WRIA 13

Initial Assessment

Henderson Inlet

Watershed

REVISED DRAFT
MARCH 2001

Thurston County
Water and Waste Management

Authored by: Tom Clingman
Telephone: (360) 357-2491
Email clingmnt@co.thurston.wa.us

WRIA 13 INITIAL ASSESSMENT –HENDERSON INLET WATERSHED

Note: This draft assessment supplements the 1995 WRIA 13 Initial Assessment (Open File Technical Report 95-10) issued March 16, 1995 by the Washington State Department of Ecology. The 1995 Report did not address the smaller watersheds in Deschutes WRIA 13.

Table of Contents

2.1.1 Major Findings and Recommendations *(To be added later)*

2.2.1 Watershed Conditions

Overview

The 30,000-acre Henderson Inlet watershed is the second largest in WRIA 13 (see Figure 1). The watershed is roughly 4 miles across (east to west) and about 16 miles long north to south. The area contains two major streams, Woodland Creek and Woodard Creek, which drain about 80% of the watershed. In addition to the two main creeks, a half dozen smaller streams drain smaller portions of the Dickerson Point and Johnson Point peninsulas. With the exception of marine bluffs ranging up to 100 feet, the watershed is flat or gently rolling. Highest elevation is only about 300 feet at Hawks Prairie on the east side of the watershed and at Chambers Prairie on the south.

Henderson Inlet is one of five inlets that form the southern terminus of Puget Sound. It is located between Budd Inlet on the west and Nisqually Reach on the east. The five mile long inlet ranges from ¼ to ¾ miles in width, averaging only about 25 feet in depth. Significant areas of the lower inlet are exposed mudflats at low tide.

Overall watershed health and function

While the upper watershed is in the urbanizing Lacey/Olympia area, much of the northern portion of the watershed is currently rural in nature. However, extensive future urban-level development is anticipated particularly in the Woodland Creek watershed, which is 90% within the designated Urban Growth Area (UGA). The elevated nitrate-nitrite levels in the streams may evidence extensive existing development of the upper watershed, particularly the extensive developed area in Tangle/Thompson Place. In comparison, McLane Creek (a relatively undeveloped watershed) has average nitrate-nitrite levels of .44 mg/liter (1/2 the Woodard level and less than 1/3 the Woodland Creek level). Key watershed health indicators for Woodland and Woodard Creek include:

	Percent Impervious [1]	Percent Within UGA (anticipated future urban development)	Benthic Index: Stream health as indicated by benthic diversity) [2]	Nitrate-Nitrite (gw loading indicator) (2
Woodland	10% (moderate)	90%	24, 22 (low)	1.46 mg/liter
Woodard	15% (moderate)	41%	36, 32 (moderate)	.81 mg/liter

[1] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, August 1995, Thurston County Storm and Surface Water Utility
[2] Thurston County Water Resources Monitoring Report: 1998-1999 Water Year, September 2000, Thurston County Storm and Surface Water Program and Thurston County Environmental Health Division

Land Use

The southern half of the watershed is mainly in existing or planned urban and suburban land use. About 25% of the Woodland Creek watershed lies within the city limits of Lacey, with the unincorporated Tanglewilde/Thompson Place also developed at urban levels. About 25% of the Woodard Creek watershed is within the city of Olympia and a smaller portion is in the city of Lacey. This includes extensive commercial development including the South Sound Mall and commercial development along Pacific Avenue. The eastern side of the watershed in Hawks Prairie is beginning to develop as a significant new commercial and light industrial center in Thurston County. The northern half of the watershed is mainly in rural residential and forest cover, with scattered subdivisions. See Figure 2.

Detailed assessment of land cover was performed in 1987 for the hydrologic modeling program [3]. In summary, major land cover categories for the watersheds of the two principal streams were:

1987 Land Cover	WOODLAND CR 18,000 ac total	WOODARD CR 4,500 ac total
Forest	47%	52%
Residential	28%	12%
Grass & Crops	17%	22%
Commercial	5%	12%

(Current land use to be added after new extract from parcel data)

[3] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, August 1995, Thurston County Storm and Surface Water Utility

Figure 1 - WRIA 13 and Henderson Inlet Watershed

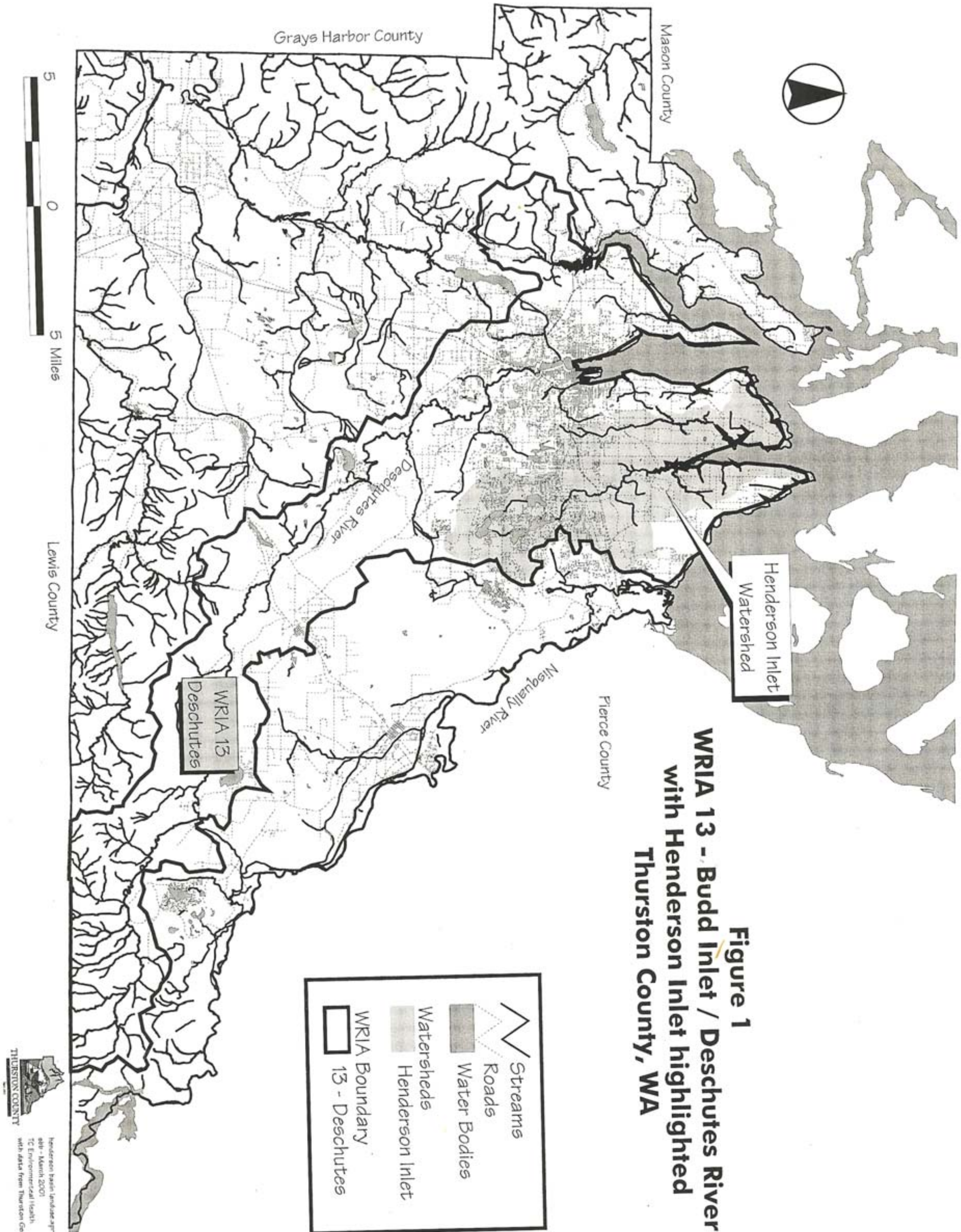
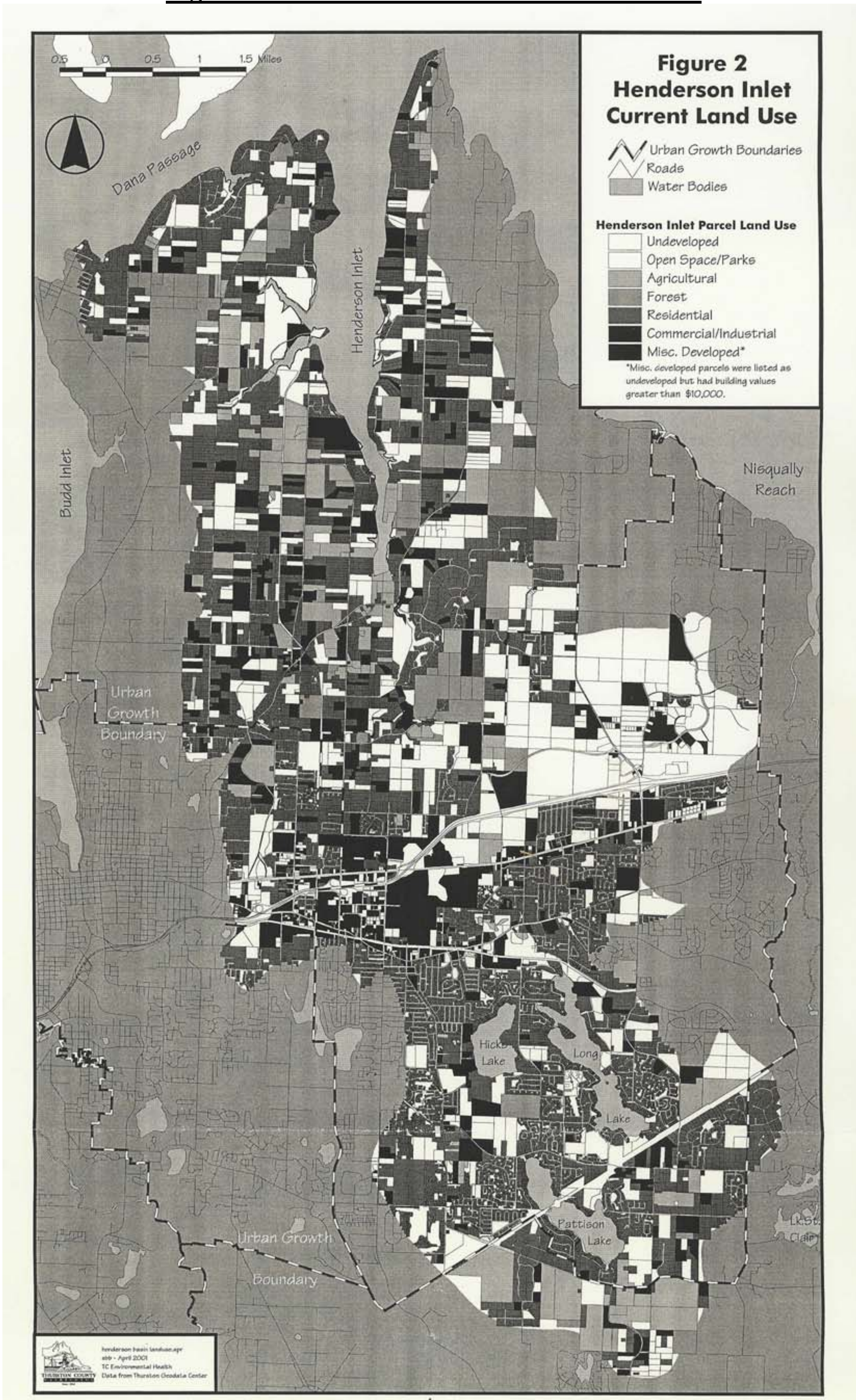


Figure 2 - Henderson Inlet Watershed Land Use



2.2.2 Beneficial Uses of Water

Instream Resources Protection Program (WAC 173-513)

The range and significance of beneficial uses of waters in WRIA 13 is evidenced by the "Instream Resources Protection Program – WRIA 13" adopted in 1980 (WAC 173-513). Surface water supply was retained to support "wildlife, fish, scenic, aesthetic, environmental values, recreation, navigation and water quality". In effect, this WAC establishes a formal water right for surface waters effective the date of adoption. Waters closed to additional consumptive appropriation included Woodland Creek, Woodard Creek, Hicks Lake, Pattison Lake and Long Lake. In addition, the WAC stipulated that all lakes and ponds were to be "retained substantially in their natural condition" in considering future permitting activities (WAC 173-513).

Salmon and other species

The 1980 DOE technical report in support of the WRIA 13 Instream Resources Protection Program noted that independent drainages in the Deschutes Basin including Woodard and Woodland Creek "provide habitat supporting chum and coho salmon. Spawning escapements have been estimated at over 12,000 chums occurring after substantial harvest in Puget Sound and terminal area catches in Eld Inlet by the Squaxin Indian Tribe. The other major independent drainage used by chum salmon is Woodward Creek, where escapements approach 1,000 spawners annually". [4]

Woodland and Woodard Creeks and a few short direct tributaries to Henderson Inlet provide about 28 stream miles of habitat for coho, chum and steelhead (see Habitat section). This important beneficial use is limited by factors including: 1). Alteration of the natural flow regime; 2.) Barriers to fish passage; and 3.) Water temperature/lack of large woody debris/excess fine sediment.[5] The marine waters of Henderson Inlet are also expected to support salmon habitat and passage.

Shellfish

Commercial and recreational shellfish production is an important beneficial use in Henderson Inlet. Shellfish harvesting is particularly sensitive to water quality conditions due to strict water quality requirements (bacteria standards) for certifying shellfish harvesting areas. Because shellfish are filter feeders, they tend to concentrate pollutants the water to the point that they may be unsafe for human consumption. There is a gradient of fecal coliform pollution impact from highest at the southern end of Henderson Inlet to lower outward. Pollution sources are thought to include on-site sewage systems, livestock, stormwater and marine mammals. [6]
In 1985, 120 acres in the lower inlet were downgraded from Conditionally Approved to Prohibited for commercial harvest. Due to declining water quality conditions in the middle inlet,

---

[4] June 1980 Deschutes River Basin Instream Resources Protection Program Including Proposed Administrative Rules – Water Resource Inventory Area 13, Washington Department of Ecology State Water Program (W.W.I.R.P.P. Series – No. 8)
[5] Salmon Habitat Limiting Factors Final Report, Water Resource Inventory Area 13, July 1999, Washington State Conservation Commission
[6] 1999 Status and Trends in Fecal Coliform Pollution in Puget Sound Embayments, Washington State Department of Health Office of Food Safety and Shellfish Programs.

several additional acres were downgraded by action of the Washington Department of Health in 2001. Local government and state agency responses will be formulated to address this downgrade.

Recreation

Long Lake, Hicks Lake and Pattison Lake are very important for recreation, with the only developed swimming beach in the Olympia/Tumwater/Lacey area being located at the City of Lacey Park on Long Lake. A future City of Lacey park including swimming access is anticipated at an undeveloped site on Hicks Lake. Public launches provide access to all three lakes for fishing and recreational boating.

Algae blooms stemming from nutrient enrichment can impair swimming and water skiing. An invasive non-native aquatic plant, Eurasian Water milfoil, was found in Long Lake in the late 1980's. This plant forms extensive dense mats of vegetation that greatly impair recreation and dramatically affect the lake's ecosystem. An integrated program of herbicide use followed by intensive surveys has reduced the infestation to a relative handful of plants controlled through annual pulling by divers. [7]

Water supply for residential, industrial and irrigation uses

Residences, industry and agriculture in the watershed rely in large part on the groundwater underlying the basin. The main exception is McAllister Springs (in Nisqually WRIA 11), which serves the City of Olympia and about 3,000 residents in the PUD service area of Tanglewilde. A few City of Lacey wells in the Meadows subdivision vicinity are also located in WRIA 11.

The Henderson Inlet watershed includes most of the Lacey Urban Growth Area and a smaller portion of the Olympia UGA. Estimated existing population in the Lacey UGA is about 50,000. Under "full build out" projections this population would more than double (see Table 1). For WRIA planning purposes, a "moderate full-build out" scenario based on the UGA Joint Plans between the cities and County is being used to forecast long-range water needs. See Table 1.

The prime importance of groundwater supplies to serve growth of the region was highlighted in the 1986 "Reservation of Future Public Water Supply for Thurston County" (WAC 173-591). The purpose of the chapter was to identify long-term water needs and establish a reservation to meet these needs. The Reservation specifically found that "the proposed use of the ground waters will result in the maximum net benefit for the people of the state". The WAC stipulates that subsequent water right applications for public water supply will receive a priority date of 1986, regardless of the actual year of application. [8]

---

[7] Long Lake Eurasian Water milfoil Eradication Project Final Report, 1995, Thurston County Department of Water and Waste Management. Also see annual reports of sites and pounds of milfoil hand-removed by divers.
[8] Thurston Metropolitan Area Coordinated Water System Plan for Water Supply Reservation, April 1982, Economic and Engineering Services for the cities of Lacey, Olympia and Tumwater. See also WAC 173-591 adopted in 1986.

Table 1 - WRIA 13 "Full Build out" Dwelling Units Projection

WRIA 13 Issue Paper #1	Minimum/Low		Moderate		Maximum (Theoretical)		2025 est.	Total Avail. Acres	
	Dwelling Units	**Population**	**Dwelling Units**	**Population**	**Dwelling Units**	**Population**	**TRPC**	**UGA Plans**	**TRPC 1999**
Olympia UGA									
1992 population		45,800		45,800		45,800			
Growth capacity (1)	28,094	63,773	42,141	95,660	56,188	127,547		5,721	4,522
Total buildout scenario		109,573		141,460		173,347	79,030		
Lacey UGA									
1990 population		47,838		47,838		47,838			
Growth capacity (2)	19,881	48,897	31,682	69,207	43,482	89,517		5,993	6,395
Total buildout scenario		96,735		117,045		137,355	94,700		
Tumwater UGA									
1994 population		17,453		17,453		17,453			
Growth capacity (3)	9,326	21,170	13,505	30,655	17,683	40,140		n/a	4,750
Total buildout scenario		38,623		48,108		57,593	38,160		
Subtotal: No.Co.UGAs		244,931		306,613		368,295	211,890	11,714	15,667
Rainier UGA									
1994 population		1,421		1,421		1,421			
Growth capacity (4)	238	707	357	1,169	952	1,875		238	692
Total buildout scenario		2,128		2,590		3,296	2,320		
Rural areas: WRIA 13									
2000 population (5)		26,745		26,745		26,745			
Growth capacity (6)	4,700	10,669	4,700	10,669	4,700	10,669			
		37,414		37,414		37,414	36,335		
TOTAL FULL BUILDOUT		284,472		**346,617**		409,006	250,545		
							340,500	Yr 2050 @ 2000-2025 av. TRPC annual growth rate	

Watershed Planning Committee direction: Use 350,000 as 2050 population benchmark for long-range projection of water needs.

Notes: North Co. UGAs data includes some areas outside WRIA 13.
(1) From Olympia Joint Plan Table XI-2. Based on footnote attached to table, "medium" is 75% of theoretical maximum units;
"Low" is 50% of maximum. Population is based on 2.27 per unit (OFM figure; used in Tumwater Joint Plan page 3-24).
(2) Lacey population capacity from Lacey Joint Plan Table 6. Dwelling units calculated from Table 5 data and multipliers on Table 6.
(3) Tumwater minimum and maximum potential new units from Tumwater Joint Plan Figure 3-4. "Moderate" forecast was created at the midpoint between the two est.
(4) Total vacant residential land in Rainier and the Short-Term UGA is included in theoretical estimate. Rainier Plan Table 11 used more conservative projection.
"Maximum" capacity scenario assumes 4 units per acre; "moderate" is the midpoint between the two estimates.
(5) TRPC customized estimate for WRIA 13 used for Rural areas. UGA estimates use entire UGA, including portions outside WRIA 13.
(6) From Env. Health initial estimate for potential exempt wells in WRIA 13.

2.2.3 Geology and Groundwater Hydrology

Aquifers in the Planning Area

Repeated glacial advance and retreat formed the geology of the Henderson Inlet watershed. While on the surface the Henderson Inlet watershed rises only about 300 feet above sea level, the underlying "topography" of the glacial deposits is much more dramatic. Total depth of the glacier-associated deposits increases from about 500 feet at Chambers Prairie to over 1,800 feet deep at Johnson Point. See Figure 3 illustrating depth to underlying bedrock in the area.

The watershed's prairies, rolling terrain and lakes reflect the advance and retreat of the Vashon Glaciation, the most recent of several glaciers that extended to the area. Beginning with a cooling period about 15,000 years ago, a continental ice mass extended from British Columbia to south Thurston County. As the climate warmed about 13,500 years ago, the glacier retreated northward. With surface water drainage to the north blocked, several temporary drainage routes were created across present-day Thurston County to the Chehalis River, conveying the Deschutes and Nisqually Rivers and glacial melt waters. As shown on Figure 4, one route roughly followed present-day Spurgeon Creek and Salmon Creek west to the Black River. Another route crossed the Lakes area in the upper Woodland Creek watershed and flowed westerly to the upper Black River.

The Vashon Drift is composed of large quantities of stratified sand and gravel deposited by the advance and retreat of the glacier. The upper formation is the Vashon recessional outwash (Qvr), which creates the hummocky terrain and the numerous lakes of the region. This upper aquifer is the source of the large springs on Woodland Creek near Martin Way (Beatty Springs).[9]

Below the Qvr is a generally confining layer called the Vashon glacial till (Qvt). This "hardpan" is composed of sand and gravel encased in a matrix of silt and clay. The depth and degree of compaction varies with the period the till was laid down, with more compact till developing beneath the heavy mass of glacial ice and less compact till forming during the glacial melting period.

At the bottom of the Vashon Drift are materials laid down during the Vashon glacial advance (Qva), which serves as a significant potable aquifer for the region. Some municipal wells and many smaller wells are located in this aquifer, which is estimated to provide about ½ of the total source for wells in the glacial deposit region of Thurston County.[10]

Below the Vashon materials lay the clay and silts of the earlier Kitsap formation, which is generally a confining layer for groundwater. Deeper still are the deposits of "penultimate" glaciation (Qc), which is beginning to be used as a municipal water source. About ½ of the totals well withdrawal in the USGS study was identified as utilizing the Qc. Deeper yet lie the "unconsolidated and undifferentiated" Tqu deposits, which are deep deposits of mixed glacial and non-glacial origin, thought to include areas of both aquifers and confining layers.

[9] Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington, USGS, 1999. Table 4 lists major springs and the associated geohydrologic units.
[10] USGS study cited above. See Table 5 for estimated groundwater use by aquifer based on the detailed study conducted in 1988.

Groundwater contours and direction of groundwater flow for the two principal aquifers was estimated by the USGS (USGS, 1999). Flow direction in the Vashon advance aquifer (Qva) is generally consistent with surface topography in the Henderson Inlet watershed. See Qva groundwater contours at Figure 5 from the USGS groundwater study for Thurston County.

In the southern part of the watershed (Lakes/Chambers Prairie area), the pre-Vashon Qc aquifer is understood to flow easterly toward the McAllister Springs vicinity, contradictory to the existing surface topography. See Figure 6. Much of this aquifer is believed to discharge to Puget Sound.[11] A significant portion of the precipitation falling in the Lakes/Chambers Prairie area does not route to surface streams in the Henderson Inlet watershed. Due to the very porous soils and flat topography, 80-90% of the precipitation falling on the upper Woodland Creek basin flows to McAllister Creek or Puget Sound without entering Woodland Creek.[12]

. Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington, USGS, 1999. See Figure 23e.[11]

[12] Woodland and Woodard Future Conditions, Thurston County, Washington, Final Results, Aqua-Terra, 1994.

