

## SECTION 2: TECHNICAL SUMMARY

### 2.1 INTRODUCTION

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The following section contains a summary of each of the technical studies performed for this assessment. More detailed analysis is provided in each of the technical appendices and within Section 3.

### 2.2 GEOLOGY AND HYDROLOGY

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#### 2.2.1 GEOLOGY

The Chehalis Basin has several distinct geologic regions with unique geologic history. For example, the headwaters arise out of the Willapa Hills, which are primarily comprised of marine volcanic and sedimentary rocks, while some other regions are primarily glacially influenced. Much of the basin is underlain by old ocean floor that was dragged up with the Olympic Mountains. The hills and valleys were carved into these slabs of oceanic rock by erosion, resulting in low rounded hills and ravines. At the end of the ice ages, meltwater from the Puget Sound glaciers flowed down the Black River and Lower Chehalis. After the ice ages ended, sea levels rose by several hundred feet and flooded the mouth of the Chehalis. This created Grays Harbor, and caused the river valleys to fill in with sediment.

The complex geologic history of the Chehalis Basin dictates to a large degree the distribution, quantity, and movement of groundwater. Primary geologic units include bedrock of volcanic and sedimentary origin, as well as glacial deposits and alluvial material. Volcanic rocks (primarily basalt flows) underlie most of the basin, but have been overlain by sedimentary deposits of marine and non-marine origin or glacial material. Near surface volcanic deposits dominate the Black Hills west of the Black River, as well as the southern Olympic Mountains. Scattered volcanics occur throughout the remainder of the Chehalis Basin.

Sedimentary rocks include those of the Eocene/Oligocene epoch and younger rocks of the Miocene epoch. The older sedimentary rocks dominate the Lincoln Creek and South Fork Chehalis Basins, in addition to terraces along the mainstem Chehalis. The younger rocks are found primarily between the Satsop and Wynoochee River valleys.

Much of the basin possesses glacial deposits from at least four different glaciations. The Black River/Scatter Creek area is underlain by approximately 100 feet of deposits from the southern terminus of the Vashon stade of the Fraser glaciation, which inundated Puget Sound. In addition, alpine glaciers have flowed south from the Olympic Mountains, shaping the surface features of much of the lower Chehalis Basin. Finally, the major river valleys contain significant deposits of alluvial material. This material is often mixed with glacial deposits, forming a complex mosaic of unsorted material.

Groundwater conditions in bedrock units are not well studied. Well records indicate that the rock may hold groundwater, but it is often at considerable depth and not present as a contiguous aquifer. Groundwater in these deeper bedrock units exists in rock fractures under confined conditions and usually does not interact directly with surface waters.

The greatest quantity of groundwater exists in the glacial and alluvial deposits found in river valleys and upland terraces. In many cases, multiple aquifers are present, which interact directly with surface waters. Groundwater conditions and interaction with surface waters has been studied to the greatest degree in the Vashon glacial deposits in the Black River/Scatter Creek area. Conditions in the mainstem Chehalis and Newaukum basin have also received considerable study. While it is known that streams and rivers in the Chehalis depend heavily on groundwater discharge for low flow maintenance, quantification of this dependence has only recently been undertaken in the most heavily studied aquifers. The degree to which groundwater pumping may affect stream flows has not been adequately documented.

## 2.2.2 HYDROLOGY

The Level 1 assessment of surface water quantity in the Chehalis Basin included several independent analyses which can be summarized under the following four headings:

- ◆ Compilation of available data (streamflow, climate, structural features);
- ◆ Analysis of gaged flows;
- ◆ Analysis of natural climate variability; and
- ◆ Undepleted gaged flows.

The products presented in this report will serve as building blocks for the Level 2 efforts.

The majority of these analyses were conducted at the basinwide scale, while others produced information by WRIA or are specific to certain subbasins. In many cases, this information will have to be refined at a subbasin level. A notable local example is the Black River Subbasin, where the hydrology of the upper basin has been greatly modified. Although Black Lake historically flowed into the Black River, at the present, at least during the dry season, there is no surface water connection from the lake to the river, and the lake flows out of the Chehalis Basin toward Percival Creek (Berg, 1993). Some of the factors believed to be contributing to this change in hydrology include: a ditch built in the 1920s from Black Lake to Percival Creek to prevent flooding; a pipeline installed in the 1960s through wetlands at the southern end of the lake, which has formed a topographical high point; and several dozen beaver dams.

### **Compilation of Available Data**

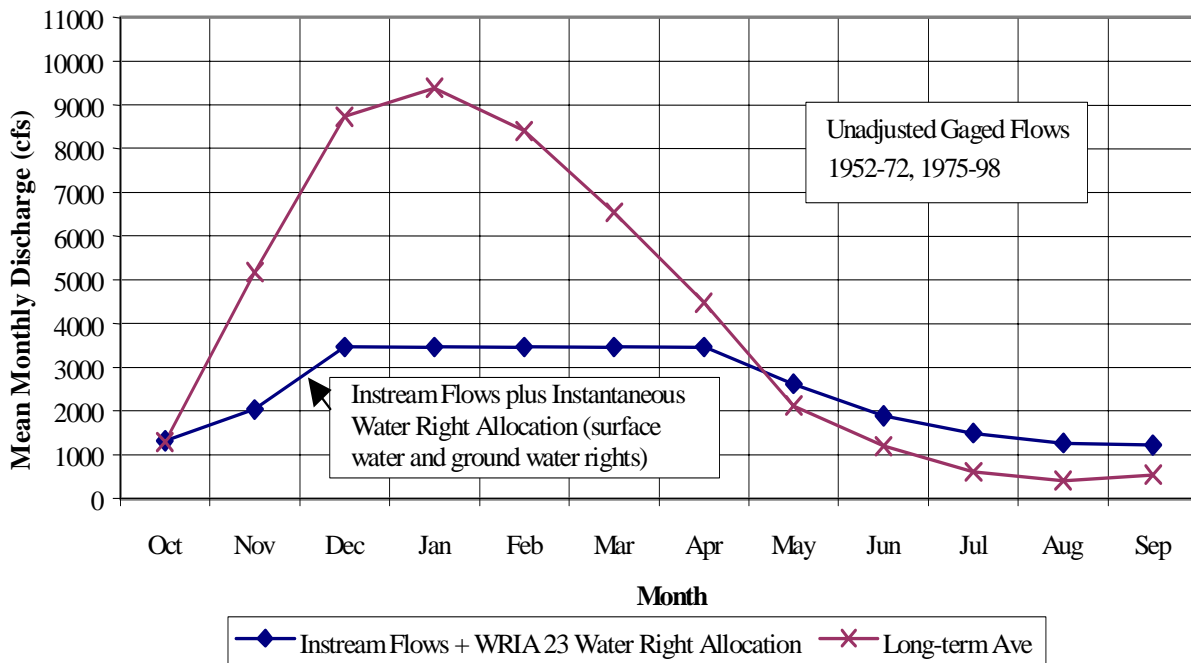
A substantial amount of hydrologic and climatic data is available for the Chehalis Basin. Of particular notice, were several streamflow stations, which have been continuously monitored since the early part of the 20th Century. Characteristics of current and historic streamflow and climate data stations located in or near the Chehalis Basin (Map 4) were identified and are presented in Appendix A, Tables A-1 through A-3. Structural features identified in the Chehalis Basin included seventy dams (Map 3). The majority of these are concentrated near the City of Aberdeen and in the Black and Skookumchuck Rivers subbasins.

## Analysis of Gaged Flows

In order to obtain an understanding of the existing flows in the Chehalis River, gaged flows at or near the mouth of each WRIA were examined. The gaged flows along the Chehalis River are influenced by upstream dams and myriad diversions. Dams typically influence the flow regime of a river by reducing the peak flows and augmenting low flows; pre-dam and post-dam data sets can represent two distinct population of flows dependent on operation policies.

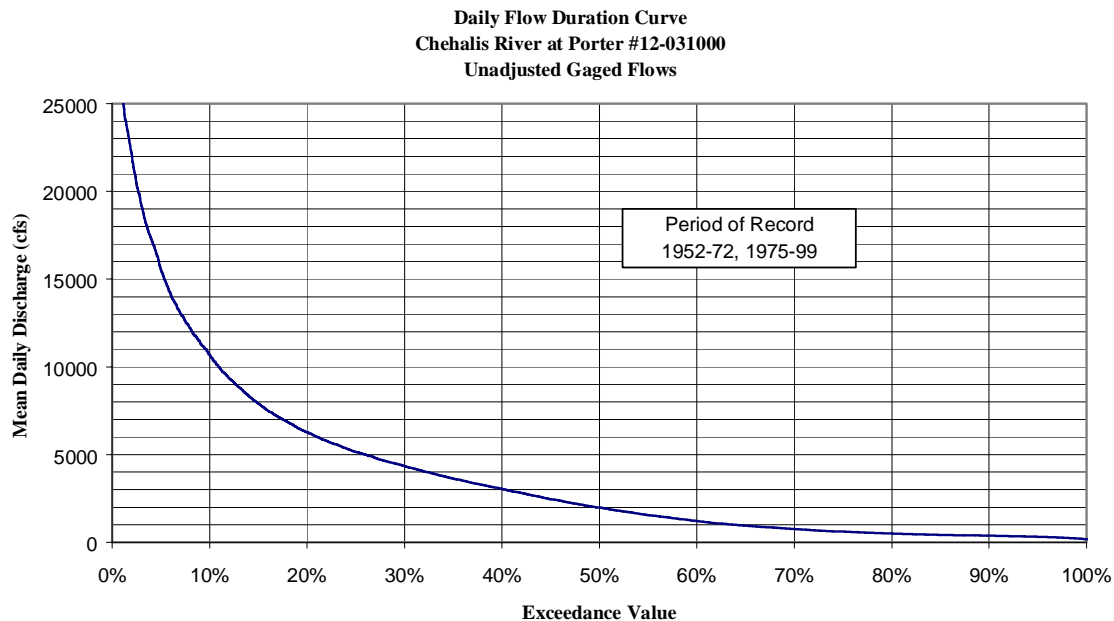
The Chehalis River at Porter (#12031000) is located at the downstream end of WRIA 23 and, therefore, reflects surface water quantity totals for this WRIA. Fifty-four dams were identified within WRIA 23, 14 of which had storage rights listed in the water rights database. The largest dam in WRIA 23 is the Skookumchuck Dam (Subbasin #9), completed in 1971. The USGS gage log notes minor effects of flow regulation from this dam on the streamflows recorded at the Chehalis at Porter gage. At this level of analysis, the impact of this and the other dams on the flow in the Chehalis River is unknown.

