4.0 BASIN CHARACTERIZATION

Boundaries for the Percival Creek basin are based on topography and the associated direction of surface water flow. The boundaries were slightly modified where man-made alterations in the natural drainage patterns did not follow the natural topography.

Black Lake was not included within the basin boundaries. The lake discharges to both the Black River and to Percival Creek via the Black Lake drainage ditch. The drainage characteristics of the lake and Black River are currently being investigated by Thurston County. Information from the Percival Creek Basin Plan will be utilized to analyze the interconnections between Black Lake, Percival Creek, and the Black River.

In the past 20 years, the 8.3-square-mile Percival Creek basin has provided the land base for a sizable portion of expanding commercial and residential districts in Olympia, Tumwater, and north Thurston County. Development of the basin began in earnest in the late 1960s with the platting of the major subdivision located at Ken Lake. Evergreen Park subdivision located on the southern terrace of the Percival Creek canyon began developing in 1969. A sanitary sewer main line was constructed on the north side of the Burlington Northern Railroad within the Percival Creek canyon in 1972.

Capital Mall was built in 1979 followed by the rapid commercial development of the surrounding area. Stormwater runoff from this commercial district enters the Black Lake Ditch via Yauger Park, a regional detention pond constructed in 1981, and the ditch that carries flows along Cooper Point Road. The Cooper Point bridge over Percival Creek was constructed in 1986.

Development of the basin’s land area has modified the basin hydrology and introduced contaminants to the creek. Changes to the basin’s land area impact the creek system in subtle but, over the years, chronic ways. Riparian zones, wetlands, and instream habitat have been degraded by urbanization. Map 6 in Appendix 1 presents existing land use in the basin.

Approximately 50 percent of the land area within the basin remains undeveloped (Thurston Geographic Information Facility, 1990). An appreciable portion of this land is comprised of uplands with moderate slopes, wetlands, sensitive areas, and open water. As outlying areas in the Olympia region and the Percival basin support continued residential development, high density land uses within the basin are expected to increase and further impact the hydrology of the basin.
4.1 Climate

The South Puget Sound region has a marine climate typical of the West Coast. Summers are relatively dry and cool; winters are mild, wet, and cloudy. Annual precipitation averages approximately 53 inches. During the wet season, rainfall is usually of light to moderate intensity and continuous over a long period of time. Snow occasionally falls within the basins.

Typical seasonal rainfall is as follows:

<table>
<thead>
<tr>
<th>Approximate Seasonal Rainfall (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
</tr>
<tr>
<td>Winter</td>
</tr>
<tr>
<td>Spring</td>
</tr>
<tr>
<td>Summer</td>
</tr>
</tbody>
</table>

Major storm events in the Olympia area have been evaluated for the purpose of characterizing stormwater runoff quantities. This evaluation generates theoretical design storms that are defined as the precipitation expected in a 24-hour time period from a storm of a given recurrence interval. Although precipitation varies with the specific geographic location, the 24-hour rainfall values are being used for stormwater facility design in northern Thurston County (Drainage Design and Erosion Control Manual for the Thurston Region, Washington, 1991).

<table>
<thead>
<tr>
<th>Storm Recurrence (years)</th>
<th>Precipitation inches/24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.80</td>
</tr>
<tr>
<td>5</td>
<td>3.75</td>
</tr>
<tr>
<td>10</td>
<td>4.35</td>
</tr>
<tr>
<td>25</td>
<td>5.10</td>
</tr>
<tr>
<td>50</td>
<td>5.65</td>
</tr>
<tr>
<td>100</td>
<td>6.15</td>
</tr>
</tbody>
</table>

The prolonged wet season in the Puget Sound area presents unique problems to estimating the quantity of runoff generated by a storm of a specific intensity and duration. Often the level of moisture in the soil profile immediately preceding a storm event is high. Given a saturated soil, only minimal amounts of precipitation can be infiltrated. This likelihood of high antecedent moisture levels in the soil requires extra care when predicting the amount of runoff that can be expected from a storm event.
Rainfall measurements are being collected at two locations within the Percival basin, as well as numerous other locations in north Thurston County. These data have been used for the computer analysis of flows in Percival Creek.

4.2 Topography

The Percival Creek basin is located between the Black Hills on the west and Capital Lake/Budd Inlet on the east.

The drainage area of the basin is, in general, moderately sloped. The Black Hills form a portion of the western boundary of the basin; several additional isolated hills are located in the southern portion of the basin. Map 4 of Appendix 1 delineates sensitive areas within the basin including steep slopes. Table A-1 located in Appendix 2 delineates the soil, land cover, and slope characteristics of the Percival basin.

The two main creek channels within the basin, Percival Creek and the Black Lake drainage ditch, originate at Trosper Lake and Black Lake, respectively. The channel morphology of the creeks generate low gradients in upper wetland creek segments and medium gradients within the deeply-incised Percival Creek canyon. Numerous year-round and seasonal tributaries, springs, and seeps enter the creek.

The basin has been divided into 13 subbasins based upon topography. These subbasins are shown on Map 3 in Appendix 1.

4.3 Soil Characteristics

The geologic history of the Olympia area plays a major role in assessing the surface and subsurface drainage characteristics of the Percival Creek basin. Some soil types within the basin are highly porous and allow the infiltration of surface water; other soil types are relatively impervious. Map 5 of Appendix 1 delineates the distribution of soil groupings within the basin.

Glacial ice from the north entered the Puget Sound region at least several times in geologic history. As the glaciers advanced and then retreated, several types of material were formed and deposited in both river channels and uplands. Within Thurston County there are deposits representing three of the four major glacial advances. All deposits in the Percival Creek basin are from the most recent glaciation.
The glacial advancement deposited and compacted sand, silt, clay, and gravel. The resulting concrete-like soil, known as till, has low permeability and therefore generates considerable stormwater runoff. The tills are fairly stable in slopes. Conversely, the material deposited ahead of advancing glaciers by melting ice, known as advance outwash, is composed of highly porous sands and gravels. A second type of outwash, recessional, was formed by retreating glaciers. The outwash soils are deeper and much better drained than the till soils. Outwash materials with a high content of silt and sand are prone to erosion; those that are more sorted and contain larger material are more resistant to erosion. Another common soil type, clay, was formed by lakes at the time of glaciation.

Non-glacial materials found in the basin include sediments deposited by lakes formed after the glaciation. These soil types, which include the silty loams, silty clays, and clays, are capable of restricting water permeability during saturated conditions. In addition, several poorly drained soils are observed in the low areas and depressions of the basin. These soils are typically saturated or nearly saturated due to high water tables.

Till dominates the northern portion of the basin, while outwash is common in the southern low lying portion of the basin. Residual soils of shallow to moderate depth typically cover the mountainous terrain in the southern and western portion of the basin.

The geologic materials underlying the surface soils of the basin include sandy gravels that have a high water-bearing capacity, till that has a limited water capacity, and non-water bearing basalts. In general, groundwater flows through the basin in a northeasterly direction to Budd Inlet.

