CHAPTER 3: BASIN CHARACTERIZATION

This section describes the physical characteristics of the basin, including:

- Surface water features
- Soils
- Vegetation
- Fish and wildlife
- Climate
- Topography
- Population
- Land use and zoning
- Recreational resources

The term "Chambers basin" is used to describe the entire drainage area covered by this plan. Smaller areas are called "sub-basins." The lakes, streams and ditches in the Chambers basin are referred to by many different names in a variety of maps and documents. In order to be clear and consistent, the following names of water bodies (indicated in map 2) have been used throughout this document:

Chambers Lake applies to the larger, northwestern portion of the large, central lake located in sub-basin CH-10. The old Chehalis Western railroad track right-of-way runs along Chambers Lake's east edge.

Little Chambers Lake applies to the smaller, eastern lobe of the large, central lake located in sub-basin CH-10. The Chehalis Western railroad right-of-way runs along Little Chambers Lake's west edge and separates it from Chambers Lake.

Chambers Ditch applies to the seasonal water course that has mostly been ditched and connects Little Chambers Lake in sub-basin CH-10 with Chambers Creek at the south edge of sub-basin CH-60.

South Tributary applies to the partly natural, partly artificial channel that connects the wetlands in the southern basin to Chambers Creek.

Chambers Creek applies to the mostly natural stream that begins at the confluence of Chambers Ditch and the South Tributary, and flows to the Deschutes River.

3.1 BASIN OVERVIEW

The Chambers basin lies just east of the Deschutes River, and takes in portions of east Olympia, western Lacey, and unincorporated Thurston County. The basin comprises 8,323 acres which drain to Chambers, Little Chambers, Ward, Hewitt and Smith lakes, Chambers Ditch, and Chambers Creek. Olympia and Lacey share jurisdiction over Chambers Lake and

Lacey has jurisdiction over Little Chambers Lake. Olympia and Thurston County share jurisdiction over Ward Lake. Hewitt Lake falls entirely within the jurisdiction of Thurston County.

The basin is bounded primarily by Burlington Northern Railroad to the north, Ruddell Road to the east, 89th Avenue SE to the south, and Henderson Boulevard and the Deschutes River to the west. The boundary was determined by the natural topography of the area and modified to reflect artificial alterations to the natural drainage patterns. Sub-basin boundaries, shown in map 3, were delineated to reflect smaller surface water drainages, for use in the computer model. The basin is part of the Deschutes River watershed.

3.2 SURFACE WATER FEATURES

In the basin plan, Chambers Creek, Chambers Ditch, and the South Tributary have each been mapped and numbered as distinct water bodies, which differs from the stream mapping used by the state's Catalog of Washington Streams (Washington State 1975). The state's catalog depicts Chambers Creek and Ditch as an "unnamed" stream (WRIA #13-0033) that extends from the Deschutes River to Little Chambers Lake. The basin plan considers Chambers Creek, Chambers Ditch and the South Tributary to be distinct water bodies because:

1. Chambers Ditch is a seasonal stream that was ditched through most of its length early in the century.
2. Chambers Creek is a natural stream with year round flow through most of its length.
3. The South Tributary is a network of natural channels, artificial ditches, and poorly defined wetlands, which flows intermittently and remains dry through most of the year.

The stream locations cited in the text (depicted in map 2) refer to stream mile from the mouth to the headwaters, and left and right bank refer to a downstream orientation. Chambers Creek's mouth on the Deschutes River is called mile 0.0, and the headwaters at the confluence of Chambers Ditch and the South Tributary is mile 1.4. Chambers Ditch mouth, mile 0.0, occurs at the confluence with Chambers Creek, and the headwaters are located at the outlet from Little Chambers Lake, mile 2.25. The South Tributary mouth, mile 0.0, occurs at the confluence with Chambers Creek, and the headwaters are located at mile 3.6.

3.2.1 CHAMBERS LAKE & LITTLE CHAMBERS LAKE

The Chambers/Little Chambers Lake complex, at 121 acres, is the largest waterbody in the basin (see map 3). Originally one lake, it was divided into two lakes connected by a narrow, 500′ long channel by construction of the Chehalis-Western railroad, completed in 1927. Chambers Lake (the western half) is approximately 63 acres in area, with a maximum depth of 5′. Little Chambers Lake (the eastern half) is approximately 58 acres, with a maximum depth of 7′. The lakes' contributing drainage area (sub-basin CH10) contains 1,376 acres. The lakes comprise 8.8% of the total sub-basin area.

The only surface water feeders to the lakes are stormwater systems from surrounding developments in Olympia and Lacey; the lakes have no feeder streams. Shallow aquifers perched on till soils underlie and surround the lakes (City of Lacey 1992b). Chambers Lake flows into Little Chambers Lake through a 500′ long channel. Little Chambers Lake forms the headwaters of Chambers Ditch.

The lakes are "eutrophic", which means that they are nutrient-rich and produce great quantities of plant growth (Hansen 1994). Eutrophication is frequently accelerated by human activities (Wetzel 1983). Lakes generally change over time from oligotrophic, or low-productivity, to mesotrophic, or medium-productivity, to eutrophic conditions. Eutrophic lakes are usually shallow, and natural sedimentation often changes them into ponds and, eventually, into wet meadows (Wetzel 1983; Cole 1983). The extensive wetlands on the northwest side of Chambers Lake were part of the lake at one time (U.S. Department of the Interior 1853). The large wetland areas along the shores produce tannins which stain the water to a tea-like color, but do not degrade its quality (Hansen 1994). Grass carp were introduced into Chambers Lake in the spring of 1990 in order to reduce plant growth (Lacey 1992). Chapter 3 contains a detailed discussion of the lakes' trophic condition, water quality and hydrology.

The earthquake of 1949 apparently reduced the flow of groundwater into the lake (Bill Case et al, letter to Thurston County, 1993). The lake tends to rise and fall with the seasons, but, during the 50s and 60s, it often fell to a very low level, possibly because of lake water withdrawals for irrigation (Bill Case et al, letter to Thurston County, 1993). Currently, the level of Little Chambers Lake is partially controlled by the elevation of a culvert at the south end where it drains into Chambers Ditch.

3.2.2 CHAMBERS DITCH

Chambers Ditch originates at the south end of Little Chambers Lake, and flows for 2.25 miles to discharge into Chambers Creek near Rich Road. At its headwaters, the ditch is approximately 3′ to 4′ deep with steep, grassy banks. Flows in the ditch usually remain fairly slow because the gradient is low. The ditch is totally dry for several months each year. It usually dries up about July or August and often remains dry until November or December.

A culvert carries the Chambers Ditch flow under the abandoned railroad tracks at the southern end of Little Chambers Lake. A screen maintained by the city of Lacey protects the culvert inlet to prevent the non-native grass carp in the lake from escaping. The culvert discharges into farmland, where all the riparian vegetation has been removed. The water in Chambers

Ditch flows slowly south for several hundred yards to a culvert under Herman Road, where the roadside ditch drains into the main Chambers Ditch.

Chambers Ditch flows south from Herman Road through a straight, steep-banked channel ranging from 3′ to 7′ deep, in sub-basin CH-30. Light forest covers the banks in a few spots, but in most places all the native riparian vegetation has been removed and weedy species have invaded the banks. The ditch exits sub-basin CH-30 through a culvert under Wiggins Road at mile 1.4.

High flows have undercut both sides of the ditch near Fuller Lane in sub-basin CH-40, causing the banks to sluff. Culverts convey the stream flow under 40th Avenue and Fuller Lane, where the ditch is about 7′ below the road surface. The ditch flows directly through the Wilderness subdivision, passing through a number of culverts, and the bottom and sides have been armored with rock rip-rap in several locations. The ditch exits the sub-basin at mile 0.7, through a 6′ by 3′ box culvert under Yelm Highway. A 32″ culvert and a 10" pipe on the downstream side of Yelm Highway discharge road runoff into the stream. The 10″ pipe was not discharging during the field reconnaissance work, despite heavy rainfall.

Below Yelm Highway, the ditch enters sub-basin CH-60. It meanders as it skirts around a small development in the 60th Avenue area, then enters a long, straight stretch before emptying into Chambers Creek. The mouth of the ditch is located on the right bank of Chambers Creek at mile 1.4 of the creek.

History of Chambers Ditch

The precise origins of the Chambers Ditch cannot be dermined with certainty from the historical records. The early documentation is confusing and contradicts itself. Several early records and maps from the drainage district reference a natural stream in the vicinity of Chambers Ditch. However, the 1853 survey map shows no creek draining from Chambers Lake to Chambers Creek. This section attempts to piece together the history of the ditch from available sources. The discussion presented here is not intended to state or imply any specific finding on whether or not Chambers Ditch is a "natural stream" or an "artifical ditch." This discussion applies only to the ditch upstream of Rich Road; the earliest surveys indicate that a natural stream existed from the general vicinity of Rich Road to the Deschutes River.