The mean monthly hydrograph for the Chehalis River at Porter (1952-72,1975-98) is displayed in Figure 2.2-1. This hydrograph represents gaged flows in the Chehalis River at Porter; it is not adjusted for regulation or the numerous unidentified diversions throughout WRIA 23. For perspective, the average bimonthly instream flows at the Porter control point (as set by WAC 173-522-020) were added to the total water right allocation for WRIA 23 (961 cfs), and plotted on Figure 2.2-1. This graph indicates that the combination of the instream flow and the instantaneous water right allocation (which includes both surface water and ground water rights) exceeds the gaged mean monthly flows from May through September.



**Figure 2.2-1**  
**Chehalis River at Porter (12-031000) Regulated Mean Monthly Hydrograph**  
**Unadjusted Gaged Flows**

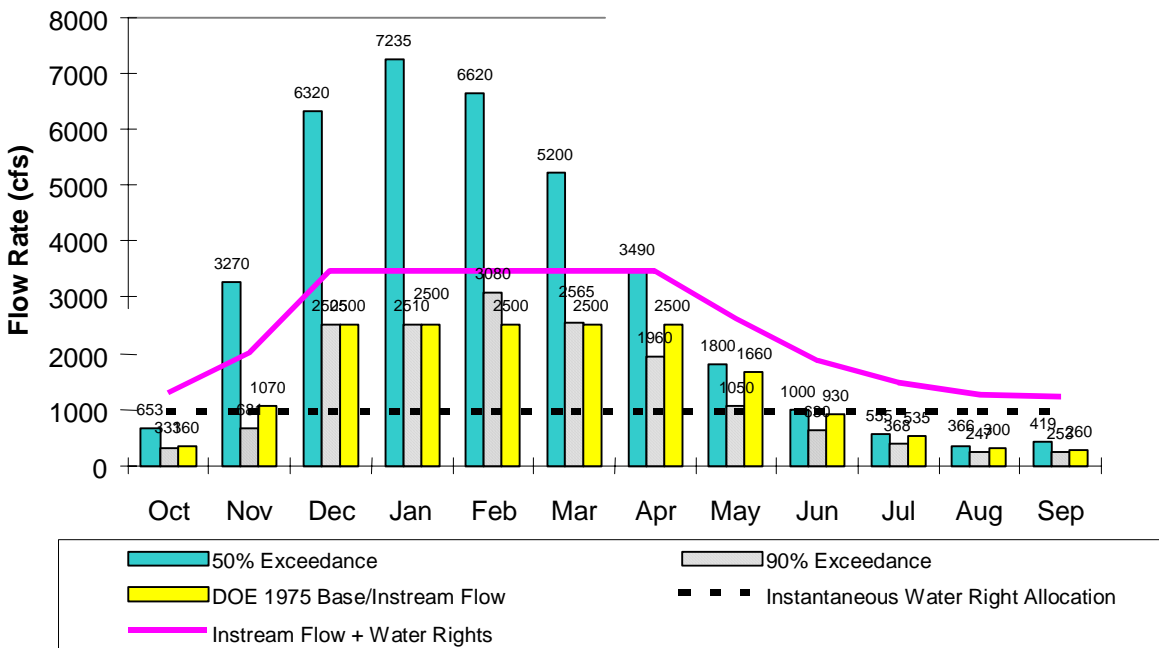
A flow duration curve for the Chehalis River at Porter (Figure 2.2-2) was generated based on the gaged flows. Flow duration curves provide an indication of the frequency distribution of flows at a station. Since exceedance values are indirectly proportional to the flow, the 90% exceedance values are always less than the 50%, the median flow value of the data series (half of the flows will be less than the 50% exceedance value and half will be greater). Of the mean daily flows recorded at the Porter gage, half have been equal to or greater than 1,980 cfs and 90% of the flows have equaled or exceeded 370 cfs. As with the hydrograph, the flow duration curve represents flows as measured at the Chehalis River at Porter gage, not adjusted for regulation or the numerous unidentified diversions throughout WRIA 23.



**Figure 2.2-2  
Chehalis River at Porter (12-031000) Flow Duration Curve  
Unadjusted Gaged Flows**

### WRIA 23 Comparison Of Streamflow And Allocated Water

Figure 2.2-3 compares the 50% and 90% exceedance values for the Chehalis River at Porter with the instream flows and the total allocated water for consumptive uses for the entire WRIA 23. In addition, the graph includes a series for the combined instream flow plus the instantaneous water right allocation. This graph indicates that the combination of the instream flow and the instantaneous water right allocation (which includes both surface water and ground water rights) exceeds the gaged 50% exceedance flows from April through October, two more months than shown in the mean monthly flow graph (Figure 2.2-1).



**Figure 2.2-3. WIRA 23: Chehalis River at Porter  
Comparison of Streamflow and Allocated Water**

Surface water quantity totals for WRIA 22 were more difficult to estimate since there was no flow data available near the mouth of the Chehalis River. Additionally, WRIA-wide totals would not be hydrologically meaningful since several of the major tributaries in WRIA 22 drain directly to Grays Harbor, not to the Chehalis River. Instead, lower Chehalis River surface water runoff was estimated at Montesano, near the upstream end of the tidally influenced reach.

Flows at Montesano were estimated by adding gaged flows (Chehalis River at Porter, Cloquallum, Satsop, and Wynoochee) and incorporating unit runoff estimates for the ungaged portions along the river valley between Porter and Montesano. Accretion flow from the 165 mi<sup>2</sup> of ungaged drainage to the Chehalis River between Montesano and the Porter Creek confluence was estimated using a combination of unit runoff values and the relationship of flows at the Chehalis at Porter gage. Mean monthly unit runoff values were generated from the 8 years of gage records available at the historic Chehalis River at south Elma station located mid-basin. These monthly unit values compared favorably to values from the longer-term base gages and therefore were used. Exceedance values for the ungaged area between Montesano and Porter were derived by using a ratio of the mean monthly to the 50% and 90% exceedance value at the Chehalis River at Porter gage. These exceedance values were then added to the accumulated values of the gaged flows (Porter gage + Cloquallum, Satsop, and Wynoochee) to represent flows available at Montesano.

The Chehalis River at Montesano exceedance values listed in Table A-6 were based on data from 1957-72 and 76-98, the coinciding years of record at the four gages. This period did include both pre- and post-dam years on the Wynoochee and, therefore the values do not represent an estimate of natural flow. Instead, the exceedance values were based on the addition of unadjusted gaged flows, which reflect the many unidentified diversions throughout both WRIA's

and regulation of the Wynoochee River. There is no instream flow control point on the lower Chehalis River near Montesano.

**Table 2.2-1  
Flow Exceedance Values for Chehalis River at Montesano**

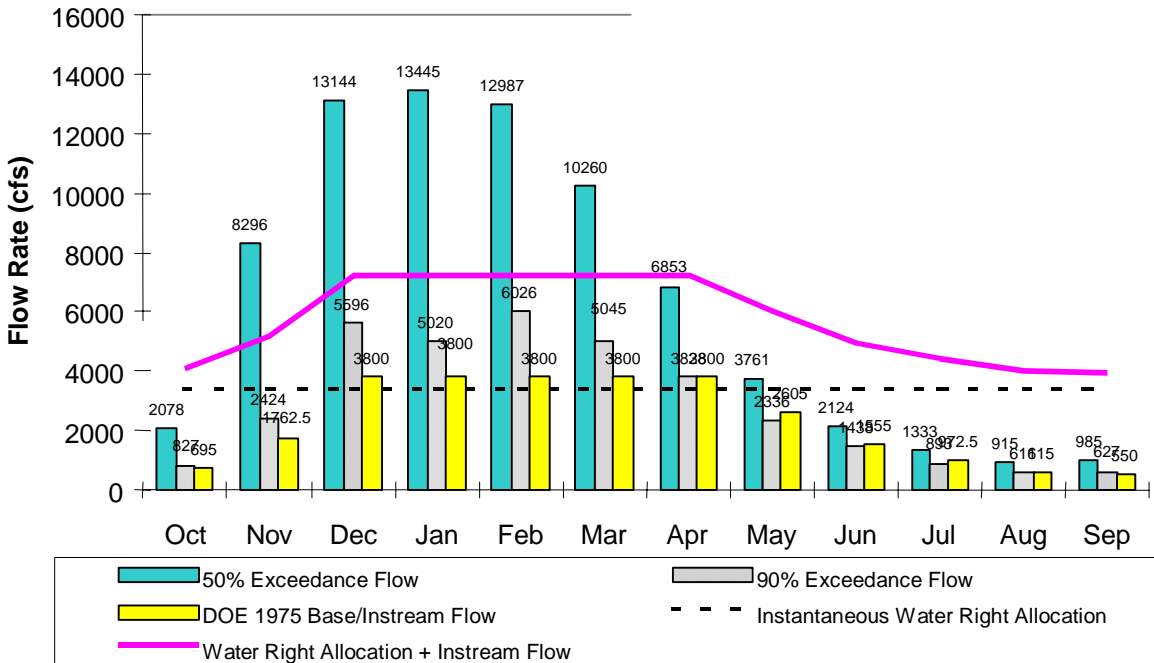
Month	Estimated Flow Exceedance Values <sup>1</sup>			
	Chehalis River at Montesano			
	50% Exceedance (cfs)	50% URO <sup>2</sup> (cfs/mi <sup>2</sup> )	90% Exceedance (cfs)	90% URO <sup>2</sup> (cfs/mi <sup>2</sup> )
October	2078	1.05	827	0.42
November	8296	4.19	2424	1.23
December	13144	6.65	5596	2.83
January	13445	6.80	5020	2.54
February	12987	6.57	6026	3.05
March	10260	5.19	5045	2.55
April	6853	3.46	3828	1.94
May	3761	1.90	2336	1.18
June	2124	1.07	1438	0.73
July	1333	0.67	893	0.45
August	915	0.46	611	0.31
September	985	0.50	627	0.32

