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Puyallup River Total Maximum Daily Load for Biochemical Oxygen Demand, Ammonia, and Residual Chlorine

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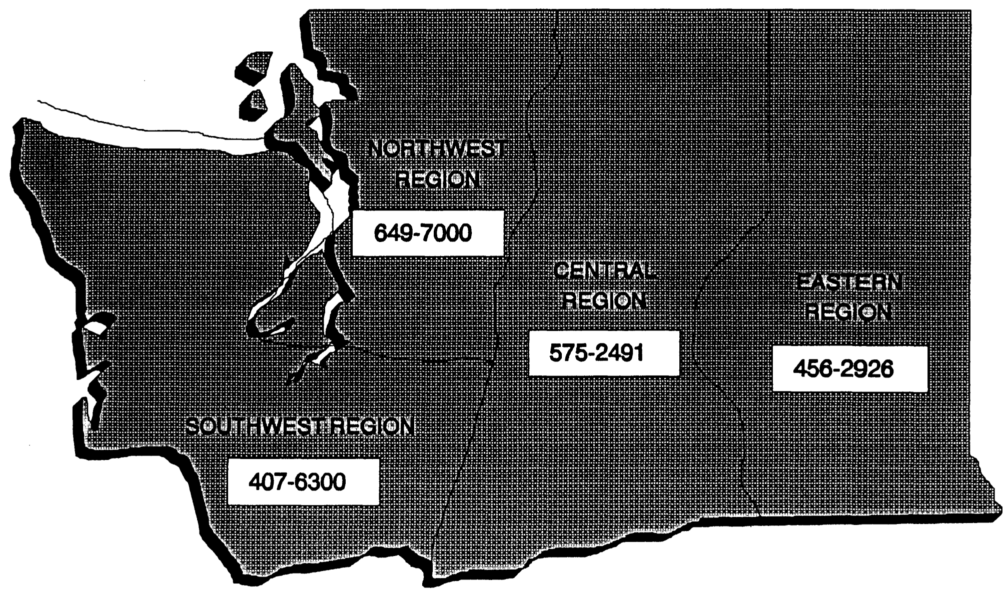

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Puyallup River Total Maximum Daily Load for Biochemical Oxygen Demand, Ammonia, and Residual Chlorine

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ABSTRACT

A water quality modeling study was initiated to develop waste load allocations (WLAs) for point sources for biochemical oxygen demand (BOD), ammonia, and chlorine in the Puyallup River basin. The dischargers permitted through the National Pollutant Discharge Elimination System (NPDES) include ten municipalities, four industrial discharges, and four fish hatcheries. Background and nonpoint source loads were also assessed. In addition to considering existing discharges and nonpoint loads, the potential impact of future dischargers was examined. This study approach is consistent with Ecology's Total Maximum Daily Load (TMDL) process, which was recently approved by EPA to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

Dissolved oxygen standards in the lower Puyallup River would not be met if significant additional BOD sources were introduced, unless currently permitted BOD loads (nitrogenous BOD from ammonia and/or carbonaceous BOD) are reduced. Reductions in ammonia loading were found to have greater potential to improve dissolved oxygen than reductions of carbonaceous BOD. Ammonia loads from existing permittees are likely to be in excess of proposed mixing zone limits for most municipal discharges. Implementation of mixing zone regulations is expected to protect the water quality criteria in all segments of the Puyallup River basin. Modeling of toxic parameters shows that assigning WLAs based on allowable dilution flows in mixing zones would not result in cumulative excess of water quality criteria for protection of aquatic life for existing and currently proposed discharges.

A TMDL is recommended that establishes WLAs based on mixing zone limitations for existing dischargers with an allocation for future growth or water quality protection. The critical condition for the TMDL is the 7-day-10-year low river flow. The proposed TMDLs are 19,500 lbs/day of 5-day BOD (BOD_5), 3,330 lbs/day of ammonia as N, and 45.9 lbs/day of total residual chlorine. With existing technology-based limits for BOD_5 and proposed mixing zone limits for ammonia and chlorine, a reserve for protection of water quality or additional loading from future growth was estimated.

1.0 INTRODUCTION

1.1 Background Information

The Puyallup River drainage basin occupies approximately 970 square miles in the Puget Lowland of Washington State (Figure 1.1). The major streams of the basin are the Puyallup River and its two largest tributaries, the White and Carbon Rivers. The first 8.3 miles of the White River are also called the Stuck River. Prior to 1906, the White River joined the Green River north of the current Puyallup basin except for occasional overflows to Stuck Creek and the Puyallup River. A flood in 1906 modified the channel to block flow to the Green River. This change was made permanent with the construction of a diversion dam at Auburn, which directs all White River flows through the channel previously named Stuck Creek.

The lower reach of the Puyallup River is a relatively flat floodplain ranging in elevation from sea level at Commencement Bay to approximately 50 feet at the confluence of the White and Puyallup Rivers. The lower Puyallup River is a salt-wedge estuary, with deeper marine water overlain by a layer of fresh water. The salt wedge generally extends less than 2.5 miles upstream from the river mouth (Ebbert *et al.*, 1987).

Existing land use is described by Ebbert *et al.*, (1987). Industrial activity is predominant below Puyallup RM 2.0. Historically, much of the lower Puyallup valley above the tide flats was used for agriculture. Small farms producing vegetables, flower bulbs, and berries are declining in numbers due to encroachment of residential and commercial development. Most of the upland developments are light to medium density residential areas. Gravel is mined commercially at several locations along the northeast and southwest valley walls.

The combined effects of all permitted discharges to the Puyallup system are currently unknown. Future development in the basin will result in requests for increased pollutant loading from municipal and industrial sources. New municipal and industrial dischargers are also likely. Given the large number of existing permits, a basin-wide evaluation of waste loads and water quality-based permits is needed. The major water quality concerns include the potential for low dissolved oxygen from the discharge of oxygen-demanding pollutants, and toxicity from the discharge of ammonia and residual chlorine. This report examines the effects of 18 permits under the National Pollutant Discharge Elimination System (NPDES) for point source discharges directly to rivers and creeks in the Puyallup basin (Table 1.1, Figure 1.2). The permitted discharges include ten municipalities, four industrial discharges, and four fish hatcheries. There are also two tribal hatcheries: one operated by the Puyallup Tribe and one by the Muckleshoot Tribe.

The primary mechanism for implementing Washington's water quality standards is provided under Section 303 of the Clean Water Act. Section 303(d) requires the states and EPA to establish total maximum daily loads (TMDLs) for all water quality limited segments (*i.e.*, those waters which cannot meet water quality standards after application of technology-based source controls). The TMDL for a given pollutant is then apportioned between point sources (waste

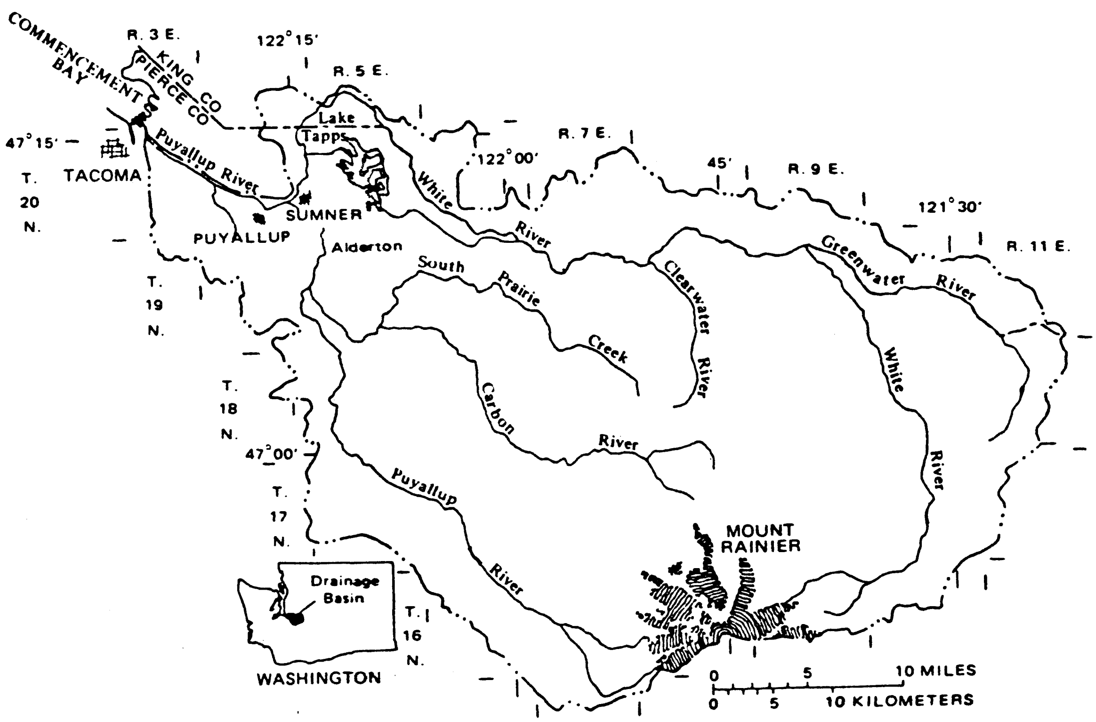


Figure 1.1. Puyallup River drainage basin showing vicinity of study area. (adapted from Ebbert et al., 1988).

Table 1.1 Summary of Puyallup River basin NPDES permits for flow, 5-day BOD, ammonia-N, and chlorine.

Permittee	Permit Expiration Date	Receiving Waters (1)	FLOW Monthly Avg (mgd)	FLOW Daily Max (mgd)	BOD Monthly Avg Conc. (mg/L)	BOD Monthly Avg Load (#/d)	BOD Weekly Max Conc. (mg/L)	BOD Weekly Max Load (#/d)	AMMONIA-N Monthly Avg Conc. (mg/L)	AMMONIA-N Monthly Avg Load (#/d)	AMMONIA-N Daily Max Conc. (mg/L)	AMMONIA-N Daily Max Load (#/d)	CHLORINE Monthly Avg (mg/L)	CHLORINE Daily Max (mg/L)
MUNICIPAL														
Puyallup, City of (WTP)	7/94	Puy	10.720	--	30	1390	45	2085	--	--	--	--	--	--
Sumner, City of (WTP)	9/97	Puy/Whi	3.420	--	30	855	45	1284	6.1	--	13.7	--	0.022	0.058
Buckley, City of (WTP)	8/85	Puy/Whi	(5) 1.000	--	30	250	45	375	--	--	--	--	--	--
Enumclaw, Town of (WTP)	7/95	Puy/Whi	(5) 2.400	--	30	336	45	504	--	--	--	--	--	--
Rainier State School (WTP)	2/85	Puy/Whi	0.420	--	30	105	45	158	--	--	--	--	--	--
McAlder Elementary (WTP)	8/95	Puy	0.009425	--	30	2.4	45	3.6	--	--	--	--	--	--
Orting, Town of (WTP)	1/94	Puy/Car	0.750	--	30	90	45	135	--	--	--	--	(6)	(6)
South Prairie, Town of (WTP)	2/97	Puy/Car/SPr	(5) 0.0382	--	20	6.3	30	9.5	--	--	--	--	--	--
Wilkeson, Town of (WTP)	4/85	Puy/Car/SPr/Wilk	0.070	--	30	18	45	26	--	--	--	--	--	--
Carbonado, Town of (WTP)	2/85	Puy/Car	0.100	--	30	25	45	38	--	--	--	--	--	--
INDUSTRIAL (2)														
Matsushita Semiconductor Corp.	6/96	Puy	0.7	1.0	15	88	30	175	20	117	32	187	--	--
Fleischmann's Yeast Co.	5/82	Puy/Whi	--	1.092	--	--	--	--	--	--	--	--	(7)	(7)
Sonoco	10/95	Puy/Whi	(5) 0.313	0.563	--	348	--	673	--	--	--	--	--	--
Beatrice Cheese Co.	4/94	Puy/Whi	0.350	0.500	30	17	--	35	23	--	32	--	--	--
FISH HATCHERY (3)														
Troutco, Inc.	(4)	Puy/Clear	6.552	--	--	--	--	--	--	--	--	--	--	--
Puyallup Tribe Hatchery	NA	Puy/Clarks/Diru	--	--	--	--	--	--	--	--	--	--	--	--
Puyallup Trout Hatchery (WDW)	(4)	Puy/Clarks	7.800	--	--	--	--	--	--	--	--	--	--	--
Muckleshoot Tribe Hatchery	NA	Puy/Whi	--	--	--	--	--	--	--	--	--	--	--	--
Trout Springs, Inc.	(4)	Puy/Canyon Falls	9.720	--	--	--	--	--	--	--	--	--	--	--
Puyallup Fish Hatchery (WDF)	(4)	Puy/Car/Voight	16.200	--	--	--	--	--	--	--	--	--	--	--

1) Puy=Puyallup R; Whi=White R; Car=Carbon R; SPr=South Prairie Creek; Wilk=Wilkeson Creek

2) Treated process except Fleischmann's, which is non-contact cooling water. Excludes stormwater and discharges to municipal facilities. Matsushita mass limits based on maximum flow of 0.7 mgd for BOD and ammonia. Beatrice ammonia limits are for November 1 - April 30; ammonia-N limits from May 1 - October 31 are 17 and 24 mg/L for monthly average and daily maximum.

3) Includes unpermitted Puyallup and Muckleshoot Tribe hatcheries. Maximum fish on hand is reported in permit applications as follows: Troutco 100,000 lbs rainbow trout; WDW 59,600 lbs rainbow, steelhead, kokanee; Trout Springs 175,000 lbs rainbow; WDF 80,000 lbs coho, chinook.

4) General permit expires 1/95.

5) For municipal WTPs, these values are design criteria and are not included as effluent limits. For Sonoco, 0.313 mgd and 0.563 mgd are the highest monthly average and daily maximum flows reported in the permit fact sheet for 1987-88 and are not effluent limits.

6) No detectable residual in final effluent. Test method not specified in permit.

7) Permit allows discharge to increase concentration in White (Stuck) River to less than 0.002 mg/L after complete mix.