The following table presents the quantity of undeveloped acres in the basin by soil type. The majority of the undeveloped acres are underlain by the relatively impervious tills. These soils generate appreciable runoff when cleared of native vegetation and compacted by construction practices (HSPF, 1991).
Table 1: Developable Acres by Soil Type  
Percival Creek Basin  
(Ref: HSPF, 1991)

<table>
<thead>
<tr>
<th>Subbasin</th>
<th>Soil Type</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Till</td>
<td>Outwash</td>
<td>Hydric</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>P-1</td>
<td>0</td>
<td>106</td>
<td>1</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>P-2</td>
<td>256</td>
<td>157</td>
<td>59</td>
<td>472</td>
<td></td>
</tr>
<tr>
<td>P-3</td>
<td>99</td>
<td>131</td>
<td>11</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td>P-4</td>
<td>549</td>
<td>135</td>
<td>0</td>
<td>684</td>
<td></td>
</tr>
<tr>
<td>P-5</td>
<td>424</td>
<td>14</td>
<td>0</td>
<td>438</td>
<td></td>
</tr>
<tr>
<td>P-6</td>
<td>12</td>
<td>57</td>
<td>0</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>P-7</td>
<td>414</td>
<td>0</td>
<td>0</td>
<td>414</td>
<td></td>
</tr>
<tr>
<td>P-8</td>
<td>106</td>
<td>0</td>
<td>8</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>P-9</td>
<td>26</td>
<td>1</td>
<td>2</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>P-10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P-11</td>
<td>70</td>
<td>31</td>
<td>0</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>P-12</td>
<td>57</td>
<td>3</td>
<td>0</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>P-13</td>
<td>183</td>
<td>37</td>
<td>4</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2196</td>
<td>672</td>
<td>85</td>
<td>2953</td>
<td></td>
</tr>
</tbody>
</table>

The computer model of the basin utilizes these soil groupings for simulations of basin hydrology. The distribution and physical properties of specific soils types found in the basin are listed in Tables A-1 and A-2 of Appendix 2.
4.4 Environmentally Sensitive Areas

Environmentally sensitive areas within the basin include wetlands, floodplains, aquifers, geologic formations, and shorelines. Many of these areas are delineated on local zoning maps and necessitate development restrictions. Map 4 of Appendix 1 illustrates the environmentally sensitive areas within the basin; Map 7 presents current zoning within the basin.

4.4.1 Wetlands

Wetlands offer some of the most productive and diverse habitat areas in the basin. There are approximately 504 acres of wetlands in the basin (Thurston Geographic Information Facility, 1990). Most of these wetlands are adjacent to the Black Lake ditch, the upstream segments of Percival Creek, and Grass Lake. These historically high quality wetlands have, in some cases, been altered by draining and replacement of hydrophilic (water loving) species with agricultural plants. Some of the wetlands still maintain a high degree of biological integrity.

In the northern portion of the basin, the City of Olympia has recently purchased 162 acres of the extensive wetland associated with Grass Lake. Like many wetlands in the north Thurston County area, Grass Lake contains extensive peat deposits. The wetland will be preserved and used for education and recreation purposes.

A comparison of the occurrence of hydric soils and known wetlands within the basin indicates that current U.S. Fish and Wildlife Service wetland maps (National Wetland Inventory, 1989) may underestimate the total wetland acreage.

The Thurston Regional Planning Commissions is currently studying the distribution of wetlands in the north county region.

4.4.2 Floodplains

Floodplains in the basins have been identified and mapped by the Flood Emergency Management Agency (FEMA). Floodplains are located adjacent to portions of the creeks, the Cooper Point Road ditch, and the wetlands in the southern and northern portion of the basin. In numerous instances the floodplains are wetlands.

4.4.3 Aquifer Sensitive Areas
Aquifer sensitive areas encompass a relatively large portion of the basin. These areas have aquifers with porous overlying soil types that may allow contaminated surface waters to reach groundwater (Thurston County, 1991).

Several aquifers at varying depths are located within the Percival Creek Basin. The largest aquifers in the basin are located in the vicinity of the Black Lake drainage ditch. The uppermost aquifer is located at ground elevation during much of the wet season. This aquifer is critical to the formation of numerous wetlands along the drainage ditch.

A deeper aquifer is located approximately 50 feet below the ground elevation in the Black Lake area. This aquifer is very large, contains high quality water, and has the potential to provide municipal water if needed in the future. However, the extremely permeable nature of the soils overlying portions of the aquifer make it sensitive to contamination.

4.4.4 Steep Slopes

Although present in a number of areas within the basin, steep and unstable slopes constitute an especially prominent problem in the Percival Creek canyon downstream of the S.R. #101 bridge. High stream flows in conjunction with unstable soils encourage bank failures, landslides, and other unstable slope conditions. Steep, but less problematic slopes, are also found in the mountainous areas of the basin.

4.5 Land Cover and Use

4.5.1 Historical Land Cover

Prior to urbanization the basin was composed primarily of second growth timber and agricultural pastures. Forests consisted of Douglas fir, Western red cedar, big leaf maple, Western hemlock, and red alder with an understory of shrubs and herbs.

The basin’s wetlands were more extensive in the past. The area including Yauger Park and extending downstream along Cooper Point Road to the Black Lake Drainage Ditch was a wetland under natural conditions. The area has been developed and the wetlands filled. Additionally, the construction of the Black Lake drainage ditch appreciably reduced the extent and quality of the wetland along the periphery of the ditch. These changes to natural wetlands have altered the hydrology of the basin.
4.5.2 Existing Land Cover

The central and northern portions of the basin are moderately to heavily urbanized; small farms and extensive wooded areas remain in the southern half of the basin. The composition of existing land cover including impervious surfaces are presented in the following table (Thurston Geographic Information Facility, 1990). This summary does not differentiate between disturbed land cover types associated with development and undisturbed forests and grasslands. Table A-1 in Appendix 2 presents a more detailed evaluation of land cover, slope, and soil characteristics.

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees</td>
<td>2,740</td>
</tr>
<tr>
<td>Grasses</td>
<td>1,038</td>
</tr>
<tr>
<td>Wetland species</td>
<td>476</td>
</tr>
<tr>
<td>Water bodies</td>
<td>92</td>
</tr>
<tr>
<td>Impervious surfaces</td>
<td>953</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5299</td>
</tr>
</tbody>
</table>

Map 6 of Appendix 1 shows the general distribution of land cover types within the basin.

4.5.3 Existing Land Use

As a result of Percival Creek basin’s location on Olympia’s expanding west side and the northern part of Tumwater, the area has experienced a higher rate of growth in both residential and commercial development than many of the region’s more established neighborhoods. Only in the southwestern portion of the basin has development been minimal.

The following table provides an overview of current and potential land use as well as existing jurisdictional infrastructure systems. The growth potential of each subbasin has been subjectively evaluated. Subbasins are identified on Map 3 in Appendix 1.
Currently 3,566 acres in the 5,300 acre basin are undeveloped (Thurston Geographic Information Facility, 1990). Of these undeveloped areas, approximately 10 to 15 percent are wetlands, excessively steep slopes, or Shoreline Management Areas. These areas are not expected to be developed given current environmental regulations. Existing land use patterns are delineated on Map 6 in Appendix 1.

The remaining 1,690 developed acres are land uses at varying from sparse residential to high commercial/industrial. Many of these areas can be expected to accommodate additional development as the basin reaches full build-out.
Current developed land use in the basin is dominated by suburban and commercial uses. A detailed evaluation of current and potential land uses is presented in Table A-3 of Appendix 2.

4.5.4 Potential Development

Forecasts indicate that the development of commercial and residential properties will continue in undeveloped and established neighborhoods of the basin (City of Olympia Comprehensive Plan, 1987; City of Tumwater, 1984).

Major increases in suburban and high-density residential land use are expected at build-out. Suburban and high-density residential development are anticipated to encompass 1,450 and 1,330 acres, respectively. This evaluation assumes the continuation of existing zoning classifications. Table A-3 in Appendix 2 presents a comparison of potential and current land use in the basin. Zoning within the Percival Creek basin is presented on Map 7 of Appendix 1.

Land use in the basin is guided by the long-term planning efforts of the local jurisdictions. In an effort to effectively manage urban development, the Cities of Lacey, Tumwater, and Olympia and Thurston County have delineated an Urban Growth Management Area (UGMA). Land use policies for the 84-square-mile area are intended to encourage high-density housing and commercial development.

As indicated on Map 2 in Appendix 1, the vast majority of the basin falls within the boundary of the long-term UGMA. A short-term boundary, that is not indicated on the map, lies closer to Ken Lake. The potential change in the UGMA does not appreciably affect the land use in the basin.