According to personal interviews with commissioners of Drainage District #3 (Chambers Drainage District), the Chambers Ditch was originally excavated in about 1902. Various early records use the names "Woods ditch," "Frank Wood ditch" and "Chambers Lake Ditch" to refer to what is now called Chambers Ditch. County records indicate that a ditch existed in 1907, when Mr. Frank Wood petitioned the county for a ditch survey.

The county engineer's report on the 1907 survey (Thurston County 1907) refers to both an existing natural "creek" in the lower reaches and an existing artificial "ditch" at the lake outlet. The report stated that "from sta. 44 (approximately 900' upstream from the current Wiggins Road) to sta. 71 (about the current location of Yelm Highway) the channel of the creek is full of brush and logs which will make the cost of clearing for a 12 foot ditch at least $300 and for a 9′ ditch, $250." The report elaborated, "from sta. 51+87 (about 100' upstream of the current Wiggins Road) the old creek channel is in a narrow swale from 1½ to 2 feet below the level of the land on either side, and in view of the fact that the land along the swale is covered with heavy timber, I believe it would be much cheaper to follow the old channel, than to cut the ditch straight through higher ground and large stumps." This is the area where the ditch meanders through what is now the Wilderness subdivision. The report also stated, "the old ditch from the lake to sta. 44 would form about one half of a 12 foot ditch, and three fourths of a 9 foot ditch."

Seven basin residents petitioned the county in 1918 to form a drainage district (Thurston County 1918) and "do all things necessary and proper to properly construct a drainage system...to start at the southern end of Chambers Lake, where the present Woods ditch starts and thence following along the line of the present ditch as nearly as practicable, and along the natural water course of the outlet of the said Chambers Lake to the place where the said watercourse intersects the Olympia-Yelm Road..." The landowners further stated that "it is necessary to deepen and change the route of the old ditch in order that lands in said vicinity can be properly cultivated."

In response to the petition, the county surveyed the proposed course of the ditch in 1919. The 1919 survey map shows what appears to be an existing meandering stream from the vicinity of Wiggins Road, through what is now Wilderness subdivision, to near Yelm Highway (Thurston County 1919).

Drainage District #3 was established by order of the Board of Thurston County Commissioners in September 1919 (Thurston County 1919). Construction of the enlarged ditch entailed approximately one and a half miles of excavation. The ditch may have been enlarged again by a CCC crew in the 1930s (Jim Zahn, personal communication, 1995). Drainage District #3 has maintained clear and open waterways since that time, to prevent flooding of property in a flat area on both sides of the ditch. The drainage district has done most of the ditch cleaning by hand removal of brush and grass, though a backhoe has been used occasionally to clean a small section of the ditch (Ernest Nelson, personal communication, 1994). Ditch maintenance has kept the ditch free from flooding and the resulting grassy vegetation provides some biofiltration of the ditch water. The most recent maintenance dredging of the ditch was conducted in 1991 in response to concerns regarding the flooding of Herman Road and Wiggins Road.

3.2.3 South Tributary

The South Tributary originates in an interconnected network of wetlands that cross through Chambers Prairie in the southern half of the basin. The tributary flows intermittently for most of the 3.6 miles between the headwaters and the junction with Chambers Ditch, and dries up for most of the year. The uppermost wetlands lie in sub-basin CH-70, north of Fir Tree Road. The tributary flows north from the wetland in a natural channel, and through a 24" culvert under Rainier Road, at mile 3.15, where flooding has occurred. North of the road, the tributary re-enters wetlands in sub-basin CH-80.

A short branch of the South Tributary originates in the wetlands of sub-basin CH-80, and joins the main tributary from the east, on the right bank at mile 2.8. The South Tributary bends around to the west as it leaves the wetlands and enters a channelized stretch along the edge of the Bonneville power transmission lines. A 24" culvert carries the tributary under the Burlington Northern railroad and back under Rainier Road at the west edge of the sub-basin, at mile 1.9.

The South Tributary enters an extensive wetland network in sub-basin CH-90. The tributary flows intermittently through this sub-basin. The channel is well-defined and about 1′ deep by 3′ wide between the wetland areas, but it disappears and the stream spreads out within the wetlands. The tributary bears north and enters a channelized stretch near the northwest corner of sub-basin CH-90, where it joins Chambers Creek.

3.2.4 Chambers Creek

Just upstream of Rich Road, Chambers Ditch and the South Tributary merge to become Chambers Creek at the south edge of sub-basin CH-60. The creek flows west from the confluence with the ditch, and exits the sub-basin through a 72" metal plate culvert under Rich Road, at mile 1.25. There is very little vegetative cover along Chambers Creek east of Rich Road.

Thurston County maintains a gauging station on the west side of Rich Road, at the outfall of the culvert (mile 1.25). The creek passes under the Union Pacific railroad trestle shortly after flowing under Rich Road. The flow through the final reach in sub-basin CH-100 is higher and faster than upstream due to a steeper gradient and additional water from many year-round and seasonal tributaries, springs, and seeps which enter the creek between Rich Road and the mouth. The creek follows a fairly straight course with few meanders and traverses a flat riparian area at the base of a steep hill below the Union Pacific railroad.

Chambers Creek enters a forested area as it nears the Deschutes River. A small dirt road at the end of 58th Avenue SE crosses Chambers Creek near the mouth, and a 72" culvert carries the creek under the dirt road. The creek in this stretch has low banks and flows through an abandoned livestock area. Chambers Creek appears to have been diverted through this area; the original channel is now blocked and functions as an overflow area.

3.2.5 Hewitt Lake

Hewitt Lake is a small pothole lake of 32 acres in Thurston County. Hewitt Lake's average depth is 28′, with a maximum depth of 56′. Hewitt Lake is primarily fed by groundwater springs and has no inlet or outlet. The gravel and sand shore of the lake supports only a sparse growth of aquatic plants. Hewitt Lake's contributing sub-basin contains 301 acres, of which the lake comprises 10.6%.

3.2.6 Ward Lake

Ward Lake is a 62-acre pothole lake with a mean depth of 33′ and a maximum depth of 67′, located immediately north of Hewitt Lake (Washington Department of Ecology 1976). It lies in the center of an area bordered by Boulevard Road on the east, Yelm Highway on the south, Henderson Boulevard on the west, and Log Cabin Road on the north. The Ward Lake sub-basin (CH-125) is approximately 313 acres, of which the lake comprises 19.8%.

3.2.6 Smith Lake

Smith Lake is a 12-acre, groundwater-fed lake in a closed sub-basin, with a maximum depth of less than 10′. According to residents, the earthquake of 1949 reduced the flow of groundwater into the lake. Prior to the earthquake, Smith Lake drained to Chambers Ditch, but now the lake level has dropped too low to drain out to the ditch, and the sub-basin has no outlet. Smith Lake's sub-basin encompasses about 97 acres, of which the lake comprises 12.4%.

3.3 SOILS

The glaciation which sculpted the Chambers basin created the soils (Crandell et al 1965) which affect the basin's drainage and hydrology. Some soil types within the basin are highly porous and allow the infiltration of surface water; other soils are relatively impervious to water.

Till Soil Glaciers produced several soil types as they advanced and then retreated. Advances 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. Many of the basin's lakes and wetlands rest on till soils. The till soils are fairly stable in slopes.

Outwash Soil Conversely, the material that washed down in the streams of advancing glaciers, known as "advance outwash," is composed of moderately porous sands and gravels. The glaciers subsequently rode over the advance outwash and compacted it, creating a fairly impervious layer. The less compacted "recessional outwash" was formed by retreating glaciers. Outwash soils are deeper and usually better drained than till soils. Outwash soils with a high silt and sand content erode easily; those with more rocks and gravel resist erosion better. The drainage characteristics of outwash soils vary greatly, depending primarily on depth, the presence or absence of underlying till, and the degree of compaction.

Saturated Soil Saturated, or "hydric" soils found in the basin include sediments deposited by lakes formed after the glaciation. These soils, including silty loams, silty clays, and clays, can restrict water permeability when they are saturated. In addition, the wet depressions in the basin contain poorly drained muck soils formed from accumulated plant debris. These soils are almost always saturated or nearly saturated due to high water tables.

Table 3-1 Soil Type by Sub-basin[1]

Sub-basin	Soil Type					
	Outwash	Till	Saturated	Open Water	Impervious Area	Total
CH-10	597	312	151	130	186	1,376
CH-20	55	12	15	12	3	97
CH-30	269	0	23	0	4	296
CH-35	100	85	39	0	3	227
CH-40	224	20	3	0	23	270
CH-50	475	10	11	17	49	562
CH-60	153	0	23	0	8	184
CH-70	64	163	166	0	2	395
CH-80	541	342	278	4	10	1,175
CH-90	1,684	236	164	6	43	2,133
CH-100	319	0	16	0	25	360
CH-110	246	0	4	32	19	301
CH-120	247	42	0	0	18	307
CH-125	198	0	9	62	44	313
CH-130	299	0	0	0	28	327
Total	5,471	1,222	902	263	465	8,323

[1] Information provided by Thurston Geographic Information Facility, 1992.