<sup>1</sup> based on the addition of daily data from four gages USGS station #12-031000, Chehalis R. at Porter, Cloquallum #12-032500, Satsop R #12-035000, and the Wynoochee R. #12- 037400 for coinciding record years 1957-72,76-98 + accretion flow to Montesano; drainage area = 1,978 mi<sup>2</sup>

<sup>2</sup> URO = unit runoff

### WRIA 22& 23 Comparison of Streamflow and Allocated Water

Figure 2.2.4 compares the 50% and 90% exceedance values for the estimated Chehalis River flows at Montesano with the instream flows on the Chehalis below Satsop (the most downstream instream flow control point) and the total allocated water for consumptive uses for both WRIs 22 & 23. In addition, the graph includes a series for the combined instream flow plus the instantaneous water right allocation. This graph indicates that the combination of the instream flow and the instantaneous water right allocation (which includes both surface water and ground water rights) exceeds the estimated 50% exceedance flows from April through October.



**Figure 2.2-4. WRIA 22 & 23 Chehalis River at Montesano  
Comparison of Streamflow and Allocated Water**

### Analysis of Natural Climate Variability

The cycles in natural climate variability in the Chehalis Basin were investigated using data from two climate stations (Centralia, and Aberdeen) and one streamflow station (Satsop near Satsop). All of the stations analyzed in the Chehalis Basin showed adherence to the regionally identified phases of natural climate variability; no alternative trends in either streamflow or precipitation were identified at this level of analysis. Appendix A and Section 3 discuss how the period of record at selected gages in the Chehalis Basin represent regional patterns. In general, the longer duration streamflow and climate stations showed a mix of wet and dry years mimicking the regional climate variability patterns.

### Undepleted Gaged Flows

Of the 30 subbasins identified in the Chehalis Basin, all but five (Decker Creek, M Fk Hoquiam, E Fk Hoquiam, Elks River, and the Chehalis Lower Reach 2 to the mouth) had some systematic streamflow records located within the boundaries. Prior to using these streamflow records to generate summary statistics representative of “natural” flows, two factors were investigated: 1. the extent of upstream regulation and abstraction of water, and 2. the climate variability over the period of record. Few of these streamflow stations have recorded flows unhampered by human uses. The actual flow at some of the stations may be near “natural” or “undepleted” by withdrawals, while many of the stations recorded flows that were substantially depleted from natural flows due to regulation or withdrawals of water for municipal, irrigation, or other uses. A detailed streamflow depletion analysis was not conducted for any of the gages in the Chehalis Basin but could be considered for a level 2 analysis; the term undepleted is used in this report to qualify the reviewed gage records.

Twenty gages located in thirteen of the 30 subbasins were identified as having sufficient streamflow data reflective of “undepleted” flows; these were termed base gages. (Note: A list of these gages and their locations is included in Appendix A). For these stations, summary statistics were generated on a monthly basis and normalized into runoff per square mile to allow comparison of runoff production across the basin. For this analysis, information was produced two scales: 1) general estimates of runoff for 6 defined hydrologic regions; and 2) specific information for the five subbasins selected for more detailed analysis.

Primarily due to the extreme variation in precipitation across the Chehalis Basin, the amount of runoff varies dramatically (up to four-fold) from 3 cfs/mi<sup>2</sup> along the low lying valley bottom area to more than 12 cfs/mi<sup>2</sup> in the upper watersheds draining the Olympic Mountains. Based on the unit runoff data, precipitation isohyets, geology, and other characteristics, the Chehalis Basin was divided into 6 hydrologically similar areas as presented in Table 2.2-2. Insufficient streamflow data existed on the South Bay tributaries (Johns, Elk, Charley) to determine representative unit runoff ranges in the Level 1 assessment.

These regions of similarity will be useful for Level 2 analyses to produce flow estimates in ungaged basins. Level 2 analyses may also involve hydrologic techniques such as correlation analysis between miscellaneous flow measurements and concurrent gage data and normalization of flows by drainage area (per unit runoff calculations for various flow events). Additionally, a core period of record could be selected to assure that undepleted flow estimates reflect the natural variability in climatic conditions. Base station streamflow records could be extended through correlation analysis with nearby gages as appropriate to cover the selected core period of record, then unit runoff calculations could be updated.

**Table 2.2-2.  
General Areas of Hydrologic Similarity within the Chehalis Basin**

Description of Hydrologically Similar Areas	Annual unit runoff range (cfs/mi <sup>2</sup> )	Winter average unit runoff <sup>1</sup>	Summer (low flow) average unit runoff <sup>2</sup>
North Bay/ Inner Harbor low-lying tributaries (Hoquiam, Lower Humptulips)	5-8	10-15	1-2
Humptulips to Wynoochee Upper Watersheds	10-12	21-24	3-4
WRIA 22 & 23 Low-lying valleys along Chehalis and tributaries	3-4	7-9	<1
Satsop River Basin	6-7	9-13	1
WRIA 23 Mid-basin major tributaries with headwaters in foothills of cascade range (Black, Skookumchuck, Newaukum)	4-5	8-9	1
WRIA 23 Upper Chehalis headwaters in Willapa Hills (Elk, SF, Stillman...)	3-5	7-10	<1

<sup>1</sup> Winter Season for this study is defined as December through March

<sup>2</sup> Summer Season for this study is defined as July through September

Detailed hydrologic analyses were undertaken in five of the 30 subbasins (Section 3) to estimate monthly exceedance values reflective of undepleted flows. For watershed planning purposes, it is important to understand the amount of time that streamflow can be expected to be at different

levels e.g. low flows, median flows. In this report, the 90% exceedance flow was presented as a marker of low flows while 50% exceedance value was indicative of normal flows.

The records generated for each of the five basins reflected some degree of anthropogenic effect. In some of the basins, (e.g. #25 the Humptulips) the estimated undepleted flows may be closer to the true value while in other basins the gaged streamflow was depleted by the cumulative impact of many small diversions upstream. Deregulating a streamflow record in mixed use, high agricultural use areas (e.g. #7 Newaukum), or mainstem (Subbasins #19) is beyond the Level 1 effort. Documenting the amount of upstream diversions may be necessary in the Level 2 assessment. In addition, in high unit runoff areas (e.g. Humptulips), the effects of neglecting a few minor water withdrawals may not substantially impact the magnitude of the flow duration curve except during the low flow season; in basins with low unit runoff, more emphasis should be placed on identifying diversions upstream of stream gages. Adequate estimates of natural flow may never be obtained short of conducting continuous hydrologic modeling.

## ***2.3 WATER RIGHTS/ WATER USE***

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The Level 1 Assessment of water rights and water use for the Chehalis Basin involved reviewing and using numerous databases and reports. The primary resources included:

- ◆ Department of Ecology's Water Rights Allocation Tracking System (WRATS)
- ◆ Department of Ecology's GEOWRATS
- ◆ Department of Health's public water systems data
- ◆ USDA, National Agricultural Statistics Service, 1997 Census of Agriculture
- ◆ U.S. Department of Commerce, Census Bureau, 1990 Census Data
- ◆ WSU Cooperative Extension
- ◆ Lewis County Conservation District

### **2.3.1 WATER RIGHTS**

The GEOWRATS and WRATS databases were used to determine the subbasin in which each water right was located. After each water right was assigned a subbasin, a summary of water rights was conducted by number of certificates, permits, and applications for ground and surface water, instantaneous right, annual volume limitations, and irrigated acres. Table 2.3-1 summarizes the instantaneous water right ( $Q_i$ ) and the annual volume limit ( $Q_a$ ) by primary purpose in each WRIA and for the total Chehalis Basin. Map 5 indicates locations of water rights in the basin. The rights were categorized as consumptive or non-consumptive rights. The latter have a lesser degree of impact on the stream network since most of the water withdrawn returns to the river downstream. Most power rights in western Washington are usually for hydropower generation and these are generally non-consumptive, however, the Centralia Steam Plant generates thermoelectric power which is highly consumptive. This must be kept in mind when viewing Table 2.3-1.

There were a total of 769 water rights in WRIA 22 (Lower Chehalis Basin) including 9 storage rights for a total allocated diversion/withdrawal amount of 3,718 cfs and volume limits at nearly 120,000 acre feet. Storage rights totaled 71,190 acre-feet. The largest number of rights was

attributed to irrigation (406) and secondly domestic use (200). There were about 10,204 acres associated with water rights assigned irrigation as a primary beneficial use; another 1,355 irrigated acres were associated with water rights for which other beneficial uses were primary, such as domestic or stock watering. In WRIA 22, 30 of the largest water rights represented 90% of the total allocated diversion/withdrawal rate; 27 surface water rights and 3 ground water rights.