The short-term boundary is expected to remain in effect until approximately 1998, when it could be expanded to the proposed long-term boundary. Residential property located between the short- and long-term boundaries is currently zoned one unit per five acres.
4.6 Recreational Resources

4.6.1 Existing Resources

Percival Creek basin contains a variety of recreational resources including developed parks and undeveloped open space areas. Several lakes and streamside trails offer local residents the opportunity to enjoy water related leisure activities.

The Percival Creek corridor is regarded as one of Olympia's most important natural amenities. The close proximity of the Burlington Northern Railroad track to the creek allows casual stream-side walking along the 1.5-mile stretch from Percival Cove to the Black Lake drainage ditch at Mottman Road. Several footpaths from the surrounding uplands access the railroad right-of-way.

Yauger Park is a multi-use facility that provides park neighborhood amenities and public ball fields in the fall, spring, and summer and stormwater detention and treatment during the winter. The park offers 41 acres of recreation opportunities including a jogging path, horseshoe pits, children's playground equipment, picnic facilities, and a wetland nature trail.

The Grass Lake Nature Park is located just north of Yauger Park. This park is the newest addition to the City of Olympia's park and open space system. Development of the park will be limited to a series of interpretive nature trails, thereby remaining a natural and passively used area. Only a small portion of the wetland associated with Grass Lake is located within the Percival Creek basin.

Additional nature trails are located on the campus of South Puget Sound Community College. This series of trails borders Percival Creek south of Mottman Road.

Percival Creek basin contains two lakes: Ken Lake and Trosper Lake. Both lakes are privately owned and do not offer public access. However, they offer recreational opportunities to the residents of the neighborhoods that surround them.

4.6.2 Potential Recreational Improvements

Recreational opportunities in the Percival Creek basin would be greatly enhanced by implementation of the Urban Trails Plan. Although still in draft form, the plan is intended to guide future trail development within the UGMA. The Urban Trails Plan is designed to be compatible with the three jurisdictions' existing parks plans and is an
action document that would enable the cities and Thurston County to proceed with trail
development outlined in their respective comprehensive plans.

A number of trails appropriate for bicycles and pedestrians are proposed for the Percival
Creek basin. The potential trails focus primarily on the Percival Creek corridor and
Black Lake drainage ditch. The trails would serve a number of purposes including
passive recreation, aesthetic benefits, and transportation corridors connecting
neighborhoods, schools, parks, commercial areas, and employment centers.

The 1990 City of Olympia Parks Plan identified needed improvements in the City's park
and open space composition. The central portion of the Percival Creek basin is currently
in need of additional open space. The plan calls for the preservation of undeveloped
areas to visibly and audibly block one land use from another.

Neighborhood parks in the northern portion of the basin are currently considered
adequate by the Olympia Parks Department. However, with future populations
anticipated to be as much as double current levels, additional neighborhood park space
will be needed. Although the Olympia Parks Department considers the Black Lake
drainage ditch wetlands an ideal area to develop low intensity parks, no formal plans
exist at this time. If the Urban Trails Plan is adopted, trails through the area may be
developed and park areas created.

4.7 Stormwater Conveyance, Treatment, and Storage Systems

Approximately 950 acres of the 5,300-acre basin are currently covered by impervious
surfaces. The developed surfaces that generate runoff capable of flowing downstream of
the particular site are termed effectively impervious. Conversely, many impervious
surfaces, such as the roof of a single family residence, generate runoff that is at least
partially infiltrated on the developed site. This portion of total runoff need not be
managed by stormwater systems and is considered noneffective. Computer modeling
(HSPF, 1991) shows that approximately 580 acres in the basin are effectively impervious,
thereby generating runoff that must be managed.

The runoff from impervious surfaces in the basin is managed to varying degrees
depending upon the drainage regulations in place at the time of project construction.
Prior to the mid 1970's, stormwater management requirements for new development
were minimal. System designs focused on the conveyance of stormwater from the
particular development. Treatment and storage were not required.
In the 1980’s new development was required to provide better conveyance and storage of stormwater, though specific treatment requirements were not in place. Conveyance and storage requirements were based on a policy of managing the 10 year/100 year storm events. Suspended solids and adsorbed contaminants were assumed to be partially removed from the detained stormwater by the process of settling.


4.7.1. Existing Stormwater Systems

The majority of the Percival Creek basin has been developed in the past 20 years, and especially in the past 10 years. Because of this development pattern, the level of stormwater management is higher than in older areas of the urban area. Some private systems are highly effective, others are undersized.

Stormwater systems in the basin include extensive piped systems in Olympia’s westside commercial and residential neighborhoods, and the rapidly developing portion of the basin within Tumwater. Smaller piped systems and roadside ditches serve outlying developments.

A simplified schematic of the piped conveyance systems within the basin is shown on Map 8 in Appendix 1. These systems discharge to Percival Creek at 15 locations along the length of the creek system. Additionally, numerous roadside ditches and dispersed overland flow contribute storm flows to the creek. The total piped system in the basin is summarized as follows:

<table>
<thead>
<tr>
<th>Pipe diameter, inches</th>
<th>Total length, miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 12</td>
<td>12.7</td>
</tr>
<tr>
<td>14 - 24</td>
<td>4.6</td>
</tr>
<tr>
<td>&gt;25</td>
<td>1.3</td>
</tr>
</tbody>
</table>

There are 83 known public and private stormwater storage and treatment facilities within the basin. A listing of the detention facilities is presented in Appendix 3, and illustrated on Map 8 in Appendix 1. A database including facility location, condition, and approximate capacity is available from the City of Olympia and Thurston County. The facility inventory provides an indication of maintenance needs and the potential for design upgrades.
Percival Creek, its tributaries, and wetlands are important natural components of the stormwater system of the basin. At current levels of stormwater management the discharges to the creek create unnaturally high flood flows that threaten the integrity of the creek system and associated sensitive areas. Stormwater runoff is also a source of nonpoint pollution. These issues are addressed in detail in Chapters 5 and 6.

The creek passes through six instream culverts. Analysis of these culverts using the U.S. Corp of Engineers HEC-2 computer model indicates that the culverts are adequately sized to convey existing as well as potential future flood flows. The impoundment of flood flows behind the culverts is expected to increase little as development continues (Thurston County, 1991). However, several of the culverts block fish passage and are detrimental to the instream habitat provided by the creek system. Table A-4 in Appendix 2 characterizes these culverts. Habitat issues are addressed in Chapter 5.

The characteristics of the stormwater systems in each of the basin’s jurisdictions are presented in the following discussions. Specific problems associated with the stormwater system are addressed in Chapter 6.

Olympia

The most extensive storm system within Olympia’s jurisdiction of the basin consists of a pipe and ditch system linking the northern portions of the basin with the Black Lake drainage ditch via Yauger Park and the Cooper Point Road ditch. More localized systems serve the Lakemoor Subdivision at Ken Lake, the residential neighborhoods located along the southern bank of the Percival Creek canyon, the Capital Auto Mall, and the South Puget Sound Community College and adjacent neighborhood. Intermittent systems are located in several of the smaller residential developments.

The City of Olympia Parks and Public Works Departments oversee the operation of Yauger Park, a multi-purpose regional detention facility. Approximately 71 acre-feet of stormwater generated by the highly developed commercial and multifamily residential areas located adjacent, and to some extent, upstream of the park are effectively stored in the park.

Lakemoor Subdivision on Ken Lake is the largest development in the basin that does not provide stormwater management. With a few minor exceptions, runoff flows from the development are discharged directly to Ken Lake and subsequently to the Black Lake drainage ditch. During major storm events, the lake generates appreciable flows to the ditch.
Public systems include several storage ponds maintained by Olympia. Seventy-one stormwater ponds have been inventoried within Olympia's jurisdiction.

**Tumwater**

Tumwater's pattern of development in the basin has generated pockets of residential land use broken by relatively large tracts of undeveloped land. This pattern has resulted in a storm system comprised principally of extensive pipe systems in conjunction with roadside ditches and natural drainage. Ten stormwater pond systems are located in Tumwater's portion of the basin.