This soils information comes from the *Soil Survey of Thurston County, Washington* (U.S. Department of Agriculture 1990). Till dominates the northern and southern basin, while outwash is common in the center. Other soil types found within the basin include Skipopa silt loam in terrace areas, Norma silt loam in low-lying depressions, and Mukilteo muck within lakeshore areas. Skipopa soils drain moderately well, but they have a seasonally high perched water table. Mukilteo muck and Norma soils usually occupy wetlands, and often contain standing water. Map 7 delineates the distribution of soil groupings within the basin.

Table 3-1 shows the basin's soil coverage in acres, by sub-basin. The soil coverage information was derived from the soil inventory conducted by the US Soil Conservation Service in 1990. Open water and impervious areas, including roads, parking lots and buildings, were interpreted from aerial photographs taken in 1987.

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 appendix B.

3.3.1 Chambers Lake/Little Chambers Prairie Soils

Nisqually, Alderwood and Yelm soils comprise most of the soil within the Chambers Lake/Little Chambers Prairie area. They typically have slow runoff and moderate to rapid internal drainage. Little Chambers prairie consists almost entirely of Nisqually and Alderwood soils, while Yelm soils are found to the west of Little Chambers Lake.

Nisqually loamy fine sand is generally very deep and gravel free, and occurs in combination with Spanaway soils on Thurston County prairies. The soil is stable and suitable for agriculture and development, but poor filtering capacity may limit septic tank usage.

Alderwood soils are shallower than Nisqually soils, contain more gravel and lie on top of very impervious glacial till (hardpan). Perched high water tables cause problems for development on Alderwood soils throughout the County, including flooded septic systems and stormwater infiltration facilities.

Yelm fine sandy loam contains thin layers of silt and very fine sand in the lower subsoil, which reduce its ability to infiltrate rainfall. Yelm fine sandy loam is widely used for forestry in Thurston County.

Mukilteo muck constitutes the shoreline soil of Chambers and Little Chambers lakes. This muck soil is always saturated and limits the potential for development close to the shoreline.

3.3.2 Chambers Prairie Soils

Chambers Prairie consists almost entirely of Nisqually and Alderwood soils, similar to Little Chambers prairie. However, a ribbon of finer, more saturated soils crosses the prairie from west to east, following the course of the South Tributary and the associated wetlands. These saturated soils include Tisch silt loam, Norma silt loam, and Mukilteo muck. They are too wet and poorly drained for development, and their agricultural capacity is also marginal.

The prairies in Thurston County occur exclusively on soils of the Spanaway-Nisqually association, which have been used to map the historic extent of prairies and related vegetation communities in the area (Rex Crawford, personal communication, 1994). The native vegetation for this soil series consists of "mainly grasses and scattered conifers" (U.S. Department of Agriculture 1990). The most common trees on these soils include Douglas-fir and Oregon white oak, with occasional lodgepole pines, but the wooded areas contain open, grassy understories. Soil survey maps and aerial photographs indicate that Nisqually soils dominate Chambers and Little Chambers prairies. The occurrence of Nisqually soils appears to indicate the historical extent of prairies in the Chambers basin.

3.3.3 Ward Lake Soils

Ward Lake and the surrounding drainage area consist entirely of Yelm fine sandy loam, which is described in more detail above. The wetness of the soil poses limitations on development and septic field use.

The soils along the Ward Lake shoreline pose severe limitations for buildings and roads. The extremely fine sand along the lake shores is highly vulnerable to erosion when cleared. A large erosion problem was observed on the south side of the lake during a reconnaissance trip in the winter of 1991 where land had been cleared for development. The bare soil was failing and in need of replanting. A few minor erosion problems associated with cleared banks were identified on other sites, but are expected to stabilize with increased vegetative cover.

3.3.4 Hewitt Lake Soils

The slopes above the north and east shores of Hewitt Lake consist of Yelm fine sandy loam and Nisqually loamy fine sand, described above. The land between Hewitt Lake and the Deschutes River, and most of the land along the bluffs at the west edge of the basin, consists of Indianola loamy sand.

Indianola loamy sand is a very deep, well-drained soil found on river terraces and ridges. The subsurface soil layer is primarily loamy sand and sand. These soils can make good building sites, but, due to poor filtering capacity, septic tanks may pose a threat to groundwater quality.

The Hewitt Lake shoreline is composed of steep Indianola soils which present limitations for buildings and roads. A few of the homes on the lake shore have minor erosion problems, apparently associated with cleared hill slopes. Once the hillsides are revegetated, the soils stabilize.

3.3.5 Aquifer Sensitive Areas

Aquifer sensitive areas are those areas where ground water is naturally susceptible to contamination from certain land uses and activities, primarily because of soil conditions and, to a lesser extent, because of shallow depths to the water table (Thurston County 1992). Aquifer sensitive areas encompass most of the basin. Map 6 illustrates the location of aquifer sensitive areas within the basin.

Several aquifers at varying depths are located within the Chambers basin. Each aquifer is identified by the soil formation that contains it. The shallowest aquifer, the Vashon Recessional Outwash, surfaces in low areas during much of the wet season. This aquifer feeds numerous wetlands in the basin.

A deeper aquifer, the Vashon Advance Outwash, is located approximately 50′ below the ground elevation in the Chambers basin. This very large aquifer contains highly potable water. About 30% of wells studied by the USGS in north Thurston County draw from this aquifer. However, the extremely permeable nature of the soils overlying portions of the aquifer make it sensitive to contamination. Rainfall infiltrating into the ground between October and April provides virtually all the groundwater recharge to this aquifer.

Large quantities of groundwater are generally available year-round. The deep aquifer is hydrologically capable of providing at least 1200 gallons per minute (Bruce Briggs, Chambers Task Force meeting, 1995). In many places the aquifer is sandy and permeability is relatively low. However, the shallow aquifer is often perched on glacial till and vulnerable to contamination from septic systems and other sources of pollution (Dion et al 1994).

3.4 VEGETATION

3.4.1 Wetlands

Wetlands are areas inundated or saturated with water for long enough periods to develop plant communities that are specially adapted to saturated soil conditions. Wetlands remove sediment and pollution from surface water, prevent floods by storing and slowly releasing stormwater runoff, and provide habitat for fish, amphibians, mammals, bird and insects (McMillan 1988). Freshwater wetlands serve as rearing habitat for coho salmon (Jeff Cederholm, personal communication, 1991) which are important to the Puget Sound commercial and sport fisheries. Studies have shown wetlands to be among the world's most productive ecosystems (Burg et al 1980). Map 4 depicts the basin's wetlands.

The county and cities classify wetlands according to the system developed by the US Fish and Wildlife Service (Cowardin et al 1979). The wetlands in Chambers basin fall into two broad classifications: Palustrine (fresh water wetlands with less than 20 acres of open water), and Lacustrine (fresh water wetlands with open water areas greater then 20 acres), which have generally similar plant species composition.

These wetland classifications are further divided into five classes with distinct vegetation types: open water, aquatic bed, emergent, scrub-shrub, and forested. Open water and aquatic bed wetlands have vegetation growing primarily on or below the water surface. Emergent wetlands are dominated by non-woody vegetation growing up out of water. Shrub-scrub wetlands are dominated by woody vegetation less than 20′ tall, and forested wetlands are dominated by woody vegetation taller than 20′ (Cowardin et al 1979).

The local jurisdictions delineate wetlands using the methods of the *Federal Manual for Identifying and Delineating Wetlands* (U.S. Department of Defense 1989). This manual uses vegetation, soils, and hydrology to determine the wetland boundaries. Local wetland regulations tie permitted land uses in regulated wetlands to the wetland's ecological functions and values, determined by applying the *Washington State Wetland Rating System for Western Washington* (Washington Department of Ecology 1991). The rating system considers size, vegetation, animal habitat, structural complexity, and the presence of listed (sensitive) plant and animal species.

The basin contains approximately 902 acres of wetlands, about 10.8% of the total basin area (Thurston Geographic Information Facility 1993). Most of the basin's wetlands are seasonally flooded areas next to the South Tributary and Chambers Lake, that support scrub/shrub vegetation. Several wetlands in the basin were ditched and drained for agriculture when the land was first settled. Some wetlands still maintain a high degree of biological integrity.

Wetlands occupy most of the shorelines on the west and south sides of Chambers and Little Chambers Lakes (Thurston Regional Planning Council 1993). Lakeshore wetland zones extend in some places up to 500′ beyond the edge of the lake, and a lobe of wetland extends north-northwest for almost a half-mile from Chambers Lake. The entire lakeshore is a sensitive and biologically important constituent of the lakes' functions, contributing to water quality as well as providing excellent wildlife habitat.