WRIA 23 (Upper Chehalis Basin) contained more than double the number of water rights than WRIA 22; 1,828 water rights for a total allocated amount of 961 cfs for direct flow diversions and ground water withdrawals. The volume limit was 116,728 acre-feet plus an additional storage volume of 35,657 acre feet (14 storage rights). Irrigation rights were tied to 33,947 acres. Forty percent of the rights (724 in number) represented 90% of the allocated water. There were a significant number of small water rights throughout WRIA 23 that spread the allocation to many rather than a few as in WRIA 22. Twenty-two rights (~1%) covered 40% of the allocation

**Table 2.3-1  
Summary of Water Right Quantities by Use<sup>1</sup>**

Primary Purpose	WRIA 22 (Lower Chehalis Basin)		WRIA 23 (Upper Chehalis Basin)		TOTAL	
	Qi (cfs)	Qa (acre feet)	Qi (cfs)	Qa (acre feet)	Qi (cfs)	Qa (acre feet)
<b>Consumptive Rights</b>						
Commercial	86.66	1,348	9.18	1,518	95.84	2,866
Domestic	616.60	5,920	45.88	6,990	662.48	12,910
Irrigation	175.84	13,102	411.60	48,202	587.44	61,304
Municipal	206.20	112,837	60.92	14,003	267.12	126,840
Stock	12.80	1,765	51.02	6,871	63.82	8,636
Other	9.53	1,236	18.82	2,249	28.35	3,485
Thermal Power*	80.0	54,360	-	-	80.0	54,360
Subtotal	1,187.63	190,568	597.42	79,833	1,785.05	270,401
<b>Non-Consumptive Rights</b>						
Fish Propagation	157.56	411	128.94	37,426	286.50	37,837
Wildlife	1.84	157	2.57	125	4.41	282
Hydro Power*	1,409.43	0	232.32	35,001	1,641.75	35,001
Subtotal	1,568.83	568	363.83	72,552	1,932.66	73,120
<b>TOTAL</b>	<b>2,756.46</b>	<b>191,136</b>	<b>961.25</b>	<b>152,385</b>	<b>3,717.71</b>	<b>343,521</b>

<sup>1</sup>Envirovision and Watershed Professionals Network assume no responsibility for the accuracy of the data provided by the Washington Department of Ecology.

\*Power rights for hydropower are generally non-consumptive, however, thermal power is highly consumptive. Most power rights were assumed to be for hydropower.

## 2.3.2 Water Use

The main categories that were investigated for water use included commercial, residential, irrigation, and stock watering. Residential water use was estimated using 1990 population data that was projected forward by applying “average” growth rates from the data for the three primary counties in the watershed. Results are summarized in Table 2.3-2.

**Table 2.3-2  
Population Data for WRIA 22 and 23 Based on Average Growth Rates**

Year	WRIA 22	WRIA 23
1990	57,600	77,000
1995	60,480	84,700
2000	64,109	94,000
2005	66,032	103,400
2010	68,673	110,640
2020	76,914	122,810

The per capita demand was estimated using design standards from the Department of Health’s Water System Design Manual (WDOH, 1999). The average and maximum day demands in each WRIA were estimated using the population data and the per capita figures calculated from the Design Manual. The average per capita demand ranged from 118 gcd to 144 gcd (Table 2.3-3); a higher demand was computed for WRIA 23 since precipitation is lower there. The maximum day demand is assumed to be double the average (WDOH, 1999).

**Table 2.3-3  
Estimated Current Residential Water Demand**

WRIA	Average Per Capita Water Demand (gcd)	Year 2000 Average Day Water Demand (cfs)	Year 2000 Maximum Day Water Demand (cfs)
22	123	12	24
23	144	21	42
TOTAL		33	66

The total residential demand is substantially lower than the allocated water; the former was estimated at 66 cfs and the latter was roughly 267 cfs (Table 2.3-1). This discrepancy was apparent in other use sectors as well. Public water systems accounted for about 55% of the demand, the remaining 45% was associated with self supplied water users. Map 6 depicts locations of public water systems. This category can be defined as those water users outside of a public water system service area that may be withdrawing/diverting water under a water right or under an exempt well (RCW 90.44.050). A pilot study was conducted to assess two different methodologies for determining exempt well usage and is described below. Given average

growth rates, future residential water use is anticipated to increase by 3 cfs over the next 20 years in WRIA 22, and by 6 cfs in WRIA 23 for the same time period.

Actual commercial/industrial water use was not determined at this level of analysis. However, the largest six commercial/industrial water rights in WRIA 22 accounted for 86% of the allocated water, while there were 27 rights for a commercial/industrial allocation of 9.13 cfs in WRIA 23.

Irrigated agriculture appears to be on the decline in both counties as cropping patterns have changed. Even in Ecology's 1976 report, it appeared that the total water allocated for irrigation was not being put to beneficial use. Actual data for the watershed was, therefore, used from the 1997 Census of Agriculture report (USDA, 1999) as a surrogate: 5,765 acres irrigated in Lewis County and 3,067 in Grays Harbor County. By contrast, there were 12,444 acres allocated for irrigation in WRIA 23 and 11,559 acres in WRIA 22.

While the number of acres irrigated may be less than the water rights, it still represents a significant use of water. Irrigated agriculture is the highest consumptive use in the Chehalis Basin with perhaps one exception; the thermoelectric steam plant in Centralia. Because of the significance of this impact on the watershed, an assessment of the relative volumes of monthly consumptive use was undertaken.

As an example of irrigation demand, if it is assumed that pasture grass is grown on the 5,765 acres irrigated in WRIA 23 and the on-farm efficiency is 50%, the annual volume demand would be 16,960 acre feet/year. For WRIA 22, a similar number was calculated and equaled 4,150 acre-feet/year. Over a four-month irrigation season the former translated to roughly 70 cfs and the latter to about 17 cfs.

Given the order of magnitude difference in the allocated and potentially irrigated acreage in both WRIs, investigation into the actual use of irrigation water may be a worthwhile effort. As irrigated lands decline, and the fact that there appears to be substantially less irrigation than the acreage allocated under water rights suggests, it would be useful to know which water rights were actually being used and which ones were not. Because irrigation represents such a high consumptive use of water, this effort may be worth the time and cost to sort out in a Level 2 Assessment. However, it would require cooperation by the farm community to be useful.

Based on the county data and water use defaults from the WDOH, in WRIA 22, probably less than 0.5 cfs is used for livestock operations, while in WRIA 23, use may be as much as 1 cfs (WDOH, 1999). Water rights associated with stock watering totaled 12.80 cfs in WRIA 22 and 51.02 cfs in WRIA 23. In addition to stock watering, these rights also were associated with 1,256 and 4,242 irrigation acres, respectively. In any event, the water rights were significantly higher than the calculated estimates of stock water demand. Relative to other water uses, this sector does not warrant further investigation.

## 2.4 WATER QUALITY

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There is a large quantity of water quality data available for the Chehalis Basin, much of it collected as part of WDOE's Ambient Monitoring Program. This means there is a relatively standard data set available for a fairly long period of record. The goal of the Water Quality Assessment was to optimize the use of this and other data to provide a summary of the water quality condition. The key questions the analysis needed to address were these; Are water quality criteria being met? Has there been a change in water quality over time? Does the quality change with distance down the mainstem? What is the condition of the tributaries, or what is known about their condition?

To answer these questions, the analysis focuses on the parameters that are most closely linked to the objectives of this watershed planning effort. This is not meant to imply that other pollutants such as heavy metals or pesticides are not a concern in the Basin. There are of course sources of these pollutants. Some may be prioritized for more detailed evaluation at some later time in the planning process. The ambient monitoring data was prioritized for the analysis because it has a higher value for answering the key questions. This technical summary primarily focuses on the mainstem. Appendix C contains the detailed assessment of the Chehalis Basin's water quality in addition to an assessment for each subbasin for which there is adequate data.

### 2.4.1 METHODS

Water quality data for the Chehalis River is available from as far back as the late 1970's. WDOE monitors a few stations on the Chehalis as part of their Ambient Monitoring Program. The result is a set of routinely collected (and therefore comparable) data for three to five stations on the mainstem of the river. There is also ambient monitoring data available for stations at or near the mouths of a number of the major tributaries. In the Upper Chehalis (WRIA 23) this data set includes: South Fork Chehalis, Newaukum, Skookumchuck, and the Black Rivers. In the Lower Chehalis (WRIA 22) recent data are available for the Hoquiam (@ RM 9.3) and the Humptulips (@ RM 23.6). Ambient monitoring data from the 1970's is available for the Wynoochee and Wishkah Rivers. Map 7 depicts the locations of these ambient monitoring stations and 303D listed stream segments.

To assess possible long-term trends in the mainstem, data for the three stations that had been monitored since the late 1970's were used. Because data was only available for the last three years in the 70's, only data from the last 3 years of each decade were used for the trend analysis, to equalize the size of the data sets between decades. During the 1990's, 5 stations were routinely monitored on the mainstem. This data is assessed separately to allow for a more comprehensive look at possible trends with distance downstream.

Parameters were selected for analysis either because they were directly related to fish habitat and flow problems (dissolved oxygen (DO) and temperature), or because they are appropriate indicators of water pollution (total phosphorus (TP) and total suspended solids (TSS)), or because they are important in the basin since they are tied to a commercial industry (fecal coliform bacteria (FC)).

A pollutant loading analysis was performed for the mainstem of the river using average concentrations and average instantaneous flow measurements. The analysis also included an estimation of point source discharge loads and a comparison to measured seasonal loads in the mainstem. Where data was available, some pollutant load estimates are also provided for subbasins. These are also based on instantaneous flow measurements.

A pollutant load and yield analysis was also performed using estimated or extrapolated median flow values (50% exceedances flows) for the mainstem and tributary stations for which the hydrologic analysis required for calculation of median flows had been done. The use of median flow values allowed for a more valid comparison with values reported in a Puget Sound-wide study and also a less flow biased comparison between subbasins within the Chehalis.