The residential developments adjacent to Trosper Lake, south of South Puget Sound Community College, and on Tumwater Hill utilize piped stormwater systems with varying levels of treatment and storage. The City of Tumwater is currently in the process of developing several regional facilities at the base of Tumwater Hill.

**Thurston County**

Portions of the basin within the jurisdiction of Thurston County are largely rural in nature and sparsely developed. The stormwater systems servicing these areas consist of roadside ditches and culverts. The county has completed an inventory of culverts and catch basins in the basin. No privately owned stormwater management ponds are located within the county's portion of the basin.

**Washington State Department of Transportation**

In addition to the stormwater systems administered by the local jurisdictions, the Washington State Department of Transportation (WSDOT) manages the runoff generated by State Route #101 (S.R. #101). Approximately 22 acres of pavement generates runoff that is discharged to Percival Creek. Six detention ponds manage approximately 25 percent of the runoff flow from the highway.
4.7.2 Effectiveness of Existing Facilities

The present level of stormwater management in the Percival Creek basin is based on the construction and maintenance of municipal and private infrastructure, and the regulation of potential developments.

In extreme cases, such as the system servicing the Cooper Point Road area, existing conveyance systems are unable to manage the runoff generated by the contributing area. These inadequacies result in flooding of developed areas. More commonly, system capacity and effectiveness is impaired by a lack of maintenance.

The storage and treatment facilities within the basin do not perform at a level adequate to preserve the physical and biological integrity of the Percival Creek system. Computer modeling conducted as part of the basin planning process indicates that flood flows have increased dramatically and drought flows decreased compared to predevelopment land cover conditions (HSPF, 1991). A detailed discussion of creek hydrology is presented in Section 5.3.

Historically, stormwater systems were maintained only in reaction to a flooding problem. Maintenance has improved for some of the systems. The City of Olympia began an aggressive long-term maintenance program for municipal systems in 1990. Additionally, new developments within Olympia’s jurisdiction are to implement maintenance programs; existing developments are being encouraged to developed maintenance programs. In the event of inadequate private maintenance, the City has the authority to maintain private systems and charge the owner for the service. Street sweeping in the City occurs every one to six weeks depending upon the level of traffic associated with the particular street.

Tumwater maintains pipe systems on an emergency basis. The last citywide cleaning of catch basins in the City was conducted in 1965. Sweeping of streets occurs every eight to 10 weeks in the highly developed areas of the basin.

Thurston County currently maintains roadside ditches on an as needed basis and has a limited pipe, culvert, and pond maintenance program. Streets in the County are swept every three to 12 months.

In general, maintenance of private as well as public systems is inadequate.

4.7.3 Ongoing System Improvements

Several stormwater management projects are either recently completed, currently underway, or expected to be completed in the near future. These basin projects are presented in the following discussion.
**Olympia**

Stormwater projects currently underway by the City of Olympia in the Percival Creek basin are as follows:

- Improving conveyance from the developed area immediately northeast of the Cooper Point Road/Harrison Avenue intersection. The project reduced a flooding problem at the intersection and adjacent development.

- Modifying a culvert system under S.R. #101 near the Friendly Village of Olympia development. The project will improve conveyance from Friendly Village to the Black Lake drainage ditch.

- Improving a downstream portion of the conveyance system between Yauger Park and the Black Lake drainage ditch. The project corrected an existing flooding problem at Black Lake Apartments and improved upstream conveyance.

**Tumwater**

The City of Tumwater is in the process of designing and constructing the stormwater infrastructure for the low, moderate, and high density residential developments on Tumwater Hill. Tumwater’s stormwater management approach calls for the creation of regional detention ponds to serve the individual developments.

Construction projects include the following:

- Development of a regional pond south of Tumwater Hill on Linwood Avenue near Rural Road. Metered flows of approximately 26 cubic feet per second (cfs) during a 100-year storm event would be released to Percival Creek (Tumwater Hill Stormwater Drainage Plan, 1989). An appreciable portion of the flows managed by the facility would be conveyed by gravity to the Percival Creek basin from the Deschutes River basin.

- Development of a storage and treatment pond on Mottman Road. The project discharges from the northeastern portion of Tumwater Hill to Capitol Lake.

- Upgrading the conveyance and storage systems on the west side of Tumwater Hill. The work involved improvements to pipe systems in Crosby Boulevard.
Washington State Department of Transportation

Planned improvements to S.R. #101 between Interstate 5 and the Black Lake interchange are currently being designed by WSDOT. Upgrades to the existing drainage system would include the utilization of roadside swales for stormwater treatment and the construction of several storage/treatment facilities. The construction project is expected to begin in 1992.
5.0 PERCIVAL CREEK CHARACTERISTICS

5.1 Overview of Creek System

Percival Creek is one of the largest and biologically most important streams in the urbanizing area of north Thurston County. Beneficial uses of the creek system include habitat for wildlife and aquatic organisms (including salmon), outdoor recreation, urban open space, education, aesthetics, and the conveyance of stormwater to Capital Lake and subsequently Budd Inlet.

Management of existing and future development within the basin is important in order to preserve what the Olympia City Council has described as a creek system "...of special environmental concern...one of the City's most significant aesthetic, recreational, and habitat resources." (Percival Creek Corridor Plan, Vol. 1, 1985.)

The creek system consists of a main stem, one major tributary, and several minor tributaries. The main stem of Percival Creek begins at Trosper Lake and flows north for approximately 2.4 miles to its confluence with the main tributary, the Black Lake drainage ditch. The Black Lake drainage ditch, a man-made channel, originates at Black Lake and, like Percival Creek, flows in a northerly direction for approximately two miles before turning to the east near Mottman Road. In addition to the creek system, the drainage basin area encompasses Trosper and Ken Lakes, and several extensive wetlands.

Computer modeling has indicated that at the confluence with the main stem, the Black Lake drainage ditch carries approximately three times the flow that is conveyed by Percival Creek (HSPF, 1991). Percival Creek downstream of the confluence flows about 1.2 miles through a deeply incised canyon to Percival Cove on the western side of Capital Lake. In turn, Capital Lake discharges through a tidal gate to the western portion of Budd Inlet.

Percival Creek includes long sections of slow moving water and extensive wetlands in the upstream reaches, and short reaches of fast flows in the downstream higher gradient reaches. The majority of the Black Lake drainage ditch has a very low gradient, and relatively uniform width and depth. The mean annual streamflow of Percival Creek at its mouth in Percival Cove is approximately 45 cubic feet per second (cfs) (HSPF, 1991).

The Percival Creek system has experienced numerous changes to the stream channel over the years. Construction of the Burlington Northern railroad along the northern streambank of the canyon segment of the creek in the early 1890's was the first major alteration of the natural stream channel. The railroad line follows the creek from
Percival Cove to the Mottman Road bridge, and in many places defines the northern streambank configuration.

The Black Lake drainage ditch was excavated in 1922. The project was constructed to drain the potential agricultural land north of the lake. Construction of the ditch entailed approximately two miles of excavation. With the abandonment of the Consolidated Drainage Improvement District #101 in 1976, ownership of the drainage ditch reverted to Thurston County. The most recent maintenance dredging of the ditch was conducted in 1978 in response to concerns regarding the rising seasonal elevation of Black Lake.

Percival Creek discharged directly to Budd Inlet prior to the development of Capital Lake in 1951. The estuary traits associated with the creek's mouth were largely lost due to the artificial water elevation of the lake.

The creek between Percival Cove and Black Lake is regulated under the Washington State Shoreline Management Act. Grass Lake, Ken Lake, and Trooper Lake are also subject to Shoreline Management Act regulations. The boundaries of the regulated areas are presented on Map 10 in Appendix 1. A discussion of the act is provided in Appendix 9.

