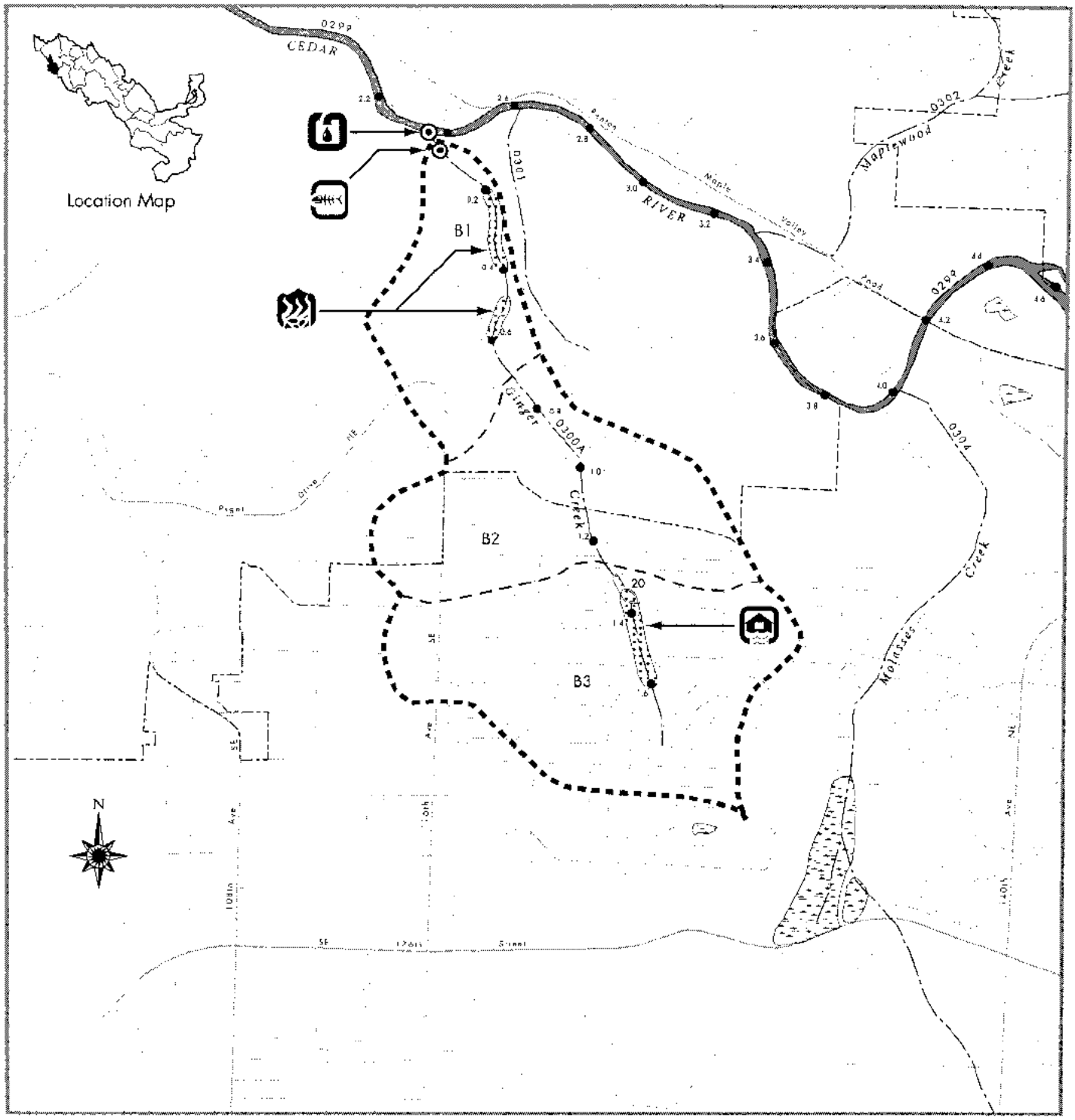
Cedar River Basin Planning Area

- Stream & Stream Number
- Unclassified Stream
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Class I Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- MS1 Catchment Number
- Problem Location/Area
- Locally Significant Resource Area
- Regionally Significant Resource Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- Erosion/Sedimentation
- Flooding

Note: Few specific areas of habitat degradation have been identified on the mainstem, but lack of healthy riparian aquatic habitat significantly affects the habitat conditions from RM 1.6 to 10.0 and RM 10.5 to 21.7.