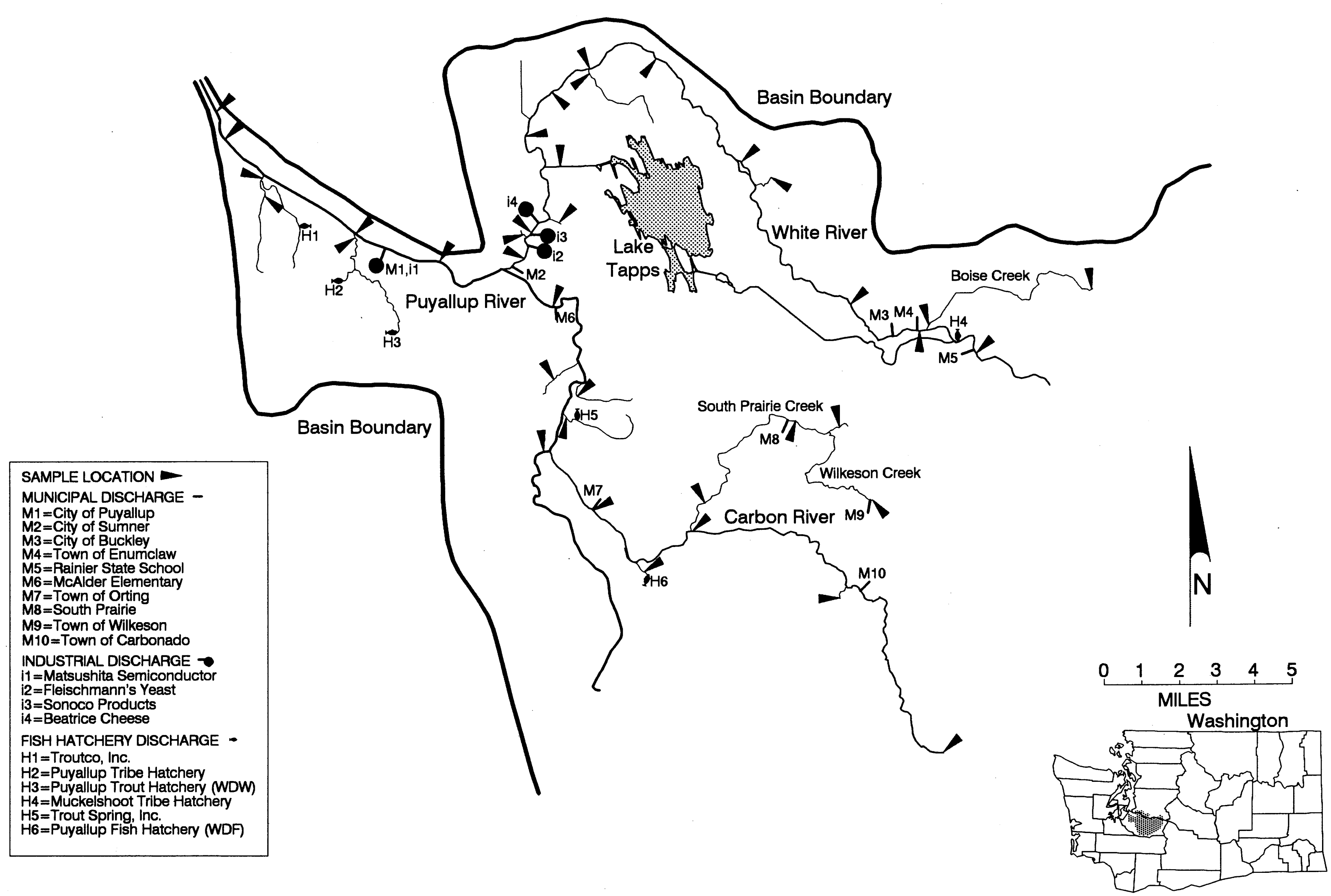


Figure 1.2. Study area map showing locations of NPDES discharges.

load allocations--WLAs) and nonpoint/background sources (load allocations--LAs). The allocations (WLAs and LAs) are implemented through NPDES permits, grant projects, and nonpoint source controls.

Section 304(l) of the federal Clean Water Act requires each state to list waters where technology-based treatment will not lead to compliance with applicable water quality standards for priority pollutants ("short" and "mini" lists) or meet fishable/swimmable goals ("long" list). For problems due primarily to point sources, the state must develop Individual Control Strategies (ICSs) for each discharger. In January 1989, the lower Puyallup River (RM 0 to 1.5) was put on the 304(l) "short" list (waters not achieving standards due primarily to point source discharge of toxic pollutants) because of reported violations of numeric water quality criteria for zinc, copper, lead, mercury, and cadmium (Ebbert *et al.*, 1987). The reported violations were assumed to be caused by the Tacoma Central WTP, which discharged to the Puyallup River at the time of sample collection. Approximately three months after being listed in the draft, Puyallup RM 0 to 1.5 was deleted from the 304(l) list because of the opinion that the diversion of the Tacoma Central WTP discharge to Commencement Bay constituted completion of the ICS and elimination of the point source discharge causing the observed water quality violations (Ecology, 1989).

The Tacoma Central WTP discharged primary effluent to the Puyallup River estuary at RM 1.7 until 1989. Several investigators found elevated levels of priority pollutants in the river water and sediments downstream from the WTP discharge to the Puyallup River (Johnson and Prescott, 1982; Johnson *et al.*, 1983; Yake, 1982; Ebbert *et al.*, 1987). USGS data from the Puyallup River (RM 5.7) and special surveys by Ecology indicate that the river has a low background concentration of metals and organic pollutants above the former discharge point of the Tacoma Central WTP (Johnson *et al.*, 1983).

Water quality conditions in the lower Puyallup River have also been investigated by USGS (Ebbert *et al.*, 1987), which maintains a quarterly water quality monitoring station at RM 5.7. Ecology also maintains monthly monitoring stations in the Puyallup River at RM 8.3 and 22.2, and in the White River at RM 0.7. The water quality classification (WAC 173-201A) of the river system ranges from Class B at the mouth of the Puyallup to Class AA at the headwaters (Table 1.2). All of the NPDES permittees discharge to Class A waters.

Section 305(b) of the Clean Water Act requires the state to assess the quality of surface waters and identify impairment of designated beneficial uses pursuant to the state water quality standards (WAC 173-201A). The most recent 305(b) assessment lists two mainstem segments as water quality limited for fecal coliform (Puyallup RM 1.0 to 10.4 and White RM 0 to 29.6). No other segments of the Puyallup, White, or Carbon Rivers are currently listed as water quality limited for any other parameters. Past 305(b) assessments listed eight waterbody segments of the Puyallup River basin with impairment of beneficial uses and two segments with threatened uses. Reported causes of impaired use in the past include priority organics, oil and grease, and metals identified by Ebbert *et al.*, (1987), as well as fecal coliform bacteria, ammonia, nutrients, dissolved oxygen, siltation, suspended solids, and noxious aquatic plants (Ecology, 1988).

Table 1.2 Summary of water quality classifications defined in WAC 173-201A for the Puyallup, White, and Carbon Rivers.

SEGMENT	CLASSIFICATION (1)
PUYALLUP	
Mouth to RM 1.0	B (brackish)
RM 1.0 to 2.2	A (brackish)
RM 2.2 to 31.6	A (fresh)
RM 31.6 to headwaters	AA (fresh)
WHITE (STUCK)	
Mouth to RM 29.6	A (fresh)
RM 29.6 to headwaters	AA (fresh)
CARBON	
Mouth to RM 23.2	A (fresh)
RM 23.2 to headwaters	AA (fresh)

1) The boundary between brackish and fresh water was estimated from salinity profiles reported by Ebbert et al. (1987).

The 305(b) listing of metals criteria violations in the past assessments was based primarily on USGS data. Recent evaluations of USGS metals data (EPA, 1992; Windom *et al.*, 1991) have demonstrated inadequacy for assessing river water quality because of significant bias. Therefore, any water quality assessments based on historical USGS metals data should be viewed with caution and probably represent a significant overestimate of actual metals concentrations. USGS metals data from the Puyallup basin were not included in the most recent 305(b) assessment.

Management of nonpoint sources of pollution is currently being addressed by the Lower Puyallup Watershed Management Committee (LPWMC, 1991). The present study is focused primarily on cumulative water quality impacts of NPDES point source discharges. Nonpoint sources are included in this evaluation by assigning conservatively high loadings predicted to correspond with design conditions for point sources.

1.2 Project Goal and Objectives

The major goal of the study is to develop WLAs for point sources of BOD, ammonia, and total residual chlorine. These parameters were selected to address the potential for dissolved oxygen depletion from carbonaceous and nitrogenous BOD, and potential toxic impacts from specific chemicals known to be present in potentially toxic amounts (un-ionized ammonia and total residual chlorine).

Pollutant loading from background and nonpoint sources (LAs) was also estimated. In addition to considering existing discharges and nonpoint loads, WLAs and LAs were also examined for potential future discharges. This study approach is consistent with Ecology's TMDL process (Ecology, 1991), which was recently approved by EPA to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

Ammonia toxicity is caused by the un-ionized fraction present in water, which is a function of temperature and pH. The water quality criteria for un-ionized ammonia may be expressed as total ammonia by dividing by the fraction of un-ionized ammonia present (EPA, 1986; EPA, 1988). For simplicity of comparison with effluent data and integration with dissolved oxygen models, all un-ionized ammonia criteria, TMDLs, WLAs, and LAs are expressed in this report as total ammonia as N.

The boundary for the present study extends to convenient sampling locations above the most remote permitted loads in the basin (Figure 1.2). The upstream boundaries of rivers in the study area are Puyallup RM 18.4, White RM 25.4, Carbon RM 17.8, and South Prairie Creek RM 7.2.

2.0 METHODS

2.1 Historical Data Review

2.1.1 Historical Water Quality Data

The Department of Ecology has collected water quality data at various locations in the basin since 1959, usually at monthly sampling intervals. Table 2.1 lists locations and periods of record for Ecology Ambient Monitoring sampling stations. The U.S. Geological Survey (USGS) also maintains a quarterly monitoring station in the Puyallup River at river mile 5.7. Statistical summaries of historical data were made using SYSTAT® version 5.0 (SYSTAT, 1990) and the WQHYDRO statistical package (Aroner, 1991).

2.1.2 Discharge Data

A schematic of currently active USGS gaging stations in the Puyallup basin is presented in Figure 2.1. In addition to the stations currently maintained, the USGS has also recorded long periods of daily discharge at several other locations in the basin (Table 2.2). Two flow diversions are present in the study area. A large portion of the White River flow is diverted from RM 24.3 through Lake Tapps and then returned to the White River at RM 3.6. The instream flow of the natural White River channel between RM 24.3 and 3.6 is currently maintained above 130 cubic feet per second (cfs) all year by agreement between Puget Sound Power and Light Company (Puget Power) and the Muckleshoot Tribe. Prior to this agreement, low flows in the reach were typically less than 130 cfs throughout the year. Puget Power diverts water from the Puyallup River between RM 41.7 and 31.2, and the Tacoma Water Department discharges water from the McMillan Reservoir to the Puyallup River at RM 18.4. Flood flows in the White River are regulated by a dam at Mud Mountain Lake, which is also upstream from the study area of this project.

USGS daily flow data were obtained from the Earthinfo Inc. HYDRODATA® program. Low flow statistics such as the 7-day-10-year low flow (7Q10) were computed based on Log Pearson Type III distributions (Linsley *et al.*, 1975). Flows at ungaged locations were estimated using mass balance by adding or subtracting adjacent gages with adjustments based on measured flow in minor tributaries or the watershed area represented. Also, low flow statistics from some ungaged tributaries were estimated by Kresch and Prych (1989) based on regression with gaged streams.

2.2 Intensive Surveys for Model Calibration and Confirmation

Two intensive surveys were conducted to sample water quality and all major loading sources within the basin at the same time. The purpose of the intensive surveys was to provide two complete data sets for calibration and confirmation of a mass balance water quality model.

Table 2.1 Summary of sampling records at Ecology ambient monitoring stations in the Puyallup basin

Station Number	Station Name	River Mile	Period of Record	Currently Active (YES or no)
10A050	Puyallup R at Puyallup (USGS)	5.7	1959-67,69-72,75-present	YES
10A070	Puyallup R at Meridian St	8.3	1971,75,78-present	YES
10A090	Puyallup R at McMillin	17.1	1971,76	no
10A110	Puyallup R at Orting	22.2	1959-62,64-72,76,78-present	YES
10B070	Carbon R near Orting	5.8	1964-65,71-72	no
10B090	Carbon R at Fairfax	17.7	1976	no
10C070	White R at Sumner	0.7	1971-72,78-present	YES
10C085	White R near Sumner	4.9	1969-70,75	no
10C090	White R at Auburn	6.3	1962-66,71,73	no
10C110	White R below Buckley	19.8	1973	no
10C140	White R near Buckley	26.3	1973	no
10C150	White R near Greenwater	41.0	1973	no
10D070	Boise Ck at Buckley	0.1	1963-65,73	no
10D090	Boise Ck near Enumclaw	6.5	1963-65	no
10E070	Salmon Cr at Sumner	0.2	1971	no
10F070	So Prairie Cr near Crocker	1.1	1976	no