Figure 3 - Depth to Bedrock in Northern Thurston County

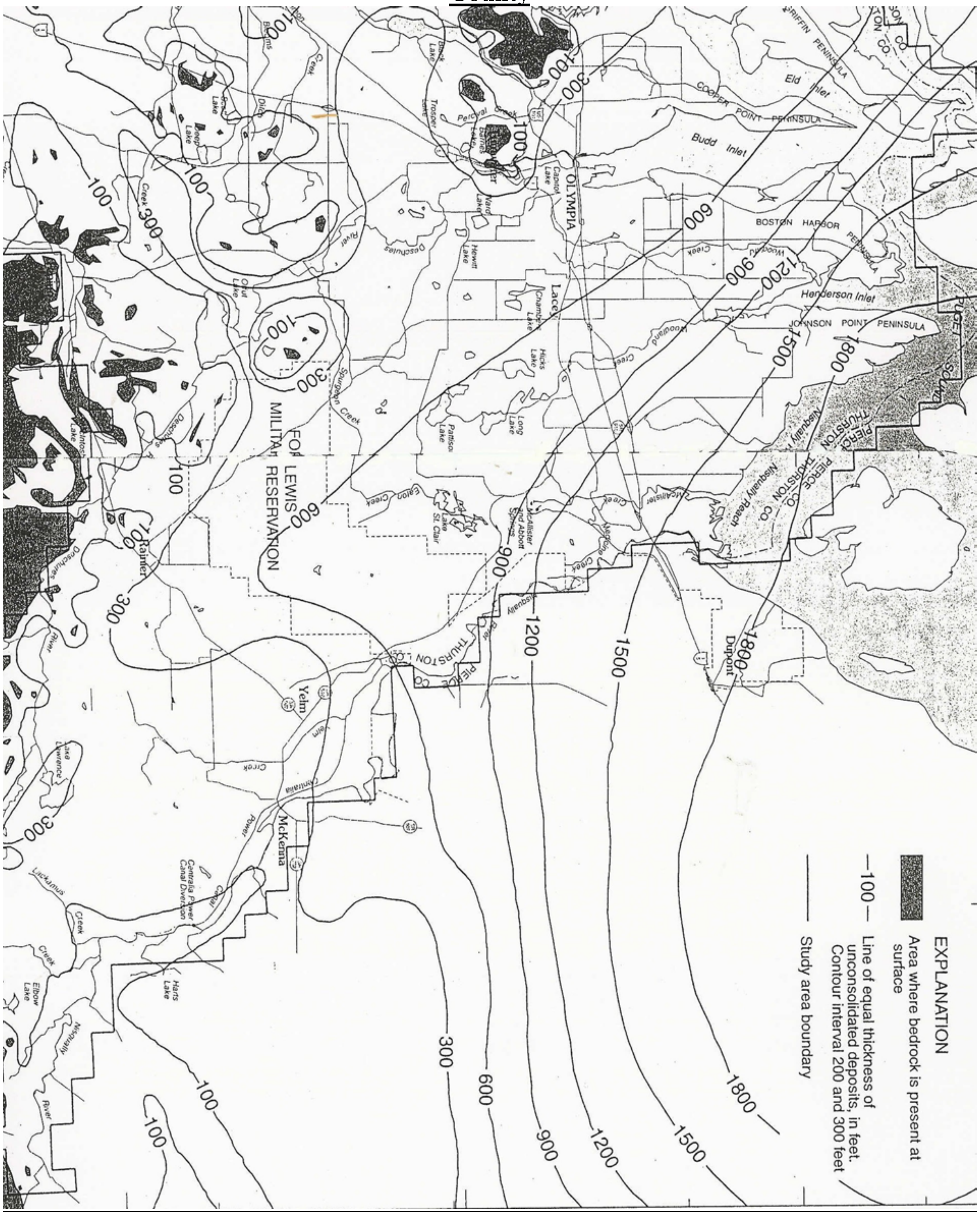


Figure 4 - Maximum Extend and Drainage Routes of The Vashon Glacier

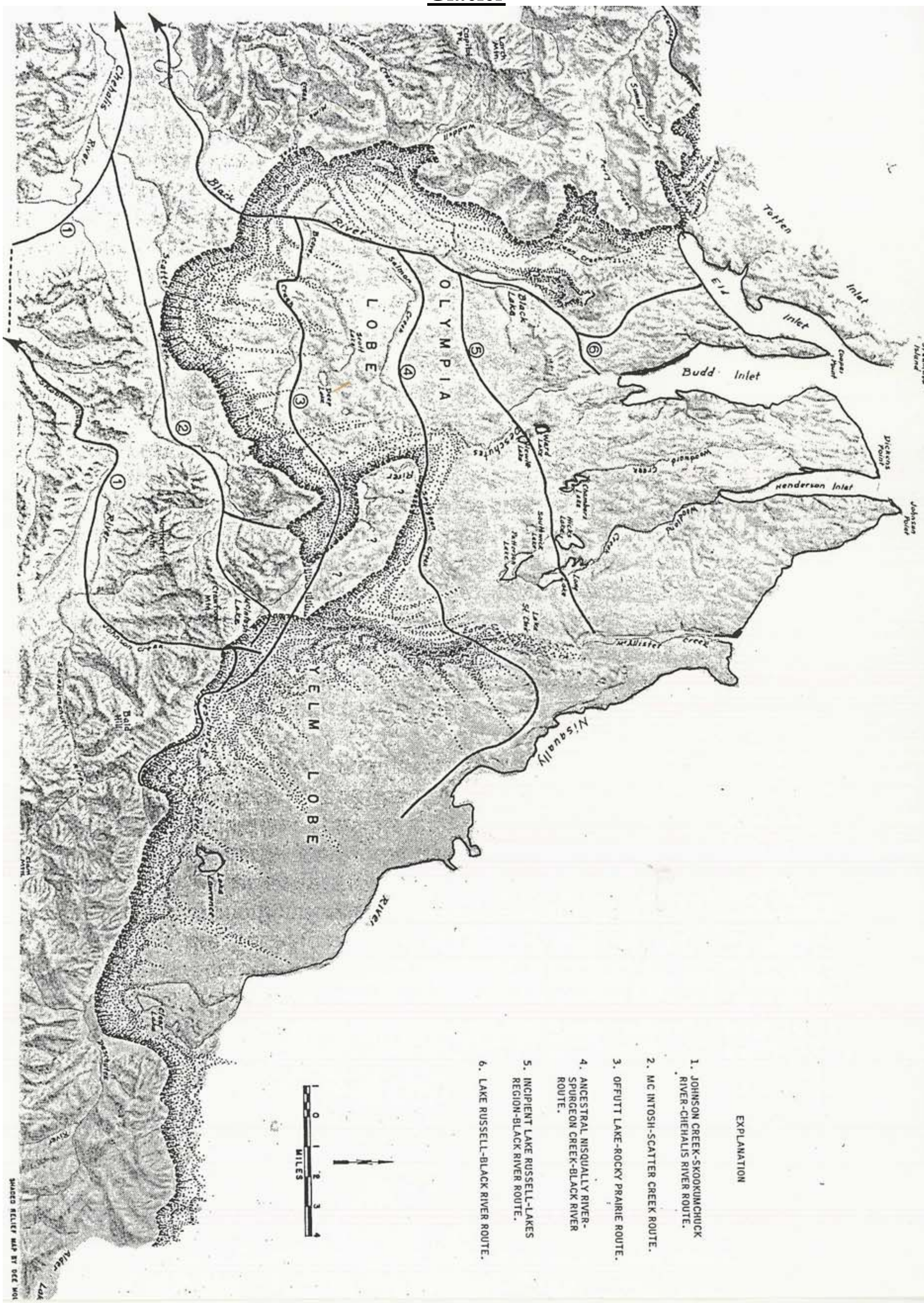


Figure 5 - Qva Aquifer Contours

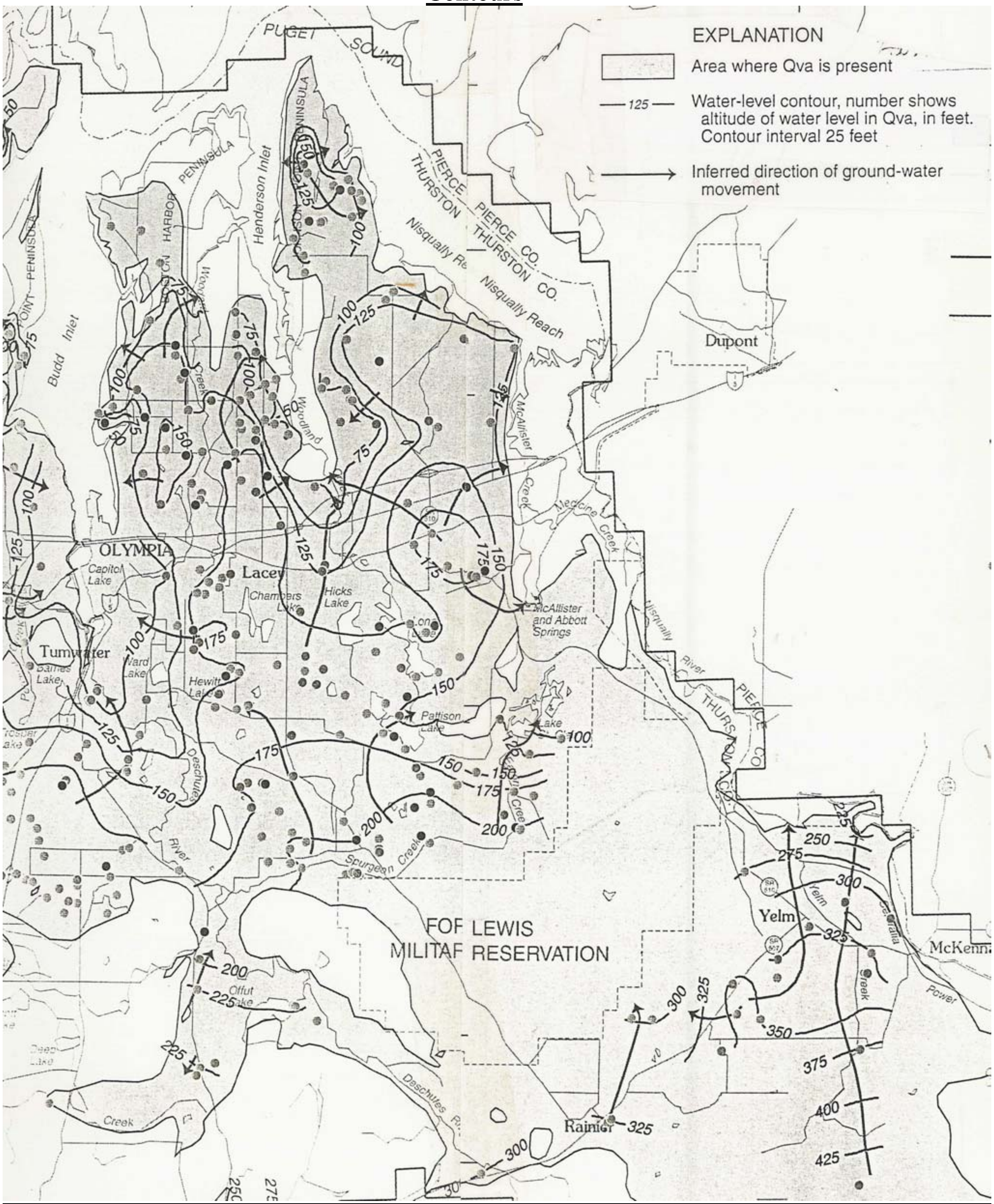
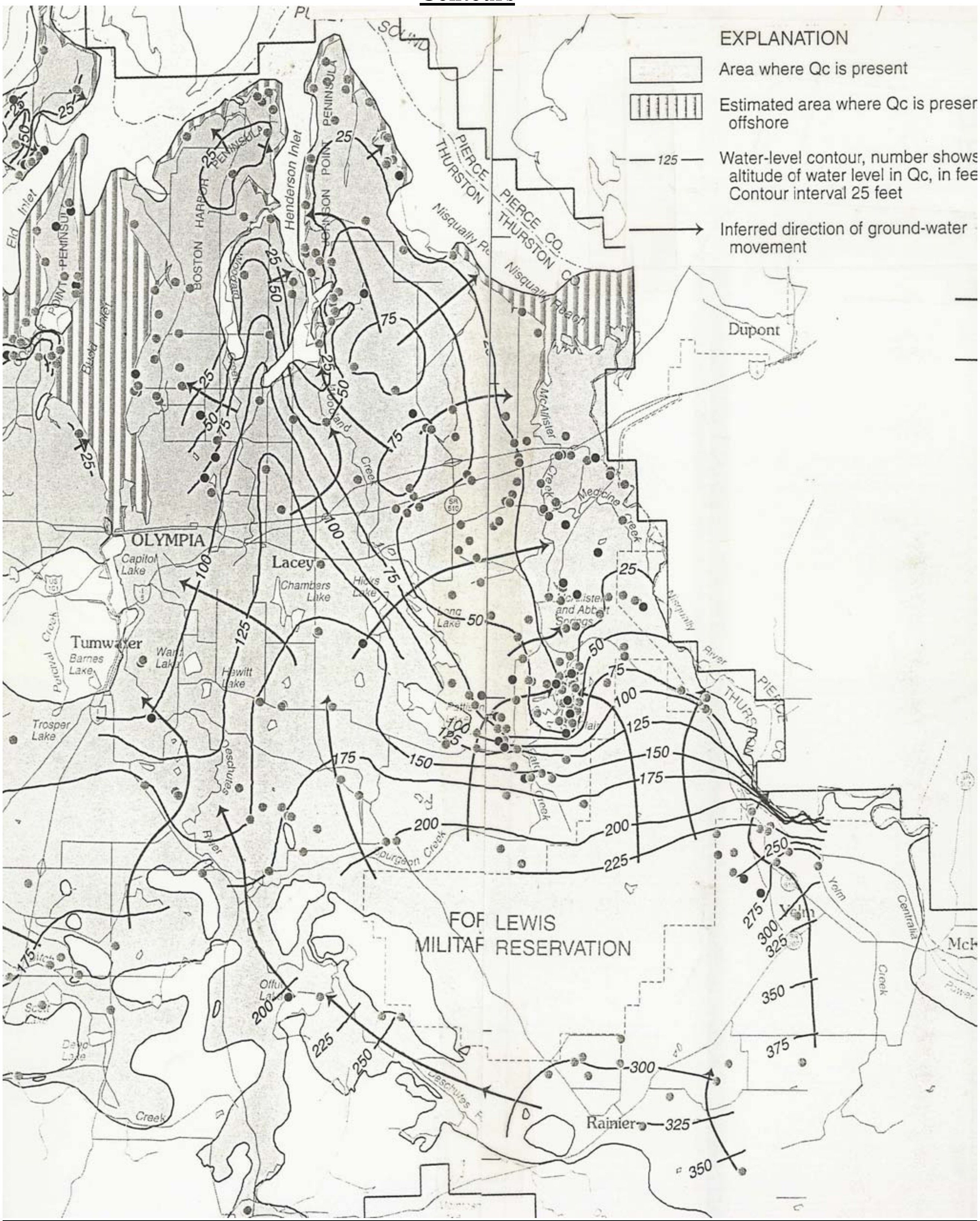


Figure 6 - Qc Aquifer Contours



Regional Groundwater Budget

One perspective on overall groundwater resources is provided by the estimated groundwater budget. For the North Thurston County Ground Water Management Area (basically all of north county including McAllister Springs) basic components of a groundwater budget were estimated by the USGS in a 1998 report. The estimated recharge from precipitation was 310,000 acre-feet; estimated withdrawal from wells (in 1988) was 21,000 acre-feet or about 7% of recharge from precipitation. The result of the USGS study indicated that most ground-water flow through the study area discharges to surface water bodies and as underflow to marine waters. [13]

A more thorough groundwater budget was subsequently developed by the USGS in a follow-up report covering for the entire glacial outwash portion of Thurston County - which includes most of the county outside the Black Hills, Bald Hills and Maytown Upland. As shown below, this water budget included assessment of secondary recharge through irrigation and septic systems. Note that water supplied to municipal water systems by diversion from springs (estimated at 24,000 acre feet or about 27% of total water use) is included in the spring discharge element. [14]

USGS Model-Derived Groundwater Budget:
Unconsolidated Sediments Area of Thurston County

Recharge: Acre-Feet per Year		
560,000	85%	Recharge from precipitation
38,000	6%	Recharge from streams and lakes
63,000	10%	Secondary recharge
5,800	1%	Groundwater inflow to study area along Chehalis
	100%	
Discharge: Acre-Feet per Year		
310,000	48%	Discharge to streams and lakes
190,000	29%	Discharge to springs and seepage faces
88,000	14%	Discharge as submarine seepage
62,000	10%	Pumping from wells
12,000	2%	Discharge to groundwater along the Chehalis River
	100%	

[13] Hydrology and Quality of Ground Water in Northern Thurston County, Washington, USGS Water-Resources Investigations Report 92-4109 (Revised), 1998
[14] Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington, USGS, 1999. See budget at page 89 and use estimate summary at page 50.

Groundwater Level Trends

The North Thurston County Ambient Monitoring Network includes well water level monitoring on a quarterly basis. For 24 wells monitored for the past four years, most had average static water levels 2 – 6 feet higher than the 1995-96 baseline. Only four of the monitored wells had water levels lower than the 1995-96 baseline during the past three years.[15]

Several years of monthly record is available for one of the monitored wells located in the Vashon Advance aquifer. As illustrated on Figures 6-A and 6-B this well recorded a marked decrease in the yearly low level between 1992 and 1995. This three-year low water level period was preceded by a three-year period of below-average rainfall, with about one year of delay between low rainfall and the start of lower well water levels. This one-year delay is also apparent for above-average rainfall in the 1994-1998 period.[16]

Water level monitoring continues through the Ambient Monitoring Network program. A recommended enhancement is addition of continuous recording devices to a few wells each year, to provide a more dynamic picture of groundwater level fluctuations and improve data accuracy.[17] As the Thurston County Groundwater Monitoring Report for 1998-1999 Water Year indicated,

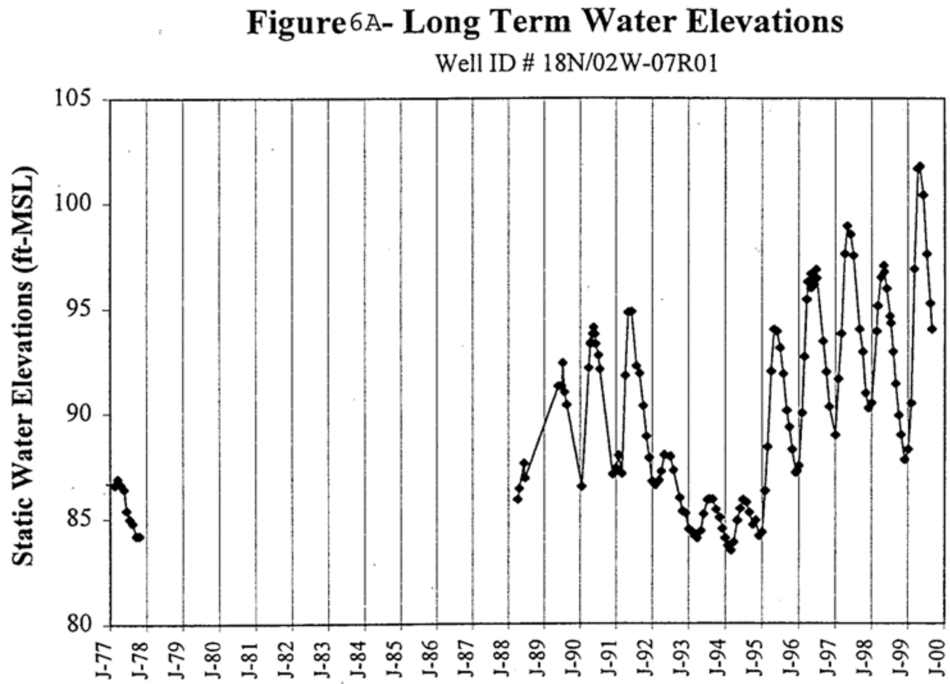
> "It is important to monitor water levels over time in order to assess the rate of water withdraws compared to recharge (rainfall). A steady decrease of water levels over a few years would suggest that water withdraws are occurring at a greater rate than recharge. This could be the result of increasing development pressure, or long-term changes in rainfall patterns. Such information will be crucial in assessing the aquifers' ability to provide an adequate supply of high quality water for a growing population while maintaining necessary base flows to surface water bodies."[18]

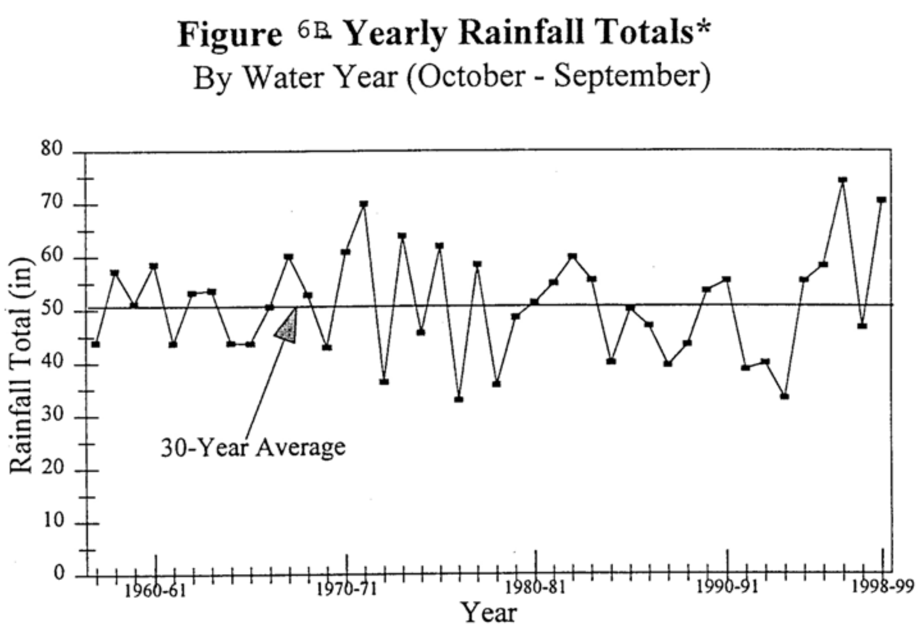
The central importance of understanding the region's aquifers in meeting future water needs was underscored by the USGS report Hydrology and Quality of Ground Water In Northern Thurston County, Washington in the discussion of the water budget of the North Thurston County Groundwater Management Area:

> "Not all water that discharges naturally is available for further ground-water development. As pointed out by Bredehoeft and others (1982), and new discharge (withdrawals) superimposed on a previously stable system must be balanced by an increase in recharge, a decrease in the original discharge, a loss of storage within the aquifer, or by a combination of these factors. Considering the ground water of northern

[15] Ground Water Monitoring Report 1998-1999 Water Year, Thurston County Environmental Health, included in Thurston County Water Resources Monitoring Report 1998-1999 Water Year. See Figure 4 in the groundwater section.
[16] Same cite. See page 301.
[17] Discussion with Sammy Berg, Thurston County Environmental Health, March 2001.
[18] Ground Water Monitoring Report 1998-1999 Water Year, Thurston County Environmental Health, included in Thurston County Water Resources Monitoring Report 1998-1999 Water Year.

Figure 6 a – Groundwater Levels





*Rainfall data provided by NOAA at the Olympia Airport

Thurston County in particular, the possibility of increased natural recharge on a long-term basis appears remote. In fact, the trend of increased residential development and central storm sewers may result in decreased recharge. Additional withdrawals, therefore, would result in a loss of storage (with an attendant decline in water levels) and a decrease in natural discharge. As discussed previously, not all natural discharge in the study area is to the sea; a large but undetermined quantity of ground water discharges to streams and springs. In those places, it is used both directly and indirectly for streamflow maintenance, fish propagation, waste dilution, recreation, and public supply. The magnitude of potential ground-water development, therefore, depends on the hydrologic effects on discharge that can be tolerated. Because it may take many years for a new equilibrium to become established, the full effects of additional ground-water development will most likely not be immediately apparent."

2.2.4 Surface Water Hydrology

There are about 35 total stream miles in the Henderson Inlet basin. The two major stream systems – Woodland Creek and Woodard Creek – total about 27 stream miles, with the remainder in several short direct tributaries to Henderson Inlet. See Figure 7.

Woodland Creek

Three distinct reaches of the Woodland Creek system are briefly described below: the Lakes area, Lake Lois reach and the lower creek. Total length of the stream is about 12 miles plus about 51/2 miles of tributary streams.

Lakes area

Woodland Creek originates in the Hicks-Pattison-Long chain of lakes. The lakes are joined by old drainage ditches dug in the late 1890's – early 1900's through wetland areas. These ditches have not been significantly maintained since the 1940's.[19] The horseshoe-shaped route through the lakes chain takes about 6 miles – one-half the total 12-mile length of Woodland Creek.