5.2 Creek Corridor

The majority of Percival Creek's riparian zone is densely vegetated with common streamside species including Douglas fir, red alder, Western red cedar, and various shrub species. Much of the creek flows through a deep canyon with high walls and a narrow flood plain. Extensive streamside wetlands are adjacent to the upstream portions of the creek and the Black Lake drainage ditch.

The highly vegetated nature of the creek corridor makes it an ideal wildlife corridor. The stream channel offers a narrow, but essentially contiguous, strip of habitat approximately six miles long that provides wildlife an access route to locations within and outside of the basin. Streamside buffers ranging from 25 to 100 feet have been established by the jurisdictions to help protect the riparian zone from development and protect the viability of the wildlife corridor.

Percival Creek flows in a steep canyon from the Black Lake drainage ditch at Mottman Road to the creek's mouth at Percival Cove. The 1.2-mile-long segment of the creek is susceptible to hillslope instability as evidenced by the geologic formation of the 200-foot deep canyon. The potential for these problems to increase with urbanization has been
noted in several previous studies of Percival Creek (Percival Creek Drainage Basin Study, 1973; Stream Corridor Management Plan for the Deschutes River, 1984; City of Tumwater Storm Water Comprehensive Plan, 1986).

The field work completed in the summer of 1990 as part of the basin planning effort showed that approximately 1,200 feet of the 6,200-foot canyon stream segment are unstable. The major storm event of November 1990 resulted in noticeable erosion on the already problematic streambanks and southern hillslope. These areas are noted on Map 9 in Appendix 1.

The steeply sloped and heavily vegetated canyon corridor provides pleasant recreational and open space amenities.

5.3 Hydrology

The clearing of land and the creation of impervious surfaces associated with urbanization of the basin have increased stormwater runoff. In turn, runoff within the drainage basin is typically conveyed downstream to the creek system. Stormwater enters the creek quickly and in great volumes rather than slowly infiltrating through the soil. This chain of events is an alteration of the natural hydrology of the basin. Evaluations of undisturbed forested lands indicate that, in many locations, surface runoff is inconsequential under natural conditions.

In an undisturbed basin, occasional flood flows act to revitalize the biological community of the creek. In contrast, the flood flows associated with urbanized basins typically have a greater magnitude and occur more frequently than do natural flood flows. These flows generate chronic and/or permanent impacts to the system.

A highly sophisticated computer model (Hydrologic Simulation Program-Fortran, HSPF) has been created by the U.S. Geological Survey and Thurston County to simulate creek flows in Percival Creek continuously for 20 years of rainfall records. The model tracks the year-round hydrology of the basin instead of limited storm event analysis provided by commonly used hydrologic models. Calibration of the model was accomplished utilizing two years of continuous flow and rainfall data. Appendix 4 presents a technical explanation of the model and statistical data.

Flows from Black Lake to Percival creek via the Black Lake drainage ditch have a pronounced affect on the hydrology of the creek system. Prior to the excavation of the drainage ditch, the hydrologic connection between Black Lake and Percival Creek was minimal.
The computer analysis of creek flows with existing land use conditions provides the following summarized findings:

- Flood flows are higher and drought flows are lower under existing land use conditions as compared to pre-development forested conditions.

- Current 2- and 100-year storm events produce flows of approximately 310 and 680 cfs at the creek mouth, respectively.

- Current 2- and 100-year low flows at the mouth of the creek system are estimated to be 4.5 and 4.2 cfs, respectively.

- Current flood flows in the creek during a 5-year storm are at least as high as those generated by a 25-year storm under past forested conditions. Similarly, flood flows from a current 2-year storm are at least as high as those generated by a 5-year storm in past conditions. Due to difficulties associated with modeling historical conditions these results, in all likelihood, appreciably underestimate the extent of flow increases.

- During various storm events, the Black Lake drainage ditch contributes 50 to 70 percent of the total flows in Percival Creek.

- Current storm flows generated by the Cooper Point Road area, the area between Sapp Road and Mottman Road, and the area along the Percival Creek canyon exhibit the greatest increases compared to estimated pre-development flows.

- Ken Lake and the Black Lake drainage ditch generate the greatest flow increases between the 2- and 100-year storm events. Ken Lake and Black Lake do not effectively store flood flows. The increase in flows from the Ken Lake subbasin with increasing storm events is proportionately higher than from any other subbasin.

- The Cooper Point Road ditch contributes 19 to 27 percent of the flow in the Black Lake drainage ditch during storm events of various reoccurrence intervals. Since stormwater release rates from Yauger Park are very modest, runoff from areas downstream of the park are appreciable.

- Approximately 60 percent of the storm flow in Percival Creek prior to its confluence with the Black Lake drainage ditch is contributed in the semi-rural portion of the basin upstream of Sapp Road.
Storm flows in Percival Creek increase approximately 15 percent between the confluence of Percival Creek and the Black Lake drainage ditch and its mouth at Percival Cove. Potential sources of these flows include numerous low to high density developments and S.R. #101.

Creek flows under drought conditions have decreased with urbanization. The magnitude of the decrease is difficult to evaluate using available computer modeling techniques.

Existing Percival Creek flood and drought flows for various reoccurrence intervals are presented in Tables A-5 and A-6 of Appendix 2. Hydrologic problems are discussed in Chapter 6.

5.4 Geomorphology

The unnatural and frequent flood flows associated with urban runoff impact the physical shape and structure of a creek. In many urban creeks these physical impacts, such as erosion and streambed scouring, may be more problematic than water quality contamination (Pederson 1981; Scott, 1982; Steward, 1983). The impacts can also be a significant cause of habitat disruption within the creek system.

The evaluation of possible impacts requires an in-depth field investigation of creek conditions and subsequent comparisons to conditions typical of natural creek systems. This work was conducted in conjunction with the Squaxin Island Tribe as part of the basin planning process. The major evaluation parameters are described below.

5.4.1 Pool:Riffle:Glide Ratio

Three major types of channel configurations are present in the creek: pools, riffles (relatively fast moving water), and glides (relatively slow moving water). These differing channel configurations support unique microhabitats for the various life stages of fish and insects that have conflicting biological needs, yet rely upon the productivity of each other. The proportion of each type of configuration within a creek segment reflects the geologic and hydrologic influences acting on the creek. Naturally occurring creeks typically have relatively equal portions of pools and riffles; creeks impacted by urbanization have a higher portion of riffles (Platts et al., 1983).

The increase in creek riffles results from an increase in sediment load. If unable to carry the higher quantity of sediment, the creek may experience an increase in channel bed elevation. In response to the rise in channel elevation, the creek will continue to erode the streambanks and increase its width. The process results in a shallow stream channel. Several studies have documented increases in channel width due to increased flows, volumes, and water velocity as well as increased floodplain elevation (Hammer, 1972; Robinson, 1976).
5.4.2 Pool Spacing

A related measurement evaluates the spacing between pools in the channel. The specific location of pools and riffles within a creek segment are in a constant state of flux even with ideal streamflow conditions; pools are filled and new ones scoured. Although dynamic in nature, a creek can be expected to maintain a relatively constant spacing between pools.

With urbanization, the channel can become wider and shallower due to high flood flows and subsequent streambank erosion. Pools have a tendency to fill with sediment and thereby increase their spacing.

5.4.3 Large Organic Woody Debris

The presence of large organic woody debris (LOD), such as tree stems and root clusters, in the creek channel is critical to the physical and biological diversity of a creek. LOD acts as a relatively fixed structure in the channel thereby dictating scour patterns. Additionally, LOD provides cover from predators and high flows.

Frequent and excessive high flows such as those in Percival Creek can remove LOD from the channel and deposit it in the floodplain and create log jams.

5.4.4 Sinuosity

Sinuosity compares the actual length of the creek between two points with the horizontal distance between the points. Healthy creeks have many channel meanders and bends; creeks subjected to high runoff volumes become straightened by the energy of the flows.