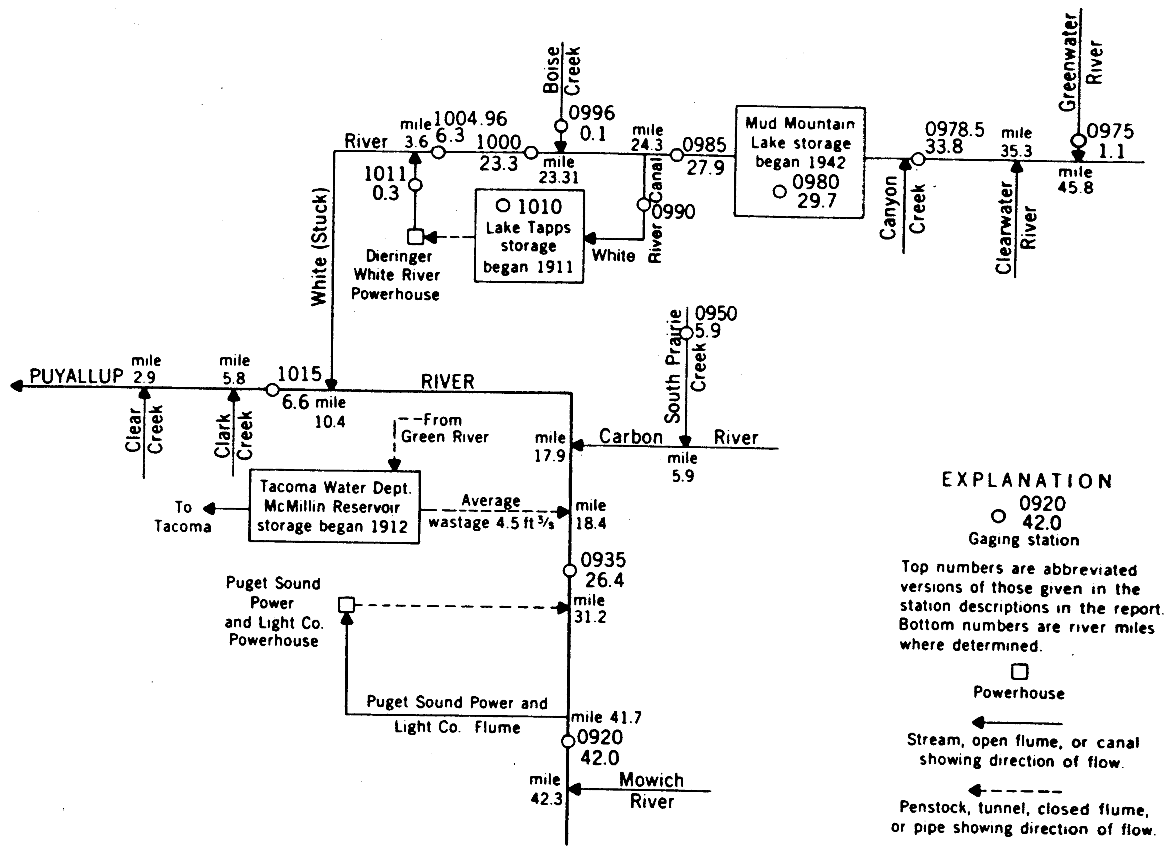


Figure 2.1. Schematic of USGS gaging stations in the Puyallup River basin (source: USGS, 1990).

Table 2.2 List of USGS gaging stations in the Puyallup basin.

USGS No.	USGS Station Name	Period of Record	Comment
12092000	Puyallup River near Electron	1909-present	
12093000	Kapowsin Creek near Kapowsin	1927-57	
12093500	Puyallup River near Orting	1932-present	
12093900	Carbon River at Fairfax	1966-79	
12094000	Carbon River near Fairfax	1912-65	
12095000	South Prairie Creek at South Prairie	1949-72,87-present	
12096500	Puyallup River at Alderton	1915-57	
12096600	White River near Greenwater	1964-70	
12096800	Dry Creek near Greenwater	1957-75	
12096950	Jim Creek near Greenwater	1965-75	
12097000	White River at Greenwater	1929-76	
12097500	Greenwater River at Greenwater	1912-77	
12097850	White River below Clearwater River	1974-76,82-present	
12098000	Mud Mountain Lake near Buckley	1943-present	Pool elevation
12098500	White River near Buckley	1942-present	
12099000	White River Canal at Buckley	1913-38,81-present	
12099500	Boise Creek near Enumclaw	1945-66	
12099600	Boise Creek at Buckley	1977-present	
12100000	White River at Buckley	1900-present	
12100496	White River near Auburn	1987-present	
12100500	White River near Sumner	1945-70	
12101000	Lake Tapps near Sumner	1911-present	Pool elevation
12101100	Lake Tapps Diversion at Dieringer	1958-present	
12101500	Puyallup River at Puyallup	1915-present	
12102200	Swan Creek near Tacoma	1951-71	Peak flow only

The two intensive surveys consisted of a water quality sampling network of 22 mainstem stations in the Puyallup, White, and Carbon Rivers, plus 16 tributary stations, 9 municipal WTPs, 6 industrial effluents, and 6 fish hatcheries. Two of the industrial dischargers that were sampled (Weyerhaeuser and Boeing) have since been discontinued. Table 2.3 lists the locations of stations used for intensive surveys. All stations were sampled on at least two days of each 3-day survey for a variety of water quality parameters. The parameters and frequency of sampling at each station are shown in Table 2.4. Appendices A and B contain the results of all lab and field measurements of water quality parameters.

The surveys occurred on September 18-20, 1990, and October 2-4, 1990. These dates were chosen because lowest flows have historically occurred during September and October. The intensive surveys were timed to capture low flow steady state conditions. The survey dates coincided with annual minimum flows. Flows during the September and October 1990 surveys were about 60% and 100% higher, respectively, than the 7Q10 flows at USGS Station 12101500 (Puyallup RM 5.7). Figure 2.2 shows actual flows at four USGS gages during the two intensive surveys. Both surveys had stable flow conditions for the preceding 3 to 5 days, which indicates steady state conditions since the time of travel from the upstream study boundary to the mouth of the Puyallup River is less than two days (see Section 4.3.1 for discussion of travel times). White River flows in the natural channel between mile 24.3 and 3.6 were significantly different during each survey--approximately 590 cfs during the first survey and 180 cfs during the second survey. This variability reflects the operation of the Lake Tapps diversion. Otherwise, Puyallup and Carbon River flows were similar during both surveys.

A rain storm occurred during the second survey after the first day of sampling was completed. Therefore, if river flows increased significantly prior to sampling, those data were excluded from model confirmation analyses. The October survey, which was used for confirmation, was limited to October 2 data for most stations in the Puyallup and Carbon Rivers because of increased flows during October 3 and 4, 1990.

Grab samples were collected directly into sample bottles or by Van Dorn or Kemmerer collection bottles. All samples were collected within one meter of the water surface. Temperature, pH, and dissolved oxygen were sampled in the early morning and late afternoon, and on additional days between September 18 and October 5, 1990, at selected stations to measure diurnal ranges (Appendix B). Other water quality parameters were generally collected randomly between the hours of 8:00 AM and 8:00 PM.

Twenty-four hour automatic compositors were installed to collect effluent samples from the largest NPDES discharges, including Buckley, Enumclaw, Orting, Puyallup, Rainier School, Sumner and Wilkeson municipal WTPs; and Mazza (currently Beatrice Cheese), National Semiconductor (currently Matsushita Semiconductor), and Sonoco industrial discharges. Grab samples were taken from the other municipal, industrial, and hatchery effluents, and for all determinations of temperature, pH, dissolved oxygen, residual chlorine, and fecal coliform. Appendix C lists all grab and composite samples collected at each NPDES discharge.

Table 2.3. Intensive survey water quality sampling station locations.

Station	Station Name	Access Location
Puyallup River		
r.m. 18.0	PUY18.0	Hwy. 162 bridge
r.m. 12.2	PUY12.2	Hwy. 162 bridge
r.m. 8.3	PUY08.3	Meridian Street N. bridge
r.m. 5.7	PUY05.7	E. 48th Street bridge
r.m. 1.5	PUY01.5	Lincoln Avenue bridge
r.m. 0.8	PUY00.8	E. 11th Street bridge
White River		
r.m. 25.2	WHI25.2	50 meters upstream from Rainier School outfall
r.m. 23.1	WHI23.1	Hwy. 410 bridge
r.m. 20.4	WHI20.4	Near Corner of 274th Ave. E. and 80th St. E.
r.m. 14.9	WHI14.9	Access from private road off SE 404th Street
r.m. 10.3	WHI10.3	Beneath overhead power lines
r.m. 8.0	WHI08.0	R Street E. bridge
r.m. 6.3	WHI06.3	GN railroad bridge
r.m. 4.9	WHI04.9	8th Street E. bridge
r.m. 1.4	WHI01.4	Fryar Avenue bridge
r.m. 0.7	WHI00.7	Main Street bridge
Carbon River		
r.m. 17.7	CAR17.7	At USGS Gage 0939
r.m. 6.1	CAR06.1	NP railroad crossing
r.m. 2.0	CAR02.0	50 meters upstream from Orting WTP Outfall
South Prairie Creek		
r.m. 7.2	SPR07.2	Access from road at right bank
r.m. 5.8	SPR05.8	Hwy. 162 bridge
r.m. 1.1	SPR01.1	Hwy. 162 bridge
Wilkeson Creek		
r.m. 4.2	WIL04.2	Hwy. 165 crossing
Boise Creek		
r.m. 5.8	BOI05.8	Upstream from Weyerhauser Mill pond outflow
r.m. 0.1	BOI00.1	USGS Gage 0996
TRIBUTARIES		
Bowman Ck	BOWMAN	
Canyon Falls Ck	CANYONFA	
Clarks Ck	CLARKS	
Clear Ck	CLEAR	
Fennel Ck	FENNEL	
Lake Tapps Power Flume Outlet	LTD03.6	
Lily Ck	LILY	
Strawberry (Salmon) Ck	STRAWBER	
Swan Ck	SWAN	
Voights Ck	VOIGHT	
Unnamed Trib at Puyallup RM 13.0	PTR13.0	
Unnamed Trib at White RM 15.0	WTR15.0	
Unnamed Trib at White RM 1.3	WTR01.3	

Table 2.3. (continued).

Station	Station Name	Access Location
MUNICIPAL NPDES EFFLUENT		
Buckley WTP	BUCKLEY	Final effluent to White River
Carbonado WTP	CARBONADO	Final effluent to Carbon River
Enumclaw WTP	ENUMCLAW	Final effluent to White River
McCalder Elementary WTP	MCCALDER	Final effluent to Puyallup River
Orting WTP	ORTING	Effluent to Carbon R. (at influent to chlorine contact)
Puyallup WTP	PUYALLUP	Final effluent to Puyallup River
Rainier School WTP	RAINSCH	Final effluent to White River
Sumner WTP	SUMNER	Final effluent to White River
Wilkeson WTP	WILKESON	Final effluent to Wilkeson Ck
INDUSTRIAL NPDES EFFLUENT		
Boeing Auburn	BOEING	Non-contact cooling water discharge to Gov't Canal
Fleischmans Yeast Co.	FLEISCHMANS	Final effluent to White River
Mazza Cheese Co. (now Beatrice)	MAZZA	Final effluent to White River
National Semiconductor (now Matsushita)	NASEMI	Final effluent to Puyallup River
Sonoco Products Co.	SONOCO	Final effluent to White River
Weyerhauser Enumclaw Mill Pond	WEYCO EFF	Mill pond effluent to Boise Ck
FISH HATCHERIES		
Department of Fisheries Hatchery	DOFIN	Influent to hatchery from Voights Ck
	DOFEFF	Effluent from hatchery to Voights Ck
Department of Wildlife Hatchery	DOWIN	Influent to hatchery from Clarks Ck
	DOWEFF	Effluent from hatchery to Clarks Ck
Muckleshoot Tribe Hatchery	MUCTRBIN	Influent to hatchery from groundwater
	MUCTRBEFF	Effluent from hatchery to White River
Puyallup Tribe Hatchery	PUYTRBIN	Influent to hatchery from Diru Ck and groundwater
	PUYTRBEFF	Effluent from hatchery to Diru Ck
Trout Springs	TRTSPRIN	Influent to hatchery from Canyon Falls Ck
	TRTSPREFF	Effluent from hatchery to Canyon Falls Ck
Troutco	TRTCOIN	Influent to hatchery from Clear Ck
	TRTCOEFF	Effluent from hatchery to Clear Ck

Table 2.4. Summary of Puyallup sampling design for intensive surveys during September 18-20 and October 2-4, 1990.

STATION	RM	FLOW	TEMP PH DO	TSS	TURB	COND	CL	ALK	HARD	TOC	CBOD5	CBODU	NH3N NO23N	TP TPN	SRP	CHLA	TREC-METALS	DISS-METALS	FC	KES
		<----- Parameters (see Table 2.5 for key to abbreviations) ----->																		
		<----- NUMBER OF STATIONS OR TIMES SAMPLED ----->																		
F I R S T D A Y :																				
PUYALLUP RIVER	18.00		2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	
	12.20	1	2	1	1	1	1	1	1	1		1	1	1	1		1	1	1	1
	8.30		2	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1
	5.70		2	1	1	1	1		1	1		1	1	1			1	1	1	
	1.50		2	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1
	0.80		2	1	1	1	1			1		1	1	1			1	1	1	
CARBON RIVER	17.70	1	2	1	1	1	1	1	1	1		1	1	1	1		1	1	1	
	6.05	1	2			1	1			1			1	1						
	2.00	1	2	1	1	1	1	1	1	1			1	1	1	1	1	1	1	
WILKESON CK	4.20	1	2	1	1	1	1	1	1	1		1	1	1	1		1	1	1	
S PRAIRIE CK	7.20	1	2	1	1	1	1	1	1	1		1	1	1	1		1	1	1	
	5.80		2			1	1			1			1	1						
	1.10	1	2	1	1	1	1	1	1	1			1	1	1		1	1	1	
WHITE RIVER	25.20		2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
	23.10		2	1	1	1	1	1	1	1			1	1	1		1	1	1	1
	20.40		2	1	1	1	1			1			1	1					1	
	14.90		2	1	1	1	1			1			1	1					1	
	10.30		2	1	1	1	1	1	1	1		1	1	1	1		1	1	1	1
	8.00		2	1	1	1	1			1			1	1					1	
	6.30		2	1	1	1	1			1			1	1					1	
	4.90	1	2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
Lake Tapps Diversion Outflow:	3.60	1	2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
	1.40		2	1	1	1	1			1			1	1					1	
	0.70		2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
MISC. TRIBS																				
Clear Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Swan Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Clarks Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Fennel Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Canyon Falls Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Voight Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Lily Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Strawberry Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Bowman Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Boise Ck		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Ptrib13.0		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Wtrib15.0		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	
Wtrib01.3		1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	

Table 2.4. Summary of Puyallup sampling design for intensive surveys during September 18-20 and October 2-4, 1990.