Hicks Lake is 160 acres in size, with an average depth of 18 feet. Water source is largely supplied by groundwater input (about 65%), with surface runoff from the surrounding area supplying nearly 20% of the estimated water budget shown below.[20] Much of this runoff is concentrated at the storm sewer outfall on Ruddle Road [21] The lake typically experiences about 4 feet of fluctuation in water level over the year. In the period since record keeping began in 1988, the difference between highest and lowest lake elevation is over 8 feet. [22]

Pattison Lake is 270 acres with average depth of 13 feet. The lake is largely fed by groundwater (73%). This groundwater input to Pattison Lake in turn is the main source for Long Lake and thus the upper reach of Woodland Creek. The ditch from Hicks Lake supplies about 12% of the annual water budget. Pattison typically varies by only about 1 – 1 ½ feet per year.

Long Lake is 330 acres in size, with an average depth of 12 feet. Water is supplied mainly by the ditch from Pattison Lake (66%) and varies about 2 feet most years. Lake elevation fluctuates with season and longer-term precipitation trends.

Figures 8, 9 and 10 identify lake elevation trends on Hicks, Pattison and Long Lakes. The water budgets prepared in the 1977 Lake Restoration study are delineated in Table 2.

---

[19] Thurston County Lakes Restoration – Environmental Description, Entranco Engineers, 1977.
[20] Same cite. The study included preparation of a water budget for the lakes.
[21] Thurston County Lakes Water Quality and Restoration Analysis, Entranco Engineers, 1978. .
[22] Thurston County Water Resources Monitoring Report 1998-1999 Water Year, Thurston County Storm & Surface Water Program and Environmental Health. Lake stage data for the lakes is collected by volunteers and included in the annual Thurston County monitoring report.

Figure 7 - Waterbodies in Henderson Inlet Watershed

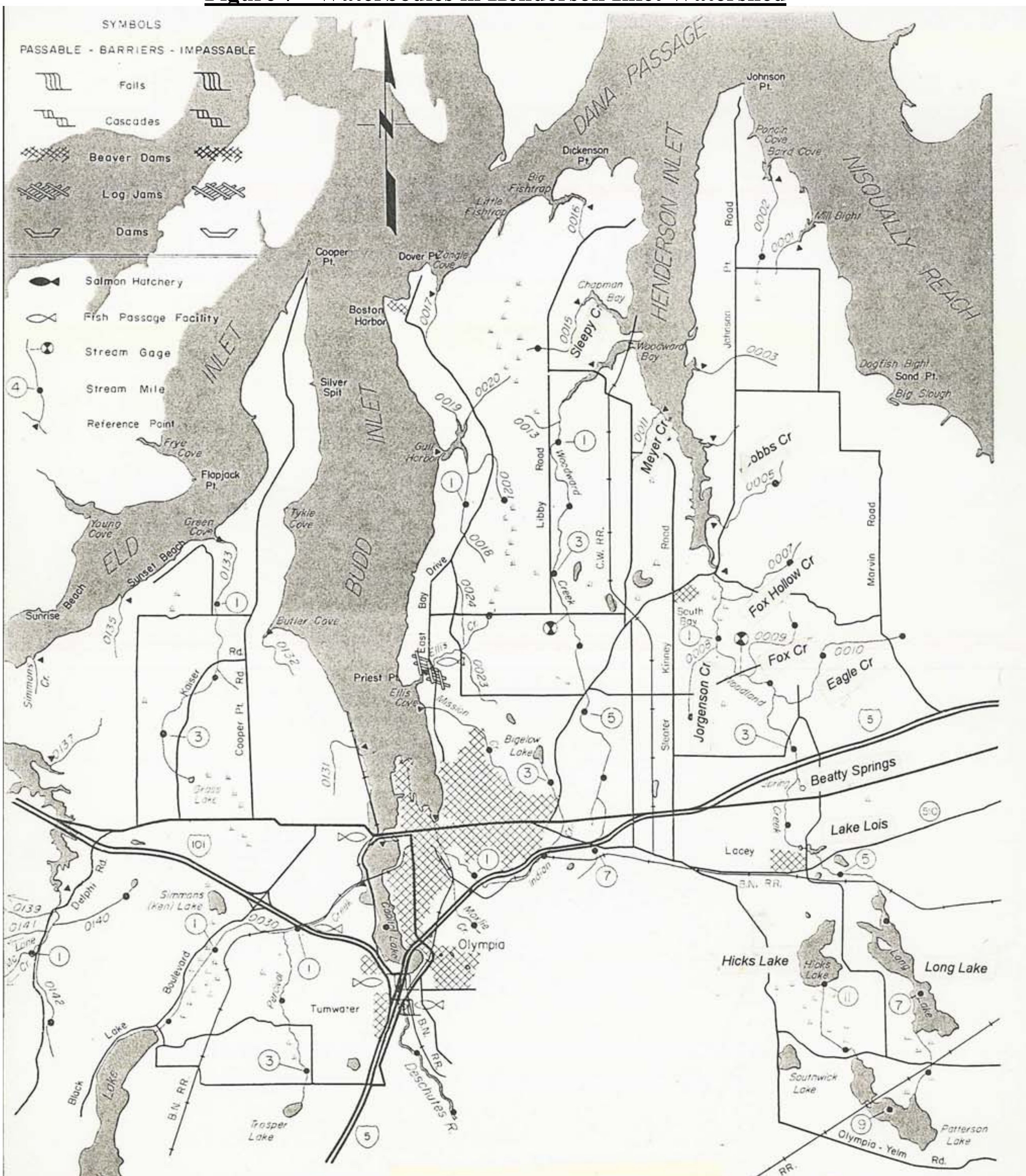


Figure 7 Streams in the Henderson Inlet Watershed
Source: "Catalog of WA Streams and Salmon Utilization, Puget ound Region", 1975,
Department of Fish and Wildlife

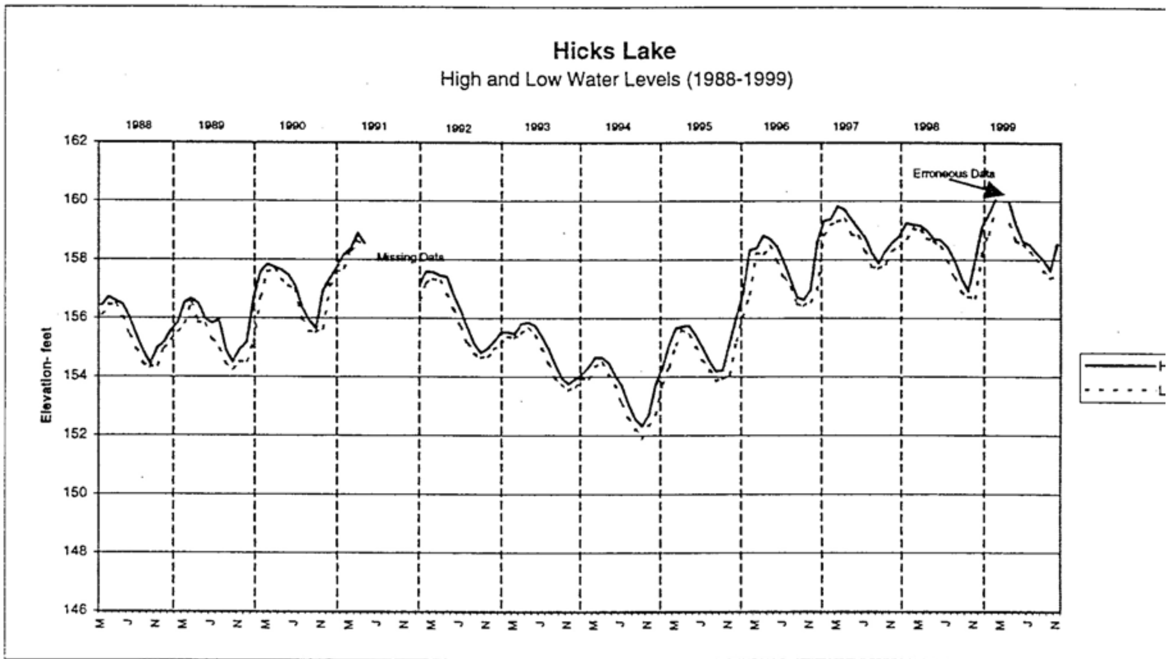
Table 2 Lakes Water Budgets

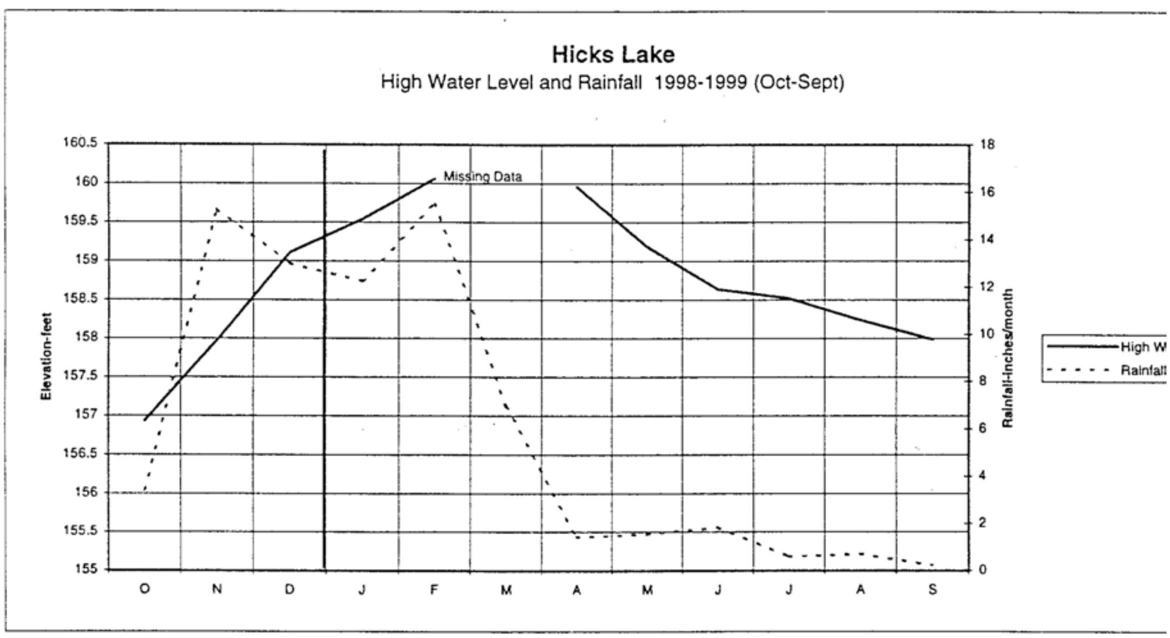
Source: Thurston County Lakes Restoration Environmental Description, Entranco, 1977

	HICKS LAKE		PATTISON LAKE		LONG LAKE	
	Volume (M3/YRX103)	Percent	Volume (M3/YRX103)	Percent	Volume (M3/YRX103)	Percent
WATER INPUTS						
Precipitation	475	16%	795	11%	982	12%
Ground Water	1,947	67%	5,448	73%	1,486	18%
Surface Water	0	0%	897	12%	5,499	66%
Surface Runoff	478	17%	286	4%	294	4%
TOTAL	2,901	100%	7,426	100%	8,261	100%
WATER OUTPUTS						
Evaporation	427	15%	841	11%	1,144	14%
Ground Water	2,473	85%	1,033	14%	3,288	40%
Surface Water	0	0%	5,510	75%	3,829	46%
TOTAL	2,901	100%	7,384	100%	8,261	100%
	Estimated Hydraulic Resident Time for a typical year = 1.13 volume/year		Estimated Hydraulic Resident Time for a typical year = 2.63 volume/year		Estimated Hydraulic Resident Time for a typical year = 2.5 volume/year	

Figure 8 - Hicks Lake

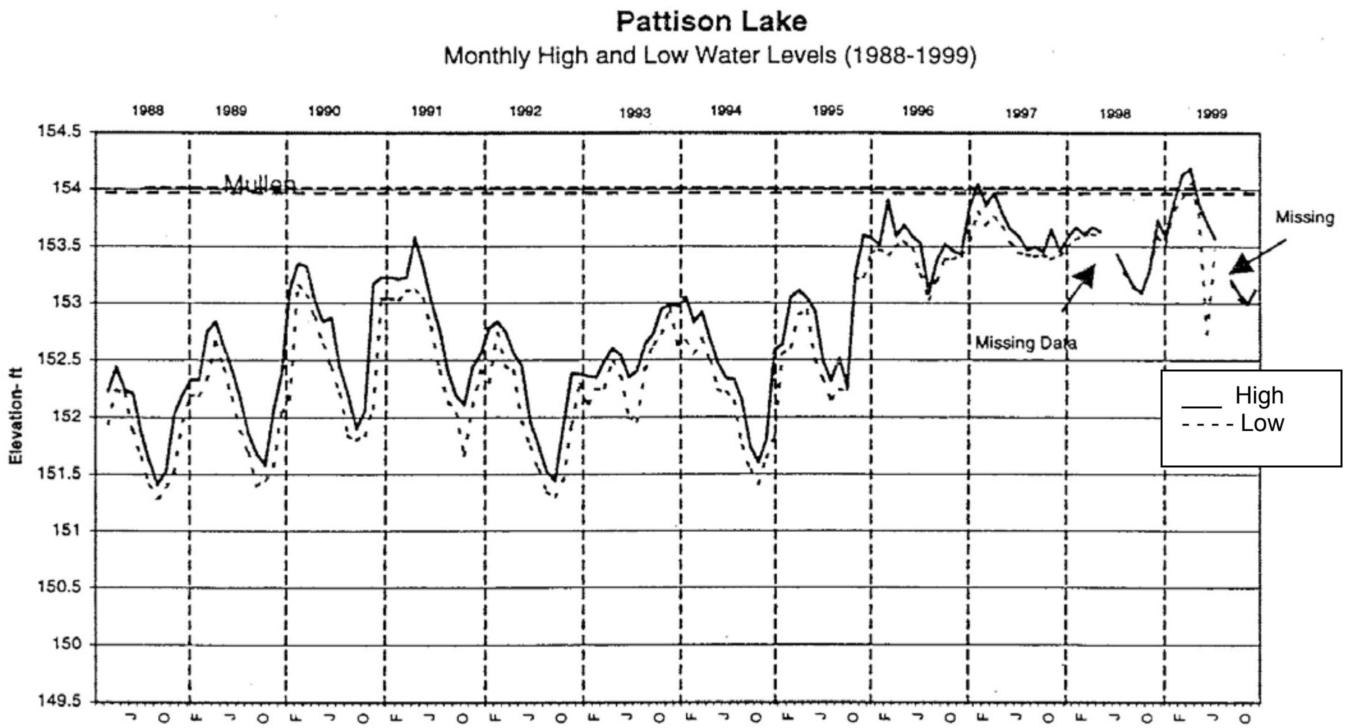
Figure 8 Hicks Lake High and Low Water Levels





Lake level data is collected by a volunteer.
Raingage is located at the Olympia Airport (NOAA)

Figure 9 - Pattison Lake Elevation



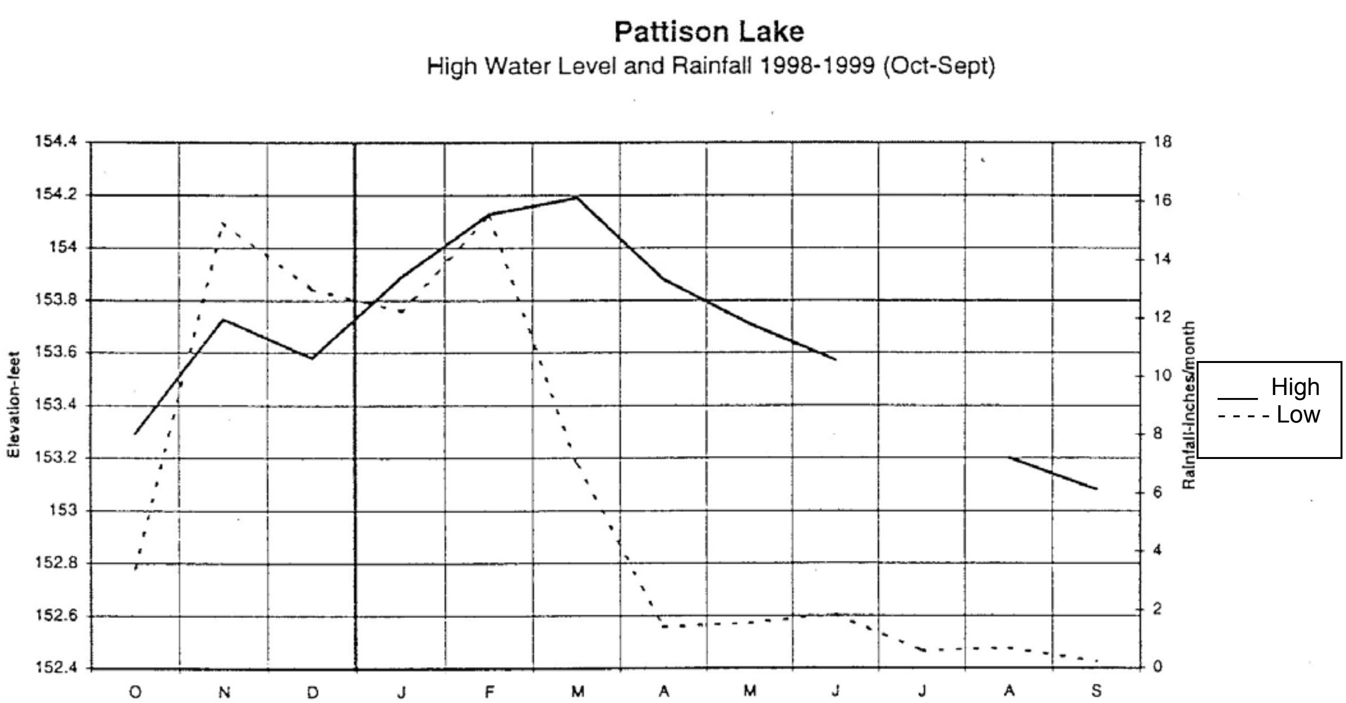
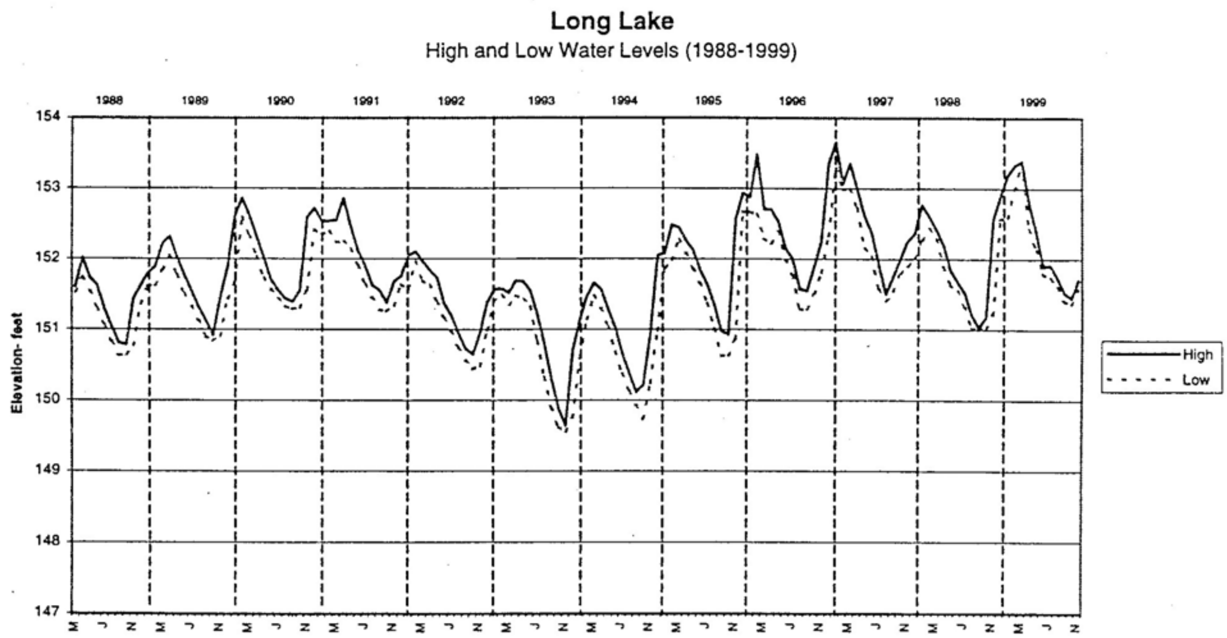
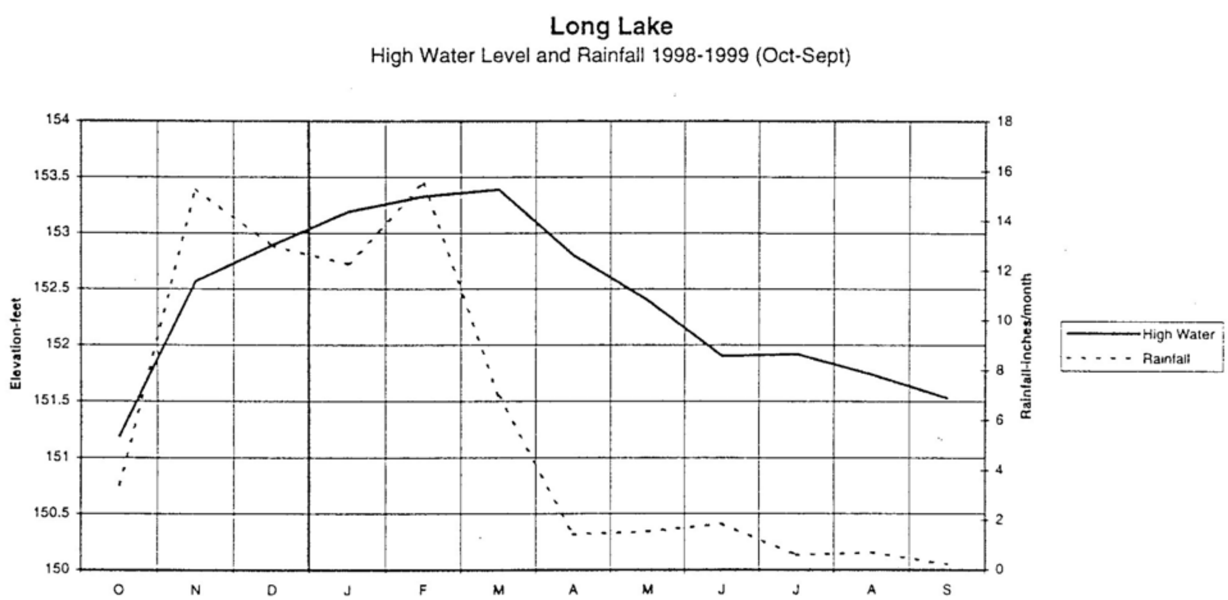


Figure 10 - Long Lake Elevation





Lake Lois Reach: Long Lake to Martin Way

Woodland Creek proper begins at the outlet from Long Lake. The one-mile section from Long Lake to Lake Lois (river mile 5.5 to 4.5) is largely a long-established ditch section with perennial flow. Between Lake Lois and just above Martin Way (stream miles 4.5 to 3.8) the stream channel often goes dry during the summer, becoming subsurface flow contributing to springs below Martine Way.

Streamflow continuous recording was collected by Thurston County at Martin Way for the water years from 1989 to 1993.[23] DOE collected monthly data at three stations between Lake Lois and Martin Way from January 1991 to September 1993.[24]

Mean flow

Stream flows in the Lake Lois reach vary widely according to season and overall precipitation. During 1993, there were 49 inches of precipitation. Average daily flow at Martin Way was 1.1 cfs, with the stream essentially dry for 278 days. In contrast, the 66 inches of rainfall in 1991 supported average flow of nearly 13 cfs, with the stream below 1 cfs for only 45 days.

There is anecdotal reference to earlier years when this reach of the stream is reported to have flowed year-around. However, there is no known stream gaging data to document or analyze this reported change in summer-flow conditions.

Peak flow

Peak flows in the Woodland Creek system above Martin Way are significantly attenuated due to storage in lakes and wetlands and infiltration into the porous soils. Hydrologic modeling was utilized for the Woodland/Woodard Creek Basin Plan to help analyze the effect of past human activities on existing streamflow. As shown on Figure 11, modeling indicates land use changes have had relatively little effect on peak flows at Long Lake or Martin Way.