N

0 ½ 1 Mile



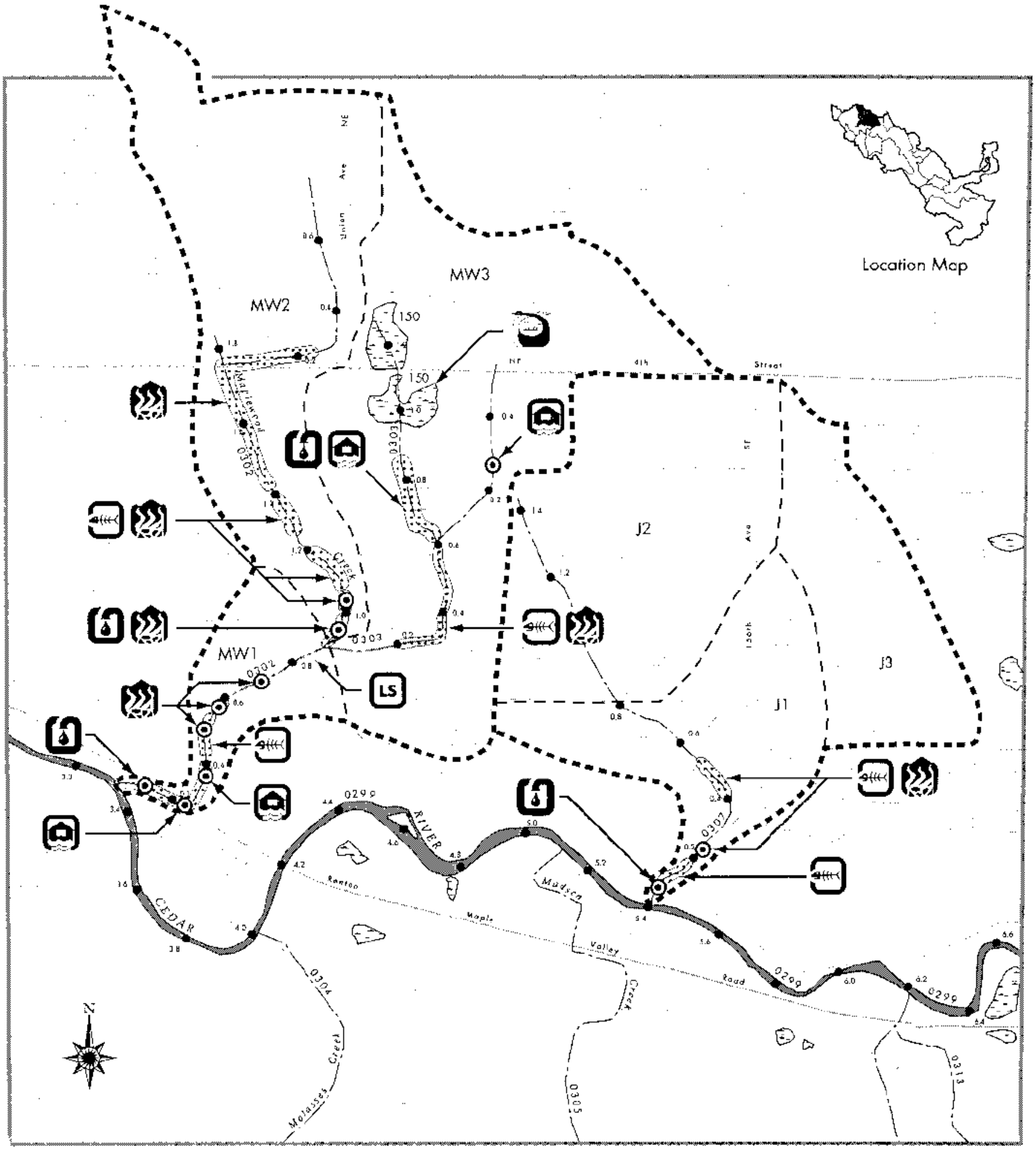
Ginger Creek Subbasin Conditions

Map 19

Cedar River Basin Planning Area

- 0199 Stream & Stream Number
- Lake/River
- 36 Stream Mile
- 5 Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- B1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problem
- Stream Habitat Problem
- Sedimentation/Erosion
- Flooding
- Renton City Boundary