5.4.5 Percival Creek Geomorphic Traits

The following table presents the quantitative geomorphic data collected during the 1990 field investigations. The subbasin segments referred to in the following table are identified on Map 3 in Appendix 1.
Table 3: Habitat Characteristics
Percival Creek Basin
(Ref: City of Olympia/Squaxin Tribe Field Survey, 1990)

<table>
<thead>
<tr>
<th>Subbasin</th>
<th>Length of Creek Segment (feet)</th>
<th>Total Culverted Creek Segments (feet)</th>
<th>Creek Gradient, percent</th>
<th>Pool/Riffle/Glide Ratio</th>
<th>LOD Pieces/100 ft</th>
<th>Pool Spacing</th>
<th>Sinuosity</th>
<th>Creek Substrate Dominant/Subdominants</th>
<th>Fish Passage Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-1</td>
<td>1,003</td>
<td>0</td>
<td>0.39</td>
<td>0:0:1</td>
<td>N/A</td>
<td>N/A</td>
<td>1.05</td>
<td>Silt/organic matter</td>
<td>–</td>
</tr>
<tr>
<td>P-2</td>
<td>4,397</td>
<td>65</td>
<td>0.39</td>
<td>0:0:1</td>
<td>N/A</td>
<td>N/A</td>
<td>1.10</td>
<td>Silt/organic matter</td>
<td>1</td>
</tr>
<tr>
<td>P-3</td>
<td>6,923</td>
<td>374</td>
<td>0.58</td>
<td>1:0:39:2.23</td>
<td>10.3</td>
<td>4.2</td>
<td>1.20</td>
<td>1-3 inches gravel/sand</td>
<td>2</td>
</tr>
<tr>
<td>P-4</td>
<td>5,451</td>
<td>0</td>
<td>0.18</td>
<td>0:0:1</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
<td>Silt/organic matter</td>
<td>–</td>
</tr>
<tr>
<td>P-6</td>
<td>4,505</td>
<td>0</td>
<td>0.11</td>
<td>0:0:1</td>
<td>N/A</td>
<td>N/A</td>
<td>1.02</td>
<td>Silt/&lt;1 inch gravel</td>
<td>–</td>
</tr>
<tr>
<td>P-13</td>
<td>7,827</td>
<td>63</td>
<td>1.4</td>
<td>1:0.85:0.36</td>
<td>4.6</td>
<td>2.7</td>
<td>1.17</td>
<td>1-5 inches cobble/&lt;1 inch gravel</td>
<td>–</td>
</tr>
</tbody>
</table>

These data are summarized as follows:

- The widening and braiding of the creek channel due to increased sedimentation is especially apparent in the downstream 1000 feet of the creek.

- The pool:riffle ratio in the Percival Creek canyon approximates a desirable split between pools and riffles. Upstream segments of the creek system are dominated by glides due the natural low channel gradient.

- The spacing of pools in Percival Creek is appreciably less than expected based on studies of similar creek systems (Keller, 1973). This high frequency of pools may be associated with increased flows resulting in increased streambank scour activity.

- LOD loadings in the creek are approximately 20 to 50 percent of loading rates obtained during research conducted on natural creek systems in western Washington (Bilby, 1984). High stormwater contributions appear to reduce LOD in the canyon segments compared to upstream creek segments. Additionally, several major log jams are present in the upper portion of the canyon creek segment.
- Sinuosity is relatively low in Percival Creek, but relatively consistent between upstream and downstream segments of the creek (subbasins P-3 and P-13). These findings may indicate some degree of straightening of the channel due to high flood flows.

These quantitative results indicate that the Percival Creek system remains a viable creek system, but is experiencing physical and biological degradation. Several of the quantitative parameters used to evaluate the creek suggest that impacts to the creek are increasing.

Table A-7 in Appendix 2 presents an evaluation of the effects of urbanization and associated runoff on physical and biological stream characteristics.

5.5 Sediment and Bedload Transport

The transport of sediment and coarse material down a creek channel by the force of water tends to increases with urbanization. The degree of transport occurring in a creek is indicated by the depth of streambed scour, channel instability, streambank erosion, and the frequency of deposition bars within the channel. The majority of the transport occurs during the initial phases of a storm event.

Based on the relatively high gradient of the creek through the canyon, the unstable canyon sideslopes, the braided creek channel upstream of the creek mouth, and the high rate of deposition at the mouth of the creek, transport rates in the canyon are expected to be moderately high.

In 1984, the rate of erosion along the streambanks in the Percival Creek canyon was estimated to be approximately 500 cubic feet per year (Thurston County Conservation District, 1984). The typical composition of the streambanks was reported to be approximately 27 percent coarse gravels and cobbles and 73 percent fine textured material. The study indicated that the gradient of the creek in the canyon would facilitate the transport of these materials.

Although subjective in nature, a comparison of the findings of the 1984 study and the 1990 basin planning field investigation indicates that erosion and subsequent transport has increased in the canyon. This comparison is based on the increased frequency and magnitude of erosional sites observed in 1990.

5.6 Fish and Wildlife

The Percival Creek basin, and especially the Percival Creek corridor, is home to a variety of wildlife. The corridor provides adequate cover, protection, and vegetation to support a wide range of wildlife species ranging from deer and bear to a variety of bird and fish species.
Great blue herons are a relatively frequent site in Percival Cove. These birds are considered a priority species by the Washington Department of Wildlife (WDW), and prefer salt and freshwater wetland habitat including seashores, rivers, swamps, marshes, and ditches. Because they are colonial breeders and use tall trees near wetlands for nesting sites, it is important to preserve as many trees in the vicinity of wetlands as possible. No known nesting areas are located in the Percival Creek basin.

Sightings of the western pond turtle have been reported along the Black Lake drainage ditch, but WDW staff have not been able to substantiate the presence of the turtle. These turtles are close to extinction in Washington State. WDW is pursuing the protection of habitat where their presence has been established.

No endangered species are known to use or live in the Percival Creek corridor or any habitat area within the basin.

5.6.1 Fish Habitat

The diverse needs of the different life stages of salmon necessitate physically and biologically complex creek and estuary habitats.

The availability of spawning habitat is typically optimum when the quantity of pools and riffles in a creek is approximately equal and appropriate sized gravels are present. Conversely, low gradient creek segments, such as the upper segments of Percival Creek and the Black Lake drainage ditch, are composed largely of slow moving waters suitable for the rearing of juvenile salmon. Salmon habitat needs are described in Table A-8 and A-9 of Appendix 2.

In an urban setting, the diversity of aquatic habitat is strongly influenced by chronic and lethal stressing factors such as water quality contaminants, water flow and velocity, and the duration of sustained high flows. Urban impacts to habitat are described in Table A-7 of Appendix 2.

The aquatic habitats in Percival Creek remain largely intact but are subject to continual degradation by the effects of urbanization. Additionally, the important estuarine environment historically associated with the mouth of the creek was eliminated with the creation of Capital Lake.

5.6.2 Anadromous Fish

Percival Creek supports spawning runs of coho, chum, fall chinook, coastal cutthroat, and winter steelhead trout. Returning adult chinook salmon vary between zero to 200 pairs of salmon per year. The other species returning to the creek number from zero to 300 pairs for each of the species (Williams et al., 1975). These historical data may overestimate
current salmon spawning in the creek. Efforts are underway to more closely monitoring salmon usage. The utilization of the creek system by chinook is limited due to the screening of the creek mouth in conjunction with the Deschutes River hatchery program. Field investigation conducted during the summer of 1990 and subsequent analysis indicate the presence of accessible spawning areas capable of supporting approximately 1300 pairs of salmon (Canada Department of Fisheries and Oceans, 1990).

A fish survey utilizing electroshocking techniques was conducted by WDW staff and the South Sound Fly Fishers in the canyon portion of the creek system in August of 1991. The investigation established the presence of approximately 17 juvenile coho salmon and 12 steelhead, cutthroat, and possibly rainbow trout at four locations.