As stated in the 1995 Woodland and Woodard Creek Comprehensive Drainage Basin Plan,

> Woodland Creek flows out of a large wetland and lakes complex that includes Hicks, Pattison and Long Lakes. The soils, lakes, wetlands and flat topography of this area absorb large quantities of rainfall and help to mitigate the impacts of development on the headwaters of the creek. Downstream from Long Lake, the creek enters Lake Lois, which stores and detains most of the stream flow. Figures 3-1- and 3-2 *(attached)* illustrate the effects of development on Woodland Creek stream flows. The peak flows at the first two locations, Long Lake and Martin Way, exhibit relatively small increase over natural flows compared to downstream locations, because of the buffering effects of the wetlands.

---

[23] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, Thurston County et al, 1995.
[24] Woodland Creek Water Quality Assessment Final Report: Ecology Building Project, DOE Report # 94 – 62, April 1994.

In 1991, a regional stormwater facility was installed just downstream from Lake Lois to treat and store stormwater from an extensive area around Lacey Boulevard. This facility further attenuated the immediate effect of storm events on this reach of the stream.[25]

There is a location of active bank erosion between Lake Lois and Martin Way near the DOE building. Banks at this site are 10-15 feet of vertical eroding sand, but the stream corridor in the vicinity is otherwise well vegetated and generally undisturbed. This bank erosion appears to have been going on for many years. [26] The impact of this particular bank erosion on salmonids is undetermined at this time, as the erosion is occurring in a reach that is dry most ears during summer low flow. Eroded sediments have the potential to affect the substrate downstream from the erosion site. [27]

Lower Woodland Creek

The lower reaches of Woodland Creek are very distinct from the upper section. Major springs just below Martin Way provide year-around flow to the creek. North of I-5 till soils are common. Till soils do not infiltrate rainfall as readily as the outwash soils in the upper watershed. Thus, several tributary streams provide seasonal or year-around flow to lower Woodland Creek, including Eagle Creek, Fox Creek and Fox Hollow Creek on the east and Jorgenson Creek on the west.

<u>Mean flow</u>

From the perspective of total annual streamflow, the major springs below Martin Way are the dominant source of water for the stream. Streamflow response to low-flow conditions is much less dramatic downstream from Martin Way due to extensive, groundwater-fed wetlands and a large, spring-fed tributary (Beatty Springs) providing year-around base flow. [28] Flow for Beatty Springs alone was estimated by the USGS at over 6 cfs (about ¼ of McAllister Springs flow). Beatty Spring is supplied by the Qvr aquifer.[29]

The 1999 DOE Baseflow Report analyzed Pleasant Glade station data from 1949-1969 and 1988-1990, which is all available record for this station (see Figure 12). Baseflow – essentially, contribution from groundwater - is estimated to provide 96% of total mean annual streamflow to Woodland Creek at Pleasant Glade. (In contrast, for the 294 stream stations statewide evaluated in the DOE Baseflow report, median annual baseflow averaged 68% of total flow.) [30]

---

[25] Woodland/Woodard Basin Plan 1995 cited above. See page 3-16.
[26] Communication with Lisa Dennis-Perez, City of Lacey, 2/6/01.
[27] <u>Salmon Habitat Limiting Factors Final Report, Water Resource Inventory Area 13</u>, July 1999, Washington State Conservation Commission
[28] Woodland/Woodard Basin Plan 1995 cited above. See page 3-16.
[29] <u>Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington</u>, USGS, 1999. Table 4 lists major springs and the associated geohydrologic units.
[30] <u>Estimated Baseflow Characteristics of Selected Washington Rivers and Streams, Water Supply Bulletin No. 60</u>, Washington Department of Ecology, 1999

The median 7-day low flow (median daily flow during the lowest continuous 7-day period) for the years 1949-69 was 11 cfs – i.e. about 50% of the median flow during this period. This is a relatively steady baseflow: in contrast, median Deschutes River 7-day low flow is about 20% of the median flow. [31] .

Peak flow

Peak flows can have a significant affect on habitat and water quality conditions. Increased peak flow can increase fine sediment loads and alter natural flow regimes that are vital to maintenance of stream habitat. Lower Woodland Creek is subject to high peak flows due to rainfall events, followed by rapid return to baseflow when rain slackens. Downstream from Martin Way, the creek responds more quickly to individual rain events due to less porous soils, absence of detention area in wetlands or lakes, and runoff associated with the large stormwater systems draining the College Street/7th Avenue area and I-5.[32]

Annual peak flow from the 1950s-60s and the early 1990s is shown on Figure 13. As shown, peak flow was generally 50-150 cfs, with highest flow in 1951 (200 cfs).

The peak discharge at measured at Pleasant Glade during the basin plan intensive data collection was 160 cfs on November 24, 1990 – almost 12 times the average flow for November. In contrast, peak flow was significantly attenuated in the Lake Lois reach. Flow at Martin Way during the same rain event peaked at about 16 cfs, only 10% of the peak flow at Pleasant Glade and only about 2 ½ times the average November flow at the site.[33]

Lower Woodland Creek is cited on the 1998 303(d) List as low-impaired based on evidence of 1.) "Intensified peak flows likely due to the storm water effect of suburban development" and 2.) Coho salmon decline. The basis for the listing was a Squaxin Island Tribe letter, which included analysis of streamflow from two periods – 1950-53 and 1988-94. These two periods were analyzed for the 2-day streamflow increase on current plus previous day precipitation sums. See SIT submittal at Attachment 1. [34]

The City of Lacey is in design phase for a stormwater treatment facility on the College/7th Avenue stormwater system. This is the last untreated stormwater outfall discharging to Woodland Creek. [35]

Current and future stream response to rainfall events

Hydrologic modeling of stream response to rainfall events was conducted for pre-development, current conditions and future build out. The modeling explored stream response to both infrequent (100-year storms) and more common storm events (2-year storm), as illustrated on

[31] [31] Estimated Baseflow Characteristics of Selected Washington Rivers and Streams, Water Supply Bulletin No. 60, Washington Department of Ecology, 1999
[32] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, Thurston County etal, 1995. See page 3-16.
[33] See above, page 3-16 – 1-17.
[34] Letter from Jeff Dickison for Squaxin Island Tribe on 2/27/96, submitted to Department of Ecology in support of 303(d) listings. Referenced in Final 1998 Section 303(d) List – WRIA 13, dated 4/4/00.
[35] Communication with Lisa Dennis-Perez, City of Lacey, 2/6/01

Figure 11. The smaller but more frequent storm events have been documented to have a greater influence on channel morphology and stream habitat than the large infrequent events such as the 100-year storm. [36]

Additional impacts are anticipated at full development even with the current (1995) drainage design standards for new development. As shown on Figure 11, significant impacts are modeled to occur on the lower creek. However, the model indicates little change over current flow conditions at Martin Way due to the significant upstream storage in lakes and wetlands and extensive infiltration of rainfall in the upper watershed, as discussed above.[37]

[36] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, Thurston County etal, 1995.
[37] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, Thurston County etal, 1995.

Table 3 Woodland Creek – Streamflow Data and Analysis Available

ITEM	DATES	SOURCE	TYPE	LOCATION	NOTES
RECORD					(Revised 2/8/01)
Streamflow daily records at Pleasant Glade	1949-69	USGS Sta.12081000	Excel spreadsheet	Tc/excel/woodland flow data/sta12081000.xls	Unit values available?
Streamflow record at 15 min interval at Pl Glade and Martin Way	1988 to 1996(PG) 1988 to 1993(MW)	TC Stormwater	Excel spreadsheet	Stormwater (new files from Nadine Romero)	Formatted to facilitate access/modeling
Streamflow misc days (instantaneous measurement) at Pleasant Glade	1983-84 @ 2 times/mo.1986-97 @ 4 winter plus 2 summer	TC Env Health	Excel spreadsheet	Tc/woodland eh flow.xls	From Sue Davis, EH. Includes water quality parameters.
Peak annual flow at PG (instantaneous value)	1950-69 and 1988-1996	USGS web site records and TC SWM	Excel spreadsheet	Tc/woodland peak annual1.xls	
Seepage Study	8/11/88	USGS "Conceptual Model of GW Flow System in Thurston Co", Table B2	Paper table in USGS report	GS report	
Streamflow monthly at RM 4.2, 3.8 +3.7	1/91 – 9/93	DOE Report # 94 – 62	Paper	DOE	Electronic availability not known
ANALYSIS					
HSPF Model Results: 2 yr & 100-yr event	Calibrated to 10/98-9/90 data.	"Woodland and Woodard Creek Comprehensive Drainage Basin Plan", 1995	Paper report & calibrated model	Report Figures 4-1 and 4-2; also Appendix C.	Potential re-run "back cast" calibrating on 1949+ USGS records?
USGS: 1-Day & 7-Day High and Low value; recurrence intervals; statistics (Pearson)	1949-69 and 1989	USGS special run (D.Kresh 12/7/00)	Paper	Paper copy	

Monthly and Annual Mean, Low and High: Duration and Exceedance % Stats	1949-69	USGS “Streamflow Statistics and Drainage Basin Characteristics for Puget Sound”, Report 84-144-A	Paper Excel spreadsheet	Paper: 3 tables of detailed statistics Excel: Monthly min, 50% & 90% only (Woodland 1949-69 mean monthly.xls)	
Flood discharge exceedance probabilities	1949-69 and 1989	USGS “Magnitude & Frequency of Floods in WA” Report 97-4277	Paper	Copy of Table 2 in file (full report on net)	
Baseflow Report: Annual mean flow, 7-day minimum, baseflow, etc.	1949-69 and 1989	DOE “Est. Baseflow Characteristics”, 1999 (Water Supply Bulletin No. 60): From HYSEP	Excel spreadsheet	Project files: woodland baseflow annualbf.xls	Basic chart created.
Baseflow monthly stats in cfs and inches/runoff	1949-69 and 1989	DOE Baseflow	Excel spreadsheet	Woodland baseflow by month.xls	
Baseflow statistics for period of record	Data from 1949-69 and 1989	DOE Baseflow	Excel spreadsheet	Doe baseflow annstats wria13.xls	
Graphs: 2-day precip correlated to streamflow increase	1950-53 vs. 1988-1994	Squaxin Island Tribe submittal to DOE for 303(d) listing 3/28/96 (Fig. 4)	Paper	Paper	Used as basis for 303(d) listing.
Average Annual Streamflows & Departure from Average	1949-69 and 1989	1995 Initial Assessment	Paper (chart)	1995 Initial Assessment Figure 5-3	Annual rainfall also displayed.
Minimum Daily Streamflow & Departures from Average	1949-69 and 1989	1995 Initial Assessment	Paper (chart)	1995 Initial Assessment Figure 5-6	
Flow Exceedance Probability Hydrograph	1949-69 and 1989	DOE Water Resources staff	Paper		10%, 50% and 90% indicated.
RELATED: Aerials: 1937, ‘48 & ‘53				TC Roads & Transportation Services	

Figure 11 - Woodland Creek 2-Year and 100-Year Peak Flows

Figure 4-1 Impact of future development on Woodland Creek 2-year peak flows

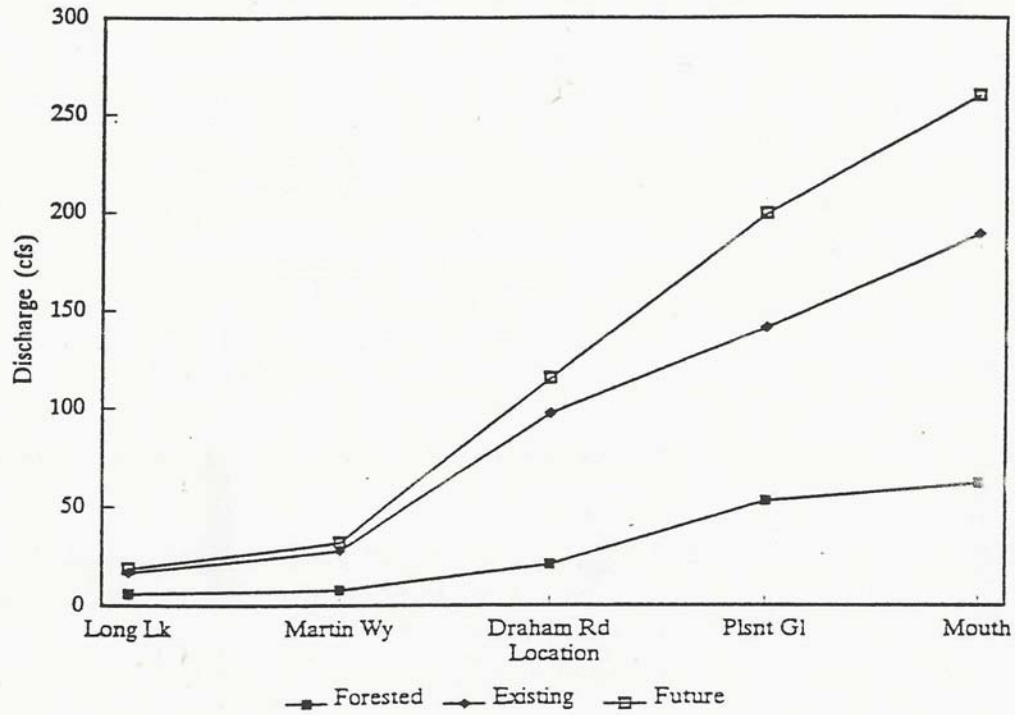


Figure 4-2 Impact of future development on Woodland Creek 100-year peak flows

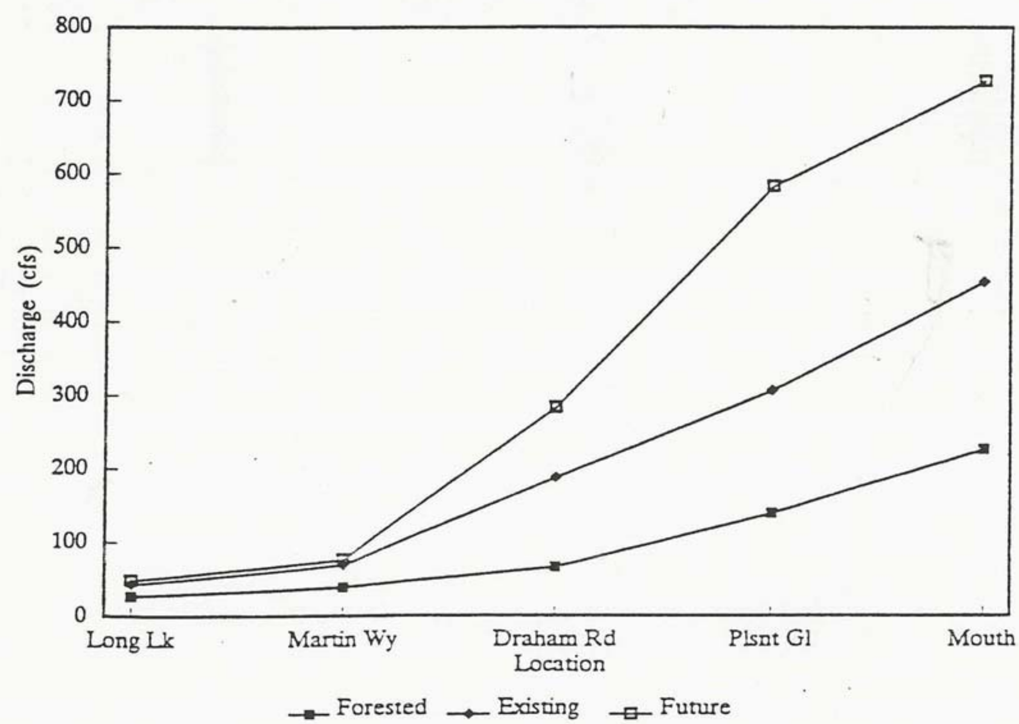


Figure 12 - Woodland Creek Monthly Mean Baseflow and Surface Runoff

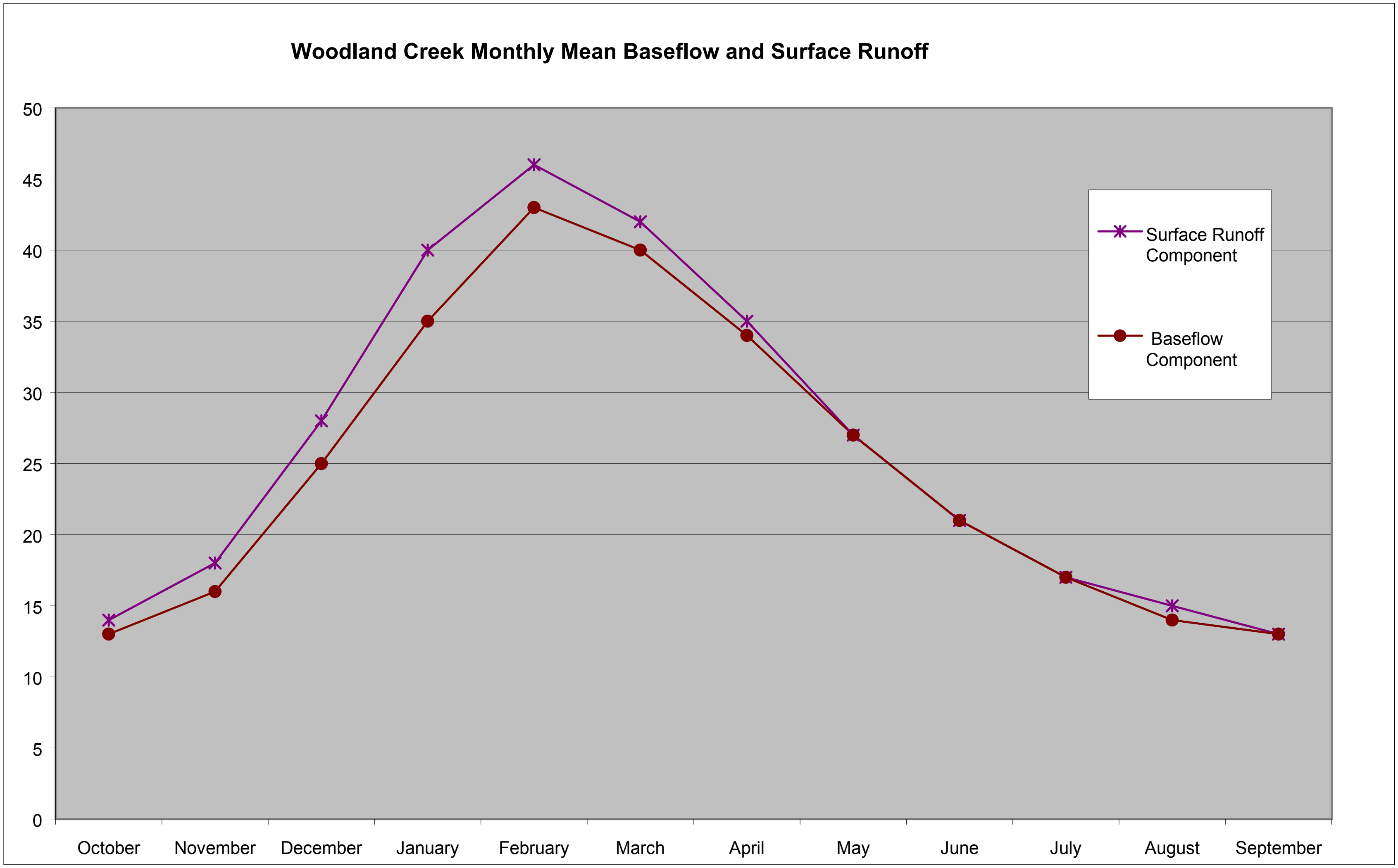


Figure 13 - Woodland Creek Annual Peak Flows

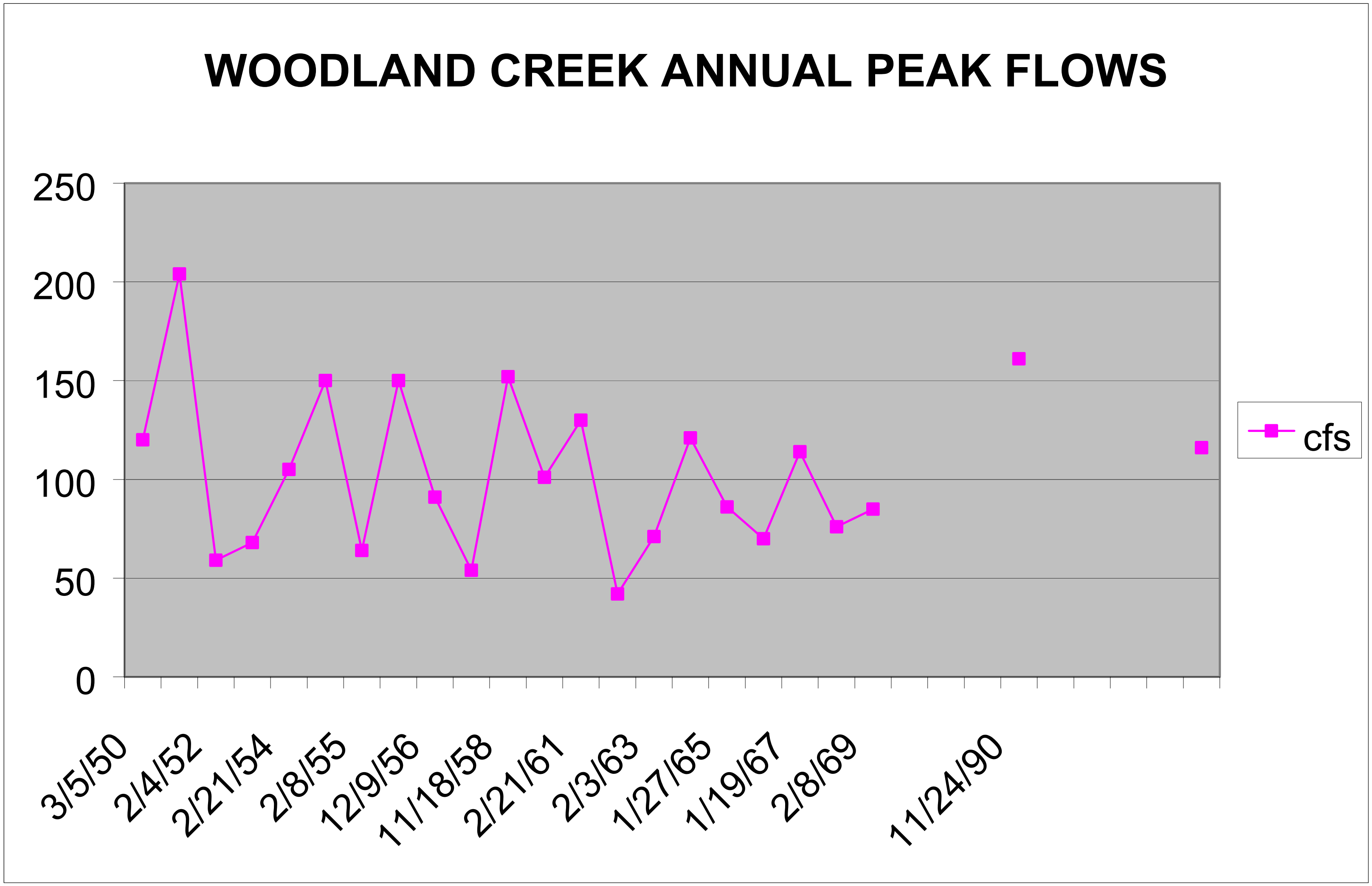
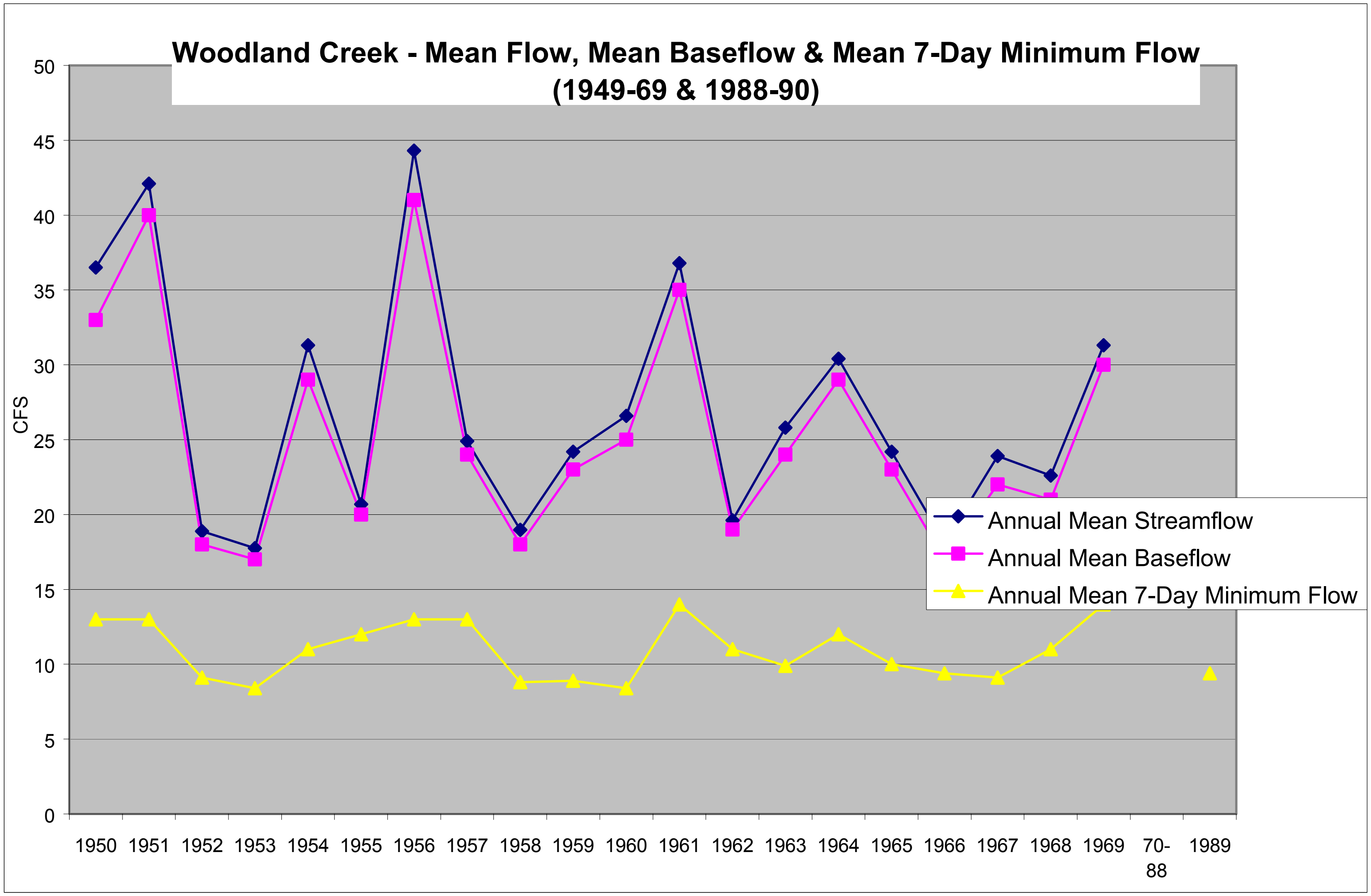


Figure 13A – Mean Flow, Base Flow and 7-Day Minimum Flow



Woodard Creek

Woodard Creek flows north from near the I-5/Pacific interchange for 7 ½ miles to Woodard Bay, about mid-way up the west side of Henderson Inlet. The watershed is very narrow, covering an area 1 – 1 ½ miles wide and about 6 miles long. Five short tributaries provide seasonal flow to Woodard Creek.