STATION	RM	FLOW	TEMP PH DO	TSS	TURB	COND	CL	ALK	HARD	TOC	CBOD5	CBODU	NH3N NO23N	TP TPN	SRP	CHLA	TREC-METALS	DISS-METALS	FC	KES
		<----- Parameters (see Table 2.5 for key to abbreviations) ----->																		
		<----- NUMBER OF STATIONS OR TIMES SAMPLED ----->																		
F I R S T D A Y :																				
MUNICIPAL WTPs (final effluent)																				
Puyallup			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Sumner			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Buckley			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Enumclaw			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Rainier St School			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
McCalder Elem			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Orting			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Wilkeson			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Carbonado			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
INDUSTRIAL (final effluent)																				
Lige Dickson (storm ro/process)			1	1	1	1	1	1	1	1		1	1	1	1		1			
Natl Semi #1 (WTP outfall)			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Fleischmans (non-contact cool)			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Sonoco (WTP effluent)			1	1	1	1	1	1	1	1		1	1	1	1		1		1	1
Mazza (treated process eff.)			1	1	1	1	1	1	1	1		1	1	1	1		1		1	1
Boeing #2 (non contact cool.)			1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Boeing #3 (Gov't Canal)		1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	
Weyerhauser (mill pond in & eff)		1	2	2	2	2	2	2	2	2		2	2	2	2		2		2	1
FISH HATCHERIES (infl and effl)																				
Troutco		1	1	2	2	2	2	2		2		2	2	2	2					
Puyallup Tribe		1	1	2	2	2	2	2		2		2	2	2	2					
Dept of Wildlife		1	1	2	2	2	2	2		2		2	2	2	2					
Muckleshoot Tribe		1	1	2	2	2	2	2		2		2	2	2	2					
Trout Springs		1	1	2	2	2	2	2		2		2	2	2	2					
Dept of Fisheries		1	1	2	2	2	2	2		2		2	2	2	2					

Table 2.4. Summary of Puyallup sampling design for intensive surveys during September 18-20 and October 2-4, 1990.

<----- Parameters (see Table 2.5 for key to abbreviations) ----->

<---- NUMBER OF STATIONS OR TIMES SAMPLED ---->

STATION	RM	FLOW	TEMP PH DO	TSS	TURB	COND	CL	ALK	HARD	TOC	CBOD5	CBODU	NH3N NO23N	TP TPN	SRP	CHLA	TREC-METALS	DISS-METALS	FC	KES
S E C O N D D A Y :																				
PUYALLUP RIVER	18.00		2	1	1	1	1	1	1	1	1		1	1			1	1	1	
	12.20		2	1		1		1		1	1		1	1					1	1
	8.30		2	1		1				1			1	1					1	1
	5.70		2	1		1		1		1	1		1	1	1	1			1	
	1.50		2	1		1				1			1	1					1	1
	0.80		2	1		1				1	1		1	1					1	
CARBON RIVER	17.70		2	1	1	1	1	1	1	1	1		1	1			1	1	1	
	6.05		2							1			1	1						
	2.00		2	1		1		1		1			1	1					1	
WILKESON CK	4.20		2	1		1		1	1	1	1		1	1			1	1	1	
S PRAIRIE CK	7.20		2	1		1		1	1	1	1		1	1			1	1	1	
	5.82		2							1			1	1						
	1.10		2	1		1		1		1			1	1					1	
WHITE RIVER	25.20		2	1	1	1	1	1	1	1	1		1	1			1	1	1	1
	23.10		2	1		1		1		1			1	1					1	1
	20.40		2	1		1				1			1	1					1	
	14.90		2	1		1				1			1	1					1	
	10.30		2	1		1		1		1	1		1	1					1	1
	8.00		2	1		1				1			1	1					1	
	6.30		2	1		1				1			1	1					1	
	4.90		2	1		1		1		1	1		1	1	1	1			1	1
Lake Tapps Diversion Outflow:	3.60		2	1		1		1	1	1	1		1	1			1	1	1	1
	1.40		2	1		1				1			1	1					1	
	0.70		2	1		1		1		1	1		1	1					1	1
MISC. TRIBS																				
Clear Ck		1	1	1		1				1	1		1	1					1	
Swan Ck		1	1	1		1				1	1		1	1					1	
Clarks Ck		1	1	1		1				1	1		1	1					1	
Fennel Ck		1	1	1		1				1	1		1	1					1	
Canyon Falls Ck		1	1	1		1				1	1		1	1					1	
Voight Ck		1	1	1		1				1	1		1	1					1	
Strawberry Ck		1	1	1		1				1	1		1	1					1	
Boise Ck		1	1	1		1				1	1		1	1					1	
Ptrib13.0		1	1	1		1				1	1		1	1					1	
Wtrib01.3		1	1	1		1				1	1		1	1					1	

Table 2.4. Summary of Puyallup sampling design for intensive surveys during September 18-20 and October 2-4, 1990.

STATION	RM	FLOW	TEMP PH DO	TSS	TURB	COND	CL	ALK	HARD	TOC	CBOD5	CBODU	NH3N NO23N	TP TPN	SRP	CHLA	TREC-METALS	DISS-METALS	FC	KES
			<----- Parameters (see Table 2.5 for key to abbreviations) ----->																	
			<----- NUMBER OF STATIONS OR TIMES SAMPLED ----->																	
S E C O N D D A Y :																				
MUNICIPAL WTPs (final effluent)																				
Puyallup			1	1		1		1	1	1	1		2	1			1		1	
Sumner			1	1		1		1	1	1	1		2	1			1		1	
Buckley			1	1		1		1	1	1	1		2	1			1		1	
Enumclaw			1	1		1		1	1	1	1		2	1			1		1	
Rainier St School			1	1		1		1		1	1		1	1					1	
McCalder Elem			1	1		1		1		1	1		1	1					1	
Orting			1	1		1		1		1	1		1	1					1	
Wilkeson			1	1		1		1		1	1		1	1					1	
Carbonado			1	1		1		1		1	1		1	1					1	
INDUSTRIAL (final effluent)																				
Lige Dickson (storm runoff & crushed rock process)			1	1		1		1		1	1		1	1						
Natl Semi #1 (discharge to Puyallup WTP outfall)			1	1		1		1	1	1	1		1	1			1		1	
Fleischmans (non-contact cooling water)			1	1		1		1		1	1		1	1					1	
Sonoco (paper mill WTP effluent)			1	1		1		1	1	1	1		1	1			1		1	1
Mazza (treated cheese process water)			1	1		1		1		1	1		1	1					1	1
Boeing #2 (non contact cooling water)			1	1		1		1		1	1		1	1					1	
Boeing #3 (Gov't Canal discharge to White R)		1	1	1		1		1		1	1		1	1					1	
Weyerhauser (mill pond influent/effluent)		1	2	2		2		2		2	2		2	2					2	1
FISH HATCHERIES (influent and effluent)																				
Troutco		1	1	2		2		2		2	2		2	2						
Puyallup Tribe		1	1	2		2		2		2	2		2	2						
Dept of Wildlife		1	1	2		2		2		2	2		2	2						
Muckleshoot Tribe		1	1	2		2		2		2	2		2	2						
Trout Springs		1	1	2		2		2		2	2		2	2						
Dept of Fisheries		1	1	2		2		2		2	2		2	2						

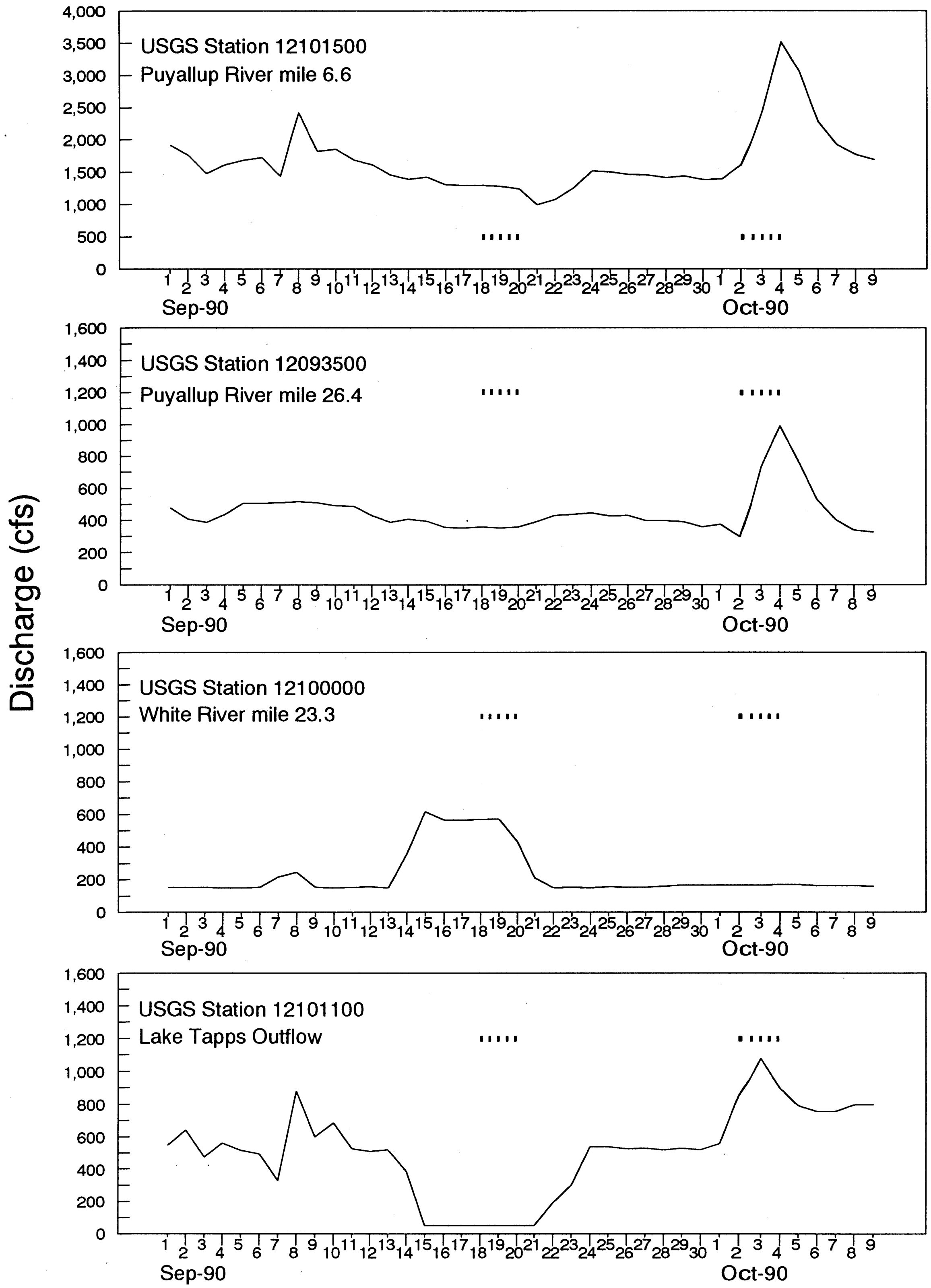


Figure 2.2. River flows during September and October, 1990.
Intensive survey dates are shown by ▪▪▪▪▪ .

Periphyton samples were collected on September 25 and October 1 and 2 at four sites in the White River (RM 25.2, 23.3, 20.4, and 8.0), at Carbon RM 2.0, and Puyallup RM 18.0 and 12.2. A detailed description of periphyton sampling methods is provided in Appendix D.

Samples for laboratory analysis were stored on ice and delivered to the Ecology/EPA Laboratory in Manchester, Washington, within 24 hours of collection. Laboratory analyses were performed in accordance with EPA (1983a), APHA *et al.,* (1989), and Huntamer and Smith (1986). Table 2.5 summarizes the parameters sampled and methods used. Quality assurance and quality control (QA/QC) analysis frequencies were as specified by Huntamer and Smith (1986).

2.3 Modeling

2.3.1 Far-field QUAL2E Model

QUAL2E is a comprehensive stream water quality model supported by USEPA (EPA, 1987). The model has been widely used to determine waste load allocations in rivers (EPA, 1983b; EPA, 1991a). The model is capable of simulating up to 15 water quality constituents in any combination desired by the user. QUAL2E was calibrated to the Puyallup River system to simulate dissolved oxygen, biochemical oxygen demand, and ammonia at steady-state conditions. Details of model calibration are presented in Section 4 of this report.

2.3.2 Velocity and Travel Time Models

Travel time is equal to river segment length divided by velocity and represents the amount of time it takes a parcel of water to travel a given distance. River velocity and travel time are important parameters for determining water quality changes for constituents that undergo chemical or biological transformations. Two techniques were used to estimate river segment velocities: 1) backwater modeling; and 2) Manning equation flow coefficients derived from dye tracer and/or cross section data. Both methods are described in detail by McCutcheon (1989). The methods used for particular river segments are summarized in Table 2.6.

Backwater modeling was accomplished using the model HEC-2 (U.S. Army Corps of Engineers, 1982). The U.S. Geological Survey calibrated the backwater model for the Puyallup River to RM 26, White River to RM 7.5, and Carbon River to RM 7.4 (Prych, 1988; Sikonia, 1990). HEC-2 was used to estimate average river velocities in these river segments at steady-state design flow.

Dye tracing was used to measure travel time in the White River between RM 23.1 and 4.9 using the method described by USGS (1981). Approximately 2.75 liters of Rhodamine WT fluorescent dye were injected at White RM 23.1 at 4:14 AM on October 10, 1990. The passage of the dye cloud was monitored at White RM 8.0 and 4.9 at 10- to 30-minute intervals to characterize the leading edge, centroid, and trailing edge. Manning equation flow coefficients were developed from the dye tracer results combined with unpublished cross-section data collected for Puget Power (Hosey and Associates, 1987) at 34 sites between RM 4.3 and 21.1.

Table 2.5. Summary of field and laboratory parameters and methods.