A major fish barrier is formed by the high gradient culvert in Percival Creek under Mottman Road. Very limited numbers of coho salmon have been reported to pass the culvert and gain access to upstream habitat segments. Fall chinook salmon are unable to pass the culvert.

In the fall of 1991, spawning chinook salmon were observed in the canyon portion of the creek.

Salmon are commonly observed in the Black Lake drainage ditch upstream of the culverts under Mottman Road. These salmon may reach the upper portion of the ditch via Percival Creek or from Washington Department of Fisheries (WDF) planting efforts in Black Lake. Although spawning areas in the creek are limited to isolated areas, the ditch does provide beneficial rearing habitat. Additional spawning areas are also available in three tributaries to Black Lake.

Percival Cove at the mouth of the creek has been used for the rearing of chinook salmon fry since the 1970s. Some of the juvenile salmon from the Deschutes River hatchery program are nurtured in Percival Cove and subsequently released to Budd Inlet. The fish culture program currently supports approximately 1,000,000 juvenile salmon and is managed by the WDF and a local sport fishing club.

5.6.3 Resident Fish

Resident fish species utilizing the Percival Creek system are reported to be limited to sculpin, dace, and lamprey (Washington Department of Wildlife, 1990 and South Sound Fly Fishers, 1991). Both fish types are primarily bottom dwellers and prefer slow moving water. Dace are typically more adaptable to less than ideal habitat than are salmon.
5.7 Water Quality

Percival Creek and the associated Black Lake drainage ditch are Washington State Class A streams (Department of Ecology, 1985). The classification indicates that the creek system can be expected to exhibit excellent water quality traits (WAC 173-201).

5.7.1 Nonpoint Pollution Sources

The evaluation of water quality in the Percival Creek basin conducted as part of the planning effort focused on characterizing existing conditions and identifying nonpoint pollution sources within the basin. Types of nonpoint pollutants include sediments, pathogens, nutrients, and toxicants. Sources of these pollutants can be spread throughout the basin and, when summed, result in considerable water quality impacts. They can be conveyed to water bodies by natural processes and by urban runoff, contaminated air, and groundwater. Several sources of nonpoint pollution are discussed below.

Stormwater Runoff

Management of stormwater has historically focused on quantity rather than quality management. Stormwater carries numerous contaminants to receiving waters. Impervious surfaces accumulate sediments, heavy metals, toxic organic compounds, pathogens, and nutrients during dry weather. With wet weather the contaminants are conveyed to water bodies by the volumes of runoff associated with these surfaces.

Stormwater from urban sources has been analyzed nationwide for U.S. Environmental Protection Agency (EPA) priority pollutants as part of the National Urban Runoff Program (NURP)(EPA, 1983). Priority pollutants as identified by the EPA are highly toxic contaminants. These pollutants include synthetic organic compounds and toxic metals. Although the NURP study revealed the presence of priority pollutants in stormwater, the potential threats to humans from the observed concentrations of these pollutants was considered minimal. Conversely, aquatic habitat can be impaired by the pollutants.

The NURP study also indicated high variability in runoff quality as a function of storm intensity and timing, land use, stormwater system maintenance, and illicit waste disposal activities. In general, residential areas provide higher levels of nutrients and lower levels of priority pollutants than do commercial and industrial land uses (Brown and Caldwell, 1989; Miller, 1984). Typically, the early stages of a storm event bring a pulse of contaminants to the creek. Attempts to monitor these pulses are often unsuccessful.

The disposal of hazardous materials via storm systems by industry, businesses, and households has also been identified as a major source of water quality contamination (Murray, 1988).
Onsite Sewage Treatment

Septic systems require regular maintenance to insure adequate treatment of waste water. Surveys conducted in north Thurston County indicate that only a minority of septic system owners maintain their systems according to the recommended schedule (Thurston County Health Department, 1989).

In addition to the potential lack of system maintenance, many of the soils in the Percival Creek basin are inherently problematic for onsite waste disposal. The relatively impervious till soils can reduce the treatment and subsequent infiltration of effluent and thereby encourage surface water contamination. Sanitary sewer service is not available in large portions of the basin’s outlying areas.

Improper Waste Management

The improper disposal of solid and liquid wastes presents a source for a wide range of contaminants. Poor waste management practices result in the placement of wastes in, or adjacent to, water bodies and stormwater systems.

Erosion

Urban development inadvertently promotes erosion by the act of clearing vegetation from the land. In addition to the impacts of erosion on the affected land segment, several downstream impacts are problematic. These include the destruction of fish habitat, the decrease in health of the biological community, and the depositing of sediments in drainage ditches and pipe systems. Sediment particles also carry and disperse pathogens, heavy metals, and organic chemicals.

Vegetation and Pest Control

Herbicides and pesticides commonly associated with urban pest management can be transported to water bodies. Additionally, fertilizers, if conveyed to freshwater, provide nutrients readily available for nuisance algae production and consequent dissolved oxygen depletion.
Agriculture

Agricultural land use within Percival Creek Basin is limited to small operations supporting several animals and/or modest amounts of crops. The likelihood of a particular agricultural entity contributing to the contamination of a water body is a function of farm size, proximity of the farm to surface water, number and type of animals, waste handling methods, and fertilizer/pesticide use practices.

Table A-10 in Appendix 2 presents summarized information addressing water contaminant sources, impacts, and chemical traits.

5.7.2 Assessment Methodology

Water quality samples from Percival Creek, the Black Lake drainage ditch, and the Cooper Point Road ditch were analyzed five times during low, moderate, and high flow conditions. Sampling and field measurements were conducted by the Thurston County Environmental Health Department. Chemical analysis was performed by a certified laboratory. Trosper Lake was investigated once in October 1991. Water quality information for Ken Lake is available from an independent monitoring effort. Map 11 in Appendix 1 identifies the water quality monitoring sites used during the study.

Creek sediments from areas prone to contamination were analyzed once for priority pollutants. Results of the water quality and creek sediment analysis are presented in Appendix 5.

5.7.3 Analytical Results

The following analytical results for fecal coliform bacteria and priority pollutants are discussed separately, while the results for other conventional water quality parameters (e.g., nutrients, temperature, dissolved oxygen, conductivity, pH, and turbidity) are presented together.

Fecal Coliform Bacteria

Washington State Class A surface water standards require that fecal coliform bacteria in freshwater not exceed a geometric mean value of 100 organisms/100 milliliters (ml), with not more than 10 percent of the samples exceeding 200 organisms/100 ml (WAC 173-201). Fecal coliform originate in animal waste and serve as an indicator of serious bacterial contamination problems.
The fecal coliform results are summarized as follows:

- Fecal coliform concentrations at some creek locations within the creek system exceed Class A standards during and following storm events. Of the 11 stations monitored during wet weather events, four stations had fecal concentrations greater than 100 organisms/100 ml. The geometric mean of all stations sampled for this storm event was 88 organisms/100 ml.

- Relatively high fecal coliform contributions originated from the highly developed Cooper Point Road/Black Lake Boulevard commercial district.

- Fecal coliform concentration increases in the Black Lake drainage ditch downstream of the outlet of the Cooper Point Road ditch may be at least partially attributed to the high levels stemming from the Cooper Point Road area.

- The geometric mean of fecal coliform levels for the sampling events conducted during low to moderate flow conditions ranged from 12 to 19 organisms/100 ml. These results show Percival Creek to be well within the Class A water standards during low and moderate flow periods.

- No major fecal coliform problems were observed in the upstream segments of Percival Creek and the Black Lake drainage ditch.

- A limited monitoring effort of Percival Creek was conducted as part of a recent study of the Deschutes River. The study generated a fecal coliform geometric mean of 48 organisms/100 ml near the creek’s mouth for the period of December 1990 to August 1991. These results were skewed due to the very high count of 6875 organisms/100ml following a major summer rainfall. Follow-up work aimed at isolating the problem associated with the high count did not reveal a continuing contamination problem (Thurston County Health Department, 1991a).