The creek originates in an extensive wetland south of I-5 and west of Fones Road. The groundwater-fed springs maintain year-around base flow in Woodard Creek. Average flow for the period of record for Woodard Creek at 36th Avenue NE (1988-1997) was 11.9 cfs. Peak flow during the period of record is 90 cfs recorded on 4/5/91. Minimum flow of 1.5 cfs was recorded several times in 1994 and 1995. [38] During typical years, the stream flow generally stays above 9 cfs. [39]

Extreme peak flows during heavy rains characterize the hydrology of Woodard Creek, but the effect is more pronounced near the headwaters. A major stormwater ditch draining South Sound Center and the Pacific Avenue/Fones Road commercial area (Fones Road Ditch) discharges near the headwaters of the creek. Further downstream, peak flows are somewhat attenuated by extensive wetlands between Fones Road and St. Peters Hospital, and the "impoundments" created by the fills for I-5, Pacific Avenue and Martin Way.[40]

Development and clearing are modeled to have had a significant impact on the more frequent flows, such as the 2-year events, which are more damaging to habitat than the rarer very high (100-year) flows. Current versus pre-development (forested condition) flows are illustrated on Figure 2.3-7. This figure includes modeled future peak flows at full build out. The predicted increases in 2-year storm flow are greater downstream because of tributaries that enter below Ensign Road. The peak 100-year storm flows are greater upstream due to runoff from the commercial area near the headwaters.[41]

---

[38] Thurston County Water Resources Monitoring Report 1996-1997 Water Year, Thurston County Storm & Surface Water Program and Environmental Health.
[39] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, Thurston County etal, 1995. See page 3-18.
[40] Same cite.
[41] Same cite.

Figure 14 - Woodard Creek 2-Year and 100-Year Peak Flows

Figure 4-3 Impact of future development on Woodard Creek 2-year peak flows

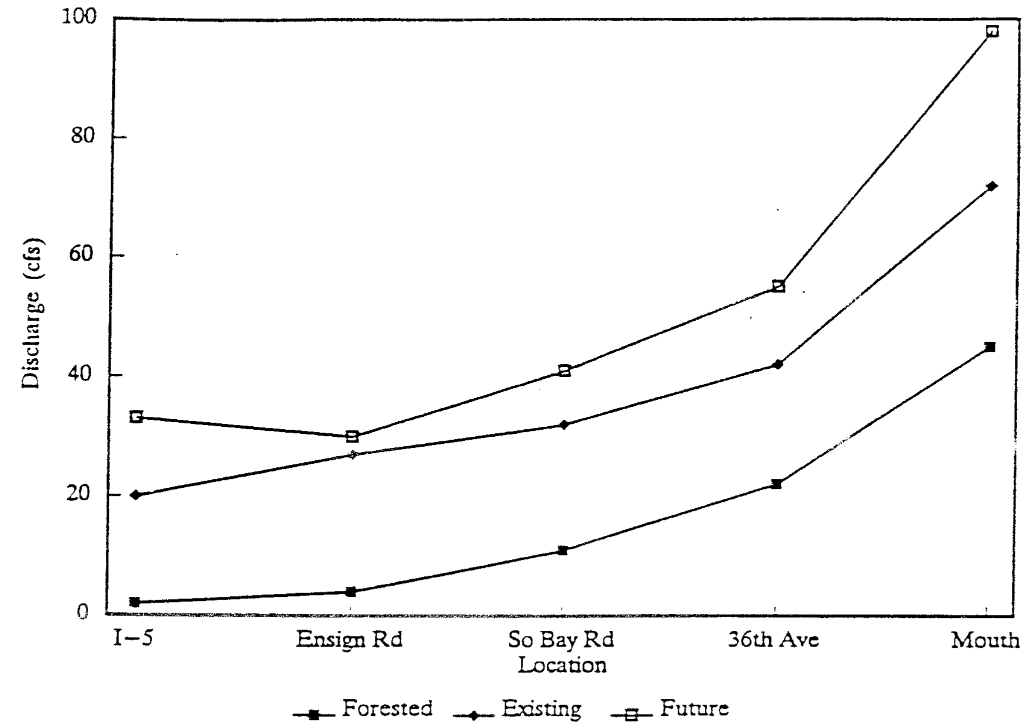
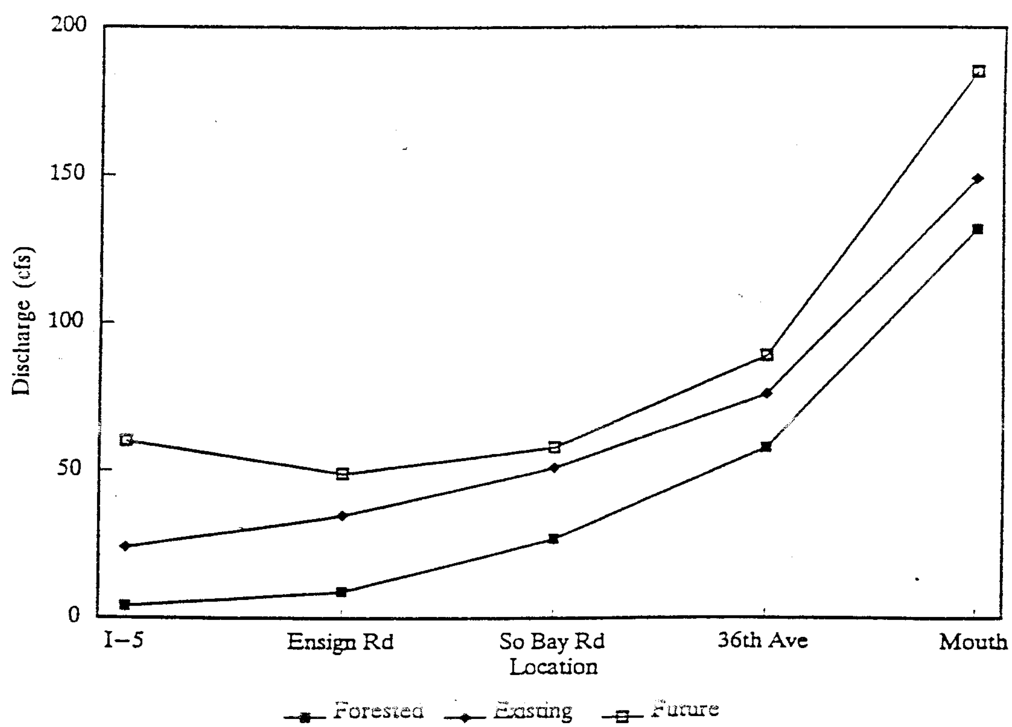


Figure 4-4 Impact of future development on Woodard Creek 100-year peak flows



Smaller Marine Drainages

Several smaller streams discharge directly to Henderson Inlet. These streams drain an area of relatively poorly drained soils formed under glacial lake and till conditions (such as Kapowsin and Skipopa), compared to the deeper rapidly draining outwash soils in the southern portion of the watershed (such as Everett soils).[42] Kapowsin and Skipopa are classed in Hydrologic Soil Group D, while Everett is in Group A. Group D maximum infiltration rates with dense vegetation are calculated at 0.60 inches/hour, which contrasts sharply with Group A infiltration with dense vegetation at 6.00 inches/hour. Thus, even in undeveloped conditions these low-permeability soils can generate significantly more runoff than the outwash soils. With clearing for pasture and other low-density uses, infiltration is further reduced (.30 inches/hour infiltration for Group D under light vegetation conditions). [43]

Due to their potential for conveying residential and agricultural pollutants to the Inlet, Dobbs, Meyer and Sleepy Creeks were intensively monitored for several years by the Thurston County Health Department. Generally, sampling included discharge measurements performed four times during winter and once or twice during the summer months.

Dobbs Creek

This 1.5-mile creek originates near Puget Road on the east side of Henderson Inlet. The creek flows through woodlands and open pastures, with gently rolling terrain.

Flows of 4 to 8 cfs were commonly measured in winter. Peak flows exceed 16 cfs (highest measured flow before the creek became too deep to measure). September flows were around .75 cfs.

Meyer Creek

This is a small (one mile long) seasonal drainage into the west side of Henderson Inlet near the end of Shinke Road. It is impacted mainly by agricultural practices. Measured flows were mainly less than 1 cfs, with flows in excess of 7 cfs occasionally measured.

Sleepy Creek

This is a 1.1-mile seasonal drainage into Chapman Bay (just north of Woodard Bay) on the west side of Henderson Inlet. The stream originates in a wetland and flows through a series of gullies and ravines to Chapman Bay. Winter flows of 6 – 13 cfs were commonly recorded. Flow was commonly absent or very minimal during the summer sampling periods.

---

[42] Soil Survey of Thurston County, Washington, 1990, USDA Soil Conservation Service
[43] Drainage Design and Erosion Control Manual for Thurston County, 1994

2.2.5 Water Rights and Water Use

Background: DOE Water Rights Data

Identification of the water volume represented in water rights is a required element of the WRIA assessment. The following points are intended to assist with understanding the nature of water rights regulation as it pertains to watershed planning.

- A water right is approved by the Department of Ecology for a particular *water source* to be put to a specific *beneficial use* at a specific location *("place of use*"). The right to utilize water is specific to this use and location, unless a permit is approved to move and/or change use of the water. And the right lapses if it is no longer needed unless a change is approved: With some important exceptions, State law stipulates that the right to use the approved quantity of water is no longer in force (*"relinquished")* if it is out of beneficial use for five years. The statute includes several provisions that may retain an unused or partially used right beyond five years, including planned development/use of the water within 15 years.

- The existing water rights database provides an accurate record of *administrative actions* by DOE over the years regarding water right applications. The existing database does *not* provide an accounting of either *actual current water use* or current *legal status* of water rights. Thus, the volume of water in the DOE database represents *theoretical maximum potential water use,* which has not been "filtered" to remove or reduce quantities to represent recent beneficial use and comply with statute. [44]

- Most water rights are *certificates* – i.e. the water use has been documented (*"perfected"*) and approved by DOE. As explained above, the database does not reflect current beneficial use or legal status of these rights. There are numerous records for rights that have been out of use for many years.

- A smaller number (but still representing a significant quantity of water) are in the form of *permits* – i.e. the designated quantity of water is still in process of being put to beneficial use at the designated location. Permits associated with a growing use such as a community water system should appropriately be larger than existing actual water use, as the utility is still "growing into" the permit.

- Another data set represents *claims* filed with the State, alleging water use that predates the requirement to obtain a permit (1917 for surface water and 1945 for groundwater). These applications were submitted without review by DOE staff to identify whether the applications are complete or if the date of use qualifies for a claim. The validity of claims can only be determined through court adjudication. Due to these significant uncertainties, claims will be briefly identified but not assessed in detail in this report.

---

[44] Throughout the document, water rights data is extracted from the Department of Ecology "Water Rights Application Tracking System" (WRATS). A limited review of the largest surface water rights in the Deschutes was conducted using the fiche records from DOE SW Region Water Resources.

- An important component of water use is not even included in the DOE data. "Exempt" wells using less that 5,000 gallons per day are excluded by statute from the requirement to obtain a water right. Cumulatively, these small withdrawals may utilize a significant quantity of water.

Groundwater Rights

Groundwater rights records for the Henderson Inlet area are summarized in Table 3 below. For purposes of this preliminary assessment, DOE water right records for WRIA 13 were divided along section lines into the various independent basins in the WRIA. There are a total of 250 groundwater right records in the watershed representing nearly 22,000 acre-feet per year of theoretical water use. As explained above, this data does not account for unused water volumes or rights that are no longer valid under State statutes or exempt uses.

Over 90% of the water volume in the DOE water right database for Henderson Inlet watershed is associated with groundwater right records: the remainder are for surface water rights discussed below. "Domestic multiple" - generally municipal or privately owned "public" water systems – is by far the largest designated use with over 18,500 acre feet/year represented in the DOE records. Agriculture is the next largest use associated with groundwater rights in Henderson watershed, with roughly 2,800 acre-feet of potential water use for irrigation on over 1,800 acres.

The table below summarizes groundwater rights data by general category of approved use.

Claims

Another set of DOE records pertain to *claims* filed for water use alleged to have been established prior to State permit requirements (1917 for surface water and 1945 for groundwater). The validity of claims can only be resolved through adjudication by the courts. No adjudication is underway or currently contemplated for WRIA 13.

Approximately 1,400 claims were submitted in the Henderson Inlet watershed, totaling about 3,700 acre-feet per year. This is a large number compared to water rights records (which total about 250 for Henderson Inlet). However, these claims were nearly all for small domestic-use wells. Total quantity contained in these claims is 3,700 acre-feet/year, compared to the 22,000 acre-feet in water rights.

Many of these claims may have been submitted for "exempt" wells. In many cases, DOE accepted claim filings without any review of basic eligibility. Thus, many of the filed claims may not meet the basic prerequisite that the use predated water rights regulation in Washington State (i.e. that the well was drilled and put to use before 1945 or the surface withdrawal was in place prior to 1917).

Variance of water rights/claims data from estimated use

As shown on the following table, the volume associated with water rights records is significantly greater than the estimated actual groundwater withdrawal within the planning area. Estimated

1998 groundwater withdrawal in the Henderson Inlet watershed was about 7,800 acre feet - approximately 1/3 of the groundwater volume represented in the DOE water rights database.

This variance between DOE water right records and estimated actual use stems from multiple sources, including:

- Many rights are no longer in use (use curtailed or now served by larger water system).

- Quantities represented in water rights are *theoretical maximums*, i.e. assumes that every permit is legally valid for the volume originally approved and every right holder uses their maximum volume during the year.

- Some water users are still “growing into” water rights particularly those in the form of water right permits.

On the other hand, the water rights data *understates* water use by a particular class of wells: Individual and small group wells using under 5,000 gallons per day. These wells are “exempt” from the requirement to obtain a water right permit from DOE. As shown on Table 3, only a handful of exempt well owners have elected to obtain a formal water right. Estimated 1998 use shown on Table 3 includes exempt wells. See further discussion exempt wells in the water use description below.

Table 4 Groundwater Rights Compared to Estimated Use

GROUNDWATER RIGHTS COMPARED TO ESTIMATED USE HENDERSON INLET WATERSHED			
	DOE RECORDS		**EST. ACTUAL USE - 1998**
	NUMBER OF PERMITS	**APPROVED QUANTITY (ACRE FT/YR)**	**(AC FT/YR)**
Public Water Systems (1)	137	18,594	5,764
Individual Domestic (2)	28	36	628
Irrigation Use Wells (3)	72	2,760	1,140
Industrial & Other Use (4)	12	562	230
Subtotal: Ground Water Rights	249	21,952	
Ground Water Claims	1,466	3,758	
TOTAL	1,871	25,710	7,762

Notes:
(1) 1998 estimate utilized pumping records from larger systems. Smaller system use calculated by multiplying customers per DOE PWS database times 130 gallons/day
(2) Individual/small group wells are exempt from water right permitting. A handful have obtained formal water rights.
(3) Irrigation water rights do not always specify annual acre-feet. Assumed 18" of annual irrigation (factor used for DOE water rights and USGS 1988 water use survey.)
(4) Irrigation and industrial well use per 1988 comprehensive USGS inventory.

Groundwater Use Estimates

Groundwater use by aquifer

The 1988 USGS groundwater use inventory identified the aquifer in which each well was developed. [45] Three main aquifers supply most wells in the area: the Vashon Outwash (Qva) Deposits of the Penultimate Glaciation (earlier glacial deposits, termed Qc), and the Unconsolidated/ Undifferentiated Deposits (Tqu).

About 70% of groundwater withdrawal in the Henderson Inlet watershed is from the Qc aquifer. Wells in the Qc typically are developed at about sea level. Both municipal and private wells utilize this important aquifer.

The shallower Qva aquifer supplies roughly 20% of groundwater, including several privately owned community water systems north of Lacey.

The deeper Tqu is increasing in importance as a source for larger municipal wells. This aquifer supplied about 6% of groundwater source in 1988 and roughly 14% in 1998. As only a few wells have been developed in this deeper geologic unit, the depth and composition of this formation is not well understood.

The following table summarizes information regarding wells in the principal aquifers in the watershed.

Table 5 - Groundwater Use by Aquifer in Henderson Inlet Watershed

Aquifer	Approx. percent of gw withdrawal	Typical well depth	Typical elevation at bottom of well
Qva (Vashon outwash)	20%	150’ - 300’ deep (average 275’)	Roughly 80’ above sea level
Qc (Earlier glaciation deposits)	70%	100’ - 300’ deep (average 200’)	Typically around sea level
Tqu (Unconsolidated deposits)	6% 1988 14% 1998	250’ - 500’ deep (average 470’)	Roughly 150’ below sea level

Public Water System Use

Fairly accurate estimates of water use can be made for the larger “public” residential water systems. Municipal and privately owned water systems serving 15 or more residential customers are termed Group A Community Public Water Systems. For this Assessment, actual well production data was obtained from the municipal water systems and the larger private utility

[45] Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington, USGS, 1999

operators. For smaller Community water systems, the number of system customers was obtained from the Washington Department of Health PWS database. This database is updated annually from water system operator reports. This preliminary assessment utilizes the same per-capita water use calculations employed by USGS in 1988: 130 gallons per customer per day in urban areas and 100 gallons per customer per day for rural water systems.

Water right records approved for "Municipal" and "Domestic Multiple" purposes are compared to estimated use for Group A Community water systems in Table 5 and illustrated on Figure 16. This is only a rough comparison of water rights and actual use. This assessment did not specifically link existing water systems with water right records (water right records are in the name of the original applicant not the current water system owner). In addition, some water right records are for wells no longer in use.

Keep in mind that the table summarizes rights and use for wells within WRIA 13. Significant additional water is supplied to development within WRIA 13 from McAllister Springs and City of Lacey wells in WRIA 11.

Table 6 - Public Water System Water Rights Vs. Estimated Actual Use

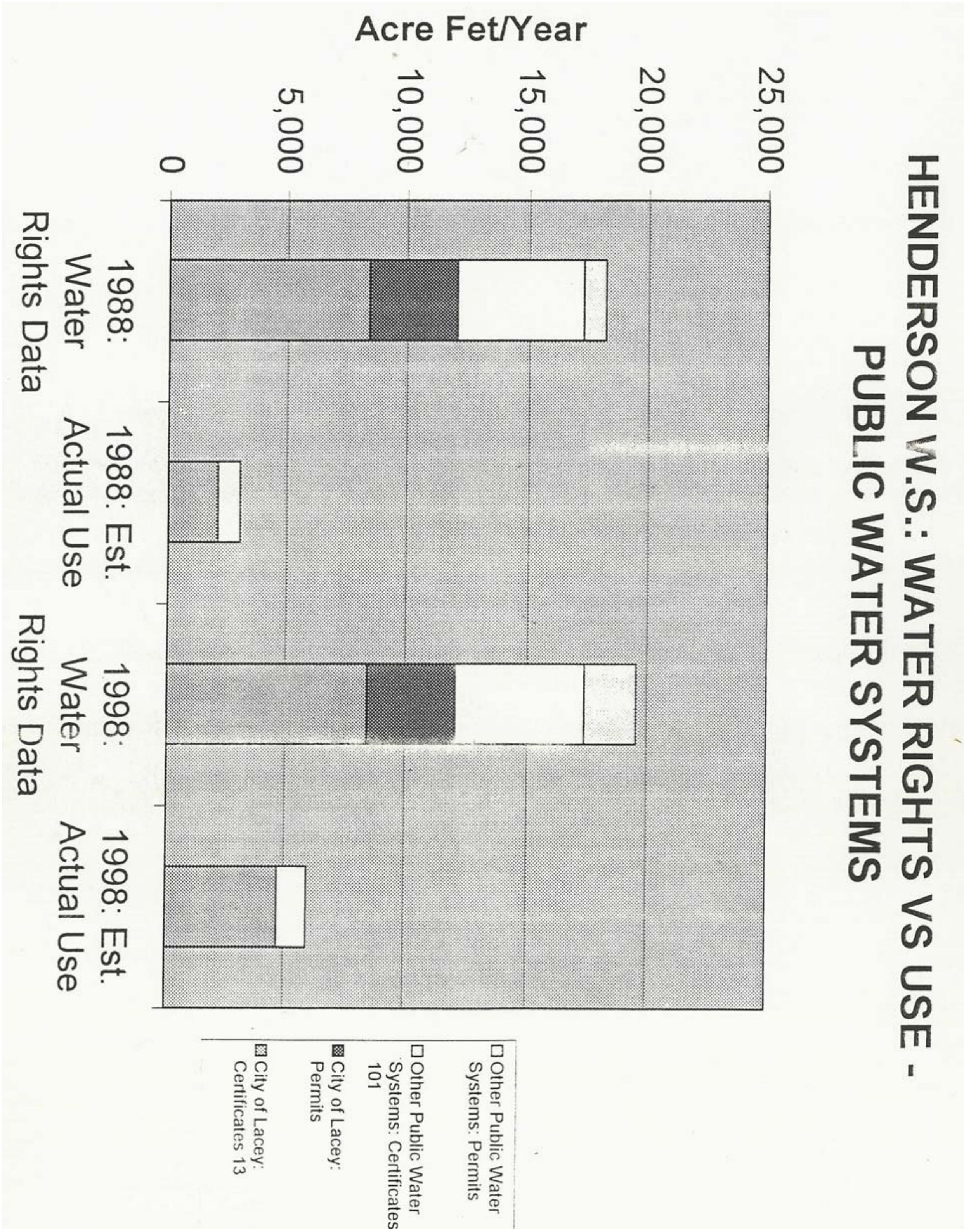
HENDERSON INLET WATERSHED INITIAL ASSESSMENT

PRELIMINARY ESTIMATE
PUBLIC WATER SYSTEMS: WATER RIGHTS VERSUS ESTIMATED ACTUAL USE

	Water Rights Data (1)				Estimated Use (3)	
	1988					
	Certificates		Permits (2)			
	Number	Acre Feet	Number	Acre Feet	Number	Acre Feet
City of Lacey	13	8,440	4	3,614	12	2,091
Non-municipal Domestic Multiple	101	5,214	5	947	70	934
Total	114	13,654	9	4,561	82	3,025
	1998					
	Certificates		Permits (2)			
	Number	Acre Feet	Number	Acre Feet	Number	Acre Feet
City of Lacey	13	8,440	4	3,614	9	4,712
Non-municipal Domestic Multiple	105	5,312	13	2,175	75	1,253
Total	118	13,752	17	5,789	84	5,966

Notes:
Preliminary estimate only. Water right records and water system records have not been specifically linked.
(1) Water rights from DOE database for "Domestic Multiple". Includes undetermined number of rights for smaller water systems not included in water use estimate and rights associated with wells no longer in use.
(2) Permits will often not yet be fully utilized. When full use is documented, these records move to "Certificate" status.
(3) Estimated use for Group A Community Public Water Systems (15 customers and over). 1988 data from USGS survey. 1998 data is actual well production for larger utilities. 1998 volume calculated from DOH data re: number of connections times use rate. Same rate used as 1988 USGS data (130 gallons per day for urban systems and 100 gallons per day for rural systems). See USGS Table B3.