## 2.4.2 WATER QUALITY CRITERIA

Water quality standards have been set for all surface waters in the State of Washington (WAC 173-201A). These standards for rivers and streams range from Class AA (Extraordinary) to Class C (Fair). The Class assigned to a particular stream or river reach is based on present and potential future beneficial uses of the water. However, the fact that a water body is listed as, for example, Class A does not signify that Class A water quality standards are met. It only means that the set of standards that define Class A waters will be used as the “ruler” to determine whether the stream or river is meeting acceptable standards.

Washington State water quality criteria (WAC 173-201A) for temperature, dissolved oxygen, and fecal coliform levels vary within the Chehalis Basin. The majority of the basin is defined as Class A (excellent) waters. Exceptions to this classification include three rivers and one mainstem reach for which Class AA (extraordinary) criteria apply, and two river sections for which Class B (good) criteria apply. Surface waters rated as Class AA include the Chehalis headwaters (Subbasin 1 and 2), the upper portion of the Humptulips (Subbasin 25), the Middle, East, and West Fork Satsop (Subbasin 17 and 18), the upper Skookumchuck (Subbasin 9), and the West Fork Wishkah and southern tributaries (Subbasin 21). Surface waters rated as Class B are the lower reach Hoquiam (Subbasin 22) and the first six miles of the Wishkah (Subbasin 21). Standard criteria for the different classes are provided in Table 2.4-1.

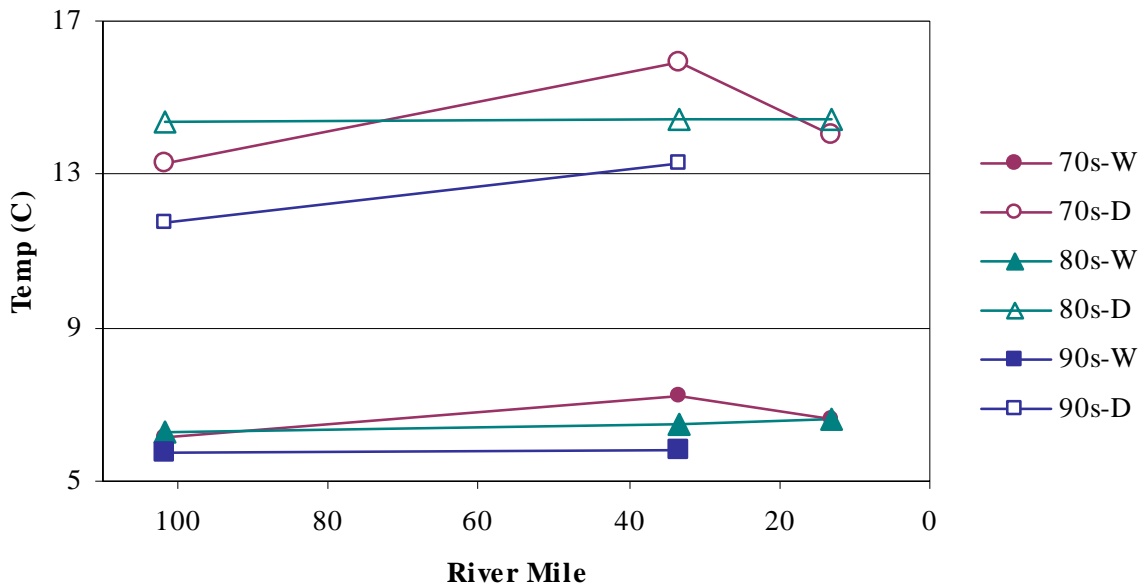
A notable exception to the Class A criteria on the mainstem Chehalis is the “Centralia Reach” (river mile 65.8-75.2). A natural sill in the river causes the water to “pool” upstream. This naturally slow moving reach has merited setting separate criteria for dissolved oxygen and temperature. The criteria for this reach includes a special condition stipulating that dissolved oxygen shall exceed 5.0 mg/l from June 1-September 15 and temperature shall be between 18 and 20.4°C (exact temperature standard depends on segment).

**Table 2.4-1.  
Washington State Water Quality Criteria.**

Class	Temperature	DO	Fecal Coliform
AA	shall not exceed 16°C from human conditions or if >16°C exists naturally, no temp increase >0.3°C	shall exceed 9.5 mg/L	shall not exceed a geometric mean of 50 colonies/100mL and shall not have > 10% of all samples exceeding 100 colonies/100mL
A	shall not exceed 18°C from human conditions or if >16°C exists naturally, no temp increase >0.3°C	shall exceed 8.0 mg/L	shall not exceed a geometric mean of 100 colonies/100mL and shall not have > 10% of all samples exceeding 200 colonies/100mL
B	shall not exceed 21°C from human conditions or if >16°C exists naturally, no temp increase >0.3°C	shall exceed 6.5 mg/L	shall not exceed a geometric mean of 200 colonies/100mL and shall not have > 10% of all samples exceeding 400 colonies/100mL

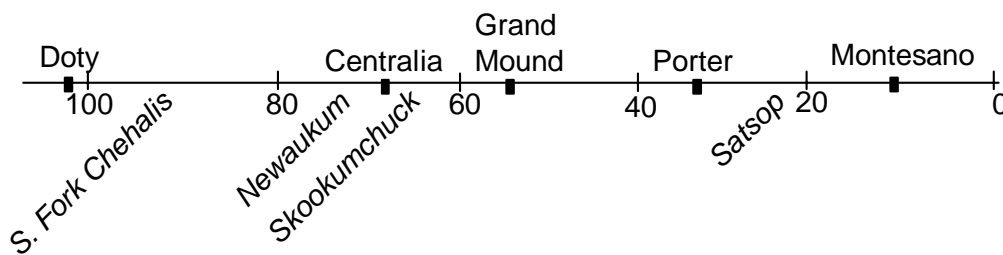
(Note: On a biannual basis the EPA creates a list of “impaired” waterways in the U.S. This is the official 303(d) List of Impaired Waterbodies, referred to as the “303(d) list”. Although there are numerous ways that a waterbody can be justified for inclusion in this list, the most frequently used method for Washington State waters is a simple assessment of whether State water quality criteria are being met. If criteria aren’t met, the waterbody, or in this case stream segment, will be added to the list. Once a stream segment is listed as impaired, it becomes the States responsibility to develop or support a plan for handling the problem. One tool used for developing strategies to improve water quality is a Total Maximum Daily Load (TMDL) study. (Appendix C contains a summary table depicting 303(d) listed segments for the Chehalis Basin.)

Water temperature has been documented as a problem in the Chehalis Basin and in a number of its tributaries. This documentation includes both direct temperature measurements, as well as field observations of reduced or eliminated riparian canopy, as described in Appendix D. Figure 2.4-1 depicts average wet and dry season temperature with river mile along the mainstem. (Figures 2.4-2 is provided to illustrate the relationship between river miles, as used in Figures 2.4-1; 2.4-3 through 2.4-7, and selected cities and tributaries.) As depicted, in terms of average dry season temperatures in the mainstem, the criteria are met. Temperatures appear to be slightly cooler at the upper mainstem station. There was no difference between the decades, thus no trend of deteriorating quality. Although comparisons between decades are interesting and may show recent water quality trends, the 1970’s would not represent a baseline condition for any of these water quality parameters. At that time, land conversion and associated loss of riparian canopy and forest cover along the river and tributaries would already have occurred.



**Figure 2.4-1**  
**Comparison of Temperature (3-Year Average) Along the Mainstem Chehalis over Three Decades.**

Although it is informative to know that the long term average seasonal (in this case August 1 through October 31) record does not indicate a temperature trend change, water quality exceedances and comparisons to criteria are more appropriately assessed by individual dates, sites, and measurements. Of the 25 segments of the Chehalis that are listed (303(d)) as having impaired water quality, 9 are listed due to temperature exceedances during the summer months when flows are lowest. All of these segments are within the upper basin except for the Humptulips. (Appendix C contains a summary table depicting 303(d) listed segments for the Chehalis Basin and those for which high temperatures are problematic.)

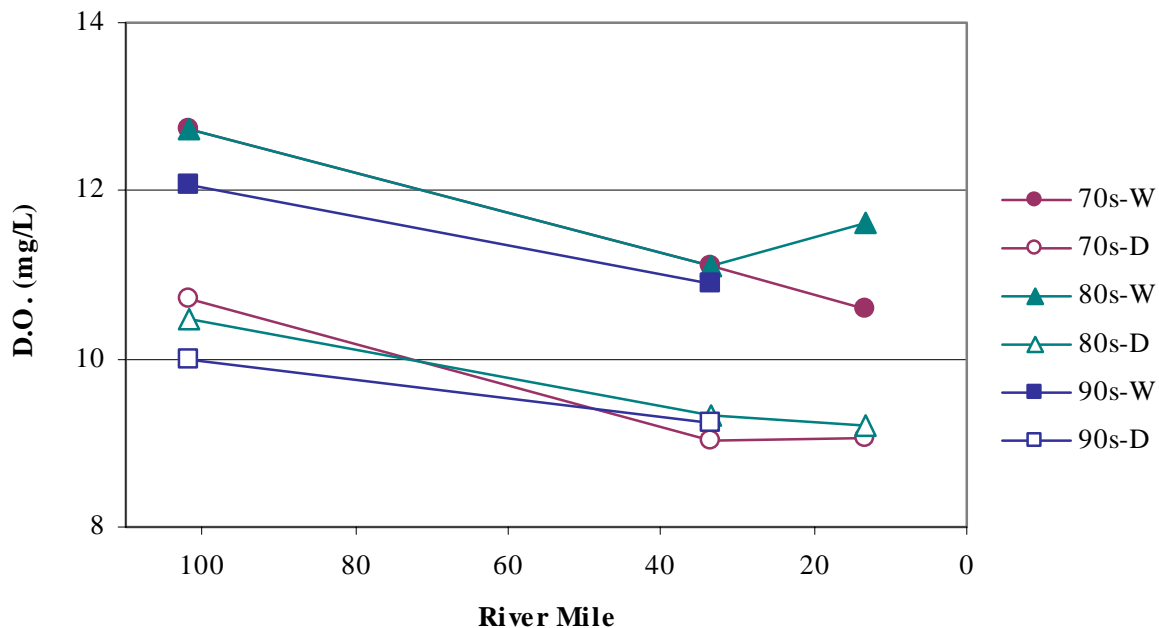


**Figure 2.4-2**  
**Mainstem Chehalis Rivermiles in Relationship to Selected Cities and Tributaries**

Dry season temperature exceedances in several tributaries in the Upper Chehalis have been reported (Pickett, 1994a). For example, the Upper Chehalis Basin exceeded temperature criteria on 62% and 24% of occasions during the June and July periods, respectively. (Not surprisingly, the highest temperatures were measured in the slow flowing Centralia Reach.) This led to the “Upper Chehalis Temperature TMDL” (Butkus, and Jennings, 1999). TMDL recommendations