Parameter	Abbreviation used in Appendix A and Table 2.4	Method
Discharge	FLOW	
Temperature	TEMP	Thermometer/thermistor
pH	PH	Field meter/electrode
Dissolved Oxygen	DO	Winkler or polarographic probe
Nitrate+Nitrite N	NO23N	Cadmium reduction
Ammonia N	NH3N	Phenate
Total Persulfate N	TPN	Persulfate digestion/cadmium reduction
Soluble Reactive P	SRP	Ascorbic acid
Total P	TP	Persulfate digestion/ascorbic acid
Alkalinity	ALK	Low potentiometric titration
Fecal Coliform	FC	Membrane filter
% Klebsiella	KES	Membrane filter
Turbidity	TURB	Nephelometer
Specific Conductance	CCON	Conductivity bridge at 25 °C
Chloride	CL	Ion chromatography
Total Suspended Solids	TSS	Gravimetric
Total Organic Carbon	TOC	Infrared detection
Chlorophyll a	CHLRPHLA	Fluorometric or spectrophotometric
Pheopigments	PHAEOA	Fluorometric or spectrophotometric
5-day Carbonaceous BOD	CBOD5	5-day incubation at 20 °C with nitrification inhibition
Ultimate Carbonaceous BOD	CBODU	Best-fit of nitrification-inhibitted incubations
Total Hardness	HARD	EDTA Titrimetric
Total Recoverable Metals:		
Silver	AG-TREC	ICP
Arsenic	AS-TREC	ICP
Cadmium	CD-TREC	ICP
Chromium	CR-TREC	ICP
Copper	CU-TREC	ICP
Mercury (Total)	HG-TREC	Cold vapor
Nickel	NI-TREC	ICP
Lead	PB-TREC	ICP
Zinc	ZN-TREC	ICP
Dissolved Metals:		
Silver	AG-DISS	ICP
Arsenic	AS-DISS	ICP
Cadmium	CD-DISS	ICP
Chromium	CR-DISS	ICP
Copper	CU-DISS	ICP
Mercury (Total)	HG-DISS	Cold vapor
Nickel	NI-DISS	ICP
Lead	PB-DISS	ICP
Zinc	ZN-DISS	ICP

Table 2.6. Summary of hydraulic estimation methods for various river segments.

RIVER SEGMENT	METHOD
Puyallup River	
RM 0 - 18.4	Backwater model
White River	
RM 0 - 8.0	Backwater model
RM 8.0 - 25.4	Manning equation from dye study and cross sections
Carbon River	
RM 0 - 7.4	Backwater model
RM 7.4 - 12.0	Manning equation from cross sections
South Prairie Creek	Manning equation from cross sections
Wilkeson Creek	" " "
Voight Creek	" " "
Canyon Falls Creek	" " "
Boise Creek	" " "
Clarks Creek	" " "
Clear Creek	" " "
Swan Creek	" " "

Channel cross-section measurements were used to develop Manning equation flow coefficients for segments of the Carbon River (above RM 7.4), South Prairie Creek, Wilkeson Creek, Voight Creek, Boise Creek, Clarks Creek, Clear Creek, Swan Creek, and Canyon Falls Creek.

3.0 EXISTING WATER QUALITY AND DESIGN CONDITIONS

When a steady-state water quality model is used to determine the TMDL and WLAs, pollutant loading is introduced into the model under a given set of assumed water quality design conditions (e.g. flow, temperature, pH). The TMDL is the sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background (EPA, 1991a). The TMDL must not exceed the loading capacity that satisfies water quality criteria at the design condition (EPA, 1988). This section is limited primarily to data needs for modeling dissolved oxygen and ammonia. An examination of nutrient limitation of phytoplankton and periphyton is also included, since eutrophication involves the interaction of algal productivity, dissolved oxygen, and ammonia toxicity issues.

3.1 Historical Data Review

The seasonal pattern of stream flow in the Puyallup River is shown in Figure 3.1. Flows usually peak twice each year: in December with the onset of winter precipitation and in June with snowmelt from high elevations in the basin. Lowest flows usually occur during August through October.

Recent trends in selected water quality parameters at the Puyallup RM 8.3 station are presented in Figure 3.2. Water quality of parameters monitored by Ecology was relatively constant over the past 10 years. The 1980-91 period was preferred in reviewing ambient monitoring data to assess current conditions and assure data quality and comparability. However, older data were evaluated for stations which were discontinued prior to 1980.

Seasonal trends in temperature, pH, dissolved oxygen, ammonia concentration, chronic and acute ammonia criteria, dissolved inorganic nitrogen (DIN equals sum of nitrite+nitrate N and ammonia N), soluble reactive phosphorus (SRP), and ratios of DIN/SRP are shown in Figures 3.3 to 3.12. These figures present box plots, which show the minimum, 25th percentile, median, 75th percentile, and maximum values for each month.

Temperatures are generally highest and dissolved oxygen lowest during summer months. Seasonal dissolved oxygen concentration trends are caused mainly by temperature changes that affect equilibrium saturation. Since water quality is more sensitive to oxygen demanding loads at higher temperature, the combination of high temperature, low dissolved oxygen, and low flow are critical conditions for dissolved oxygen impacts. The percent of saturation of dissolved oxygen is less seasonally variable than concentration, although summer values may be supersaturated from photosynthetic activity. Summer pH also tends to be elevated because of photosynthesis.

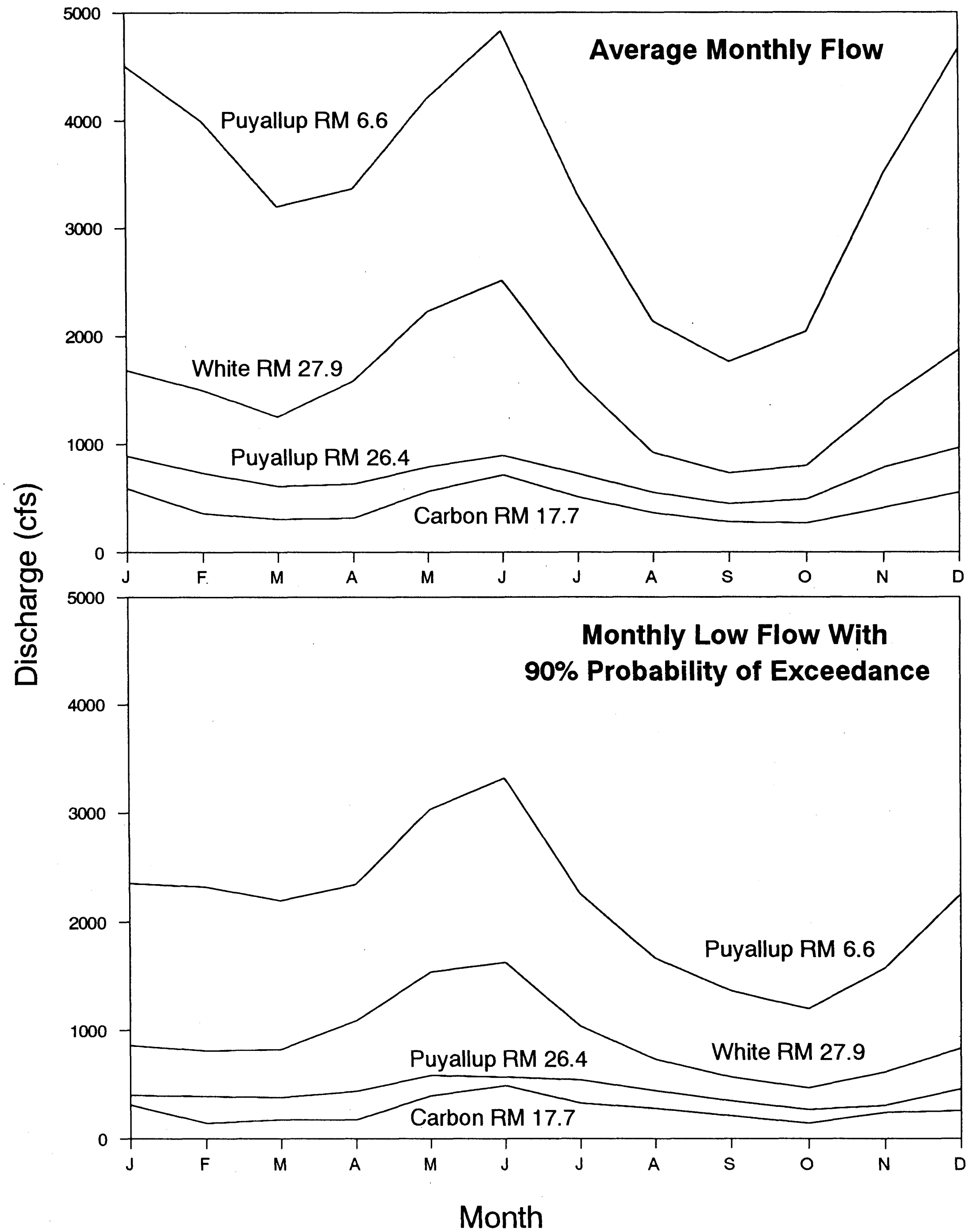


Figure 3.1. Monthly average flows and low flows with 90 percent probability of exceedance for selected stations in the Puyallup River basin. (Source: USGS, 1985).

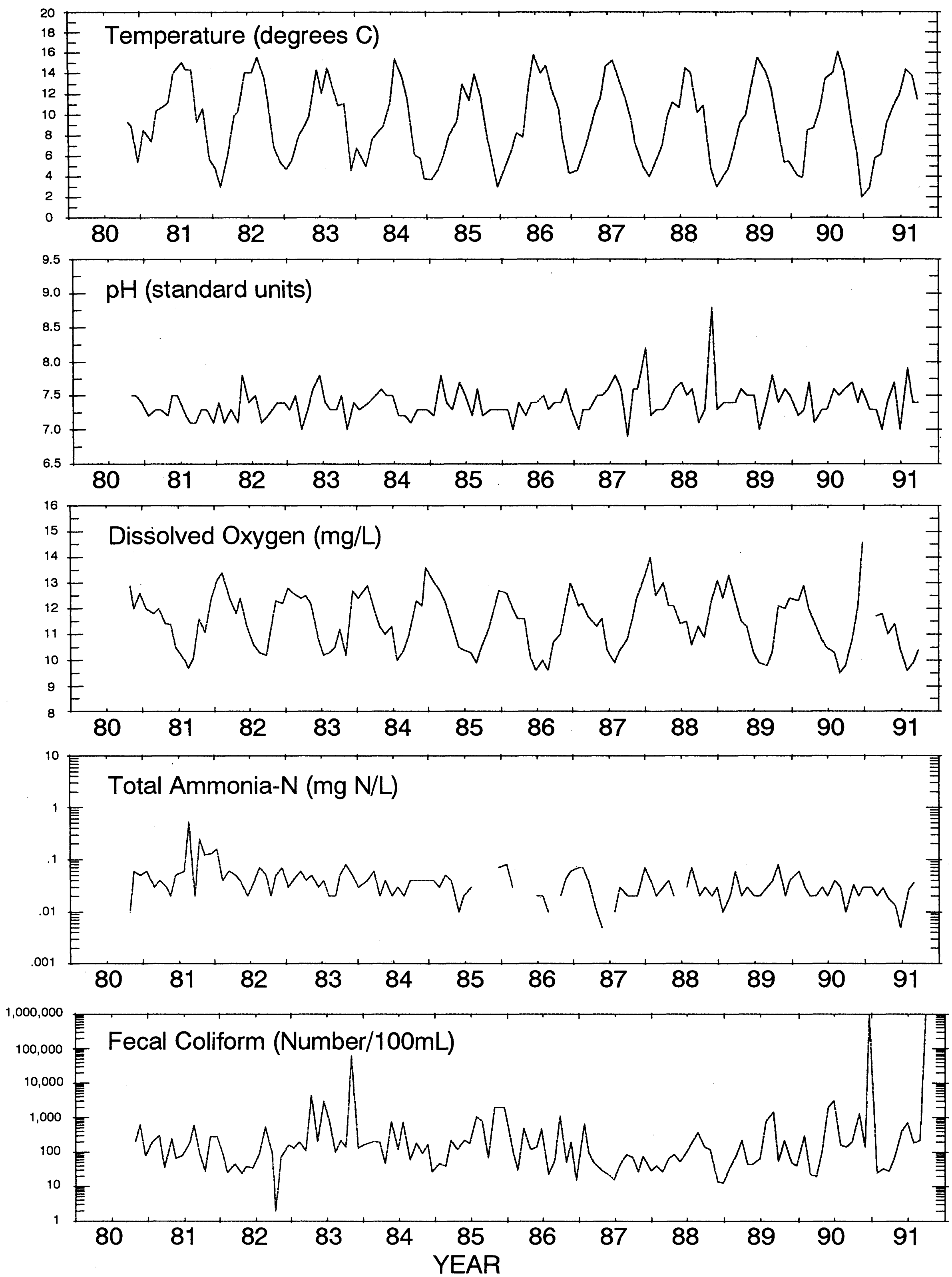


Figure 3.2. Water quality trends in the Puyallup River at mile 8.3 between 1980 and 1991.