Figure 15 - Water Rights Vs. Use – Public Water Systems, Henderson Inlet Watershed



Exempt Well Use: Single-family and Small Community Wells

Water service through "exempt" wells is provided through individual wells or small "Group B" Public Water Systems. In general, up to 6 houses have been allowed on one "exempt" well serving a Group B system – i.e. up to 5,000 gallons per day. For this assessment, all developed parcels not included in a Group A Community water system service area were assumed to have exempt wells.

Exempt well numbers were estimated from parcel information. As the following table indicates, estimated water use by existing exempt wells in the watershed is approximately 628 acre feet/year. This is about ½ the estimated annual water use by all non-municipal public water systems in the watershed. Exempt wells would roughly double if the area were fully developed under current zoning. Notably, exempt wells would increase by about 60% simply through development of all existing vacant lots – without any further subdivision review or approval.

Table 7 – Estimated Exempt Well Water Use in the Henderson Inlet Watershed

	Dwelling Units	Household Size	Per Capita Use (Gallons Per Day)	Daily Use (Gallons)	Annual Use (Acre Feet)
Existing Dwellings	1,660	2.6	130	561,080	628
Vacant Lots	970	2.6	130	327,860	367
Potential New Lots	1,030	2.6	130	348,140	390
TOTAL	3,660			1,237,080	1,386

Industrial Wells Water Use

A few industrial operations in WRIA 13 supply their own water, such as the Ostrom mushroom farm. The USGS comprehensive groundwater use survey in 1988 identified about 230 acre feet/year of withdrawal for these independent industrial wells (about 3% of total estimated groundwater use). For this initial assessment, use is assumed to be roughly the same as the 1988 survey.

Irrigation Wells Water Use

For this assessment, agriculture operations and golf courses supplying their own water are assumed to use approximately the same quantity of water as in the 1988 USGS groundwater use inventory. This estimated use is 1,140 acre feet/year, which equals less than 15% of total use. Other irrigation at schools and other locations provided by public water systems is included in the Public Water System use estimates above.

Groundwater withdrawal impacts on streamflow

A key water resource management concern is potential impact of groundwater withdrawals on streamflow, through withdrawal from aquifers that are in continuity with surface waters.

Aquifer depths and flow directions

Many of the larger wells in the watershed are in aquifers located significantly deeper than surface water bodies. The Tqu wells are typically located about 150 feet below sea level. Qc wells are typically developed at approximately sea level. [46] The Qc aquifer, which supplies about 30% of water supply in Thurston County, tends to flow northeasterly out of the Henderson watershed toward McAllister Springs and McAllister Creek vicinity.[47]

Despite the depth of many larger wells and the presence of one or more aquatards, there is the potential for withdrawal from deeper aquifers to affect the upper aquifers. Because the aquatards are not always completely impermeable and may be missing in some areas, they do not completely preclude the possible vertical movement of water. This downward flow is one of the ways in which lower aquifers in the area become recharged. [48]

Localized impacts to streams in WRIA 13

Flow direction of the shallowest productive aquifer, the Qva, is generally consistent with surface water flow for Woodland Creek. These wells are typically around 80' above sea level. (See Figure 5.) Qva wells located south (upstream) of the Woodland Creek mouth withdraw roughly 400 acre-feet of water per year. This withdrawal equates to approximately .6 cfs in withdrawal over the year. Using the conservative assumption that all Qva withdrawal from this vicinity is in 100% continuity with Woodland Creek streamflow, withdrawal would equal roughly 7% of minimum flow and 3% of mean streamflow. See Figure 15.

A principle baseflow source for Woodland Creek is Beatty Springs near Martin Way. Flow was estimated by the USGS at over 6 cfs - about ½ of the mean 7-day low flow for the creek of 11 cfs. Beatty Spring is supplied by the Qvr aquifer. Estimated well withdrawals from the Qvr up gradient of Beatty Springs equals less than .1 cfs (about 50 acre-feet per year). The Qva (next deeper aquifer) is utilized for several small community wells up gradient of Beatty Springs: Total estimated withdrawal for these wells is about 150 acre-feet per year or .21 cfs. Assuming 100% continuity of all these Qvr and Qva wells with the aquifer supporting Beatty Springs, total withdrawal would be roughly .3 cfs – about 5% of summer-period flow at Beatty Springs.

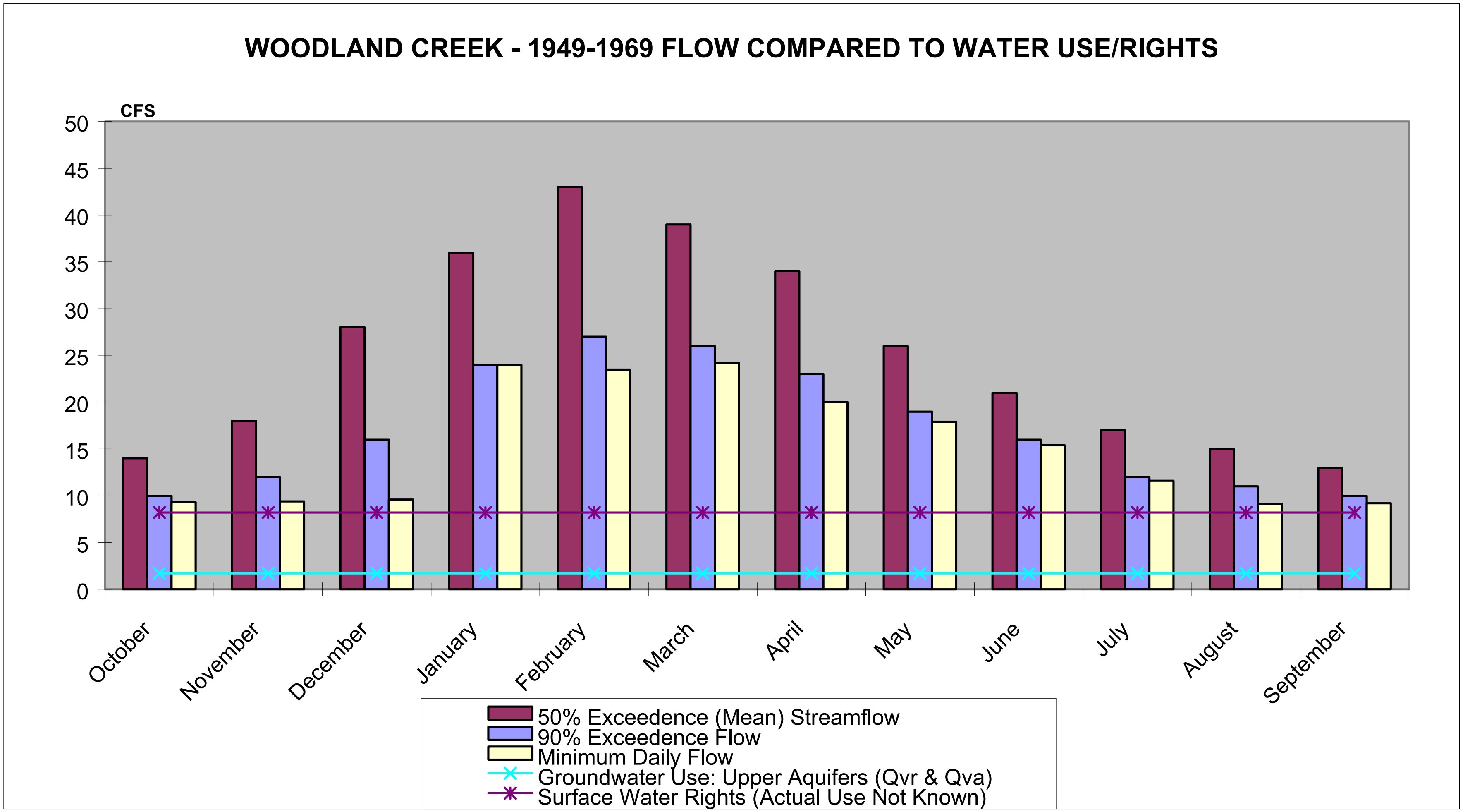
---

[46] Hydrology and Quality of Ground Water in Northern Thurston County, Washington, USGS Water-Resources Investigations Report 92-4109 (Revised), 1998

[47] Conceptual Model and Numerical Simulation of the Groundwater Flow System in the Unconsolidated Sediments of Thurston County, Washington, USGS, 1999

[48] Northern Thurston County Ground Water Management Plan, 1992. See section 2, particularly pages 2-9 and 2-10

Figure 16 - Woodland Creek 1949-1969 Flow Compared to Groundwater Use & Surface Water Rights



Surface Water Rights and Use

Surface water rights represent only about seven percent of total annual volume in water rights records for the Henderson Inlet watershed. However, the potential for direct withdrawal from surface waters during the low-flow period heightens policy concerns related to surface water permit records.

Table 7 summarizes surface water right records for the various waterbodies in the watershed.

Lake Surface Water Right Records

As shown on the following table, about 120 small water rights were issued to withdraw water from Hicks, Pattison and Long Lakes. The total volume of water associated with these rights totals about 130 acre-feet/year. The places of use for these surface water rights have been provided with municipal water service or privately operated water systems for domestic use. However, a handful of small landscape irrigation withdrawals may persist on these lakes, withdrawing water during the summer period.

Three larger Pattison Lake rights for irrigation purposes total 615 acre-feet per year. This is a significant volume of potential withdrawal from the 370-acre lake, equaling about 10% of total lake volume of 3,600 acre-feet. Status of these large irrigation rights has not been determined.

Woodard Creek Surface Water Right Records

About 1.6 cubic feet per second (cfs) of withdrawal is represented in the 11 surface water right records pertaining to Woodard Creek. This is about equal to minimum recorded flow on the creek, which has an average flow of about 10 cfs. Actual surface withdrawal and status of these rights is not known.

Woodland Creek Surface Water Right Records

The 10 water right records pertaining to Woodland Creek and associated springs have a total instantaneous volume of about 6.5 cfs. In comparison, the lowest 7-day low flow (mean value over the seven continuous days with lowest flow) is 11 cfs. Average mean flow is about 24 cfs. Thus, the volume of water in the water rights records is about ½ of 7-day low flow and a quarter of mean flow over the period of record.

Figure 15 compares minimum daily flow and average monthly flow values for 1949-1969 to Woodland Creek surface water rights. The water right value is maximum instantaneous withdrawal (in most cases, permits also include maximum annual withdrawal which would preclude continuous withdrawal at the maximum rate for the entire year as illustrated).

Total maximum withdrawal rate for all Woodland Creek rights nearly equals minimum streamflow. However, many of these rights are not in use. Actual use and status of the surface rights to Woodland Creek has not been documented.

One of the largest Woodland Creek rights is in the name of St.Martin's College, which allows .5 cfs withdrawal to a total of 150 acre-feet/year for irrigation and domestic multiple uses. The other very large right is 5 cfs for fish farm, domestic and small-scale irrigation use from springs associated with Woodland Creek (Beatty Springs). While this multiple-use right is coded in the summary data table as “consumptive”. However, the fish farm activity would return nearly all utilized flow to the stream.

Table 8 - Surface Water Rights Records In Henderson Inlet Watershed

	NUMBER OF RIGHTS	CUBIC FT PER SECOND (Qi)	ACRE FEET/ YEAR (Qa) (1)	ACRES IRRIGATED
Hicks Lake				
Small Domestic &/or Irrigation Rights	24	0.5	29	11
Larger Irrigation Rights (>.4 cfs)	0	0.0	0	0
Subtotal	24	0.5	29	11
Long Lake				
Small Domestic &/or Irrigation Rights	59	1.2	62	27
Larger Irrigation Rights (>.4 cfs)	0	0.0	0	0
Subtotal	59	1.2	62	27
Pattison Lake				
Small Domestic &/or Irrigation Rights	35	0.5	40	22
Larger Irrigation Rights (>.4 cfs)	3	4.1	615	410
Subtotal	38	4.6	655	432
Woodard Creek				
Small Domestic &/or Irrigation Rights	10	0.7	51	30
Larger Irrigation Rights (>.4 cfs)	1	0.8	123	82
Subtotal	11	1.6	174	112
Woodland Creek and Associated Springs				
Small Domestic &/or Irrigation Rights	7	0.5	56	38
Larger Irrigation Rights (>.4 cfs)	3	6.05	157.5	105
Subtotal	10	6.5	214	143
Other Named Streams & Lakes				
Small Domestic &/or Irrigation Rights	9	0.3	43	27
Larger Irrigation Rights (>.4 cfs)	1	0.4	60	40
Subtotal	10	0.7	103	67
Unnamed Sources				
Small Domestic &/or Irrigation Rights	63	6.8	429	263
Larger Irrigation Rights (>.4 cfs)	0	0.0	0	0
Subtotal	63	6.8	429	263
TOTAL SURFACE WATER RIGHTS				
Small Domestic &/or Irrigation Rights	207	10.5	710	418
Larger Irrigation Rights (>.4 cfs)	8	11.4	956	637
TOTAL SURFACE WATER RIGHTS	215	21.9	1,666	1,055

Notes:
(1) Many surface water rights for irrigation do not specify annual quantity (acre-feet).
Where acreage is specified, data assumed 1.5 acre feet/year (common quantity used by DOE for irrigation.)
Data pertains to water right records not actual use or legally valid quantities.

2.2.6 Surface Water Quality

Good water quality is required to support all of the beneficial uses we enjoy from the streams, rivers, and lakes in WRIA 13. According to the kind of uses a water bodies can be expected to support, W.A.C. 173-201 assigns water quality classification to each water body. When a water body fails to meet the standards due to human activity and one or more intended uses are impaired, section 303(d) of the Federal Clean Water Act requires it be placed on a state list of impaired water body. For those listed waters, the state must set priorities for clean-up efforts and establish total maximum daily loads (TMDL) to improve the water quality to meet established standards. Based on data collected by Thurston County, Squaxin Island Tribe, and WDOE over the past decades, several WRIA 13 water bodies are listed as Aimpaired≅ on the 303(d) list.[49] Water quality problems do exist for other WRIA 13 fresh water bodies that are excluded from the 303(d) list for various programmatic reasons, including the existence of an action program to address the impairment.

Streams

Water Quality Data Sources

Water quality data was collected by Thurston County for virtually all streams entering Henderson Inlet from 1983 to 1987. Small creeks included in this data collection were Dobbs Creek, Meyer Creek, and Sleepy Creek. Monitoring has been conducted from 1983 to present on Woodland and Woodard Creeks. See Table 8 identifying water quality and quantity data available for the watershed.

The principal source of current water quality data is the Thurston County Water Resources Monitoring Report issued for each water year. This report is available from Thurston County Environmental Health.

Fecal coliform

Fecal coliform is the most common identified pollutant in the area. This pollutant is very significant for commercial and recreational shellfish harvesting, as strict water quality standards apply to shellfish harvesting areas due to concern about potential disease transmission. Fecal coliform pollution also affects recreational shellfish harvesting. This pollutant is a particular concern in the Henderson Inlet drainage area and the Nisqually Reach. Commercial shellfish harvesting areas in these two locations were downgraded in November 2000 due to elevated fecal coliform levels.[50] This triggered a State requirement for the County to create a "Shellfish Protection District" to identify and correct the pollution sources leading to the downgrade.

The DOE 303(d) list for fecal coliform includes Dobbs, Sleepy, Woodard and Woodland Creeks. Woodland and Woodard Creeks are significantly contributors of fecal coliform pollution in the

[49] Final 1998 Section 303(d) List – WRIA 13, dated 4/4/00

[50] 1999 Status and Trends in Fecal Coliform Pollution in Puget Sound Embayments, Washington State Department of Health Office of Food Safety and Shellfish Programs.

South Puget Sound area. See Figure 17 from the DOE SPASM study, which is a draft map of fecal coliform loading from streams and from facilities with a discharge permit (NPDES).

Nitrates

Nitrogen loading to the Sound is of increasing concern, particularly due to increased eutrophication and algal productivity in Puget Sound. These conditions could affect water quality-dependent uses including shellfish and fisheries. DOE is conducting a study of nitrogen loading to the South Sound from point sources and streams, which may lead to each source being limited to an assigned "allocation" in order to reduce nitrogen loading to the South Sound. WRIA 13 streams are a contributor of nitrogen loading to the South Sound. See the draft map of nitrate loading from NPDES sources (facilities with discharge permits) and freshwater tributaries at Figure 18.[51]

Nitrate sources include yard and agricultural fertilizers, manure from livestock and pets, and septic systems. Nitrates enter streams and lakes through surface runoff and shallow groundwater. Woodland Creek has an elevated level of nitrates compared to other area streams. Woodland mean nitrate + nitrite level is 1.46 mg/liter, compared to the relatively undeveloped McLane Creek at .44 mg/liter.

There are also areas of elevated groundwater nitrate levels in the WRIA. Monitoring wells in the Qva aquifer in the Lakes area have nitrate levels exceeding 4 mg/liter, compared to average value in the North County Ambient Monitoring Network of 1.6 mg/liter. [52]. The shallower aquifer in the Martin Way/Hawks Prairie area has experienced elevated nitrate levels from extensive local development. Some shallow wells have been abandoned in favor of municipal service from deeper wells.[53] While the deeper aquifer utilized for larger water systems may have some protection from the upper water table, the shallow aquifer provides baseflow to the streams – which then flow into Henderson Inlet and other marine waters, potentially contributing elevated nitrate levels to the Sound.

Water Temperature

Higher temperatures impair habitat for salmon and other aquatic organisms. Woodland Creek is included on the 303(d) list for violation of temperature standards in the vicinity of Martin Way (Lake Lois reach). The listing was based on 7 excursions beyond the upper criterion out of 25 samples at RM 4.2 between 1991 and 1993. [54] In sampling from 1983-1997 at Pleasant Glade, summer temperature is usually below the standard of 16 degrees C; however, readings as high as 18.1 degrees have been identified. No temperature standard violations have been recorded in ten years of monitoring on Woodard Creek. .[55]

---

[51] Department of Ecology South Puget Sound Model Nutrient Study preliminary products. For project description go to Internet at www.ecy.wa.gov/programs/eap/spasm.
[52] Thurston County Water Resources Monitoring Report 1998-1999 Water Year, see Ground Water section page 307 and 308.
[53] Study of On-Site Systems in Tanglewilde-Thompson Place-Bicentennial Developments, Thurston County Environmental Health for LOTT, 1999.
[54] Final 1998 Section 303(d) List –WRIA 13, Department of Ecology, April 2000.
[55] Thurston County Water Resources Monitoring Report 1998-1999 Water Year.

Dissolved Oxygen

Summer dissolved oxygen levels in Woodland and Woodard Creeks are often near the Class AA standard of 9.5 mg/liter. Since 1988, Thurston County Environmental Health has documented five violations of the standard on Woodland Creek (most occurring in 1992) and seven violations on Woodard Creek. Both Woodland and Woodard Creek are included on the 303(d) list for this parameter.

Heavy metals

In 1997, water samples from Woodland and Woodard Creeks were analyzed for heavy metals. Copper and zinc were detected in nearly all samples. While samples from both streams exceeded the levels set for chronic 4-day average toxicity, the toxicity standards do not directly apply as they are based on dissolved metal concentrations rather than total recoverable metals; and the chronic exposure standard is based on a 4-day average (not a grab sample.) However, the results give an indication that metals contamination is occurring, potentially from stormwater impacts. [56]

Biological Indicators

The diversity, population, and species composition of the aquatic macroinvertebrates in a stream are indicative of the condition of its watershed, riparian area, and water quality. Measurements conducted in 1998 and 1999 for biological integrity using the macroinvertebrate community rated Woodard with "moderate" biological integrity, while Woodland sampling indicated a "low" biological integrity at Pleasant Glade and a "moderate" score at Draham Road.[57]

---

[56] Thurston County Water Resources Monitoring Report 1998-1999 Water Year, see Woodard and Woodland sections.

[57] Thurston County Water Resources Monitoring Report 1998-1999 Water Year, see Benthic Macroinvertebrates Monitoring section. Stream Team volunteers collected Woodland data for this report. Woodard data is from Thurston County Environmental Health monitoring.

Table 9 – Henderson Inlet Water Quality & Quantity Data Available

HENDERSON INLET – WATER QUALITY AND QUANTITY DATA AVAILABLE

LOCATION	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	Pre '80
DOBBS CREEK																			
Water Quality				TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	
MEYER CREEK																			
Water Quality				TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	
SLEEPY CREEK																			
Water Quality				TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	
WOODARD CRK																			
Water Quality	TC	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1) DOE(8	TC(1) DOE(8	TC(1) DOE(8	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	
Macroinverte-brate	TC	TC(1)	TC(1)																
Flow monitoring			SWM(6	SWM(6	SWM(6	SWM(6	SWM(6	SWM(6	SWM(6	SWM(6	SWM6	SWM 6	SWM6						
WOODLAND CRK																			
Water Quality	TC	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	TC(1)	
Macroinverte-brate	TC	TC(1)	VOL(1)																
Flow monitoring						SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM (2	SWM(2						'49-'69 (7)
Baseflow Analysis											DOE(4								
Seepage Study													GS(3)						

PRECIPITATION STATIONS																			
Fairgrounds	SWM (2	SWM (2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM (2	SWM(2						
12th Ave NW	SWM (2	SWM (2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM(2	SWM (2	SWM(2						
Olympia Airport	NOA A	NOA A	NOAA	NOAA	NOAA	NOAA	NOAA	NOAA	NOAA	NOAA	NOAA	NOA A	NOAA	NOA A	NOA A	NOA A	NOAA	NOA A	NOAA
GROUNDWATER: WELL LEVELS AND WATER QUALITY																			
North Co. Ambient Network	TC(5)	TC(5)	TC(5)	TC(5)	TC(5)	TC(5)					GS (6)		GS (6)						

References:

1. Water Resources Monitoring Report: 1997-98 Water Year, Thurston County SWM & Environmental Health. TC indicates data collected by Thurston County Environmental Health staff. VOL is volunteer collected data.

2. Thurston County Storm and Surface Water Utility continuous gaging data for streamflow and precipitation (reported in Annual Report, reference 1 above).

3. Conceptual Model and Numerical Simulation of the GW Flow System in the Unconsolidated Sediments of Thurston County, 1999, USGS (Water-Resources Investigations Report 99-4165). In seepage studies conducted In 1988, data was collected from 14 stations along the Deschutes (Vail Road to mouth) and from 9 stations along Woodland Creek (Pattison Lake inlet to near mouth).

4. Estimated Baseflow Characteristics of Selected WA Rivers and Streams, 1999, DOE (Water Supply Bulletin No. 60). All available years of continuous monitoring were utilized. Year indicated on table was latest year of available data.

5. Thurston County Environmental Health: Ambient monitoring of 40 wells in the North Thurston County Groundwater Management Area. Reported in (1) above. Also conduct short-duration special studies.

6. USGS assessed water level for over 600 wells in 1988 and 1990. Comprehensive water quality data collected in 1999 for over 350 wells. Groundwater consumption was also estimated for 1988. Reported in (8) above and in Hydrology and Quality of Ground Water in Northern Thurston County, 1998 (USGS Water-Resources Investigations Report 92-4109 revised).