0 ¼ ½ Mile



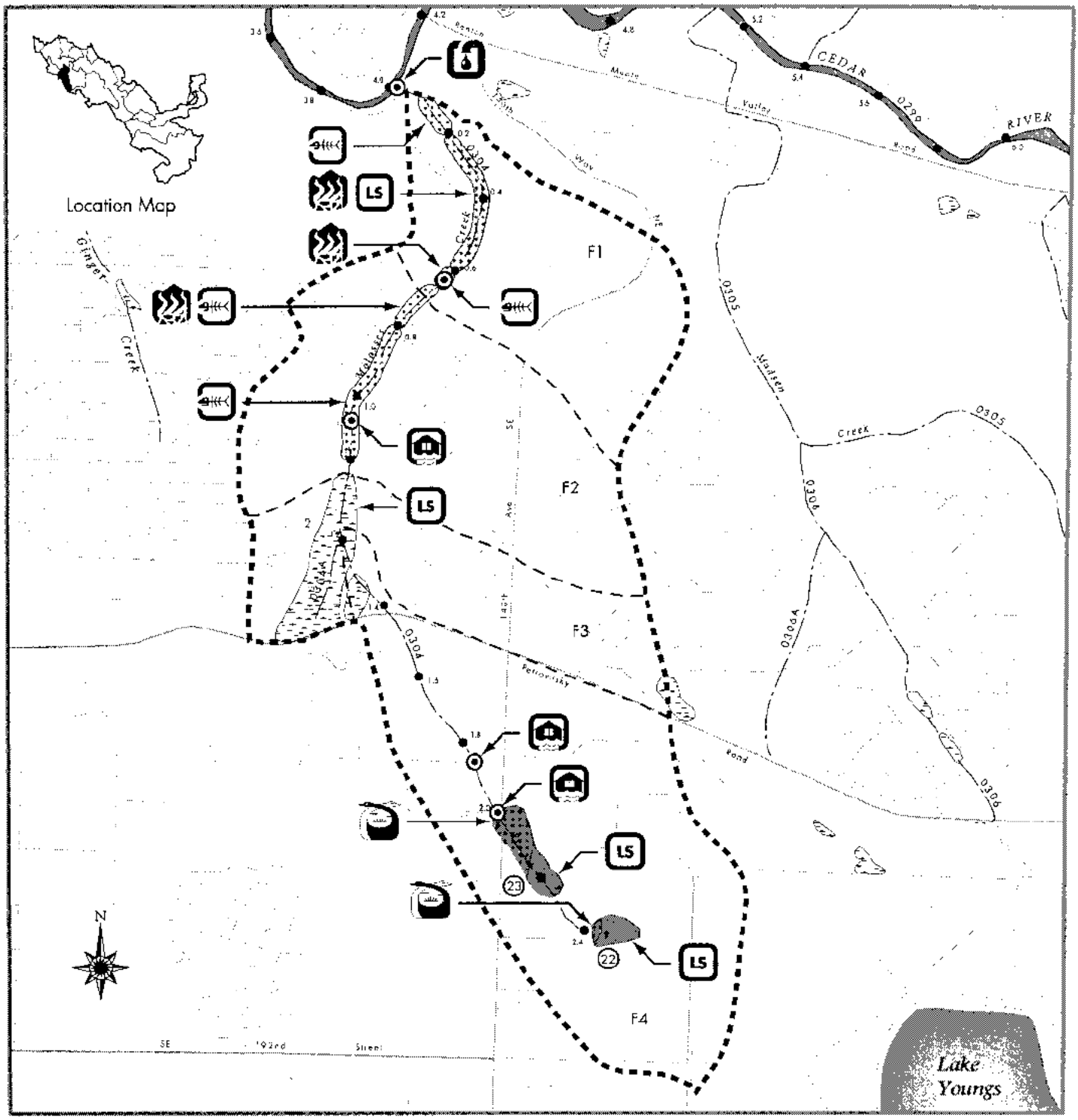
Maplewood & Orting Hills Subbasin Conditions

Map 20

Cedar River Basin Planning Area

- 0299 Stream & Stream Number
- Lake/River
- 36 Stream Mile
- 5 Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- MW1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- Erosion/Sedimentation
- Locally Significant Resource Area
- Flooding