were to increase riparian shading along the upper mainstem and its tributaries and disallow additional water withdrawals. Given the width of the Chehalis, it is doubtful that increased shading to the mainstem will substantially reduce temperatures. Notwithstanding the many other benefits from riparian shading of the mainstem, increases in shading of the tributaries may have a more significant impact on temperature regimes throughout the upper basin. Another recommendation of the study (Butkus and Jennings, 1999) was to reduce the width-to-depth ratio in three tributaries (Black River, Newaukum River and South Fork of the Chehalis River) to improve dry season temperatures (Butkus and Jennings 1999).

Similar to temperature, it is the late summer period (dry season) when dissolved oxygen concentrations can reach critical levels. As depicted in Figure 2.4-3, the average dry season dissolved oxygen concentrations at the three mainstem stations met the water quality criterion (8.0 mg/l) for Class A waters. Dissolved oxygen does appear to decline with distance downstream. No differences were found across the three decades.



**Figure 2.4-3**  
**Comparison of Dissolved Oxygen Concentrations (3- year average) along the Mainstem of the Chehalis over Three Decades.**

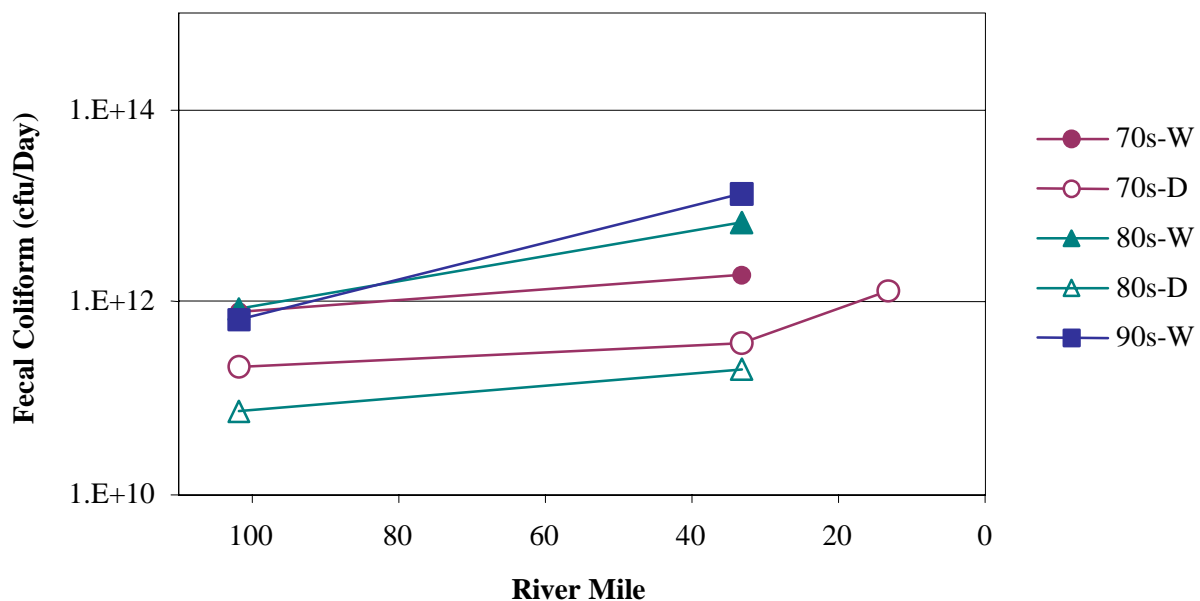
As with temperature, individual measurements of dissolved oxygen indicate that at some locations, the criterion is not met. Dissolved oxygen concentrations have also been found to be problematic in segments of the Chehalis. Of the 25 impaired segments listed on the 303(d) list, 11 are listed due to dissolved oxygen problems. With the exception of the Humptulips, all tributaries that did not meet the DO standard are located in the Upper basin. As previously described (Section 2.4.2), the slow-flowing Centralia Reach represents a natural condition that is largely responsible for the temperature and DO problems. New standards have recently been set to reflect this natural condition.

A TMDL was carried out by WDOE to examine contributing factors to the oxygen conditions in the upper basin (WRIA 23). The author recommended reductions in point and non-point sources of oxygen depleting contaminants (Pickett, 1994a).

Other than the Black River, there were no tributaries where both temperature and dissolved oxygen did not meet standards. However, this combination of high temperature and low DO existed throughout most of the Chehalis mainstem. This represents a critical set of conditions for fish health and survival.

FC bacteria represent a third parameter for which there is water quality criteria. It is the most common reason for listing of tributaries or segments in the Chehalis. Of the 25 listed segments, 19 are listed due to FC bacteria exceedances. Again, these segments are almost exclusively located in the Upper Basin. (Appendix C contains a summary table depicting 303(d) listed segments for the Chehalis Basin.)

Figure 2.4-4 depicts FC bacteria loads as estimated for the mainstem stations. At the upstream station, there is little difference between wet and dry season loads and there is no change across the decades. This could indicate that these load values represent a close to baseline condition. However, it is also possible that reproduction of bacteria during warmer weather is compensating for the increased load during wet, or that a local nonpoint source (e.g. manure spraying) is higher in summer. Although the data record is incomplete for the downstream stations, it suggests only slight increases in load during the dry season and more notable increases during the wet season. This indicates the fecal coliform sources located downstream of RM 101 (Doty) are also nonpoint related.



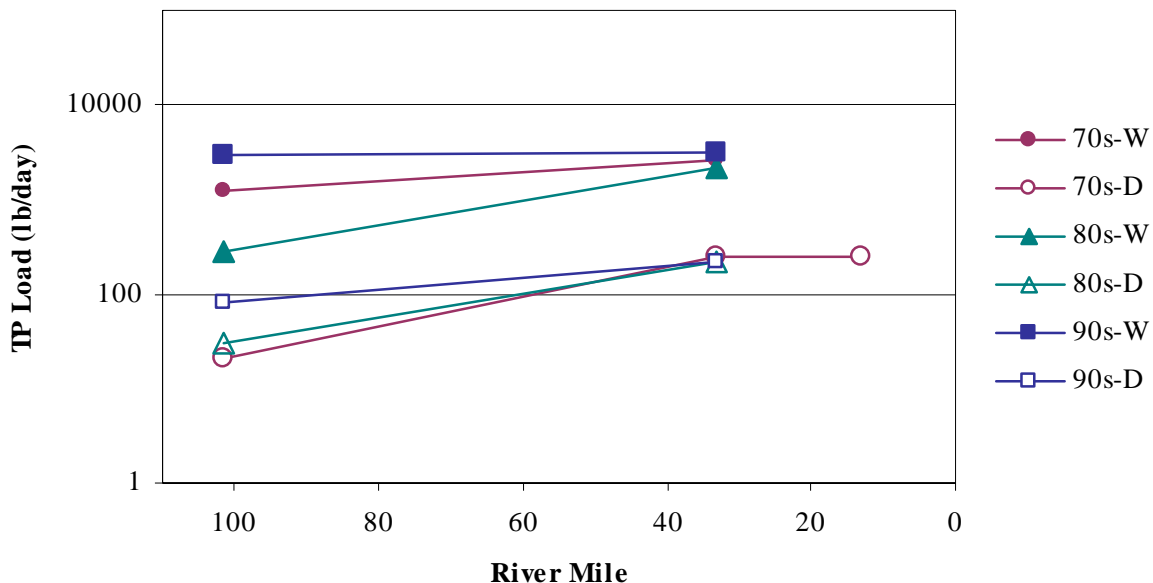
**Figure 2.4-4**  
**Comparison of Fecal Coliform Loads (3-year geometric mean) along the Mainstem of the Chehalis over Three Decades.**