7. USGS ADAPS database for Station 12081000.

8. Woodland Creek Water Quality Assessment Final Report: Ecology Building Project, DOE Report #94-62, Patterson and Dickes April 1994.

Figure x. Annual load of fecal coliform from tributaries and NPDES sources (efdc_inflows.apr)

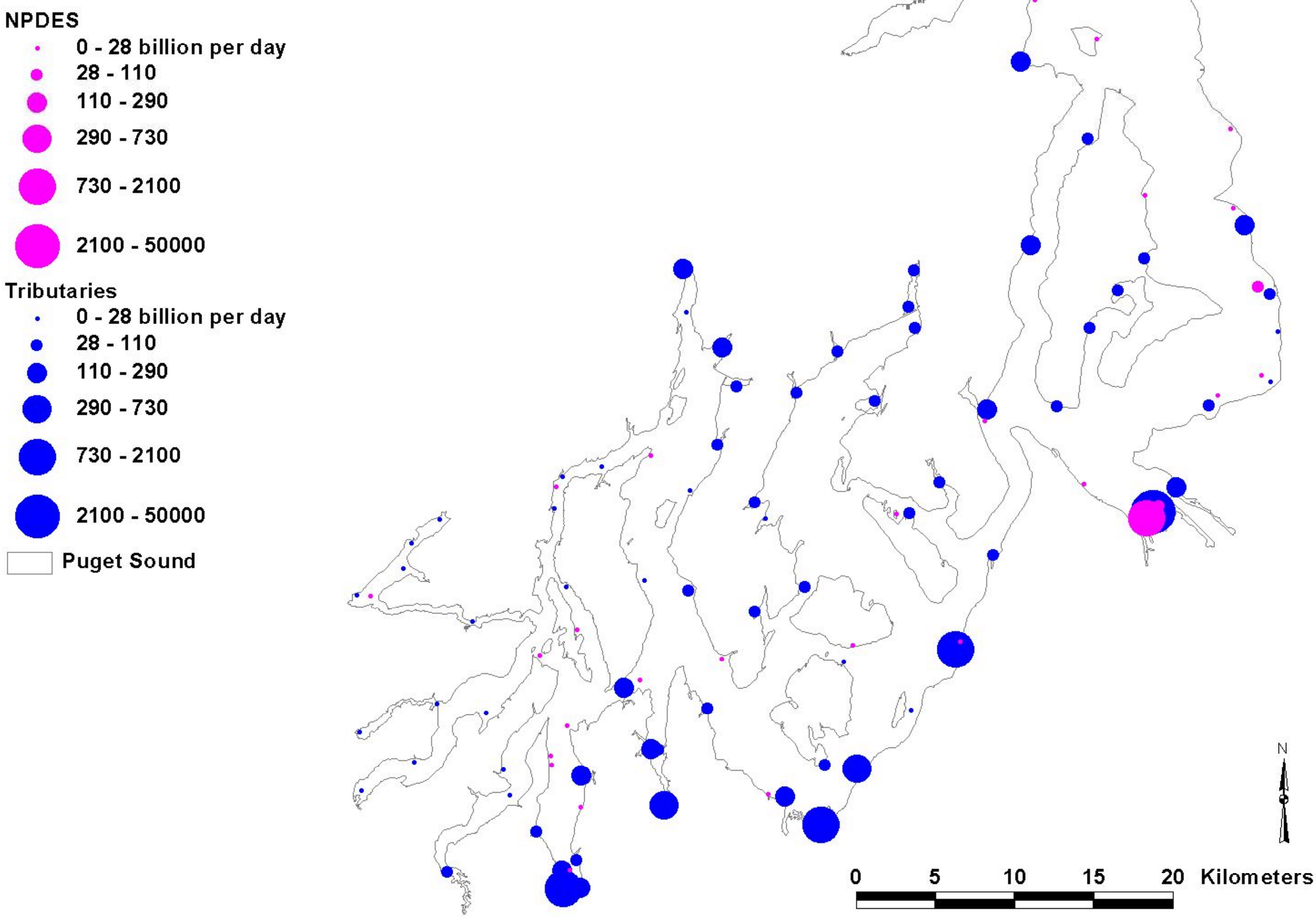
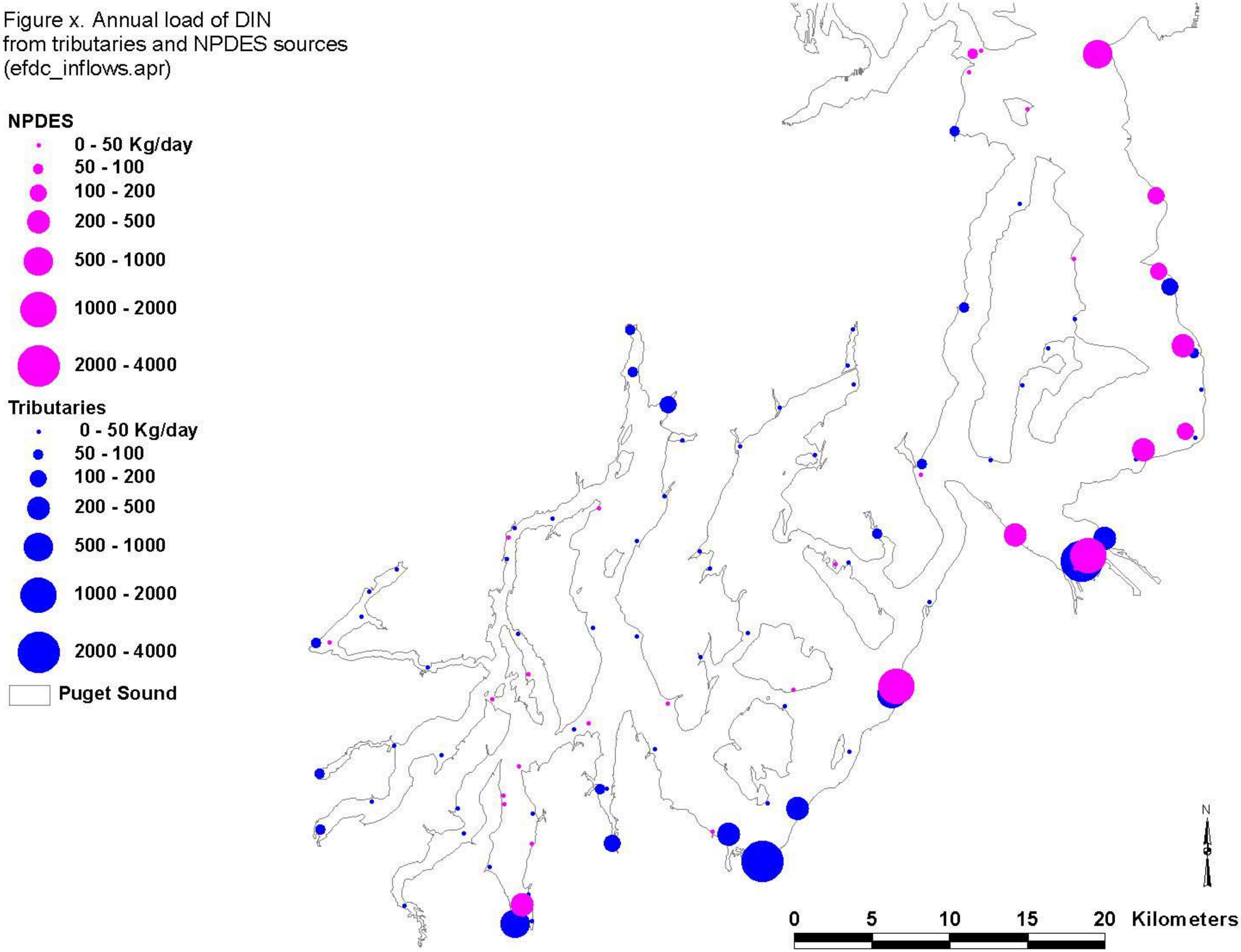


Figure x. Annual load of DIN
from tributaries and NPDES sources
(efdc_inflows.apr)



Hicks, Pattison and Long Lakes

Data Sources

Lake water quality data has been collected for several years for Hicks, Pattison and Long Lakes. Extensive data on multiple parameters was collected in the late 1970's and early 1980's as part of the grant-funded Lakes Restoration program. The effort was sponsored by Thurston County in response to lake residents' concerns that water quality conditions in the lake chain were deteriorating and could be further impaired by future development. [58] Thurston County Environmental Health has collected data on Long Lake since 1989. Thurston County staff has also collected several years of data on Pattison and Hicks Lake. [59] Secchi disk (water clarity) information is available for various lakes from the Department of Ecology.

Lake Enrichment

Overloading with nutrients is a key pollution concern regarding lakes. High nutrient levels trigger algae blooms, which can significantly impair recreational activities during the period of the bloom. Fish and other species can also be impaired by oxygen depletion from algae bloom decay. While some common algae species are capable of producing toxins, no toxic blooms have been documented on any Thurston County lake.

A standard measure for lake water quality is the "trophic state" index which indicates the level of nutrient enrichment (or productivity). See Figures 19 to 22 summarizing trophic conditions in the three lakes.[60] Most of the lakes in this WRIA are in a "eutrophic" (or highly productive) category. While the natural geological conditions under which they were formed contributed significantly to the lakes= current water quality conditions, urban development along their shorelines, direct storm water discharges of runoff from developed upland areas, and inflow of nutrient-enriched shallow ground water have accelerated the rate of eutrophication.[61]

Hicks, the first lake in the chain, are generally considered a "mesotrophic" or moderately productive lake, but 1999 data is better defined as eutrophic. However, algae growth did not seem to interfere with uses of the lake. [62]

Pattison Lake is divided into two basins by the railroad fill. Both basins are generally in a mesotrophic-eutrophic condition. Annual fluctuations in water clarity conditions are most likely a reflection of fluctuations in summer weather conditions, which influence algae production in

---

[58] Multiple studies were performed as part of this project from 1977 to 1985. Results of the 1976-77 water year intensive monitoring are reported in Thurston County Lakes Water Quality and Restoration Analysis, Entranco, 1978. Overall data results are included in Final Report: Pattison and Long Lakes Restoration Project Final Report: Pattison and Long Lakes Restoration Project, Entranco, 1985.
[59] Thurston County data is compiled into the annual Water Resources Monitoring Report issued for each water year. Summer period data is displayed from the period of available record, as reflection of trophic (enrichment) condition. Each year, seasonal trends in field parameters including temperature and dissolved oxygen are also graphed.
[60] Same cite.
[61] "WRIA 13 Issue Paper #5: Fresh Water – Water Quality" 8/00, Thurston County for WRIA Watershed Planning Committee
[62] Thurston County Water Resources Monitoring Report 1998-1999 Water Year, page 163.

the lake. The south basin also occasionally experiences filamentous algae growth that floats to the surface and interferes with boating and fishing. [63]

In Long Lake, the south basin – which receives surface water from Pattison Lake – generally exhibits higher nutrient levels and impaired water clarity compared to the north part of the lake. Data from the south basin is firmly in the eutrophic classification. A whole lake alum treatment in 1983 reduced the amount of phosphorus in the water column and phosphorus being released from the sediments, which resulted in increased water clarity and decreased algae growth for several years. Since that time the effectiveness of the alum treatment has diminished, and the lake is returning to its previous condition. [64]

Phosphorus is the limiting nutrient in the lakes. A major Lake Restoration effort was pursued in the late 1970's and early 1980's to identify the sources of phosphorus to these lakes. A principle source of phosphorus loading to all three lakes was understood to be internal cycling from sediments and plant decay. Groundwater and surface water were other contributors. Nonpoint sources were calculated to be a small percentage source.[65] However, these "new" inputs are very significant as they add to the "pool" of phosphorus, which can be recycled many times in the lake through algae and plant growth and decay.

As part of the adopted Lake Restoration Plan, improved septic design standards were adopted and drainage design enhancements were proposed. Lakewide alum treatments were applied to Pattison and Long Lakes in 1983 to reduce phosphorus release from lake sediments. (Hicks Lake was determined to not require treatment to significantly reduce phosphorus levels). Post-application monitoring indicated that internal loading of phosphorus on both lakes was reduced to about 1/3 of pre-treatment levels.[66]

An updated phosphorus budget was derived for Long Lake in 1994.[67] It was determined that mean annual in-lake total phosphorus levels had increased from the post-alum treatment level of 18 mg/liter to 30 mg/liter. Pre-treatment levels were 38 mg/liter. The updated phosphorus budget derived in 1994 was:

In-lake sediments	45%
Stream (from Pattison Lake)	28%
Aquatic plants	18%
Nonpoint sources	9%
Total	100%

[63] Same cite. Page 200.
[64] Same cite. Page 175.
[65] Thurston County Lakes Water Quality Analysis and Restoration Plan, 1982, Entranco Engineers
[66] Final Report: Pattison and Long Lakes Restoration Project Final Report: Pattison and Long Lakes Restoration Project, Entranco, 1985.

[67] "Long Lake Phosphorus Control Strategy Technical Memorandum", Entranco, 1994.

Figure 19 – Hicks Lake Trophic State Indices

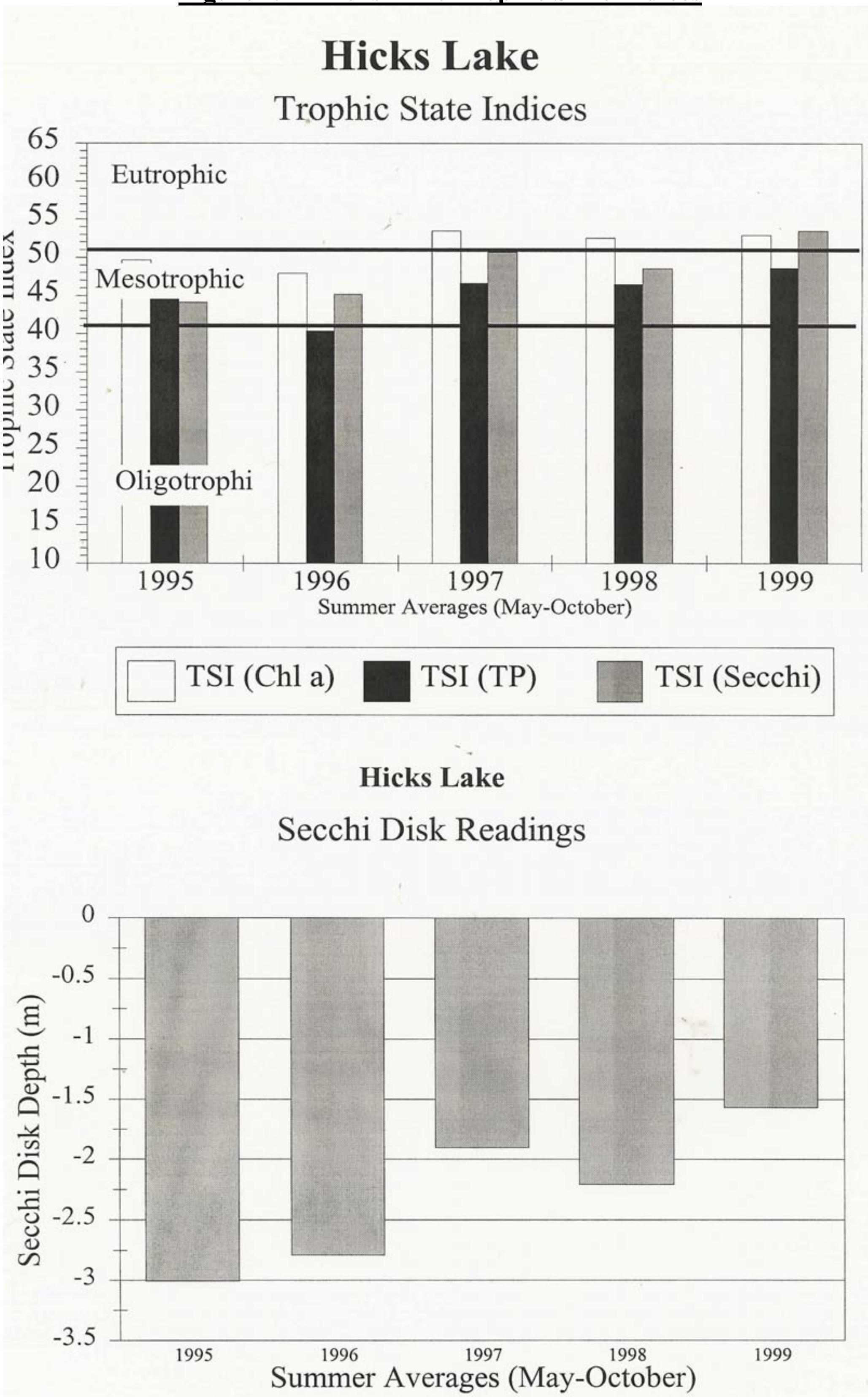
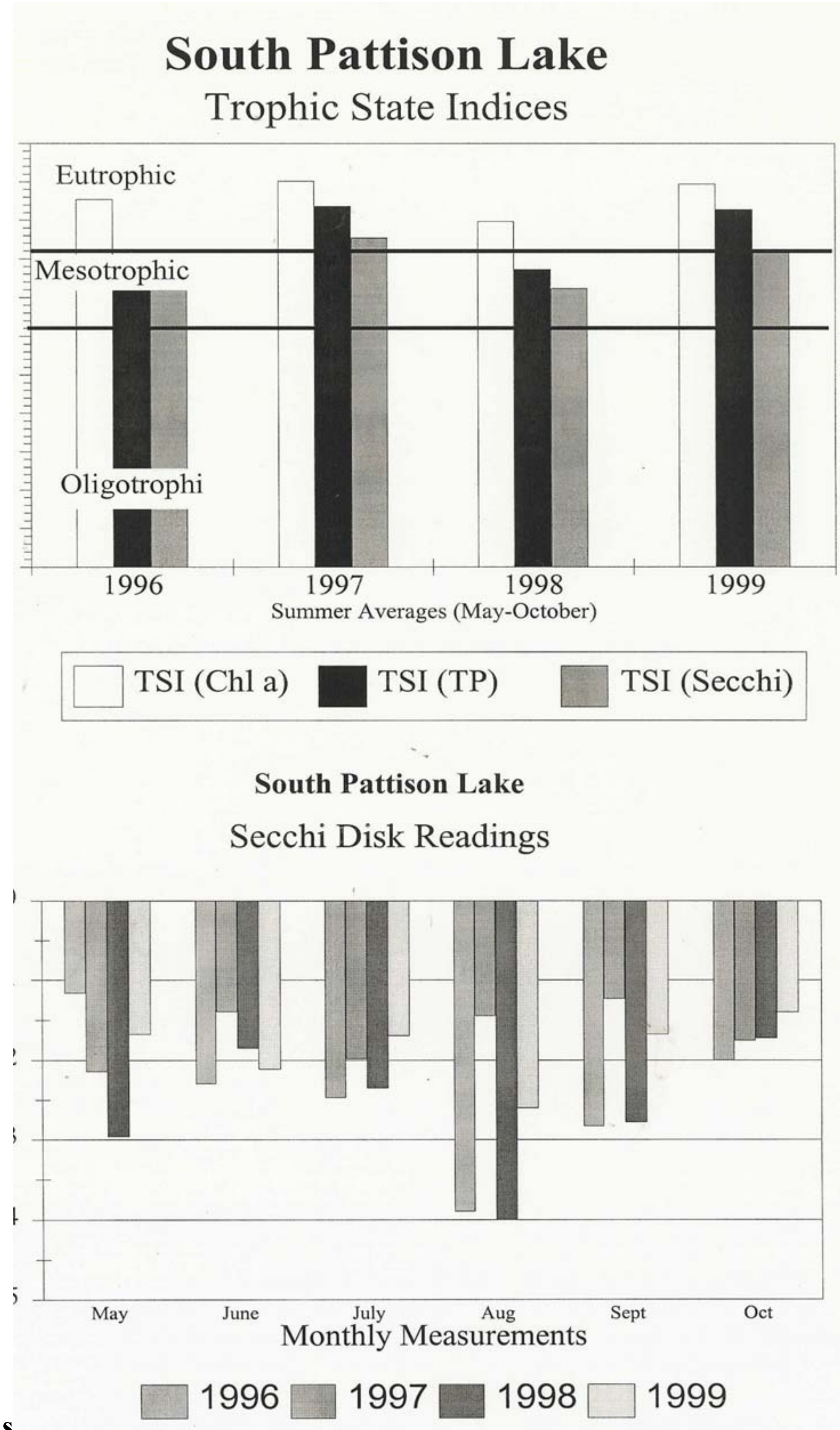
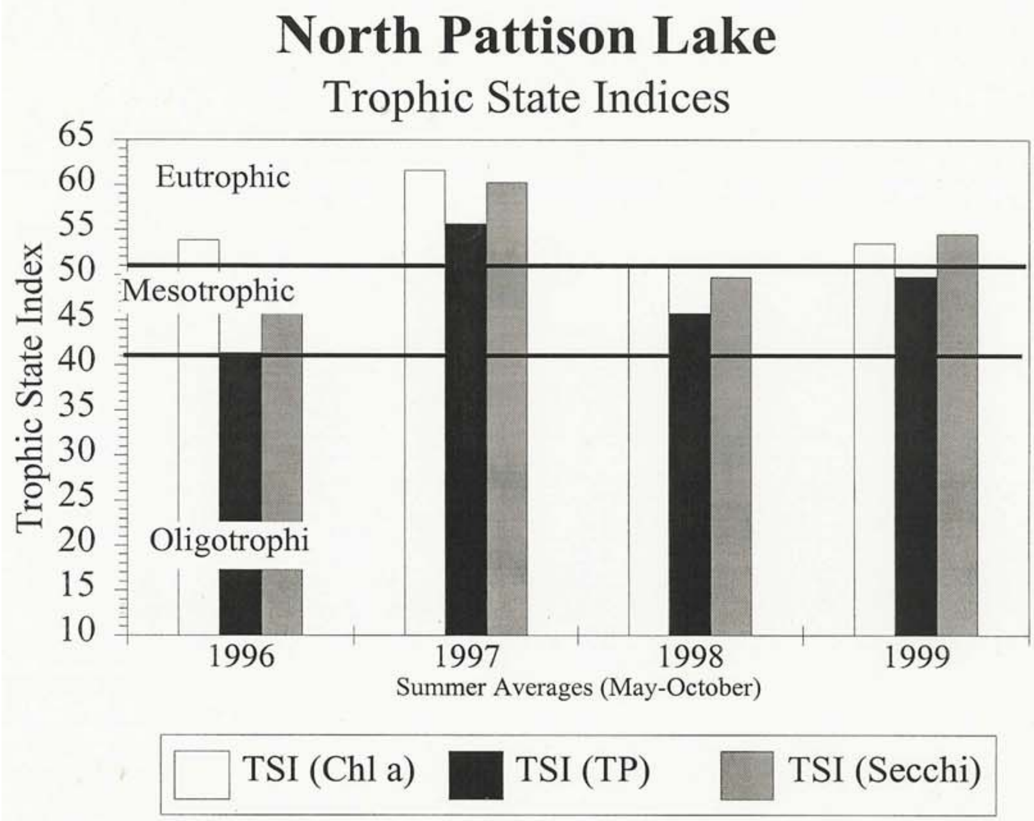