0 ½ ½ Mile



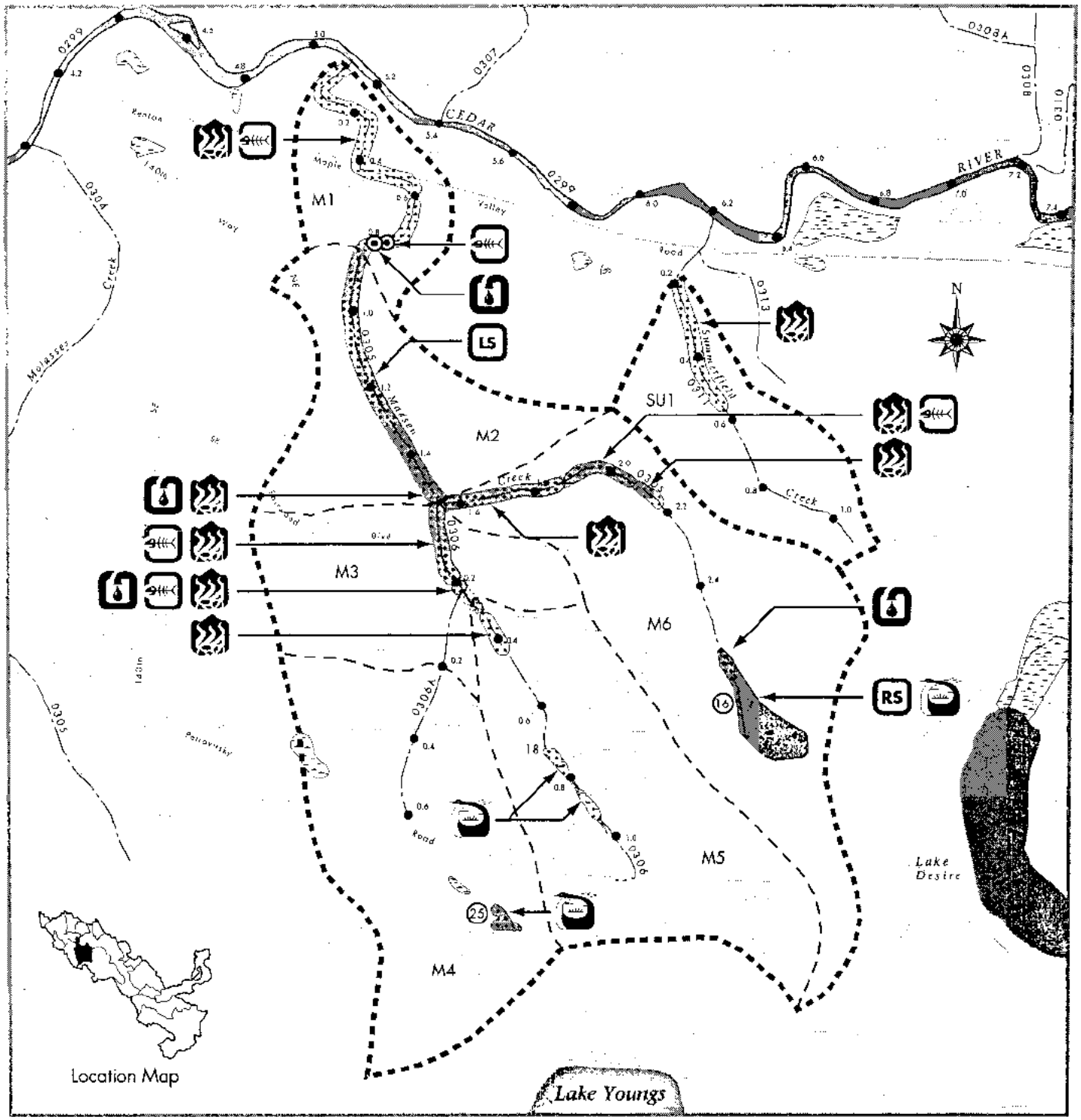
Molasses Creek Subbasin Conditions

Map 21

Cedar River Basin Planning Area

- Stream & Stream Number
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Class I Wetland & Number
- Subbasin Boundary
- Catchment Boundary
- F1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- Locally Significant Resource Area
- Erosion/Sedimentation
- Flooding

0 ¼ ½ Mile



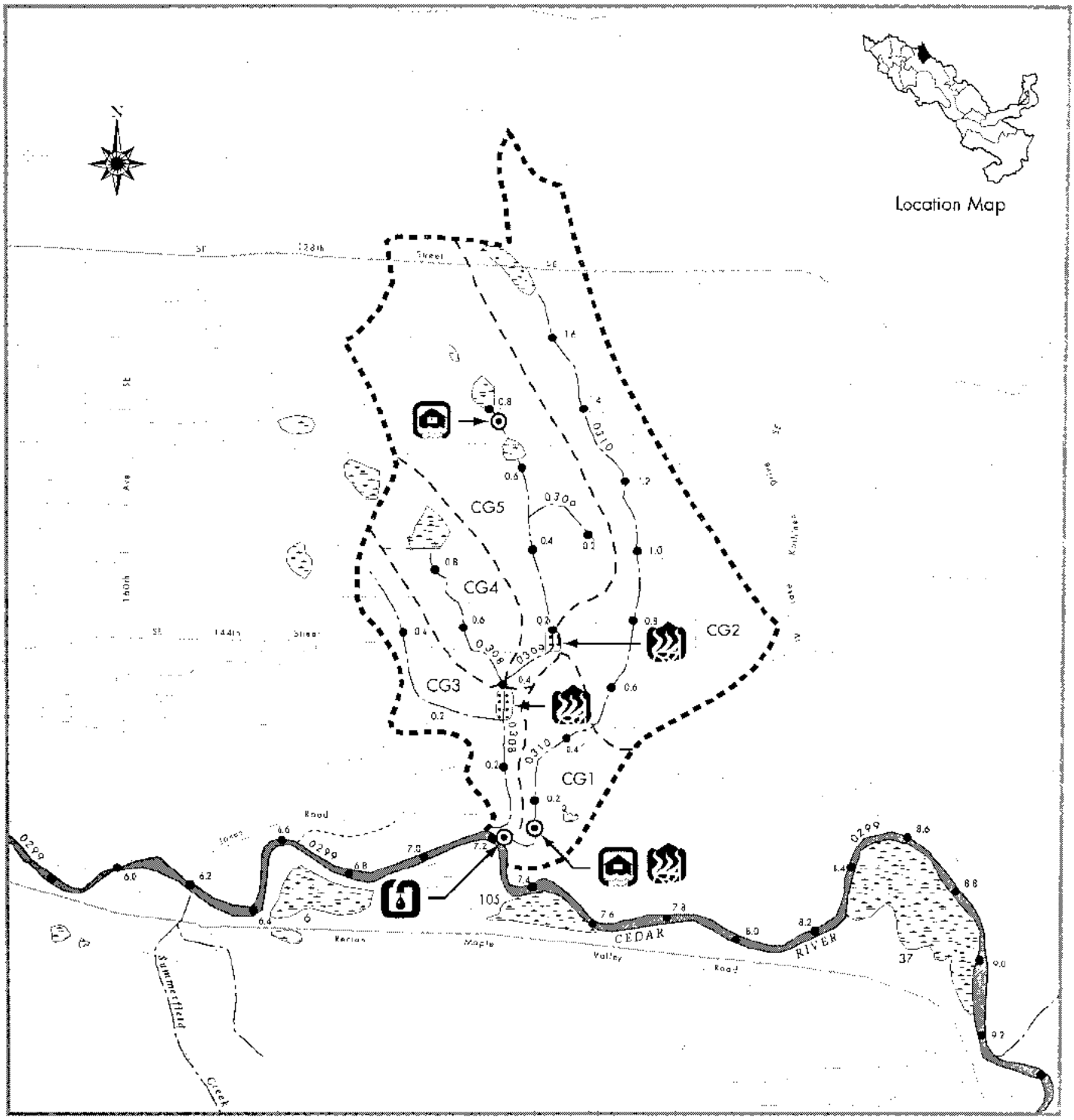
Madsen Creek & Summerfield Subbasin Conditions