The southern half of the basin draining to the South Tributary contains most of the wetlands. Extensive wetlands feed the headwaters of the tributary, located in sub-basins CH-70 and CH-80. The wetlands dominate most of CH-70 and a large portion of CH-80, connected by the South Tributary which flows west from one wetland area to the next. Other wetlands in sub-basin CH-80 are not connected to the South Tributary by surface water, but may have groundwater linkage. The South Tributary flows through wetlands for most of its length in sub-basin CH-90, following the low, central depression through western Chambers Prairie.

3.4.2 Forests

Western Washington and Oregon comprise the most densely forested region in the United States (Franklin and Dyrness 1973). The earliest surveys of the Chambers basin area indicate that forests consisting of "principally fir and cedar with thick undergrowth" covered large portions of the basin, particularly the areas south of Chambers Creek, and west and southeast of Chambers Lake (U.S. Department of the Interior 1853). These historic vegetation patterns correspond closely to the native vegetation associated with the basin's soils (U.S. Department of Agriculture 1990).

Ancient forests generally consisted of trees of all ages and sizes. Slower growing western hemlock tended to replace Douglas-fir as the climax species, because of its ability to tolerate the shady growing conditions of the forest floor better than Douglas-fir (Kruckeberg 1991). However, natural processes such as fire, wind, drought, insect damage and disease created openings where Douglas-fir flourished. The resulting forest had a canopy of multiple layers, which intercepted large quantities of rainfall, reduced air and soil temperatures, created habitat for a wealth of wildlife, and offered excellent conditions for numerous mosses and ferns. These were some of the most productive forests in the world (Franklin and Dyrness 1973).

Most of the original forests were logged in the late nineteenth century, and forests of red alder and Douglas-fir grew rapidly in the altered, sunnier conditions (Kruckeberg 1991). Much of the second-growth Douglas-fir was cut again within the past 50 years. Very few examples of ancient forest systems remain anywhere in the Puget trough (Kruckeberg 1991). No ancient forests remain in the Chambers basin. The existing second and third growth forests are structurally less complex than the forests they replaced (Franklin and Dyrness 1973), so they offer less stormwater protection and habitat diversity. Nevertheless, the existing forests significantly reduce stormwater runoff (Nelson 1992). Logging of lowland forests around north Thurston County increased substantially during the 1992-1993 period due to record high timber prices. Residences, commercial buildings, and roads are rapidly replacing much of the existing forests.

Conifer forests, mixed forests, and remnant oak woodlands comprise the upland forested areas in the Chambers basin. Second growth Douglas-fir, western red-cedar, and western hemlock dominate the conifer forests. Mixed forests in the area include conifers and broad leaf trees such as red alder, big leaf maple, vine maple, quaking aspen, and black cottonwood.

The basin contains remnant stands of mature Oregon white oak growing alone and in association with Douglas-fir and lodgepole pine, mostly along the edges of prairies. Oak woodlands and prairies used to be much more widespread, but Douglas-fir has steadily encroached on them for at least 140 years (Franklin and Dyrness 1973).

Several authors have described the annual prairie burns conducted by indians before the first white settlers arrived (Franklin and Dyrness 1973; Kruckeberg 1991). Annual, low-burning grass fires would have favored oaks and suppressed Douglas-fir, because annual fires would have killed the fir seedlings, but the oaks (unlike fir) would resprout from stumps. Conversely, fire suppression has allowed Douglas-firs to invade the previously burned areas (Franklin and Dyrness 1973; Kruckeberg 1991), which thrive in recently burned areas as long as the burns are not frequently repeated. There is increasing evidence that oak regeneration is not keeping pace with oak mortality (Kruckeberg 1991). The oak woodlands are critical habitat for many birds and mammals (Washington Department of Wildlife 1991). Numerous studies have found that oak woodlands are some of the most important wildlife habitats in North America, supporting almost 400 bird and mammal species.

3.4.3 Riparian Areas

Riparian zones are the areas where plants and soil interact directly with a stream or water body. Riparian zones can be broad and extensive in floodplains, or narrow and contained in steep ravines. Riparian areas play a complicated and critical role in the basin ecosystem. The vegetation creates shade and in-stream fish habitat, provides food for aquatic insects, prevents erosion, and reduces the force of stream flows (Gregory 1991). Water quality benefits include removal of nutrients from subsurface flow, and filtering of sediments in runoff (Lowrance et al 1984; Peterjohn and Correll 1984). The soils in riparian areas also trap significant amounts of nutrients and heavy metals (Glick et al 1991). Riparian forests also serve as habitat for a variety of wildlife (Washington Department of Fish and Wildlife 1995).

Some of Chambers Creek's riparian zone is densely vegetated with streamside species such as black cottonwood, Douglas-fir, red alder, western redcedar, and various shrub species. In the flat prairie areas, the riparian zone is a wide flood plain vegetated with wetland shrubs and emergent species such as sedges and rushes. Agriculture has changed many of these areas and the native vegetation has been virtually replaced by non-native plants such as the extremely tenacious reed canary grass. Reed canary grass can withstand large water level fluctuations, periodic droughts, submersion up to a few feet, and moving water. Most of Chambers Ditch is vegetated with reed canary grass.

3.4.4 Prairies

Prairies are relatively uncommon in western Washington, and Thurston County contains some of the best examples (Franklin and Dyrness 1973; Lang 1961). The prairies in this region formed in a long crescent of outwash soils along the leading edge of the last glacier, extending from Pierce County through Thurston County and into Mason County. Grassy prairies have been used for agriculture since the middle 1800s (U.S. Department of the Interior 1853). Some areas that are no longer being farmed may be naturally changing to forest vegetation as conifers encroach on the prairie edges (Franklin and Dyrness 1973).

Weir Prairie, in the Thurston County portion of Fort Lewis, served as an example of undisturbed prairie vegetation in a 1961 study of Thurston County prairies, which became the basic description of prairie plant communities in the widely accepted classification method of Franklin and Dyrness. Prairies are dominated by Idaho fescue, a native perennial bunch grass, with thick moss between the grass clumps (Lang 1961). Nonnative grasses and Scotch broom have invaded many prairies. Native wildflowers such as shooting stars, violets, camas and balsam root dot the prairies. *Aster curtus* is a state-listed sensitive plant species which occurs on prairies in the basin (Washington Department of Natural Resources 1994).

Prairies have rapidly diminished in area since settlement by Europeans, as a result of development, fire suppression, and encroachment by Douglas-fir (Kruckeberg 1991). The understory in these areas consists primarily of Scotch broom, an invasive non-native shrub, as well as snowberry, kinnikinnick, and sedges and grasses.

Chambers basin contained several prairies prior to development (U.S. Department of the Interior 1853). Chambers Prairie was converted to agricultural use by the earliest European settlers in the basin (Historical Research Associates 1992). The remaining prairies are dominated by a mixture of native and introduced grasses, with scattered broad-leaf trees, and wetland vegetation in the potholes. Oregon white oak stands often occur along the edges of prairies. The prairies of Chambers basin are associated exclusively with Nisqually and Alderwood soils. The discussion of historical land cover, later in this chapter, contains more details about prairie soils.

3.5 FISH AND FISH HABITAT

Chambers basin contains habitat which supports a variety of fish. The basin contains wetlands, shallow, warm lakes, cold, deep lakes, seasonal drainage ditches, and a year-round creek. The fish and fish habitat can be sensitive to stormwater management practices (Bisson 1992). This section describes the existing fish and fish habitat in the basin.

3.5.1 Overview of Fish and Fish Habitat

Chambers basin contains both anadromous and resident fish species. Anadromous fish are species that mature in salt water and spawn in fresh water, including salmon, steelhead, and sea-run cutthroat. They often use different parts of the stream system for spawning and rearing (Miller and Brannon 1981). Anadromous fish are not native to Chambers Creek or the Deschutes River, because Tumwater Falls prevented anadromous fish from entering the river system before a fish ladder was installed there.

Resident fish are species which remain in or near the same water body for their entire life cycle, and do not move back and forth between salt water and fresh water. Resident fish in the basin include resident cutthroat trout, large-mouth bass, perch, crappie, spiny ray, Olympic mud minnow and sculpin.

The habitat conditions required by anadromous fish vary according to species and life stage, but generally include cold water, low sediment load, high dissolved oxygen levels, clean gravel for spawning, aquatic insects for food, and overhanging vegetation, logs, and large rocks for cover and resting places (Sedell et al 1982). They also require relatively unrestricted passage between rearing and spawning areas and salt water. A healthy riparian corridor and natural stream hydrology can supply most of these requirements in an undisturbed stream system.

Riparian vegetation plays an important role in providing habitat for fish (Gregory et al 1991). Overhanging trees, shrubs and grasses provide cover and resting places for fish. The shade from trees and shrubs cools the water which increases the oxygen levels available to fish. Leaves and needles fall into the creek and provide food for insects which form the base of the food chain in the stream system. Trees and roots fall into the creek and create pools, trap food, and offer resting places for fish. Live roots stabilize the stream banks and prevent erosion, and trees and shrubs take up water and reduce soil saturation.