### 2.4.3 POLLUTANT LOADING

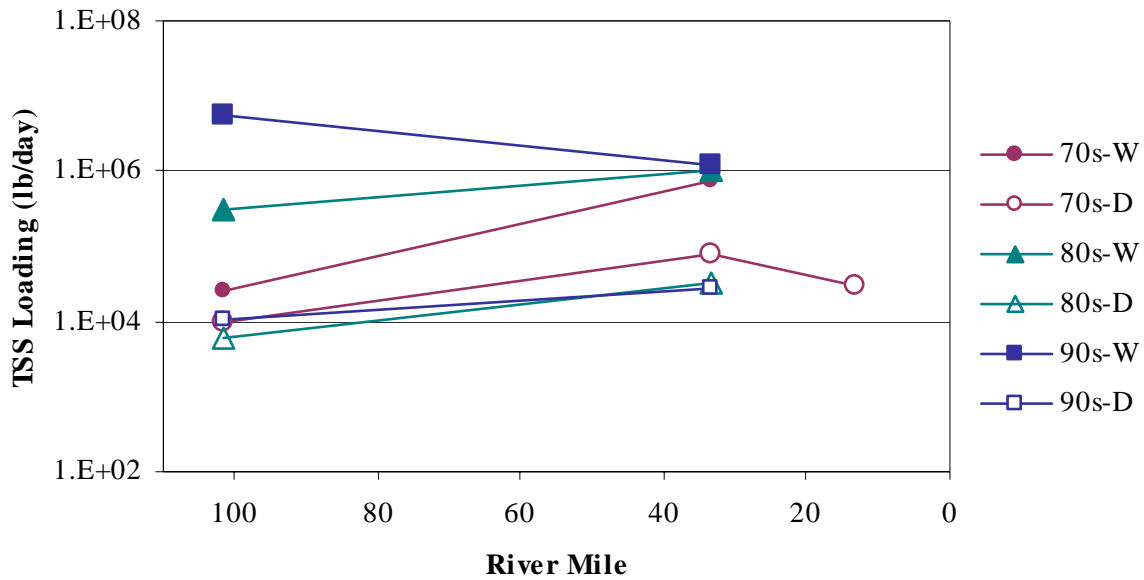
Phosphorus (TP), suspended solids (TSS), and fecal coliform (FC) bacteria were selected for the loading analysis. Although all are naturally occurring substances, they are also indicators of pollution when they occur at high levels. Calculations of “pollutant load” (the volume contributed per day) and “pollutant yield” (the load standardized by watershed size) can be useful for comparing between sources and contributing areas.

Under natural conditions, or conditions where all the land and water in the watershed is contributing equivalent amounts of these constituents, it would be expected that the load would increase with distance downstream. This would simply occur from continued inputs of water with its natural concentrations of these constituents/pollutants. To some extent the difference between wet and dry season loads of pollutants can be used to make general determinations about point and nonpoint sources of pollution. Generally, point sources of pollutants have a tendency to contribute a consistent pollutant load throughout the year. Thus, in a stream where point sources are prevalent, the pollutant loads may not change greatly between seasons. Conversely, nonpoint sources of pollution tend to be associated with the wet season and will result in increased loading during that season.

Figure 2.4-5 and 2.4-6 depict the changes in pollutant loads for total phosphorus (TP), and total suspended solids (TSS) for the three mainstem Chehalis stations for all three decades. (FC bacteria loads were previously described (Figure 2.4-4). These figures were all based on averages of instantaneous flow and pollutant concentration data for the stations.



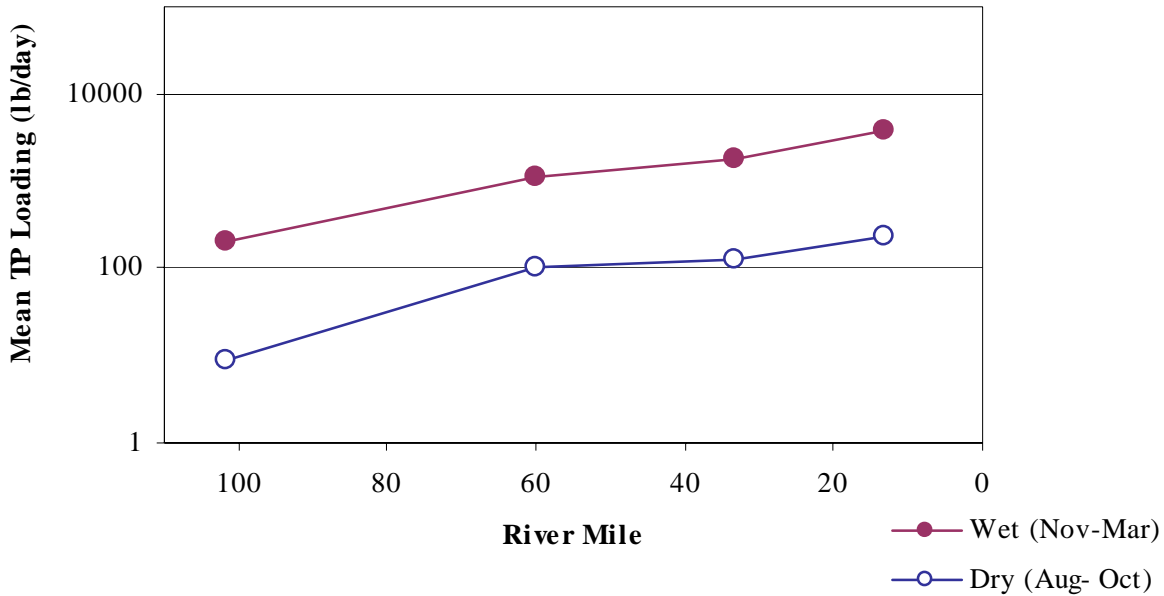
**Figure 2.4-5**  
**Comparison of TP Loads (3-year mean) along the Mainstem of the Chehalis over Three Decades.**



**Figure 2.4-6**  
**Comparison of TSS Loads (3-year mean) along the Mainstem of the Chehalis over Three Decades.**

The load of all three pollutants was higher during the wet season and there was a general increase with distance downstream. This indicates that nonpoint sources of pollution are important in the basin. Further, the pollutant load for all three parameters did increase with downstream distance in the dry season, indicating that the difference between stations may represent the natural affect of increased basin size on loading. What is perhaps more interesting is to note that for both TP and TSS, the wet season load in the 1980's and 1990's were consistently at the same level at the station furthest upstream and the downstream station. This is a notable exception to what would normally be expected. It indicates that the upstream portion of the basin is contributing a significant pollutant load and is likely a nonpoint source. The fact that FC bacteria did not display this tendency may further indicate that the source is not likely to be agricultural, pointing to current or past logging practices as a likely source or cause of TP and TSS loading.

An additional monitoring station was included in the 1990's on the Chehalis mainstem just below the Centralia Reach. To further assess possible downstream trends in pollutant loads, TP data for the 1990's was graphed (Figure 2.4-7). In this case median flows were used to calculate the loads. The figure depicts a more definitive downstream trend of increasing loads that occurred during both seasons. It also indicates that the biggest change occurred within the segment marked by the Centralia Reach.



**Figure 2.4-7**  
**Comparison of the Chehalis River Mean TP Loading in 90s**

To further address the question of point versus nonpoint sources of pollution, an analysis of point source contributions was undertaken. By using the list of NPDES permit holders in the basin and regional median wastewater pollutant concentrations (Embrey and Inkpen, 1998), an estimate of loading from permit holders was calculated. Then the total phosphorus loading from NPDES permitted discharges to the mainstem at Porter and Montesano was calculated to determine the contribution to seasonal loading.

The cumulative permitted TP loading to the mainstem at Porter was estimated at 377 lb/day. While this represents only 13% of the wet season load, it represents more than 100% of the average dry season TP loading. A similar result was calculated for Montesano. The cumulative TP loading from the municipal and industrial wastewater treatment plants was estimated at 427 lb/day, 16 % of the total wet season load and almost three times the dry season load. These NPDES contributions to the TP loads represent the potential for NPDES discharge. They were calculated based on discharging at design capacity and regional median concentrations. This can be expected to largely over estimate their actual contribution, especially during the dry season. However, it does reflect differences in expected seasonal loadings.

The final consideration in the loading analysis is whether there has been a change over the three decades that cover the period of record. There is no evidence of changes in loads of TP or FC over the period, at any stations during either dry or wet seasons. There does appear to be a steady increase in TSS loading at the uppermost station during the wet season.

## 2.4.4 POLLUTANT YIELDS & COMPARISONS WITH OTHER PUGET SOUND BASINS

Pollutant yields are load estimates that have been “corrected” to account for the land area that contributes to the basin. Table 2.4-2 contains a summary of calculated pollutant yields for four mainstem stations and the two tributaries for which median flows were available. TP yields were calculated to be similar along the mainstem, the highest was measured in Montesano. The Humptulips had the highest overall TP yield, however it was within the same range as the other stations. TSS yields were substantially higher at Dryad and in the Humptulips.

**Table 2.4-2  
Pollutant Yields for Chehalis Basin Mainstem and Tributary Stations.**

River Mile	Location	TP Yield (tons/yr-mi <sup>2</sup> )			TSS Yield (tons/yr-mi <sup>2</sup> )			IN Yield (tons/yr-mi <sup>2</sup> ) <sup>1</sup>
		Wet	Dry	Average	Wet	Dry	Average	Average
101.7	Dryad	0.31	0.01	0.14	343	2.3	143	1.43
59.9	Prather Rd.	0.23	0.02	0.12	90	1.1	42	1.59
33.3	Porter	0.26	0.02	0.13	107	1.3	49	1.92
13.15	Montesano	0.39	0.02	0.18	93	30	48	2.22
0.1	Newaukum	0.15	<0.01	0.08	155	11.3	7.8	2.03
23.6	Humptulips	0.41	0.03	0.2	396	6.1	186	1.15

<sup>1</sup>IN=inorganic nitrogen. This information is provided to allow comparisons to other basins in the Puget Sound

Table 2.4-3 contains a summary of TP and IN (inorganic nitrogen) yield results from other large river basins in the Puget Sound region that can be used for comparison. The basins range from quite impacted urbanized systems (e.g. Green River and Puyallup), to more rural systems (e.g. Nooksack and Stilliguamish). As shown, there are no strong relationships between yields of these pollutants and known degraded systems (i.e. the Green and Puyallup are no higher overall than the Nooksack and Stilliguamish). By comparison Chehalis and tributary streams (Table 2.4-2) exhibited TP yields that were within the same range, although slightly lower than the average measured in other Puget Sound basins. The reverse was true for IN; the yields were basically within the same range, but generally higher in the Chehalis. In fact, with the exception of the Humptulips, all of the calculated yields were higher than the average IN yield calculated for the other large river basins.