Map 22

Cedar River Basin Planning Area

- Stream & Stream Number
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Class I Wetland & Number
- Subbasin Boundary
- Catchment Boundary
- M1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- LS Locally Significant Resource Area
- RS Regionally Significant Resource Area
- Erosion/Sedimentation
- Flooding

0 ¼ ½ Mile



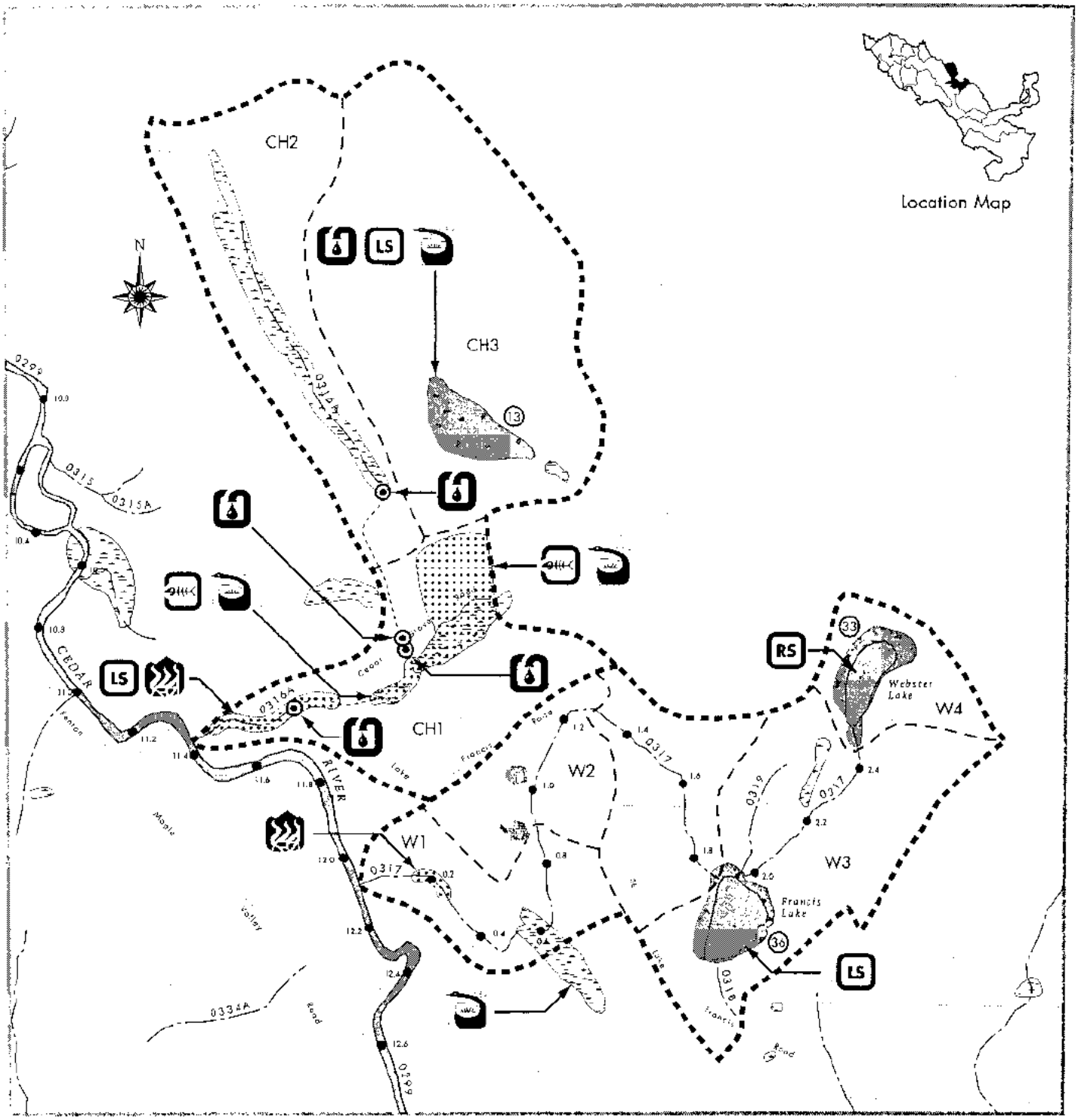
Cedar Grove Subbasin Conditions

Map 23

Cedar River Basin Planning Area

- Stream & Stream Number
- Unclassified Stream
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- CG1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problems