Riparian vegetation also enhances stream water quality (Lowrance et al 1984). Shrubs and groundcovers filter sediments out of runoff entering the stream. Trees and shrubs absorb large quantities of nutrients such as nitrogen and phosphorous which are significant constituents of agricultural and urban runoff. Riparian soils are especially effective at removing nitrogen from water. Studies in Maryland have found that a 50′ wide buffer strip between agricultural lands and streams can remove more than 75% of the nitrogen and more than 40% of the phosphorous from sub-surface water before it reaches the streams (Peterjohn and Correll 1984).

A complex stream network of pools and riffles with appropriately sized, clean gravels generally indicates good spawning habitat (Bisson 1992). Conversely, low gradient stream segments with few riffles, such as much of Chambers Creek and Chambers Ditch, flow too slowly for spawning but serve as rearing areas for juvenile salmon. Coho salmon rear in wetlands and slow water areas for up to a year before migrating to salt water.

Urbanization tends to degrade aquatic habitat by introducing water quality contaminants, reducing riparian vegetation, increasing sediment load, increasing the intensity of winter stream flows and reducing summer base flows (Nelson 1992; Reinelt et al 1990).

3.5.2 Fish and Habitat of Chambers/Little Chambers Lake

Chambers Lake Fish

Historically, cutthroat trout, bass, perch, catfish, crappie and spiny ray inhabited Chambers and Little Chambers Lakes (City of Lacey 1992). Cutthroat have mostly disappeared from the lake in recent years. The University of Washington, in cooperation with the Washington Department of Wildlife, introduced triploid grass carp into the lake in the spring of 1990 as part of an experimental program to control weed growth (City of Lacey 1992). Bass fishermen on the lakes have reported that the grass carp improved the conditions somewhat (Jay Hunter, personal communication, 1994).

The Department of Fish and Wildlife manages the lake primarily for warm water species, although they occasionally plant cutthroat. The fishing season on Chambers and Little Chambers Lakes is open year-round.

Chambers Lake Fish Habitat

The habitat of Chambers and Little Chambers Lakes is generally more suited to warm water, resident species than cold water anadromous species, although ground water flowing into the lake keeps temperatures low enough for some colder species to survive. The lake has large areas of aquatic vegetation that some warm water species use for refuge. The lake has been blocked to anadromous species for several years by screens that hold in the grass carp. The habitat is highly sensitive to water level changes, because the lake is so shallow that fluctuations as small as one foot can significantly change the water temperature and the amount of available habitat (Jay Hunter, personal communication, 1994).

3.5.3 Fish and Habitat of Chambers Creek and Chambers Ditch

Chambers Creek and Ditch Fish

The 1.25 mile segment of Chambers Creek below Rich Road supports rearing runs of coho salmon, as well as coastal cutthroat, and winter steelhead (Jim Fraser, personal communication, 1993). Coho and sea-run cutthroat trout are the primary anadromous fish species that use Chambers Creek. Coho tend to arrive in spawning streams late in the fall and prefer to spawn in smaller, gravel bottom streams (Miller and Brannon 1991). Coho fry frequently migrate slightly downstream to nearby rearing areas shortly after emerging. They remain in the stream throughout the summer, but they usually migrate abruptly into the upper reaches of small tributaries at the onset of fall rains, often seeking wetlands and slow-water areas (Jeff Cederholm, personal communication, 1994). They remain in the upstream rearing areas until they migrate to sea as fingerlings in late winter.

Washington Department of Fisheries staff conducted a fish survey on the lower creek in March 1993, using electroshocking techniques. The investigation established the presence of coho, steelhead, and cutthroat in Chambers Creek below Rich Road. The 1993 fish survey also established the presence of cutthroat and steelhead in or above the Rich Road culvert, a crappie in Chambers Ditch near Herman Road, and stickleback in Chambers Creek (letter from Jim Fraser to Department of Natural Resources 1994). Another electrofishing survey in the spring of 1995 found cutthroat trout in the segment through the Wilderness subdivision upstream of Yelm Highway and in the South Tributary (letter from Jim Fraser to Ben Alexander 1995).

Resident fish species in Chambers Creek include sculpin, dace, and lamprey (Washington Department of Wildlife, personal communication, 1990). These species are primarily bottom dwellers and prefer slow moving water. Dace are typically more adaptable than salmon to poor habitat conditions. The Department of Wildlife reported that the only endangered species known to use or live in the Chambers Creek corridor or any habitat area within the basin is the Olympic mud minnow, which is listed by the state but not by the federal government.

Residents' reports of fish use in Chambers Ditch vary widely. Some residents report having seen no fish for the past 20-50 years (Jerry Sandberg, public meeting 1994; Ed Schilter, public meeting, 1994; Gordon Boe, public meeting, 1994). Other residents report seeing significant numbers of juvenile coho in the wetlands above Rich Road (Grant Fiscus, public meeting, 1994), and one resident reported seeing adult salmon as far upstream as Wiggins Road Ditch during a heavy rainfall (Linda Kirkland, telephone communication, 1995).

Chambers Creek Fish Habitat

Chambers Creek offers three types of coho habitat. The segment near the mouth contains a few spawning sites. The lower reach provides year-round rearing habitat from the springs below Rich Road to the mouth. The segment from the springs below Rich Road up to a point below Yelm Highway provides winter rearing habitat as long as the creek is flowing.

A short segment near the mouth of Chambers Creek contains the best remaining habitat for anadromous fish in the basin, including rearing habitat and limited spawning habitat in fairly good condition. The stream bed contains relatively clean, sediment-free gravel. Large trees and a well-developed understory near the creek provide shading and protection from predators. Large logs in the stream channel provide cover for fish.

Upstream from the mouth, the habitat quality declines. The riparian tree canopy gives way to open fields south of the creek below Rich Road, though some trees remain. The north side has healthy forest cover on the hill below the railroad grade. The gravel just downstream of the culvert under Rich Road is small (< 1") and highly sediment-laden. The culvert may block fish passage during certain flows, although limited numbers of coho have been reported to pass through it. This segment of the stream contains very little large woody debris, rocks, or other features that could reduce the impact high-velocity flows through the culvert.

The Department of Natural Resources classifies all of Chambers Creek and Chambers Ditch as a Type 3 waterbody. This classification, defined in the state's Forest Practice Rules (WAC 222-16-030), indicates the relative value of the stream for anadromous fish spawning and rearing. Type 1 represents the best waterbodies used by fish and Type 3 represents the worst waterbodies used by fish. Types 4 and 5 waterbodies are not used by fish.

The lower 1/4 mile of the South Tributary upstream of Rich Road offers viable seasonal habitat for migrating fish, with fair overhanging cover and in-stream woody debris. The upper reach of the South Tributary does not offer viable habitat. The tributary does not flow reliably, and drains to a large wetland with no distinct mouth. Upstream, it has been channelized through agricultural lands, and disappears frequently in the extensive wetlands. The substrate is poor and there is very little large organic debris in the channel. The South Tributary has not been assigned a water body type by the state.

Chambers Ditch Fish Habitat

Chambers Ditch dries up between Rich Road and Little Chambers Lake for most of the year. The ditch provides some rearing habitat when it is flowing, but it does not contain enough pools, riparian vegetation, or cover to offer good habitat.

The long, straight section of Chambers Ditch north of Herman Road has little streamside shrubs or tree canopy, and flows sluggishly during those months when it contains water. Reed canary grass has invaded much of the ditch because of the lack of native riparian vegetation and the slow, seasonal flows. The lack of canopy cover over the channel allows the sun to heat the water in warm weather. East of Wiggins Road, the ditch substrate consists of fine sand and silt, with no gravel suited to spawning. There is no large woody debris in the ditch.

West of Wiggins Road (in CH-40), a few short ditch segments have minimal amounts of gravel, which has become heavily laden with sediment. Below the culvert under Wiggins Road, the flow gains velocity. The ditch then flows through the Wilderness subdivision, where there is more tree canopy, but the channel has been armored with rock rip-rap.

The ditch enters another grass-choked stretch with no canopy cover below Yelm Highway (in CH-60). The substrate contains no gravel, and the area is not suitable for spawning, although rearing salmon might find some refuge in this reach during winter storms. As the ditch passes below a small development on 60th Loop SE, it spreads out into a large wetland that is crisscrossed with several ditches. The wetland could provide winter rearing habitat for coho.

3.5.4 Fish and Habitat of Ward Lake

Ward Lake Fish

The Washington Department of Fish and Wildlife (DFW) plants rainbow trout in Ward Lake every year for the opening day of the fishing season (letter from Terry Lovgren 1990). The DFW also plants kokanee in Ward Lake, because it is one of the county's deep, cold lakes where kokanee can thrive. However, kokanee are not self-sustaining in Ward Lake because the lake has no feeder stream, which kokanee generally require for spawning (Jay Hunter, personal communication, 1994). The lake also contains large-mouth bass. Currently, the lake has a limited fishing season, but the DFW is considering changing to a year-round season (Jay Hunter, personal communication 1994).