Figure 20 – South Pattison Lake Trophic State Indices



ns

Figure 21 – North Pattison Lake Trophic State Indices



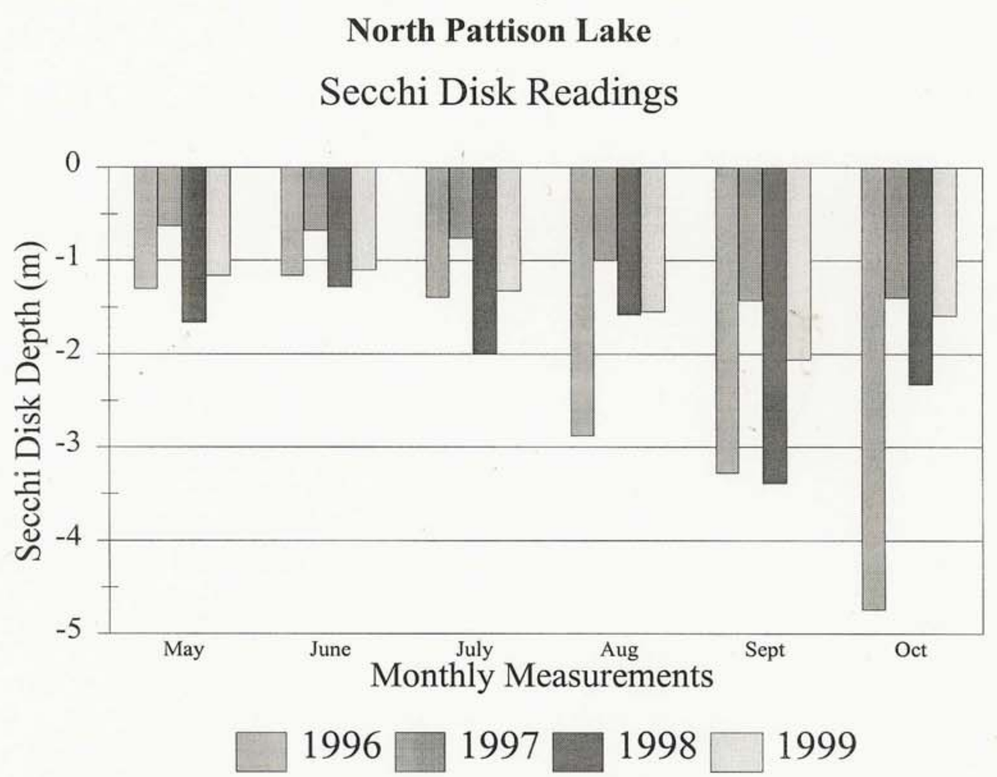
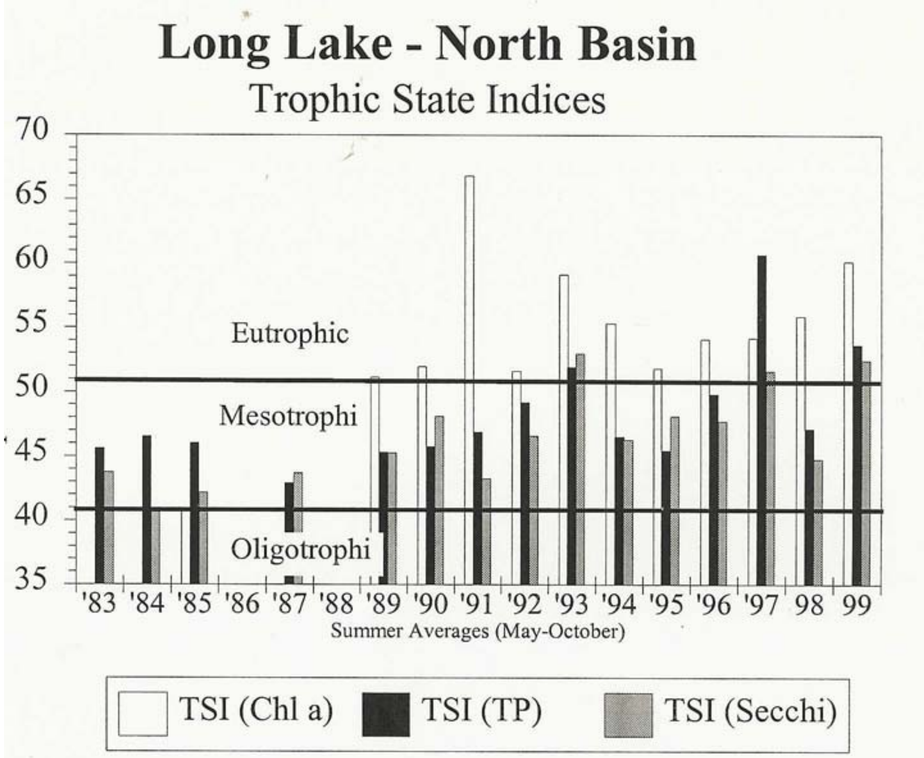
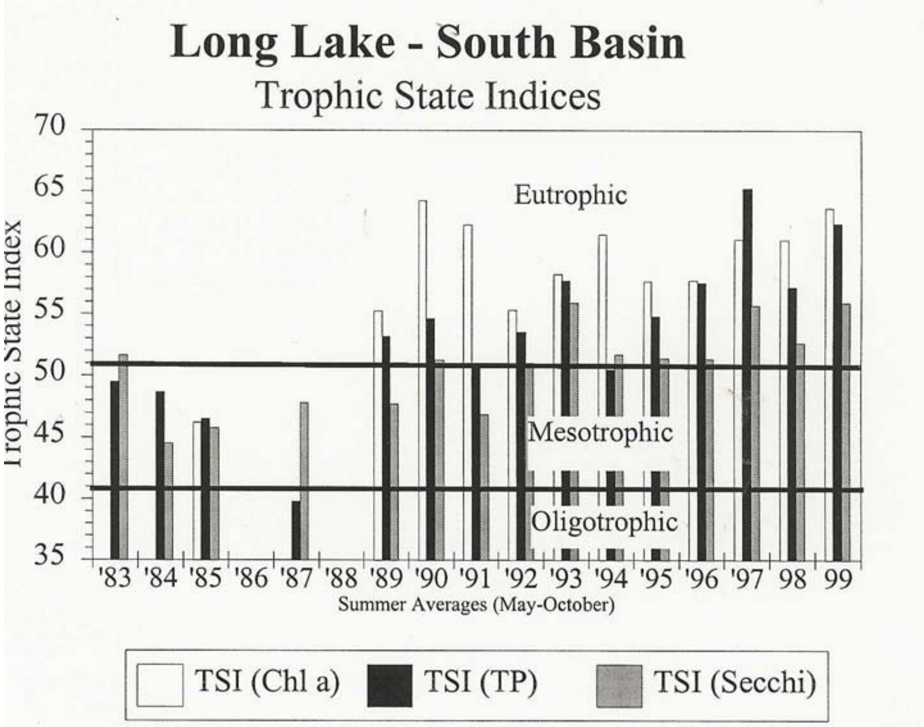


Figure 22 – Long Lake Trophic State





2.2.7 Groundwater Quality

Nitrate is commonly sampled in groundwater as an indication of water quality conditions. The maximum contaminant level for drinking water is 10 mg N/liter. Thurston County has adopted a Contaminant Action Level intended to trigger consideration of potential sources and possible actions at 4 mg/l.

Comprehensive groundwater quality data was collected in the mid-1980's as part of the USGS groundwater study and model.[68] Ambient sampling is conducted twice per year for 37 wells in northern Thurston County. Approximately a dozen of these wells are in the Henderson Inlet watershed. In 1998-99, no well in the ambient network exceeded the maximum contaminant level. However, nine of the wells exceeded the Contaminant Action Level.

For 22 monitoring wells, data exists for 1989 and from 1995 to 1999. Nitrate concentrations increased in seven of the 22 wells and decreased in two wells. The other wells had very small differences. Nitrate levels have increased over the sampling period in all but the deepest aquifer, the undifferentiated deposits (Tqu) and bedrock (Tb).

A larger set of wells is sampled for nitrate through the Thurston County Environmental Health lab. Mean nitrate level for these samples over the past several years is shown below. In many cases, these samples are submitted to comply with public water system operating requirements. Overall, the samples represent human exposure to nitrate rather than the true content of the various aquifers and values would be expected to be lower than the true mean of nitrate in Thurston County's aquifers. [69] However, they may be useful in examining overall trends.

Implications of the following data table as described in the North County Ambient Monitoring Network report for 1998-99 water year: "The data indicate a slow increase in mean nitrate levels in northern Thurston County. We believe the spike in 1997 was related to the high rainfalls of that period. The data for southern Thurston County show a similar increase over the same time period."[70]

Mean Nitrate Levels – Well Water Samples submitted to Thurston County Environmental Health Lab		
Year	**Mean nitrate (ppm)**	**Number of samples**
1989	1.0	359
1995	1.2	110
1996	1.1	208
1997	4.3	389
1998	1.6	399
1999	1.7	238

[68] Hydrology and Quality of Ground Water in Northern Thurston County, WA, USGS Water-Resources Investigations Report 92-4109 (Revised)
[69] Ground Water Monitoring Report 1998-1999 Water Year, Thurston County Environmental Health, included in Thurston County Water Resources Monitoring Report 1998-1999 Water Year. See page 308-b.
[70] Same cite.

Existing and Emerging Water Quality Programs

A wide range of actions has been taken or is being initiated to address water quality problems. These are summarized on the following table.

In addition to the larger-scale efforts summarized in Table 9, a Lake Management District has funded aquatic weed control, monitoring and other activities for Long Lake since the late 1980's. The "Integrated Management Plan for Long Lake" (1995) provides overall guidance to aquatic plant management and algae control activities.

Table 10 - Existing Or Upcoming Water Quality Programs Affecting WRIA 13

Issue	Area	Parameters	Timeframe
303(d) List – List of “impaired” waterbodies issued by DOE per Federal Clean Water Act	Nearly all significant streams; inlets; some lakes	Wide range of pollutants and habitat impairments	Fall 2002 – DOE initiates scoping in WRIA 13 for priority Total Maximum Daily Loads (TMDLs) to restore polluted water bodies. Five-year process is generally anticipated for a TMDL. 2013 – TMDLs for waterbodies on 1996 303(d) list scheduled to be complete.
South Puget Sound Model Nutrient Study (SPASM) – DOE study of loading from treatment plants and tributaries	South Sound	Nutrients, Biochemical Oxygen Demand (BOD), and Dissolved Oxygen	January 2001 - Calibrated model of loading from various sources June 2002 – Final report. Following June 2002 – Possible TMDL allocating loads from various sources to restore So. Sound water quality.
Shellfish Protection Districts – County-created district to respond to State downgrade of commercial shellfish harvesting area due to documented water pollution (RCW 90.72)	Nisqually Reach and Henderson Inlet watersheds	Fecal coliform bacteria and other associated pollutants such as nutrients and BOD.	Late 2000 – DOH downgraded shellfish status in portions of Henderson Inlet and Nisqually Reach. State/local agencies to identify a response strategy. First quarter 2001 – Shellfish Protection Districts anticipated to be formed by County Commissioners Following early 2001 - Action program to identify and correct pollution affecting the downgraded areas
LOTT Wastewater Resource Management Plan	Olympia/Lacey/Tumwater Urban Growth Area	Various contaminants in wastewater flow are treated. Higher standards will be required for wastewater reuse.	December 1998 – LOTT Partners adopt Plan, refers to DOE 2002 – Initial “satellite” treatment/reuse facility anticipated; proposed to be located in Henderson watershed (Hawks Prairie area).
Development Regulations – Land use plans and ordinances of the County and cities; design standards for erosion and stormwater control.	County-wide; specific regulations apply to aquifer recharge areas, riparian corridors, other sensitive areas	Fine sediment, various pollutants associated with residential and commercial development	Currently – All jurisdictions have Growth Management plans and development regulations 2001 – New stormwater design manual based on new DOE requirements 12/02 – Comprehensive Stormwater Management Programs (NPDES) approved by DOE
Comprehensive Drainage Basin	All urban-area stream	Streamflow (replicate pre-	Basin Plans have been adopted for each urban-area

Plans – Hydrologic modeling of alternative futures; recommended capital projects and activities to address water quality & flooding.	watersheds	development runoff conditions); pollutants from roads and other urban developed areas	watershed identifying activities and facilities to address quantity and water quality issues. Implementation on-going; varies by Basin Plan
Early Warning Levels and Contaminant Action Levels Policy - Groundwater nitrate levels of concern that may warrant a response plan. (Thurston County Board of Health Resolution H-2-96)	County-wide. Applies where well samples document elevated nitrate levels.	Nitrate contamination of groundwater through human activities	1992 – Recommended in Northern Thurston County Groundwater Management Plan 1996 – Adopted by County Board of Health Implementation on-going
Designated Wellhead Protection Areas – Protects the recharge area for wells serving larger “public” water systems. Water systems submit capture area maps and protection plans to DOH for approval. Complemented by special land use regulations adopted by County and cities.	County-wide. State planning requirement applies to all Group A water systems (15 or more hookups).	Groundwater contaminants.	1992 – Recommended in Northern Thurston County Groundwater Management Plan 1997 – Special Thurston County land use standards adopted for wellhead areas serving 1,000 or more customers July 1999 – Original target date for all Group A systems to comply with State DOH WHPA plan requirements. (Only partial compliance to date).

2.2.8 Fishery Habitat

Stream Habitat

Both Woodland Creek and Woodard Creek have good spawning and rearing habitat conditions for at least some of their reaches: gentle to moderate gradient, good pool/riffle conditions, cold water and gravelly beds. Estuarine habitat in fairly pristine conditions exists at the mouth of both creeks. In general, the lower portion of the creek corridors are in rural uses and zoned for low density (one unit per five acres). In contrast, the upper portion of both streams is either developed in suburban/urban uses or designated as Urban Growth Area where land use is intended to intensify in coming years. This poses multiple challenges for protecting habitat from common results of urbanization, including removal of large woody debris from the stream channel; reduction of vegetated riparian corridor width; and changes in hydrology. [71]

A detailed habitat survey was conducted on the 1-½ mile reach of Woodland Creek from Draham Road to Pleasant Glade Road in 1992. The survey found overall good habitat conditions suitable for salmonid rearing, with suitable spawning habitat in the upper reaches. However, the portion of the study area adjacent to suburban residential development (Woodland Creek Estates near 15th Avenue) had significantly fewer woody debris complexes. The study identified these debris complexes as providing the most fish habitat over the range of anticipated flows in the creek. [72] Habitat at the entire range of flows is particularly important for coho, as coho juveniles remain in the stream for a full year after leaving the gravel nests. [73]

Off-channel rearing is a key habitat requirement particularly for over wintering species such as coho. Fox Creek (inventory number 130009) has been identified as an important off-channel site. The one-mile long creek has good riparian cover and open water wetlands totaling approximately 30 acres. The 30-acre watershed has been identified as a Focal Priority Watershed with importance for Woodland Creek. However, in the overall context of WRIA 13 salmon habitat Fox Creek received a "low" protection priority ranking. Several wetlands associated with Woodland and Woodard Creek have the potential to function as refuge from high flows. Documentation is limited. [74]

Salmon utilization

About 17 miles of stream habitat usage is documented within the Henderson Inlet watershed. Additional areas may provide seasonal use for juveniles or isolated spawning areas. A summary of documented salmonid species utilization, habitat limiting factors and stock status is provided

---

[71] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, 1995, Thurston County.
[72] Analysis of Existing Fish Habitat in a Portion of Woodland Creek, Thurston County, Washington, Caldwell and Johnson, 1992. Report is included in the Woodland/Woodard Drainage Basin Plan cited above.
[73] "The Relative Role of Habitat in Health Populations of Natural Spawning Salmon", Smith, Carol. This brief comprehensive summary is included as an appendix to the Salmon Habitat Limiting Factors Final Report for WRIA 13, WA Conservation Commission, July 1999.
[74] Identification of Salmon Refugia for Protection in WRIA 13, Thurston Conservation District, June 2000.

in Table 10.[75] Other species documented within the system include cutthroat trout, rainbow trout and Olympic mud minnow. [76]

In Woodland Creek, chum, coho and chinook spawn principally in the 3.3 miles of lower Woodland Creek below Beatty Springs and the other springs in the vicinity. Juvenile coho, steelhead and cutthroat utilize the lower 3.3 miles and upper 1.0 mile for year-around rearing and the Lake Lois reach (where flows are often intermittent) for seasonal rearing. [77] A few additional miles of documented salmon habitat utilization are provided in Woodland Creek tributaries.

Woodland Creek salmon spawning presence has been documented for several years. Data collected since 1956 indicate a decline in coho numbers. [78], Recent year data is shown on Table 11. [79]

---

[75] Salmon utilization information is from Salmon Habitat Limiting Factors Final Report for WRIA 13, WA Conservation Commission, July 1999.

[76] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, 1995, Thurston County. Table 3-1 provides a listing of fish found in Woodland and Woodard Creeks in a survey conducted November 28, 1990.

[77] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, 1995, Thurston County. A 1991 letter from P. Powers, Washington Department of Fisheries, is cited as the source for information on areas utilized by salmon in Woodland and Woodard Creeks.

[78] Woodland and Woodard Creek Comprehensive Drainage Basin Plan, 1995, Thurston County. A 1991 letter from Chuck Baranski, Washington Department of Fisheries, is cited as the source for this data.

[79] Spawning Ground Database for Woodland Creek, from Ron Egan, WDFW.

Table 11 History of Fish Presence in Woodland Creek

Source: Washington Department of Fish and Wildlife		
YEAR	***SPECIES***	***COUNT***
1990	COHO	41
	Annual Subtotal	**41**
1991	COHO	26
	Annual Subtotal	**26**
1992	COHO	176
	CHUM	5
	Annual Subtotal	**181**
1993	COHO	87
	CHUM	145
	CHINOOK	2
	Annual Subtotal	**234**
1994	COHO	119
	CHUM	293
	STEELHEAD	1
	Annual Subtotal	**413**
1995	COHO	68
	CHUM	115
	Annual Subtotal	**183**
1996	COHO	85
	CHUM	104
	CHINOOK	1
	Annual Subtotal	**190**
1997	COHO	92
	CHUM	96
	CHINOOK	5
	Annual Subtotal	**193**
1998	COHO	111
	CHUM	80
	CUTTHROAT	4
	Annual Subtotal	**195**
1999	COHO	6
	CHUM	1
	CHINOOK	48
	Annual Subtotal	**55**
TC:ss/wria/178/93531/3197/woodlandcreekfish.xls		

Woodard Creek has about 7 miles of documented habitat usage. The upper half of the creek has a low gradient with isolated riffles. This portion of the stream supports juvenile rearing with limited spawning activity observed in the isolated riffles. The downstream 3 ½ miles of Woodard Creek has a low to moderate gradient and a good pool/riffle configuration. Chum, coho, steelhead and sea-run cutthroat have been observed spawning in this reach. There is no comprehensive data set regarding salmon occurrence in Woodard Creek.

Limiting Factors

Significant factors and recommended actions identified in the WRIA 13 Salmon Habitat Limiting Factors Final Report (LFA) and subsequent investigations include:

Urban stormwater runoff

Urban stormwater discharge is a significant factor for both creeks. Woodland Creek is impacted particularly by drainage from the College Street area entering the creek between Martin Way and I-5. Woodard Creek headwater receives significant stormwater runoff from the South Sound Center/Pacific Avenue commercial area. The LFA recommended reviewing stormwater projects identified in the 1995 Woodland/Woodard Comprehensive Basin Plan to reprioritize projects to address impacts on salmon habitat.

<u>Status of remedial stormwater projects:</u>

- Woodland Creek: The College Street stormwater system discharges to Woodland Creek above I-5. This is the last large untreated stormwater outfall in the City of Lacey. Design and land acquisition are in process for a project to attenuate peak flow impacts and improve water quality in the College Street Ditch system. Lacey is also working on improving habitat along portions of Woodland Creek in the Martin Way to I-5 springs area and above Lake Lois.

  Thurston County's 20-Year CFP (which has not yet been funded) includes projects to address stormwater runoff from the Martin Way/Tanglewilde area that discharge to Woodland Creek. However, the 2000 Six-Year Capital Facilities Plan for stormwater facilities does not include any projects in the Henderson Inlet Watershed.

- Woodard Creek: The City of Lacey is lead agency for Fones Road Ditch outfall improvements to reduce peak flow and improve water quality. Preliminary design for the project is complete and property acquisition is in process.

Instream flow

The LFA recommends that the Watershed Planning process address larger issues of instream flow and hydraulic continuity. See Water Rights and Water Use section above for discussion of estimated groundwater withdrawal and theoretical volumes associated with water right records.

Fish barriers

Barrier culverts were identified on several small tributary streams: Jorgenson Creek and Eagle Creek on Woodland Creek; Furlong Creek (130013) and Lemon Creek (130014) on Woodard Creek. Potential fish passage problems were also noted at the Pleasant Glade Road crossing on Woodland Creek. The LFA recommended prioritizing and correcting these barrier problems. [80] Additional stream assessment following the 1999 LFA led to identification of the Pleasant Glade culvert as a significant barrier between good spawning areas in lower Woodland Creek and prime rearing areas upstream, including Fox Creek. [81]

<u>Status of remedial actions</u>*:* Pleasant Glade culvert replacement was the top-ranked request submitted for the Second Round 2000 Salmon Recovery Board funding. Thurston County Roads and Transportation Services is the project proponent.

Restoration of functional riparian zones

For both Woodland and Woodard Creeks, the LFA identified the need for short-term actions restore Large Woody Debris in the channel and long-term reestablishment of high-density conifer presence in the riparian zone. Riparian zone integrity will also be a key to addressing water temperature concerns.

[80] WDFW Fish Passage Barrier Database, SSHEAR, 1999. Data included in LFA at Table 9.
[81] <u>Identification of Salmon Habitat Refugia for Protection in WRIA 13</u>, TCD, June 2000.

Table 12 Henderson Inlet Watershed Salmon Usage and Habitat Limiting Factors

FROM 1999 "SALMON HABITAT LIMITING FACTORS FINAL REPORT"					
STREAM (Index Number)	**SPECIES**	**Documented usage (miles)**	**Total stream miles**	**DESCRIPTION**	**LIMITING FACTORS FOR STREAM HABITAT (1)**
Woodland	Chinook	3.1		Below Martin Way, large springs support perennial flows and salmon	Urban stormwater impacts: Intensified peak flow, reduced low flow.
130006	Coho	5.1		usage. Goes dry above Martin Way, although historical references	Culverts (especially on tributaries)
	Chum	5.0		to salmon in this stretch is asserted.	Water temperature, low d.o. and excess fine sediment.
	Steelhead	5.1			Riparian habitat disturbance and lack of LWD
	Subtotal	5.1	11.0		Bank erosion in Lake Lois/Martin Way section: Downstream bedload.
Fox Hollow Crk	Coho	0.4		Small trib entering Woodland at Mile 0.4. Drains subdivided area to east.	
# 130007	Subtotal	0.4	1.3		
Jorgenson Crk	Coho	0.4		Enters at left bank River Mile 1.1	
# 130008	Subtotal	0.4	1.0		
Fox Creek	Coho	0.3		Small trib entering Woodland at Mile 1.1. Drains undeveloped/wetland area.	Pleasant Glade Rd culvert is partial block for adults and total block for
# 130009	Chum	0.0		Important rearing habitat in Woodland system (2)	juvenile migration from good spawning area downstream in Woodland Cr
	Subtotal	0.3	1.2		to prime rearing area in Fox Creek.(2)
Eagle Creek	Coho	1.1		Enters at right bank Mile 2.1. Begins east of Marvin Road. Watershed	
#130010	Chum			largely undeveloped but within designated UGA.	
	Subtotal	1.1	2.0		
Woodard #130012	Coho	7.0		Most of creek is utilized as habitat. Headwaters is in urban area	Alteration of natural flow regime
	Chum	3.6		near I-5 and Pacific Avenue.	Culverts block access to tributaries
	Steelhead	7.0			Elevated water temperature
	Subtotal	7.0	7.5		Riparian habitat and LWD impaired
SMALL DIRECT TRIBS TO HENDERSON INLET					
Dobbs Creek	Coho	1.5		Small direct stream to east side of Henderson Inlet.	Poor water quality (fecal coliform) but data indicated improvement
#130005	Chum	1.5		Drains wooded and pasture area.	following ag improvements (3)
	Subtotal	1.5	1.5		

Sleepy Creek	Coho	1.0		Small creek runs to Chapman Bay on west side of inlet.	Fecal coliform pollution and high turbidity; likely impact from ag uses (3)
#130015	Subtotal	1.0	1.1		
TOTAL: STREAMS IN HENDERSON INLET WATERSHED				**STOCK STATUS AND DESCRIPTION**	
	Chinook	**3.1**		May be strays; self-supporting population not documented.	Note: Incidental sightings not included. Subtotals reflect miles of documented salmon habitat usage for the waterbody (not additive from individual species usage).
	Coho	**16.8**		Deep Sound stock status in question (1994 SASSI rated "healthy".)	
	Chum	**10.1**		Henderson chum may be distinct stock; status rated "unknown".	
	Steelhead	**12.1**		Stock origin or status not classified.	
	Total miles	**16.8**	26.6		

(1) Source is Habitat Limiting Factors Final Report, WRIA 13 (1999) unless otherwise noted.
(2) TCD Refugia Study (2000)
(3) Water Resources Monitoring Report 1997-98 Water Year (Thurston County)

tc/excel/wria13/henderson salmon distribution1.xls