- Erosion/Sedimentation
- Flooding

0 ¼ ½ Mile



Cedar Hills & Webster Lake Subbasin Conditions

Map 24

Cedar River Basin Planning Area

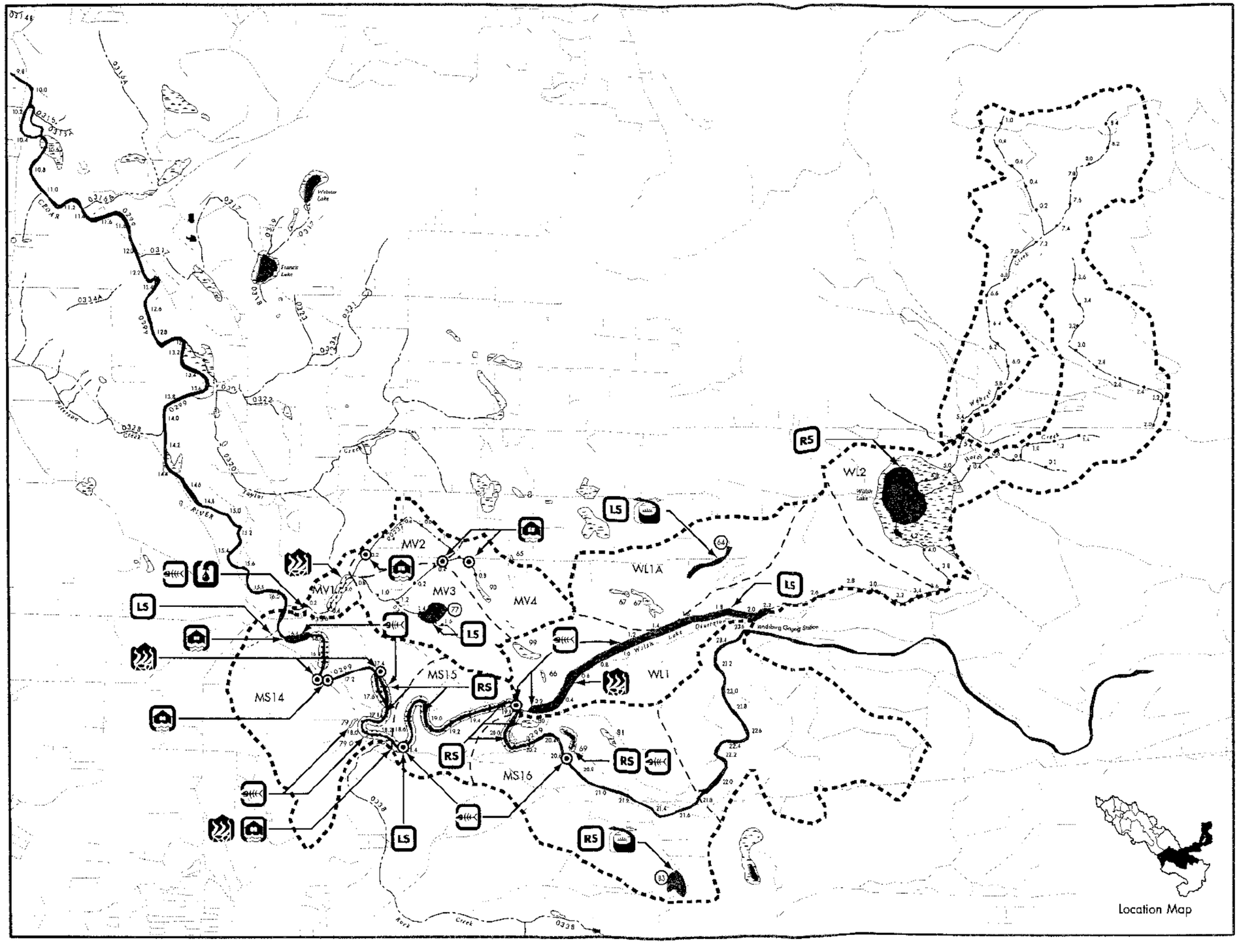
- 0299 Stream & Stream Number
- Unclassified Stream
- Lake/River
- 3.6 Stream Mile
- 5 Wetland & Wetland Number
- (5) Class 1 Wetland & Number
- Subbasin Boundary
- Catchment Boundary
- CH1 Catchment Number
- Problem Location/Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- LS Locally Significant Resource Area
- RS Regionally Significant Resource Area
- Stream Habitat Problem
- Erosion/Sedimentation