Ward Lake Fish Habitat

Habitat conditions in Ward Lake are generally good. The south and west shores of the lake still contain native lakeshore vegetation, which is critical for fish habitat. Most of the native vegetation has been removed on the developed north and east shores.

During dry years, the lake level drops significantly (see chapter 4), which reduces the amount of lake shore habitat, affects the aquatic vegetation growth, and also makes the boat launch difficult to use.

3.5.5 Fish and Habitat of Hewitt Lake

The Washington Department of Fish and Wildlife plants Hewitt Lake with cutthroat trout every two to three years (letter from Terry Lovgren 1990). The DFW has occasionally planted a few salmon in the lake as well. Hewitt Lake also contains large mouth bass. Hewitt Lake is open to fishing year-round, and the habitat in the lake is generally good (Jay Hunter, personal communication, 1994).

3.6 WILDLIFE AND WILDLIFE HABITAT

3.6.1 Wildlife

Chambers and Little Chambers Lakes and the surrounding wetlands provide habitat for a wide range of wildlife species. At least thirty different water fowl species use the lake, as well as raptors such as bald eagles and Cooper's hawk (see appendix C for a list of bird species), and otters have been observed in Chambers Lake (Nelly Mitchell, personal communication, 1993).

Great blue herons are a relatively frequent sight on Chambers and Little Chambers Lakes. These birds are considered a priority species, and prefer salt and freshwater wetland habitat including seashores, rivers, swamps, and marshes (Washington Department of Wildlife 1993). Because they breed in colonies and use tall trees near wetlands for nesting sites, it is important to preserve as many trees in the vicinity of wetlands as possible (Washington Department of Wildlife 1991). There are no known nests located in the Chambers basin.

Mammals known to occur in the vicinity of Ward and Hewitt lakes include Columbia black-tailed deer, Townsend's chipmunk, Douglas squirrel, racoon, opossum, beaver, and coyote. Birds include pileated woodpeckers and red-tailed hawks (Washington Department of Wildlife 1993). A green heron nest is located on the west side of Ward Lake (Cedar Wells, personal communication, 1995). The state Department of Fish and Wildlife has designated pileated woodpeckers as candidate species for threatened or endangered listing, in danger of failing or declining, or vulnerable to impacts such as loss of habitat (Washington Department of Wildlife 1991).

3.6.2 WILDLIFE HABITAT

Chambers basin contains a variety of wildlife habitat. The City of Olympia conducted a habitat study that included northern Chambers basin (Shapiro & Associates 1994). The study mapped and rated wildlife habitat remaining in the Olympia urban area and identified several significant wildlife habitat units. Habitat areas designated Category I (best) contained at least one of the following features: documented occurrence of threatened or endangered species; bog or fen with at least 5 acres of adjacent upland forest or wetland; or, unbroken habitat of at least 75 acres and at least 700′ wide.

The study found that the area west of Chambers Lake and undeveloped land between Ward and Chambers Lakes constitute the largest remaining blocks of Category I wildlife habitat in southeastern Olympia, outside of Priest Point Park. The authors noted that the Chambers Lake wetland areas "contain some unique vegetation communities. The northwest arm of Chambers Lake is a bog community dominated by sphagnum moss and buck bean at the center, surrounded by a perimeter of Labrador tea. Upland forests provide habitat for numerous wildlife and act as a substantial buffer for the wetlands" (Shapiro and Associates 1994).

The study recommended protecting seven "medium-sized" habitat units in Olympia's long-term Comprehensive Plan, based on their biological value. The east side of Olympia contains six of these areas, and four of them lie completely within the Chambers basin, the largest of which is the area west of Chambers Lake. Two areas recommended for inclusion lie further west of the lake, and the area south of Hewitt Lake recommended for inclusion "is the only medium-sized unit with any connection to substantial wildlife habitat outside the UGMA." The area is developing quickly, which could limit the availability of habitat areas identified in the study.

3.7 CLIMATE

Summers are usually warm and fairly dry, and winters are mild and wet in Thurston County. The annual temperature averages about 53 °Fahrenheit, and annual precipitation averages 51", which falls mostly as rain. Snow falls infrequently and deep frosts occur occasionally during winter months. The average frost-free growing season is about 166 days, but it varies with distance from the waterfront and elevation above sea level.

Winter daytime high temperatures average from 40°F to 50°F, with night time low temperatures around 30°F. Daily high temperatures average 70°F to 80°F during July through September. High temperatures exceed 90°F about six times each summer, usually accompanied by lowering humidity.

The autumn rains usually begin about mid-October, driven inland toward the Cascade Mountains by predominant winds from the west southwest, originating in the Pacific Ocean. Rain continues with few interruptions through spring. Winter rain is usually light to moderate and continuous. Spring, summer, and fall showers can be heavy and intense for short durations. Rainfall averages almost 1" per month in July and August, and about 2" per month in May, June and September. About two-thirds of the days are sunny in July, August, and September, and about half are sunny during May and June.

Table 3-2 Typical seasonal rainfall

Season	Rainfall (inches)
Fall	10
Winter	28
Spring	10
Summer	4

Major storms in the Chambers basin were evaluated to relate precipitation to stormwater runoff, for use in the computer modeling of the stream system. Rainfall-runoff relationships were developed for 24-hours storms of various "recurrence intervals," defined as the frequency with which storms might occur. For instance, a "24-hour, 2-year storm" is a rainfall lasting 24 hours that is intense enough that it is only expected to recur, on average, once every two years. When engineers design stormwater facilities to accommodate the flows from such a storm, it is called the "design storm" or "design event". Although precipitation varies with the specific geographic location, the design events used for stormwater facility designs in Thurston County are based on average values shown below, contained in the *Drainage Design and Erosion Control Manual for Thurston County*, 1994.

Table 3-3 Design Storm Events for Thurston County

Storm Recurrence Interval (years)	Precipitation (inches per 24 hours)
2	2.80
5	3.75
10	4.35
25	5.10
50	5.65
100	6.15

The prolonged wet season in the Puget Sound area presents unique problems for estimating the quantity of runoff generated by a storm of a specific intensity and duration. The level of moisture in the soil immediately preceding a storm event varies throughout the rainy season. When the soil is saturated, very little rainfall infiltrates into the ground, so most of it becomes runoff. Saturated soils create special problems for predicting the amount of runoff from a storm event.

Rainfall was measured in the Chambers basin, as well as at many other locations in north Thurston County. Rainfall data from the basin were used for the computer analysis of flows in Chambers Creek and Chambers Ditch, because rainfall levels vary significantly from one location to another in the county.

3.8 TOPOGRAPHY

The Chambers basin lies within the topographic area known as the Puget Sound lowland. Prairies and rolling lowlands created and sculpted by glaciers dominate the region's landscape, broken by hills and small peaks which rise to elevations of 2,600'.

At least three distinct glaciers advanced across the basin and created the landscape we see today, by a variety of processes (Crandell et al 1965). Advancing glaciers pulverized rocks and pushed large quantities of sand and gravel into the area, at the same time that their great weight compacted the material beneath them. As segments of the glaciers broke and moved at different speeds, the sand and gravel formed long ridges and mounds.

Massive floods from both advancing and receding glaciers eroded deep valleys and deposited vast amounts of sediments throughout the area. Later glacial movements filled the valleys and depressions with newer materials (Bretz 1913; Crandell et al 1965).

Receding glaciers left large blocks of ice in their wake, and subsequent floods and glacial advances piled new material around the remnant ice blocks. When the ice blocks eventually melted, they left deep depressions surrounded by hills of sand and gravel, which became the kettles (locally known as "potholes") that characterize parts of Thurston County (Bretz 1913; Crandell et al 1965). Many of the county's most productive sand and gravel mining operations are located in these pothole areas. Other areas of glacial retreat left broad gravelly plains spread over compacted clay and sediment, which became the Puget Sound prairies.

The Chambers basin is located on a plateau ranging in elevation from 110′ to 320′ above sea level, between the Deschutes River to the west and the Nisqually River to the east. Level prairies cover much of the Chambers basin, but the northeast corner of the basin contains hills and potholes. Ward and Hewitt Lakes occupy the largest of these potholes, with no natural inlets or outlets. Slopes generally range from 0 to 3 percent, with few steep slopes except around the potholes. The basin has been divided into 15 sub-basins based upon topography (shown on map 3).

A low, north-south trending rise of gravelly hills between Wiggins Road and Boulevard Road attains a maximum elevation of about 280′. The ridge slopes down to a level plain containing Chambers Lake and Little Chambers Prairie on the east. The ridge drops down to the potholes containing Ward and Hewitt Lakes to the southwest. Southwest of the lakes, an 80-foot bluff separates the edge of the basin from the Deschutes River.

Chambers Lake occupies the low spot of the plateau comprising Little Chambers prairie, which lies at an elevation of about 200′ and rises slightly to the southeast. Smith Lake sits in an isolated depression directly south of Chambers Lake, and another small, unnamed lake occupies a depression a little further south. Each of these lakes are low spots on an essentially level plateau that stretches from the north end of the basin to the south end.