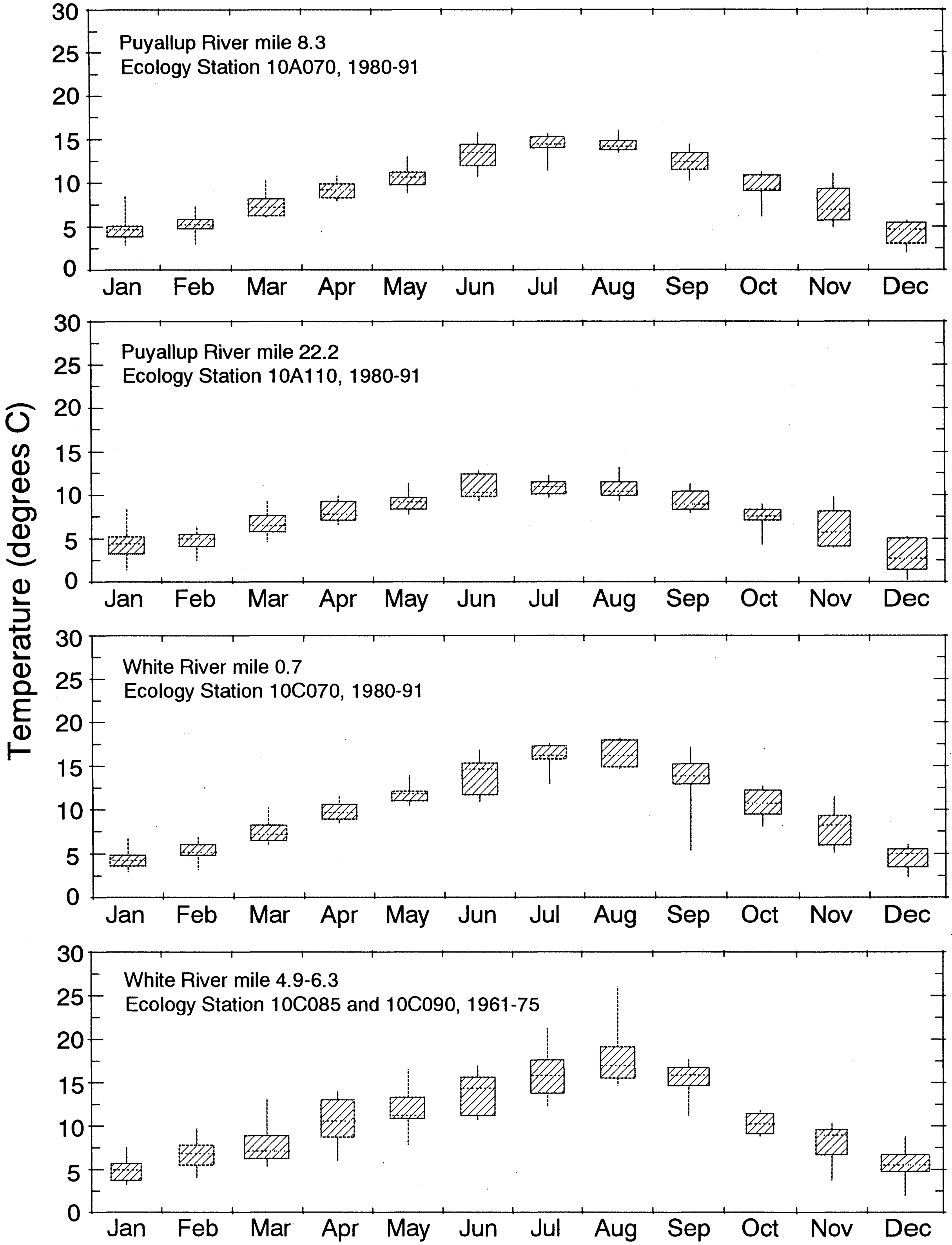


Figure 3.3. Monthly temperature at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

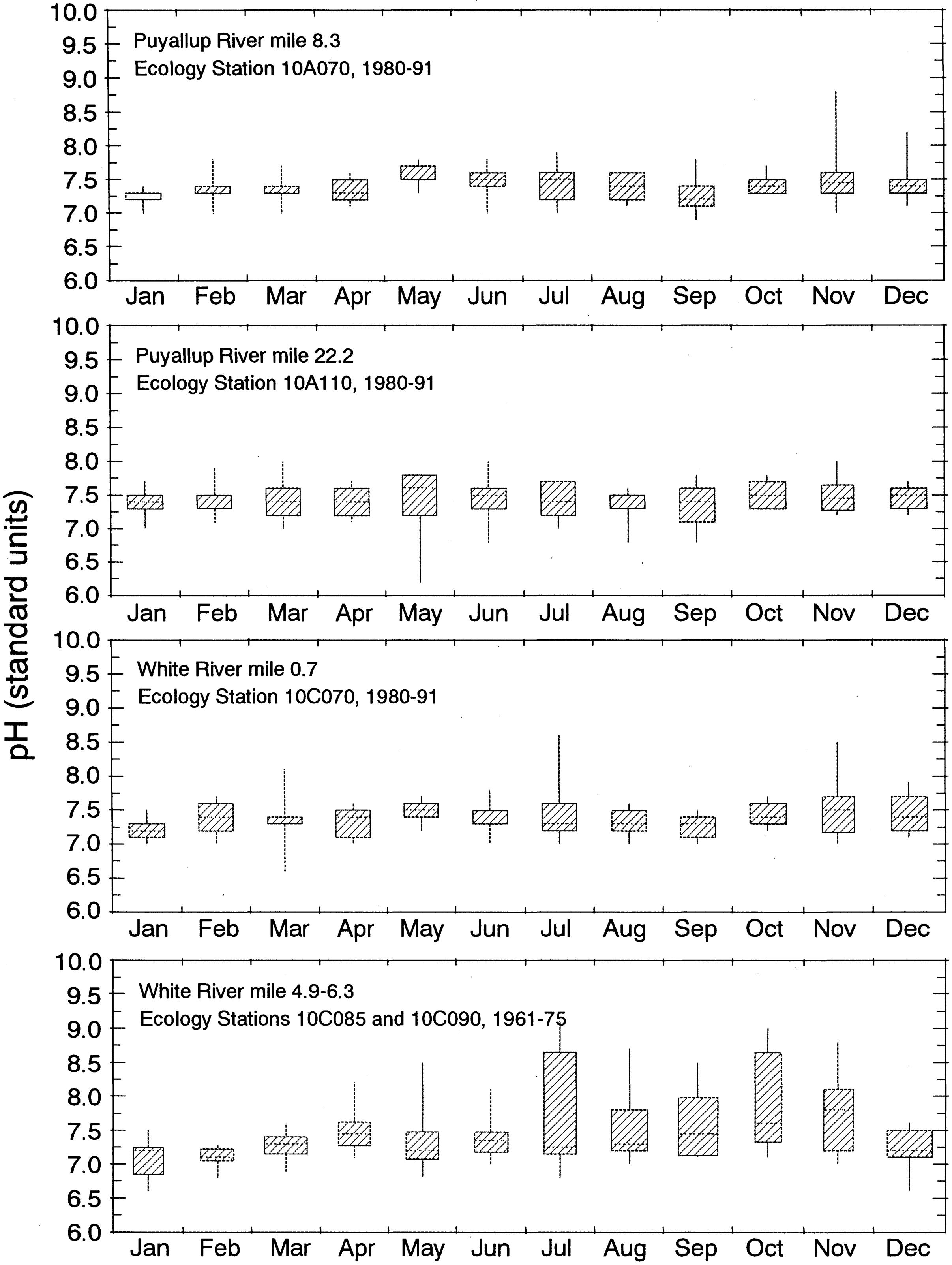


Figure 3.4. Monthly pH at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

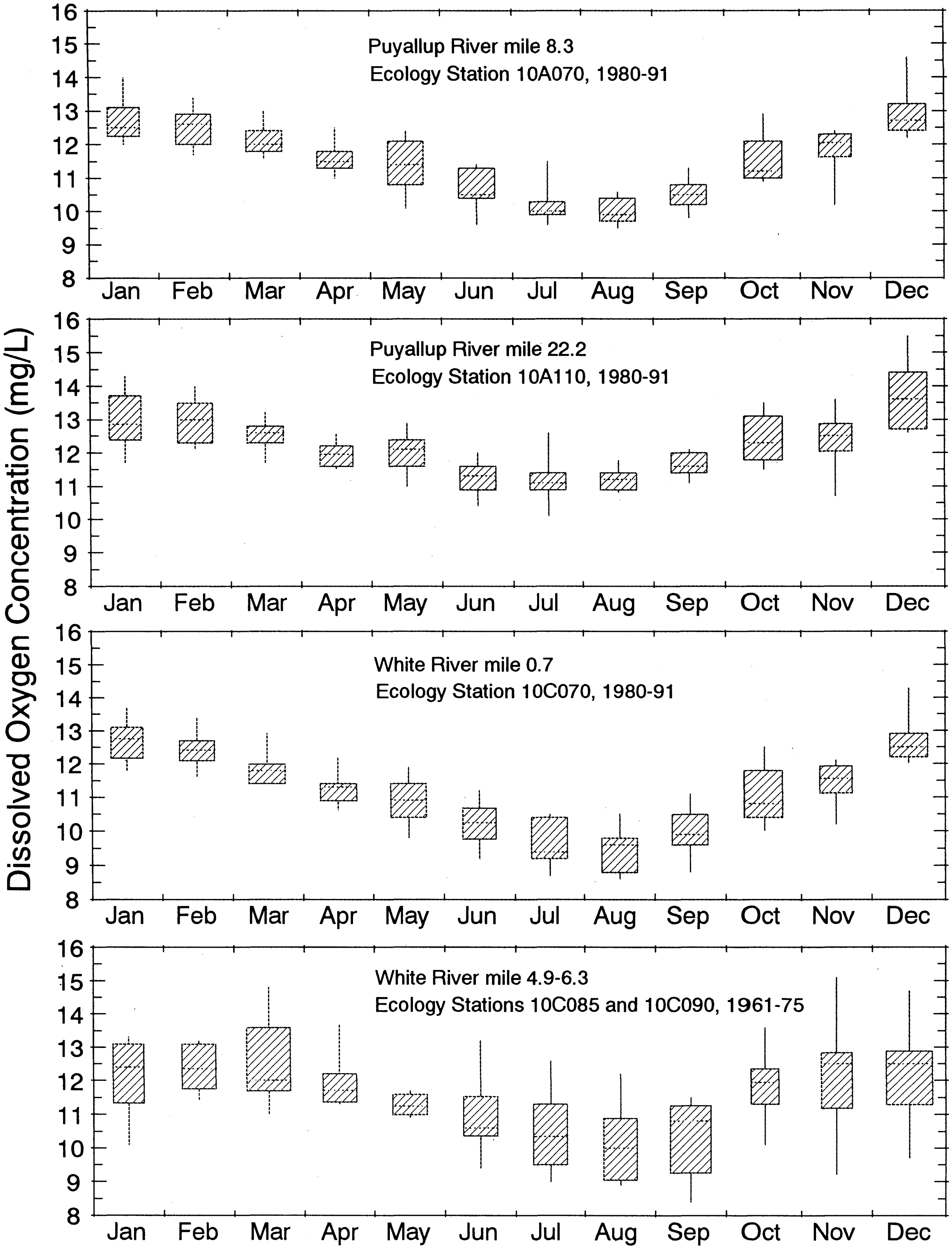


Figure 3.5. Monthly dissolved oxygen concentrations at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

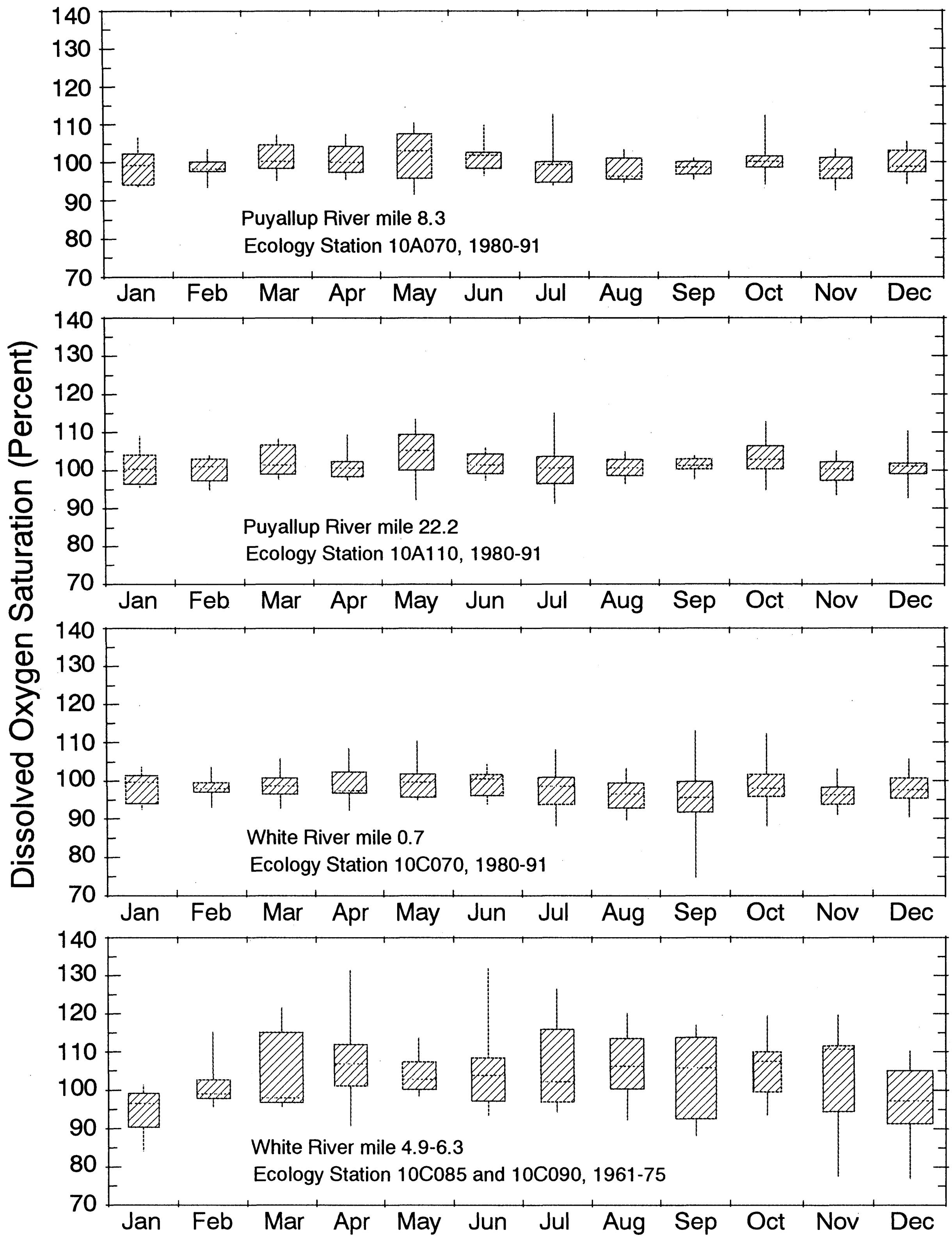


Figure 3.6. Monthly dissolved oxygen percent saturation at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