Similar low levels of fecal coliform bacteria have also been observed in previous water quality monitoring work conducted in the Percival Creek system (Capital Lake Restoration Analysis, 1983).

**Priority Pollutants**

The concentration of priority pollutants in freshwater samples is commonly below analytical detection limits. Investigative methods focus on analyzing the concentrations of these pollutants in sediments. Contaminants tend to be adsorbed and retained by sediments.
Class A water quality standards require that "toxic concentrations shall be below those which may adversely affect characteristic water uses, cause acute or chronic conditions to the aquatic biotic, or adversely affect public health" (WAC 173-210-047). A list of priority pollutants has been developed by EPA. Unfortunately, suggested acceptable upper limits on organic compound concentrations in Washington fresh waters and sediments have not been established.

Following a review of criteria used throughout the United States, the decision was made to evaluate the freshwater sediment data with respect to criteria for organic contaminants in Puget Sound marine sediments (Tetra-Tech, 1987). Since these criteria are applicable to marine sediments and not freshwater sediments, the evaluation of contamination threat is qualitative in nature. Past studies in the Olympia area have used similar evaluation techniques (Thurston County Health Department, 1989).

Similarly, trace metal concentrations were evaluated using interim criteria established for dredged materials in the Great Lakes (Wisconsin Department of Natural Resources, 1985). Trace metals of concern included arsenic, cadmium, copper, lead, mercury, nickel, and zinc. Lead and arsenic are especially toxic and potentially carcinogenic.

The results of the evaluation are as follows:

- Toxic organic compounds were identified at all six sampling sites in Percival Creek, the Black Lake drainage ditch, and the Cooper Point Road ditch. The highest concentration and variety of these compounds occurred in the Cooper Point Road ditch and the outlet of Black Lake.

- Seven contaminants exceeded lower threshold concentrations established by the evaluation criteria; three of these contaminants also exceeded the higher threshold concentration.

- None of the organic contaminants were observed in Percival Creek upstream of its confluence with the Black Lake drainage ditch.

- Organic contaminants in the sediments of the ball fields of Yauger Park were consistently below threshold values. Yauger Park is a multipurpose regional stormwater management/recreational facility. The concentrations were under the threshold for impacts to biological communities subjected to long-term exposure, and therefore do not pose a human health threat.

- Sediments collected from the two dedicated detention ponds in Yauger Park contained concentrations of bis(2-ethylhexyl)phthalate in excess of the high threshold value. This contaminant is common in urban settings and was found in the heavily urbanized portions of the creek system.
• Mercury, lead, zinc, nickel, and arsenic concentrations at several sampling stations of the creek system exceeded the Wisconsin criteria. Sediments in the Cooper Point Road ditch generated the highest trace metal concentrations. Sites located at the outlet of Black Lake and the Cooper Point Road ditch also exhibited high concentrations.

• Sediments collected in Yauger Park exhibited elevated concentrations of lead and zinc in the dedicated stormwater detention ponds, but not in the ball fields. Zinc, an element commonly associated with vehicles and steel pipes, exceeded the recommended biological threshold by two- to three-fold in the detention ponds.

The results of the sediment analysis and a comparison to the evaluation criteria are presented in Appendix 5.

Conventional Water Quality Parameters

The Washington standards for Class A freshwater require that:

• Temperature not exceed 18° C.
• Dissolved oxygen concentration exceeds 8.0 mg/l.
• pH range between 6.5 and 8.5.
• Turbidity not exceed 5.0 NTU over background levels.

Summarized findings of the study are as follows:

• Temperature, dissolved oxygen, pH and turbidity of Percival Creek were typically within acceptable levels. Several exceptions were observed.

• Dissolved oxygen level in the upstream wetland segments of Percival Creek was 7.2 mg/l during moderate flow conditions. Low oxygen levels in this stream segment are not unexpected due to its slow moving, shallow, and warm temperature during moderate to low flow conditions. In addition, the monitoring event occurred in October when algal growth was at a peak. Consequently, dissolved oxygen levels were reduced. Dissolved oxygen concentrations of 6.0 mg/l are considered to be acutely toxic for salmon embryo and larval stages; concentrations of less than 3.0 mg/l are acutely toxic for other salmon life stages.

• The Black Lake drainage ditch exhibited a pH slightly below 6.5 during several sampling events. The relatively low pH is expected due to the presence of wetlands. The overall pH of the Percival Creek system is approximately 7.0.
Percival Creek Characteristics

- Turbidity levels generally remained low for all sampling events. Background turbidity levels were estimated using low flow turbidity data collected during an early monitoring program (Capitol Lake Restoration Analysis, 1983). Based on these data, only the samples collected in the Cooper Point Road ditch exhibited excessive turbidity. However, turbidity during certain periods of storm events may well exceed the recommended levels. Relatively clear flood flows have historically been typical of the creek system (City of Olympia, 1973).

- Although not addressed in water quality standards, nitrogen (nitrate + nitrite-N and total Kjeldahl nitrogen) and phosphate concentrations were also monitored. The nutrients typically enter receiving waters via fertilizers and animal wastes. Both nutrients stimulate algal growth in fresh waters.

- Nitrate + nitrite-N concentrations were greater in Percival Creek than in the Black Lake drainage ditch. The Cooper Point Road/Black Lake Boulevard area generated low concentrations of nitrite + nitrate-N.

- Phosphorous levels at the mouth of Percival Creek were high during one monitoring event, but were not repeated during a subsequent monitoring event. Phosphorous levels were relatively high at the outlet of Trosper Lake, but decreased downstream. The Cooper Point Road/Black Lake Boulevard area downstream of Yauger Park produced relatively high levels of phosphorous. In general, phosphorous levels in the creek system are, in all likelihood, higher than natural conditions. These levels may prompt algal growth in Percival Cove.

5.7.4 Lake Water Quality

A study of the water quality, hydrology, and limnology in Ken Lake has recently been completed (McCord, 1989), and an ongoing monitoring program is currently being conducted by the Lakemoor neighborhood. The results of these investigations indicate that algae production in the lake is currently at moderate levels. However, high levels of nutrients in the lake sediments may increase the problem in the future.

Trosper Lake can be classified as mesotrophic based on data collected during the basin planning study and historical data (U.S.G.S., 1985). This classification indicates a biological condition tending toward increased aquatic plant growth due to elevated nutrient availability. Conditions are currently not problematic, especially considering the similarity of data collected in 1981 and 1991. Additionally, few homes with the associated potential for water contamination are located immediately adjacent to the shoreline of the lake. Lake monitoring data on Trosper Lake collected during this study is presented in Appendix 5.
5.7.5 Summary of Water Quality Conditions

Given the urbanized nature of the Percival Creek system, water quality is relatively good. Characteristics are summarized as follows:

- Fecal coliform bacteria levels are typical well below State Class A limitations. During winter high flow conditions, the standards are modestly exceeded.

- Faulty septic systems do not appear to be an appreciable problem in the areas of the basin adjacent to the creek.

- The greatest threat to water quality appears to be nonpoint contributions associated with vehicular traffic and extensive impervious surfaces.

- Trace organic and metal priority pollutants levels are low in the creek, but relatively high in the Cooper Point Road conveyance system.

- Water quality in Trosper and Ken Lake is moderately high, but potentially problematic in the long-term.

- Nutrient levels in the creek are modest, but may be contributing to algal growth and oxygen depletion in Percival Cove and Capital Lake.

Efforts to protect water quality in the creek should focus on two comprehensive approaches:

- Prevention of nonpoint source contributions to the creek. These efforts should focus on pollution prevention education, the use of Best Management Practices (BMPs) for development, and the correction of identified problems through regulatory and enforcement procedures.

- Provide stormwater treatment for the Cooper Point Road area of the basin. The voluminous and contaminated flow from this area is the primary threat to the high water quality in the creek.