Chambers Prairie extends across the southern basin and lies at a slightly higher elevation of about 210′ to 230′ above sea level. A low, indistinct rise divides the southern edge of the basin from the Spurgeon Creek drainage. The basin attains a maximum elevation of 320′ above sea level in the southeast corner.

Chambers Ditch traverses the northern Chambers basin and the South Tributary traverses the southern part. Chambers Creek drains into the Deschutes River at the basin's lowest elevation of about 110′ above sea level.

3.9 POPULATION

Population growth in Thurston County slowed down to 30% in the 1980s after averaging 62% in the 1970s, when it was one of the fastest growing counties in the nation (Thurston Regional

Planning Council 1991). Most of the growth in the seventies occurred in unincorporated areas of the county, which experienced an amazing 99% increase in population. Unemployment remained fairly stable at an average of 7.1 % in the seventies. Thurston County, along with the rest of the nation, experienced an economic recession in the 1980s, and population growth in the unincorporated county fell to 37%. Unemployment jumped to 12.2% in 1982. Growth in employment covered by the Employment Security Act dropped from 70% between 1970 and 1980 to 42% between 1980 and 1989 (Washington State Department of Employment Security, 1990).

Housing construction trends in the county paralleled population trends. The total number of housing units in the unincorporated county increased by 123.9% from 1970 to 1980, but housing increased by only 43% from 1980 to 1990 (US Bureau of Census 1992; Washington State Office of Financial Management 1992). The average residential selling price increased 230%, from $18,400 in 1970 to $60,800 in 1980. The average residential selling price rose only 33%, from $60,800 in 1980 to $80,700 in the fourth quarter of 1989 (US Department of Housing and Urban Development 1990).

Migration into the county from other areas was the major factor contributing to the population growth in Thurston County in the 1970s and 1980s, as opposed to natural increases from births (Washington State Office of Financial Management 1990; Thurston Regional Planning Council 1991). Migration into the county was highest in the mid-1970s, when unemployment remained stable and housing prices were relatively low. Migration into the county decreased in the 1980s, following explosive increases in housing prices and rising unemployment.

Thurston Regional Planning Council developed population forecasts for the county through the year 2015, to comply with state growth management planning requirements. TRPC divided the county into 377 individual planning areas (called "Transportation Area Zones" or TAZs), and analyzed birth and death rates, employment growth patterns, vacant buildable land, and historic growth trends for each TAZ. Separate low, medium and high forecasts were developed for each TAZ, and they were compiled into county-wide forecasts. The local jurisdictions officially adopted the medium growth forecast in 1993. The forecast will be updated every two years, and will serve as the basis for planning and funding the local area's future capital facilities.

The Chambers basin population forecast was derived by overlaying the basin boundaries on the map of TAZs, and compiling the locally adopted medium-growth population forecasts for each TAZ within or partially within the basin.

Table 3-4 Population Forecast for the Chambers basin

YEAR:	1993	1995	2000	2005	2010	2015
POPULATION:	16,322	18,592	20,914	22,925	25,544	28,424

3.10 LAND USE AND ZONING

This section describes historical land cover, existing land cover, existing land use, zoning, and potential future development. These attributes were quantified in acres for use in the hydrologic model of the basin. The existing conditions provide a baseline from which to estimate the changes from natural conditions and project future impacts.

Land cover refers to the physical characteristics of the land surface, such as forest, grass, or impervious area (pavement, roofs, etc.). The historical land cover was projected primarily from soil types. Existing land cover was derived from soil maps and aerial photographs.

Land use refers to the human uses and activities on the land, such as residential development, agriculture, and commercial development. Existing land use was derived from planning department records and aerial photographs.

Zoning refers to the types of development allowed by local ordinances. Existing zoning was provided by local planning departments, and reflects the best data at the time of writing, but zoning was being revised by all the jurisdictions as this plan was developed.

Other regulations which influence land use patterns include critical areas ordinances, and septic system and stormwater system design requirements (summarized in chapter 1). These regulations may limit the amount of buildable land on a given parcel, limit the number of people that can live on a given parcel, or require special designs to reduce the impacts to natural resources or public health and safety. Land values, construction costs, current timber prices, tax considerations, proximity to services, and aesthetics also influence land uses. Land uses have a major impact on water quality and basin hydrology. Throughout the county and nationwide, urban-level development has been associated with severe water quality and quantity problems.

3.10.1 HISTORICAL LAND COVER

As previously noted, the basin's native vegetation consisted primarily of prairies, forests, and wetlands. The native vegetation descriptions developed by the Soil Conservation Service for the basin's soils (U.S. Department of Agriculture 1990) were used to simulate natural conditions in the basin hydrologic model. Vegetation mapped in the first survey of the area (U.S. Department of the Interior 1853) supports the SCS vegetation descriptions.

A review of archeological records for the basin revealed the old homestead of the Chambers family. Settling in 1847, the Thomas M. Chambers family were among the first white immigrants in the Puget Sound area. Thomas' son, Andrew Jackson Chambers, established a farmstead on what is now the eastern edge of the Indian Summer Golf and Country Club development, on Rainier Road south of Yelm Highway (Historical Research Associates 1992). The Daughters of the American Revolution installed a plaque at the blockhouse site on Rainier Road in 1929.

Soil maps and surveys indicate that the basin's wetlands covered more of the basin's land in the past (U.S. Department of the Interior 1853; U.S. Department of Agriculture 1990). The area extending from Chambers Lake, along Wiggins Road, to Chambers Ditch was a wetland under natural conditions. Some of the wetlands have been filled for development. Construction of Chambers Ditch reduced the extent and affected the quality of the wetlands in this area. The changes to the natural wetlands have altered the hydrology of the basin.

The basin historically contained extensive prairies, associated exclusively with Nisqually and Alderwood soils. Puget Sound prairies occur primarily on Spanaway and Nisqually soils (Rex Crawford, personal communication, 1994). For the purposes of modeling natural stream conditions, all Nisqually and Nisqually/Alderwood complexes were assumed to have been grass lands, and all other soils were assumed to have been forested.

3.10.2 Existing Land Cover

As Olympia, Lacey, and the Urban Growth Management Area of the County developed, Chambers basin experienced considerable urban growth. 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. Table 3-5 summarizes the existing land cover in the basin as of 1987, including impervious surfaces (Thurston Geographic Information Facility 1993). The land cover types do not differentiate between disturbed and undisturbed lands. For example, the grass category includes lawns, pastures and prairies.

3.10.3 Existing Land Use and Zoning

This section describes the dominant existing land use in each area of the basin, and summarizes existing zoning. The basin is generally most developed in the northern, urban half and least developed in the unincorporated county area to the south. Map 8 depicts current zoning for the basin. The zoning reflects existing land use, with urban-density residential and commercial zoning within the city limits, primarily suburban-density residential zoning in the Urban Growth Management Area, and rural, low-density residential development in the

Table 3-5 Land cover in Chambers basin

Land Cover Type	Acres
Forest	2,506
Grass	4,187
Wetlands	902
Open Water	263
Impervious Surfaces	465
Total	8,323

unincorporated area. Table 3-6 provides an overview of current and potential future land use, and a summary of utility services, in each sub-basin. Growth potential was determined from zoning and extent of undeveloped land (TRPC 1993).

Zoning influences the use of land in the basin. Local zoning ordinances determine the types and density of development allowed in the basin. The local zoning codes which apply to the basin recognize residential, commercial and industrial land uses. They also set maximum densities for residential development, stated in terms of "dwelling units" or simply "units" per acre. A "dwelling unit" is a unit designed to house one family, such as an apartment, half of a duplex, or a single family home. The actual allowable density may vary according to the specific design of a development and other land use regulations.

Each jurisdiction sets its own zoning codes, and the cities and county work together to develop zoning codes for the urban growth management area. The zoning designations vary widely between jurisdictions, and city and county zoning codes use vastly different definitions of high and low density development. City zoning generally permits much denser residential development, although most land owners develop their land at much lower densities than the maximum allowed.

Olympia permits residential developments of 16-18 units per acre throughout the basin. Lacey permits residential development ranging from 2-16 units per acre in various parts of the basin, as well as some commercial development. Thurston County permits residential development of 4-8 units per acre in most of the Urban Growth Management Area, but limits residential development to 1 unit per 2-5 acres in the rest of the basin.