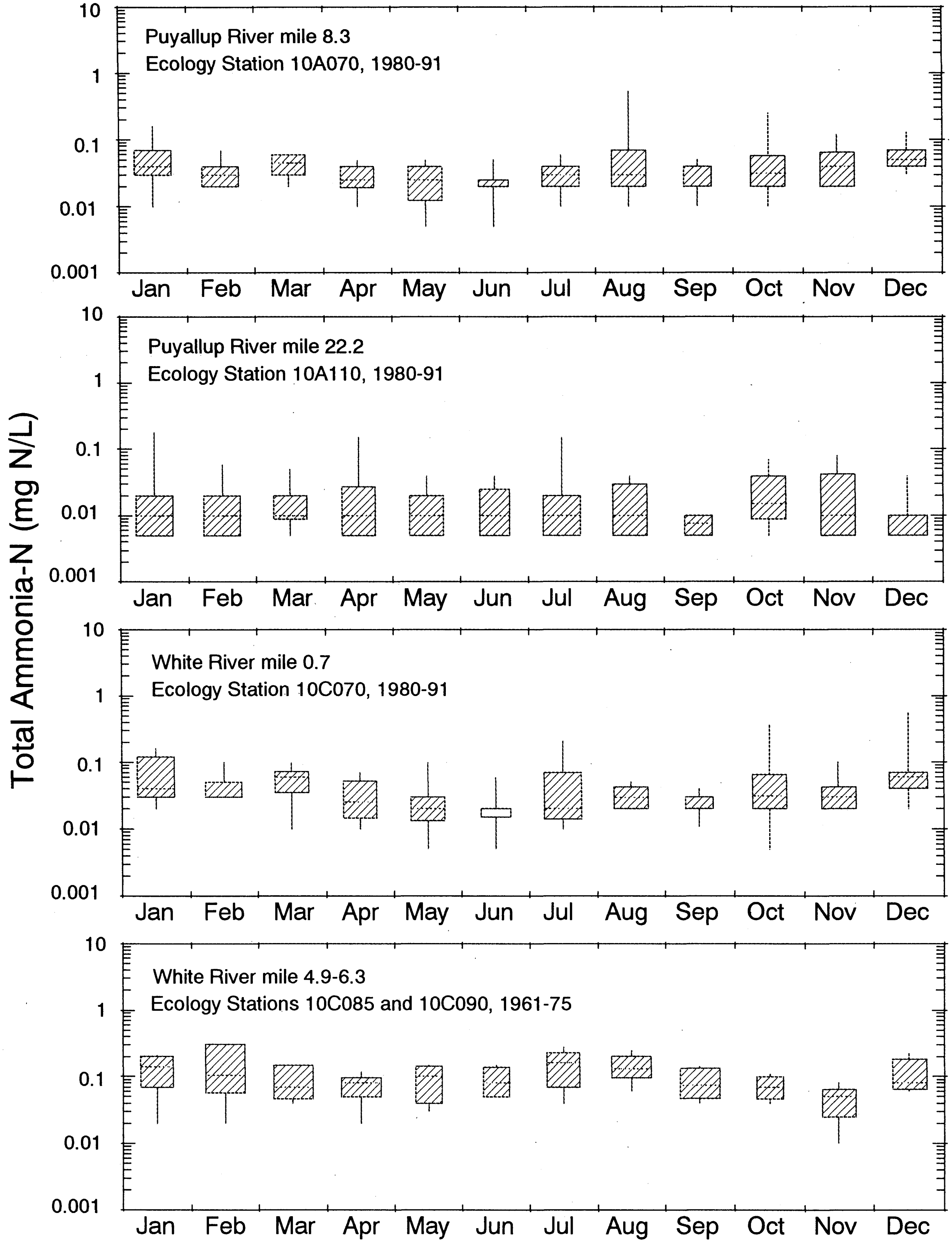


Figure 3.7. Monthly total ammonia at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

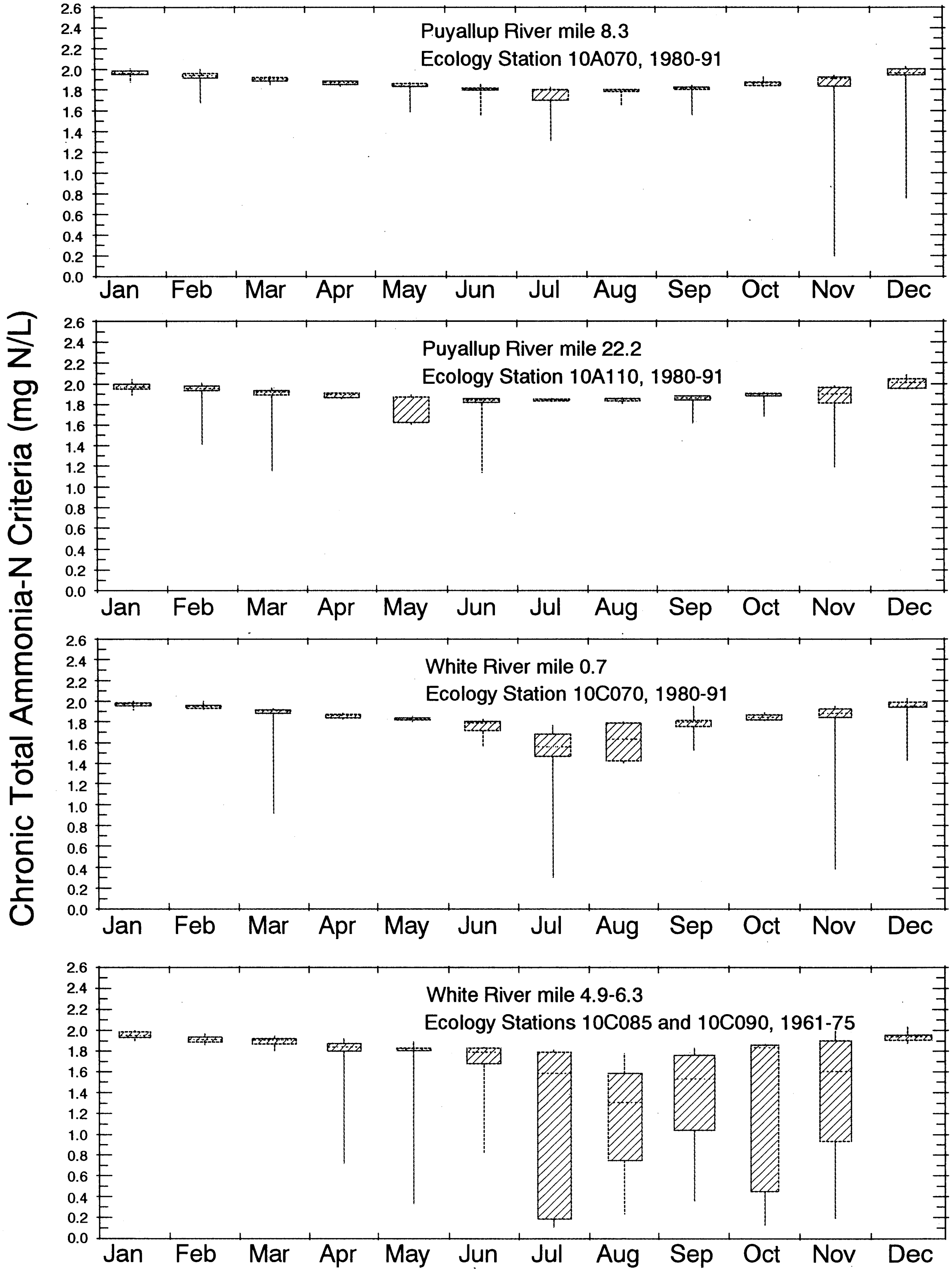


Figure 3.8. Monthly chronic total ammonia N criteria at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

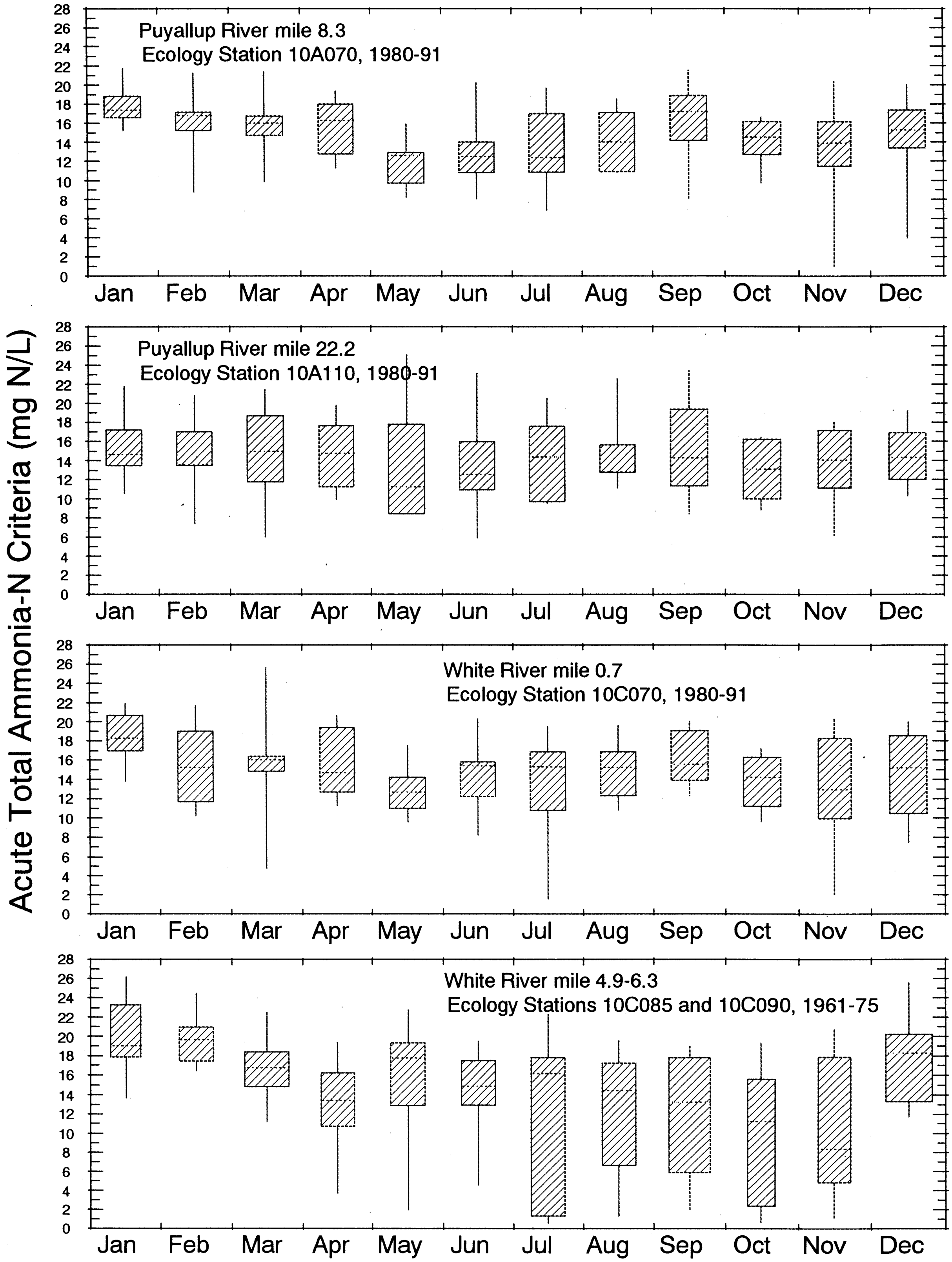


Figure 3.9. Monthly acute total ammonia N criteria at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

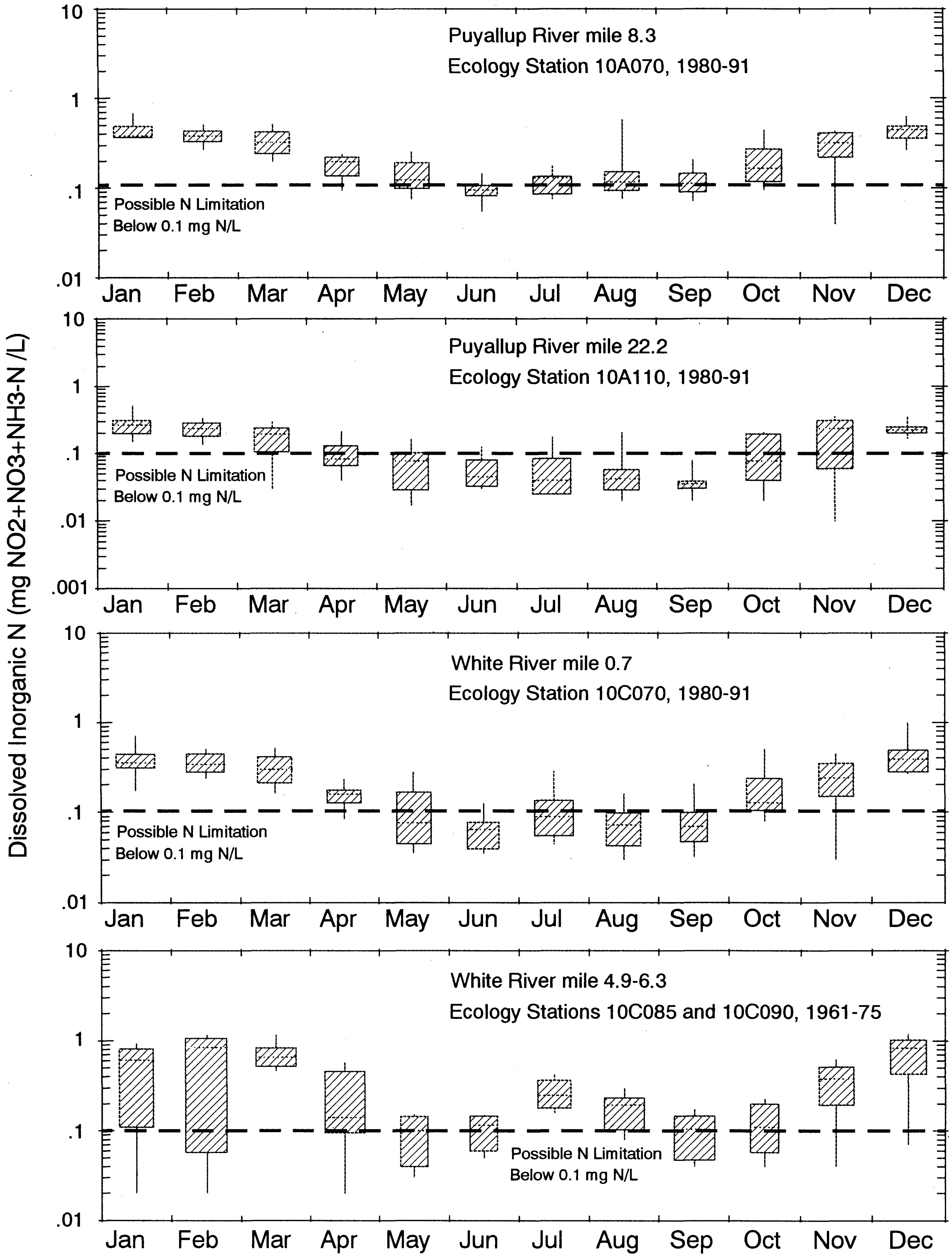


Figure 3.10. Monthly dissolved inorganic N (NO2+NO3+NH3-N) at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