0 ¼ ½ Mile

Map 25

Middle Cedar River Mainstem & Subbasins* Conditions

Cedar River Basin Planning Area

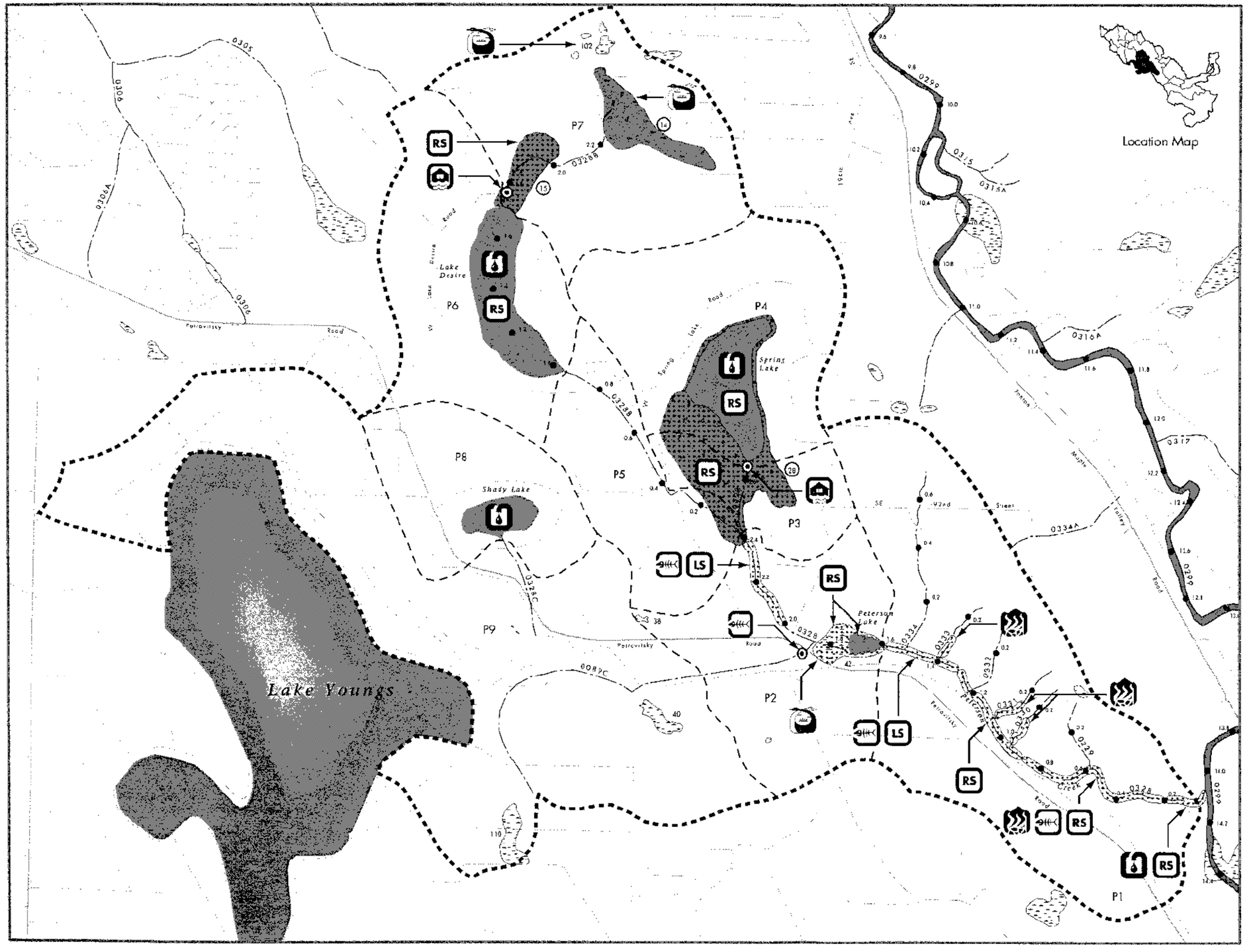


- 0299 Stream & Stream Number
- Unclassified Stream
- Lake/River
- 3.6 Stream Mile
- 30 Wetland & Wetland Number
- (30) Class I Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- MV1 Catchment Number
- Problem Location/Area
- LS Locally Significant Resource Area
- RS Regionally Significant Resource Area
- Areawide Nonpoint Water Quality Problems
- Wetland Habitat Problem
- Stream Habitat Problem
- Erosion/Sedimentation
- Flooding