**Table 2.4-3**  
**Pollutant Yields Measured in Selected Puget Sound River Basins.**  
(Source: Embrey and Inkpen, 1998)

River Basin	TP	IN
Deschutes	0.1	1.0
Nisqually	0.09	0.6
Puyallup	0.4	1.0
Green	0.2	1.2
Snohomish	0.2	1.8
Stilliguamish	0.4	2.0
Skagit	0.2	0.9
Nooksack	0.3	1.8
Average	0.24	1.29
Highest in Study <sup>1</sup>	0.4	2.8
Lowest in Study <sup>1</sup>	0.05	0.3

<sup>1</sup>These were the highest and lowest values measured in a study of 22 river and stream basins in the Puget Sound Basin.

## 2.4.5 GRAYS HARBOR

This water quality assessment encompassed the mainstem of the Chehalis River and its tributaries for which there is reliable data. This report does not provide an analysis of Grays Harbor. Grays Harbor, at the mouth of the Chehalis watershed, has been the focus of a number of studies. The conditions within the estuary vary depending on the location, the degree of tidal and wind mixing, and degree of density stratification (Jennings, 1996). The harbor is separated into an inner harbor area and an outer harbor area, each with different water quality classifications under the water quality standards. The inner harbor is designated as a Class B water and is listed under section 303(d) of the Clean Water Act as not meeting water quality standards for fecal coliform bacteria. The outer harbor is a Class A water body. While the outer harbor is not listed as impaired on the 303(d) list for fecal coliform, Jennings indicates that there is mounting evidence that this indicator parameter may be a concern in some areas of the outer harbor (Jennings, 1996).

A recently published TMDL conducted by WDOE indicated that the primary source of the fecal coliform loading was from the Chehalis River; with the Humptulips, Hoquiam, Wishkah, and Satsop rivers accounting for nearly 80% of the total loading (Pelletier, 2000). The TMDL established a 65% reduction in the non-point source load allocations; and the TMDL established wasteload allocations for the two major point sources (Weyerhaeuser Cosmpolis and Weyco) (Pelletier, 2000).

## 2.4.6 LAND USE RELATIONS

Recognized non-point sources of pollution to the watershed include agricultural and forest practices, urban stormwater, and failing septic systems (Pickett, 1994a). Land within the basin is dominated by forestlands (82.7%). Logging activities in these areas can contribute suspended

solids to the streams. The high TSS loads measured at the upstream station on the Chehalis and the Humptulips likely reflect that affect. Although agriculture represents only 10.7 % of the landuse in the watershed to Montesano, the agricultural land is typically adjacent to the river corridor. Thus, the level of impact can outweigh expectations based on land use. Agricultural activities contribute fecal coliform, BOD, and nutrients (phosphorus, nitrogen, etc.) to the mainstem and a number of tributaries. Although urbanized areas represent less than 2% of the watershed at Montesano, they also contribute to increases in TSS, nutrients, and bacteria. In urbanized areas without municipal sewers, failing septic systems can result in fecal coliform and nitrate loading of a stream segment.

## **2.4.7 CONCLUSIONS**

Water quality in much of the basin and its tributaries has been described as impaired in numerous WDOE studies. The Upper Basin is where most of the water quality problems have been documented. No long term improving or deteriorating trends were noted in this analysis. One or two subbasins have high TSS loads and yields, and generally IN yields appear to be high throughout the basin. However, it is the temperature and dissolved oxygen problems that seem most critical, in view of the fish habitat issues and relation to streamflows.

Last, it should be noted that one of the defining characteristics of water quality studies is that there is a strong tendency to look for problems where it is suspected some occur. As detailed in this assessment, the Upper basin of the Chehalis has the majority of documented water quality problems. Since there is more human activity in the Upper Basin, this probably reflects the real condition. However, it may also reflect the fact that little monitoring is occurring in the streams in the Lower basin.

## ***2.5 FISH HABITAT/CHANNEL MODIFICATION/STOCKS***\_\_\_\_\_

### **2.5.1 CURRENT FISH HABITAT CONDITIONS**

While situations do vary to some degree between subbasins, some basin-wide patterns are clear. These also agree with the conclusions of previous analysts (Hiss and Knudsen 1993, Wampler et al., 1993). As a result of past and present land use practices, stream channels in the Chehalis watershed show a consistent pattern of riparian vegetation removal, shade reduction, and reduction in streambank stability leading to bank erosion and elevated levels of instream sediments. While few measures of existing woody debris levels were found, comparison to historic information and past legal stream cleaning practices indicate that instream woody debris levels are either non-existent or much lower than historic levels. While information about loss of side channel and wetlands habitats is more anecdotal, patterns of timber harvest and agricultural practices have left stream channels in a more simplified state than in pre-settlement periods, with less streambank stability, lowered shading levels, and simplified instream habitats with fewer, or no, side- or off-channel habitats available. While summer water temperatures in much of the Chehalis watershed may have been historically somewhat high (above preferable for salmonid fish, but sublethal) due to relatively low elevations of many of the stream channels in the basin, riparian vegetation removal, lowered shading levels, and degradation of streambank stability have most likely contributed to increases in the magnitude and range of this problem.

Because of the size of the Chehalis watershed, watershed-wide conclusions are necessarily very general. A more appropriate level of detail is the subbasin level. Habitat conditions by subbasin are presented in Appendix D. It is recognized that in some situations, habitat conditions may be in some partial recovery from past damages; this is most likely on forested lands managed under federal or state forest practices, where protection of riparian corridors has become the rule during the last few decades. Because little change in protection or restoration of riparian corridors on agricultural lands has occurred in the last few decades, riparian conditions in those land uses rely more on the individual landowner's discretion. In those land uses, riparian and stream habitat conditions will vary widely, and no estimation of the amount of recovery of riparian function can be made at this level.

### **2.5.2 CHANNEL MODIFICATIONS**

As with most western Washington stream systems, the Chehalis has a land use history focused on timber harvest and agriculture. Many associated activities, such as splash damming and wood removal, have had an affect on hydrologic conditions and resultant channel/habitat conditions.

River channel conditions prior to European settlement were very different than those seen today. Most low-gradient river channels in Western Washington and Oregon consisted of complexes of river, wetlands, beaver ponds, sloughs, logjams, and side channels, with both standing trees and instream wood very common and plentiful. Draining land for farming began early in the settlement period in Grays Harbor County, from the mid-1800's. Ditching and draining activities by individual landowners were very common in the 1880-1920 period (Van Syckle, 1980; Sedell and Luchessa, 1981). In many rivers, woody debris was not only cleaned out of the stream channel, but was also used to dike off sloughs and side channels in order to consolidate and straighten the stream channel. During the 1930's, when the Works Project Administration was active, many stream channels in agricultural areas were cleared of brush (Sedell & Luchessa, 1981).

Riparian vegetation removal in many streams in the watershed has been a result of both timber harvest and agriculture. Buffer strips of varying widths began to be left during the 1980's, and are mandated now on forest lands. Therefore, while the historical disturbance was extreme, riparian areas on timberlands can be seen as in recovery from past practices, although the recovery period may be as long as several hundred years. In addition, riparian vegetation removal, and riparian areas in degraded condition as a result of agricultural practices, have been documented widely throughout the watershed (Wampler et al., 1993 see Appendix D for a summary by subbasin).

### **2.5.3 FISH STOCK STATUS AND TRENDS**

A total of two spring chinook stocks, seven fall chinook stocks, two chum stocks, seven coho stocks, two summer steelhead stocks, eight winter steelhead stocks, one bull trout/Dolly Varden stock, and two coastal cutthroat stocks have been identified in the Chehalis watershed. No pink salmon or sockeye salmon stocks were identified in this area (SASSI 1993, WDFW 1998a, 2000).

Of the thirty-one stocks identified, stocks classed as “healthy” included:

Chehalis spring chinook,  
Humptulips, Hoquiam, Wishkah, Wynoochee, Satsop and Chehalis fall chinook,  
Humptulips and Chehalis fall chum,  
all seven coho stocks in the watershed, and  
Humptulips, Hoquiam, Wishkah and Wynoochee winter steelhead.

Stocks classed as “depressed” included:

Satsop summer chinook, and  
Satsop and Skookumchuck/Newaukum winter steelhead.

Stocks classed as “unknown” included:

Johns/Elk fall chinook,  
Humptulips and Chehalis summer steelhead,  
South Harbor streams winter steelhead,  
bull trout/Dolly Varden for the entire Grays Harbor/Chehalis area, and  
coastal cutthroat trout for both the Humptulips and Chehalis  
(SASSI 1993, WDFW 1998a, 2000).

One stock, Wynoochee spring chinook, was classed as “disputed”. For further discussion see Appendix D.

Some population trend information was identified. A stable or positive population trend was identified for Chehalis spring chinook, all of the fall chinook stocks except Johns/Elk and South Bay tributaries. It should be noted that, even with positive trends, most anadromous stocks in the Chehalis Basin are present at far fewer than their historical numbers (Hiss and Knudsen 1993).

Negative trends were identified for Satsop summer chinook, and Satsop and Skookumchuck/Newaukum winter steelhead. These trends gave rise to the depressed classification for these populations.

Population trends of “unknown” were identified for Johns/Elk and South Bay tributaries fall chinook, Humptulips and Chehalis summer steelhead, South Harbor winter steelhead, Humptulips and Chehalis coastal cutthroat trout, and bull trout/Dolly Varden for the entire basin (SASSI 1993, WDFW 1998a, 2000). Wynoochee spring chinook were also identified as “unknown”, but the trend is probably negative, as discussed above.

No population trends were identified for the “healthy” Humptulips and Chehalis fall chum stocks; all seven coho stocks; and Chehalis, Humptulips, Hoquiam, Wishkah and Wynoochee winter steelhead stocks (SASSI 1993).