Table 3-6 Land Use Characteristics of Chambers basin

Sub-basin	Dominant Land-Use	Effective Impervious Area, Acres	Growth Potential	Sanitary Sewer Service	Stormwater System
CH-10	High Resid	186	High	Partial	Interm.
CH-20	Mod. Resid	3	High	Partial	Interm.
CH-30	Mod. Resid	4	High	Partial	Interm.
CH-35	Mod. Resid	3	High	Partial	Interm.
CH-40	Mod. Resid	23	Moderate	No	None
CH-50	Mod. Resid	49	High	No	Interm.
CH-60	Mod. Resid	8	Moderate	No	None
CH-70	Sparse Resid	2	Low	No	None
CH-80	Sparse Resid	10	Low	No	None
CH-90	Sparse Resid	43	Low	No	None
CH-100	Mod. Resid	25	Low	No	Partial
CH-110	Mod. Resid	19	Low	Partial	Yes
CH-120	Mod. Resid	18	High	Partial	Yes
CH-125	High Resid	44	Low	Partial	Yes
CH-130	Mod. Resid	28	High	Full	Yes

The Chambers basin has experienced a high residential and commercial growth rate because it is located on the edge of the Urban Growth Management Area. Only in the southern portion of the basin has development been minimal.

Chambers/Little Chambers Lake Area Land Use

Chambers/Little Chambers Lake sub-basin (CH-10) has several distinct areas. It contains the highly urbanized residential area on north and east sides of Little Chambers Lake, the more rural but developing west side of Chambers Lake, and the moderately developed southern area. The outskirts of many of the residential neighborhoods are beginning to push toward the rural areas, with more and more apartments and housing developments under construction. The sub-basin has several different land use zones that vary from rural to a small, light industrial area in the central region.

The east side of the sub-basin near Little Chambers Lake, located in the city of Lacey, contains mostly residential development of 2-4 houses per acre, interspersed with larger farm lands. A large retirement community and a mobile home park exist in this area. Development in the area south of Chambers Lake is less dense and includes more farms. The zoning is mainly urban medium-density (up to 8 units/acre) or low-density (up to 4 units/acre) residential. The northeast corner of the sub-basin contains apartments and is zoned for urban high-density residential development.

The city line dividing Lacey and Olympia follows the old Chehalis Western railroad between Chambers and Little Chambers Lakes. The tracks are no longer used, and Thurston County has acquired the right-of-way for a public trail. A public fishing access and boat launch is located at the northern tip of Chambers Lake, on the Olympia side of the city limits.

The city of Olympia jurisdiction stretches from the west side of the lake all the way to the west edge of the basin. Development in this area is partially rural and partially medium-density residential, and the area is developing rapidly. Large portions of land remain undeveloped on the west side of Chambers Lake. The area between the lake and Hoffman Road, north of Wiggins Road, is zoned for multifamily residential development up to 18 units/acre. The rest of the basin within the Olympia city limits is zoned for residential development up to 16 units/acre.

Chambers Ditch/Smith Lake Area Land Use

The Chambers Ditch area (CH-30,40 & 60) contains medium-density residential development, primarily in the Wilderness subdivision west of Wiggins Road, and around Smith Lake. The rest of the land is rural, but developing rapidly. North of 40th Avenue, the ditch flows through land zoned by Olympia for residential development at 16 units/acre. South of 40th Avenue, the ditch flows through an unincorporated area within the Urban Growth Management Area, zoned for urban medium-density residential development (4-8 units/acre).

Smith Lake sub-basin (CH-20) lies mostly in Thurston County and is also zoned for urban medium-density development. The lake recently started experiencing increased residential development. Three new homes built in 1993 on the southern shoreline were the first homes to be built right on the shore. Presently the north shore of the Smith Lake is undeveloped. The eastern sub-basin and part of the sub-basin to the south (CH-50) lie within Lacey city limits. The Lacey area is zoned for urban medium-density residential development (4-8 units/acre) and includes a site zoned for a business park.

Ward Lake Area Land Use

The northern half of the Ward Lake sub-basin (CH-125) lies within the Olympia city limits, and the southern half is in unincorporated Thurston County. Within Ward Lake sub-basin, land use is a combination of rural residential and medium-density residential development. The western portion contains rural residences, agricultural land and undeveloped areas; the eastern portion includes several areas of suburban-density subdivisions.

The average residential density around Ward Lake is 4-8 units per acre. High-density residential developments lie to the north and the south of Ward Lake. Older homes on larger lots and Briggs Nursery occupy the west side of the lake. Land on the lower banks of the west side of the lake is presently undeveloped.

Ward Lake basin is zoned for residential development of 4-8 units/acre in the county portion of the sub-basin. The northern portion within Olympia city limits is zoned for residential development up to 16 units/acre.

Hewitt Lake Area Land Use

Hewitt Lake sub-basin lies entirely within unincorporated Thurston County. The lake is located south of Yelm Highway, surrounded by homes. The Hewitt Lake sub-basin contains predominantly medium-density residential development. The undeveloped southern portion of the sub-basin is beginning to develop rapidly. The entire sub-basin is zoned for medium-density residential development (4-8 units/acre). Little new development has occurred on the Hewitt Lake shores since the late 1960s.

South Tributary/Chambers Prairie Area Land Use

Almost the entire South Tributary/Chambers Prairie area (sub-basins CH-70,80 & 90) lies outside the Urban Growth Management Area in unincorporated Thurston County. Agricultural lands and rural residential property predominate in this area. Much of the area contains undevelopable wetlands.

Most of sub-basin CH-90 is zoned for rural residential development at a maximum density of 1 unit/2 acres. The long, predominantly wetland area surrounding Chambers Creek is zoned for 1 unit/5 acres, and the edge of the sub-basin north of the BPA power lines is zoned for urban medium-density residential development (4-8 units/acre). Sub-basin CH-70, which consists mostly of wetlands, is zoned for 1 unit/5 acres, as is the west half of CH-80. The eastern half of CH-80 lies within the McAllister Geologically Sensitive Area, which is zoned for a maximum of 1 unit/5 acres and has additional restrictions on commercial land uses. Most of the land north of the Burlington Northern railroad in this sub-basin is zoned for industrial uses.

3.10.4 Potential Future Development

The local jurisdictions' Comprehensive Plans and Urban Growth Management agreement guide zoning policies. The Urban Growth Management Area (UGMA) boundary, adopted by Lacey, Tumwater, Olympia and Thurston County in 1988 in order to limit urban sprawl, cuts right through the middle of the Chambers basin. The UGMA boundary affects the basin by setting the development densities and defining the extent of city sewer and water services.

The local jurisdictions adopted both long and short-term UGMA boundaries in 1988. The short-term boundary is intended to be revised every 10 years, and developments within the long-term boundary must apply for special dispensation to receive a sewer or water extension. As indicated on map 2, the majority of the basin falls within the city limits or the long-term UGMA. The map does not show the short-term boundary, which lies closer to Chambers Lake.

The maximum possible development of all developable lands under current regulations, called "build-out", would entail major increases in suburban and high-density residential land use. Build-out of the basin would create a total of 1,378 acres of impervious area, or 16% of the total basin. In the past, most landowners have not developed to the maximum allowable density in the suburban and urban areas. Chapter 3 discusses build-out in greater detail.

3.11 RECREATIONAL RESOURCES

3.11.1 Existing Resources

Chambers basin contains a few public recreational resources such as developed parks and undeveloped open space areas. The Department of Fish and Wildlife maintains public access for fishing and boating on the eastern shore of Ward Lake and the north end of Chambers Lake. The Department of Fish and Wildlife prohibited using the Ward Lake access for swimming in 1994. Hewitt and Smith Lakes have limited access.

The county recently purchased the Chehalis-Western railroad right-of-way for development as a public trail. The master plan for this trail system was completed in 1994. The trail will lead along the edge of Little Chambers Lake and extend for 5 miles to Spurgeon Creek. Several footpaths from the surrounding developments could access the railroad right-of-way. Construction could begin as soon as 1995, depending on the availability of grant funding.

The City of Olympia Parks, Recreation and Cultural Services Department operates LBA Park, a 22 acre, multi-purpose recreational facility that provides picnic facilities and public ball fields in the fall, spring, and summer. The park also offers a jogging path, horseshoe pits, and children's playground equipment.

There are currently 19 miles of trails within the three cities and the UGMA. Seventy-six percent of those trails occur within existing parks. Of the 19 miles of trails there are 13 miles in Olympia, 1 mile in Lacey, and 5 miles in the County (Urban Trails Plan, January 1992).

3.11.2 Potential Recreational Improvements

Recreational opportunities in the Chambers basin would be greatly enhanced by implementation of the Urban Trails Plan, which was approved by Olympia and Lacey in 1992. The plan is intended to guide future trail development within the UGMA, consistent with the local jurisdictions' existing parks plans. Thurston County's planned trails will connect with, and complement the trails outlined in the Urban Trails Plan.

The Urban Trails Plan proposes several bicycle and walking trails for the Chambers basin, mostly along the Chehalis-Western railroad right-of-way and in the Chambers Lake area. The trails would offer 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, including additional open space in the central portion of the Chambers basin. The plan calls for the preservation of undeveloped areas to visibly and audibly buffer between differing land uses.

The City of Olympia plans for more parks to accommodate projected growth in the northern portion of the basin. The city has identified the Chambers Lake wetlands as an ideal area for low-intensity parks which offer opportunities for passive recreation such as bird watching.