* Includes Walsh Lake & Dorre Don Subbasins

N

0 ½ 1 Mile



Map 26

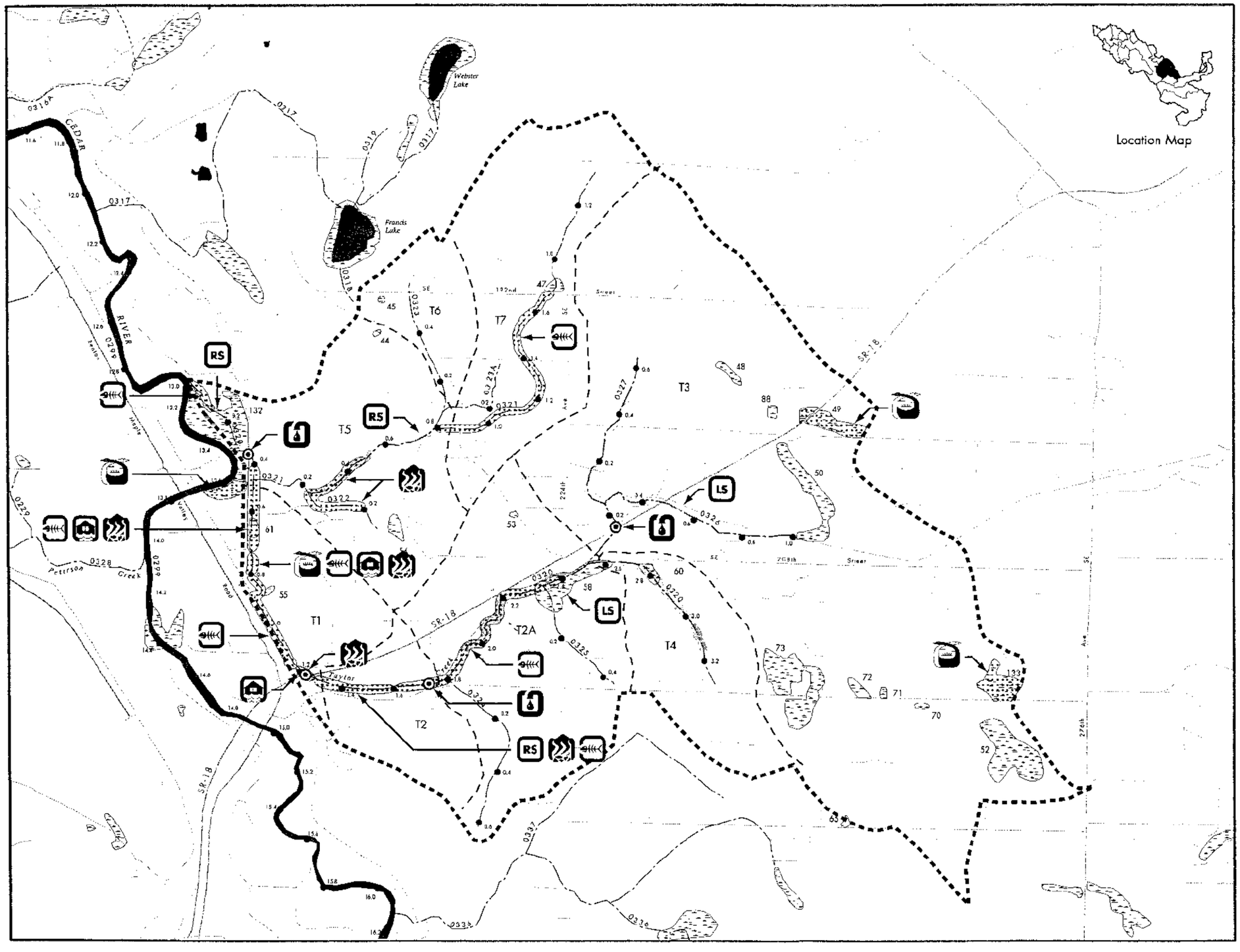
Peterson Creek Subbasin Conditions

Cedar River Basin Planning Area

- Stream & Stream Number
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Class I Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- P1 Catchment Number
- Problem Location/Area
- LS Locally Significant Resource Area
- RS Regionally Significant Resource Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- Erosion/Sedimentation
- Flooding

N

0 ¼ ½ Mile



Map 27

Taylor Creek Subbasin Conditions

Cedar River Basin Planning Area

- Stream & Stream Number
- Lake/River
- Stream Mile
- Wetland & Wetland Number
- Subbasin Boundary
- Catchment Boundary
- T1 Catchment Number
- Problem Location/Area
- LS Locally Significant Resource Area
- RS Regionally Significant Resource Area
- Areawide Nonpoint Water Quality Problem
- Wetland Habitat Problem
- Stream Habitat Problem
- Erosion/Sedimentation
- Flooding

N

0 ¼ ½Mile