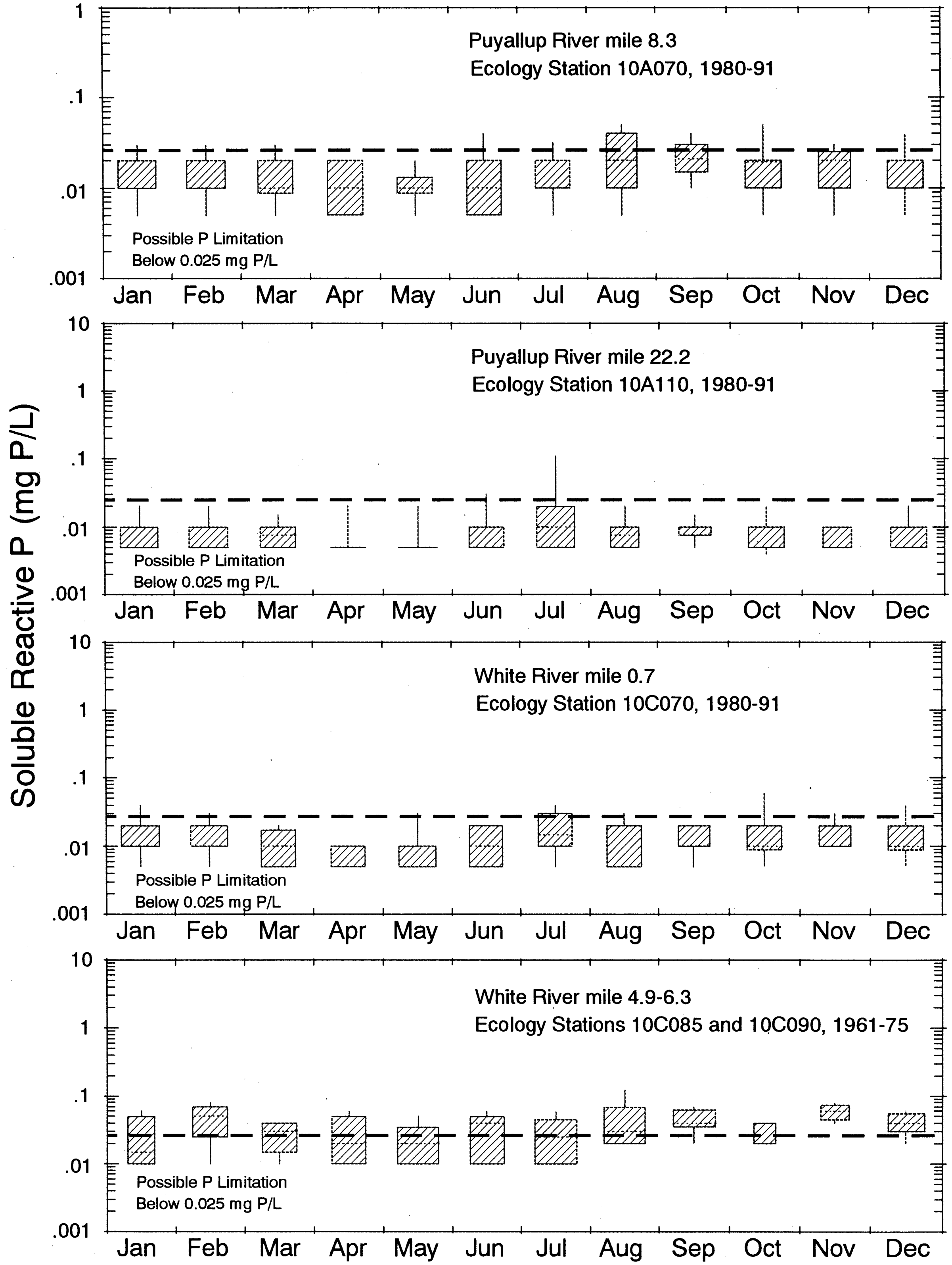


Figure 3.11. Monthly soluble reactive P at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

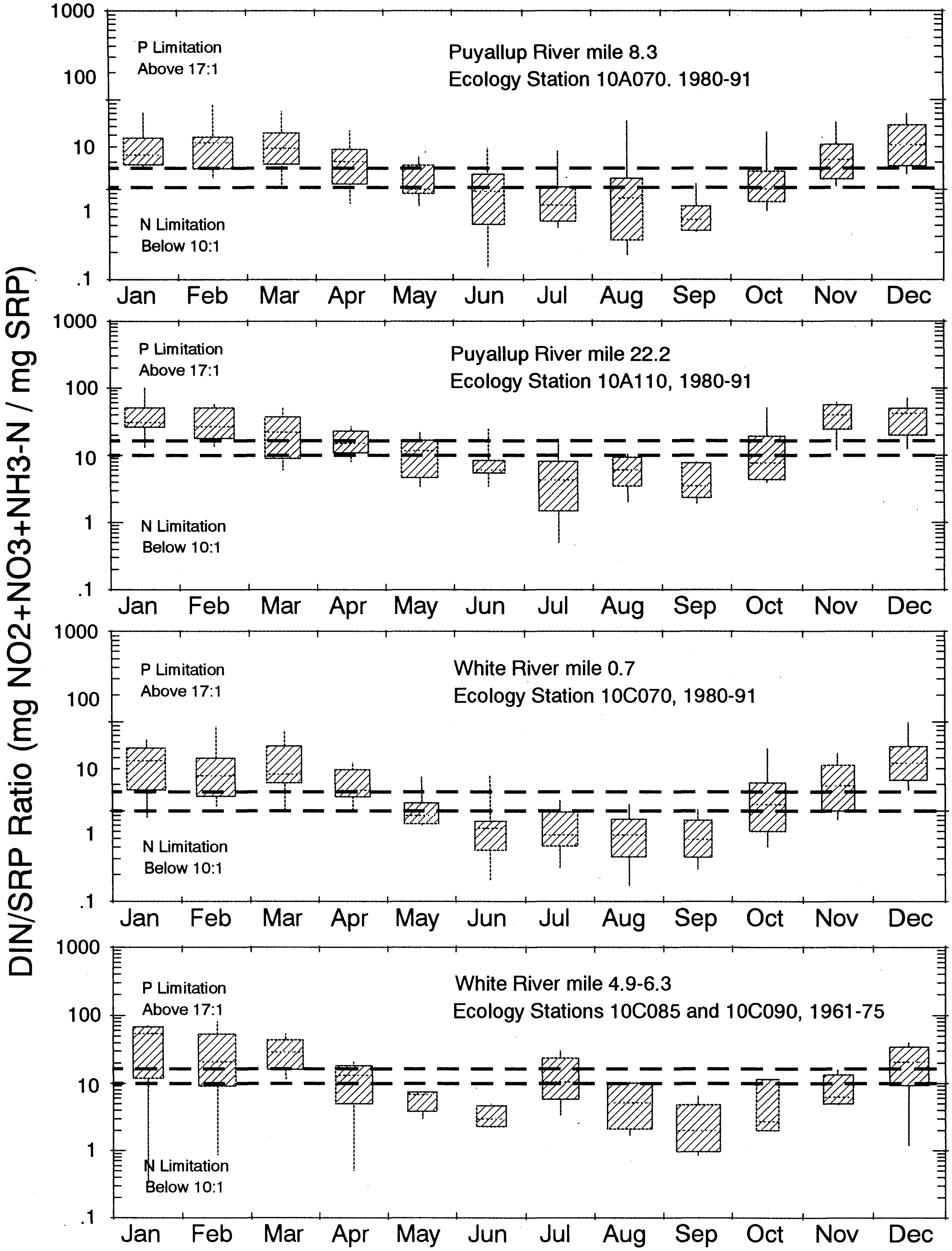


Figure 3.12. Monthly ratios of dissolved inorganic N to soluble reactive P at Puyallup River mile 8.3 and 22.2, and White River mile 0.7 and 4.9-6.3.

The concentration of total ammonia does not exhibit strong seasonality. However, the water quality criteria for ammonia are seasonally affected by temperature and pH. Ammonia criteria are most limiting during summer periods of high temperature and pH. This combination indicates that low flow periods of minimal dilution of point sources are expected to be the critical condition for ammonia. Conditions in the natural White River channel between diversion to, and outflow from, Lake Tapps appear to be most limiting for ammonia due to frequency of high pH between April and November.

The possibility of nutrient limitation of algal productivity was explored using dissolved inorganic N and soluble reactive P concentrations (Figure 3.10 and 3.11) and the ratio of DIN/SRP (Figure 3.12). Concentrations of DIN and SRP were assumed to be in excess of possible limitation if concentrations exceeded approximately five times the half-saturation concentration based on Monod kinetics of algae growth (Thomann and Mueller, 1987). Applying this criterion, both N and P concentrations may be low enough to limit growth during summer. However, the ratios of DIN/SRP suggest that N may be more limiting than P during the growing season.

Table 3.1 summarizes typical and extreme conditions of temperature, pH, dissolved oxygen, and ammonia (concentration and criteria) for six ambient stations. In general, the headwater stations (Puyallup RM 22.2 and Carbon RM 5.8) have coolest temperatures, highest dissolved oxygen, and lowest ammonia concentrations. The natural White River channel between RM 24.3 and 3.6 is represented by pooled data from two stations sampled from 1962 to 1975 (RM 4.9 and 6.3) which show warmest temperatures, highest pH, and most restrictive ammonia criteria.

3.2 1990 Intensive Surveys

3.2.1 Supplemental Design Conditions

Data from the 1990 intensive surveys supplemented historical data for estimating design conditions. Waterbody segments with older, sparse, or nonexistent historical data were represented by the 1990 data. The 1990 surveys confirm the sensitivity of the White River, especially between RM 24.3 and 3.6, to ammonia inputs because of high pH (Figure 3.13). The cause of high pH and supersaturation of dissolved oxygen appears to be growth of attached algae or periphyton rather than phytoplankton. Phytoplankton (suspended algae) growth rates would have to be greater than ten times the theoretical maximum rate reported in scientific literature to explain the suspended chlorophyll increases observed in the river (Thomann and Mueller, 1987). Chlorophyll concentration increases in the river water appear to be caused mostly by scouring of benthic algae. Velocities in the Puyallup River system do not appear to provide sufficient time for development of nuisance levels of phytoplankton biomass.

Table 3.1. Summary of typical and extreme conditons for water quality parameters in the Puyallup and White Rivers based on Ecology ambient monitoring monitoring data.

Parameter	Location	Period of Record	Number of Samples	Annual Median	Critical Annual 10 %tile	Critical Annual 5 %tile
Temperature (deg C)	Puyallup r.m. 8.3	1980-91	131	9.4	14.4	15.2
- highest percentile	Puyallup r.m. 22.2	1980-91	131	8.0	11.3	11.8
	Carbon r.m. 5.8	1964-72	50	7.6	11.5	12.4
	White r.m. 0.7	1980-91	131	10.2	16.2	17.4
	White r.m. 4.9-6.3	1962-75	124	10.4	16.9	17.9
pH (standard units)	Puyallup r.m. 8.3	1980-91	131	7.4	7.7	7.8
- highest percentile	Puyallup r.m. 22.2	1980-91	131	7.4	7.7	7.8
	Carbon r.m. 5.8	1964-72	50	7.3	7.4	7.5
	White r.m. 0.7	1980-91	131	7.4	7.7	7.7
	White r.m. 4.9-6.3	1962-75	125	7.3	8.2	8.7
Dissolved Oxygen (mg/L)	Puyallup r.m. 8.3	1980-91	130	11.5	10	9.8
- lowest percentile	Puyallup r.m. 22.2	1980-91	129	12.1	11	10.8
	Carbon r.m. 5.8	1964-72	50	11.9	10.8	10.6
	White r.m. 0.7	1980-91	129	11.1	9.4	8.9
	White r.m. 4.9-6.3	1962-75	124	11.6	9.7	9.1
Diss. Oxygen Saturation (%)	Puyallup r.m. 8.3	1980-91	130	99	106	108
- highest percentile	Puyallup r.m. 22.2	1980-91	129	101	107	110
	Carbon r.m. 5.8	1964-72	50	99	107	108
	White r.m. 0.7	1980-91	129	98	104	106
	White r.m. 4.9-6.3	1962-75	124	102	117	120
Chronic Total Ammonia-N Criterion (mg N/L) -lowest percentile	Puyallup r.m. 8.3	1980-91	131	1.9	1.7	1.6
	Puyallup r.m. 22.2	1980-91	131	1.9	1.8	1.6
	Carbon r.m. 5.8	1964-72	50	1.9	1.8	1.8
	White r.m. 0.7	1980-91	131	1.8	1.5	1.4
	White r.m. 4.9-6.3	1962-75	124	1.8	0.72	0.21
Acute Total Ammonia-N Criterion (mg N/L) - lowest percentile	Puyallup r.m. 8.3	1980-91	131	15	10	8.2
	Puyallup r.m. 22.2	1980-91	131	14	9.6	8.4
	Carbon r.m. 5.8	1964-72	50	17	14	13
	White r.m. 0.7	1980-91	131	15	10	9.0
	White r.m. 4.9-6.3	1962-75	124	16	3.7	1.3
Total Ammonia-N Concentration (mg N/L) - highest percentile	Puyallup r.m. 8.3	1980-91	121	0.03	0.07	0.08
	Puyallup r.m. 22.2	1980-91	121	0.01	0.04	0.07
	White r.m. 0.7	1980-91	121	0.03	0.10	0.14

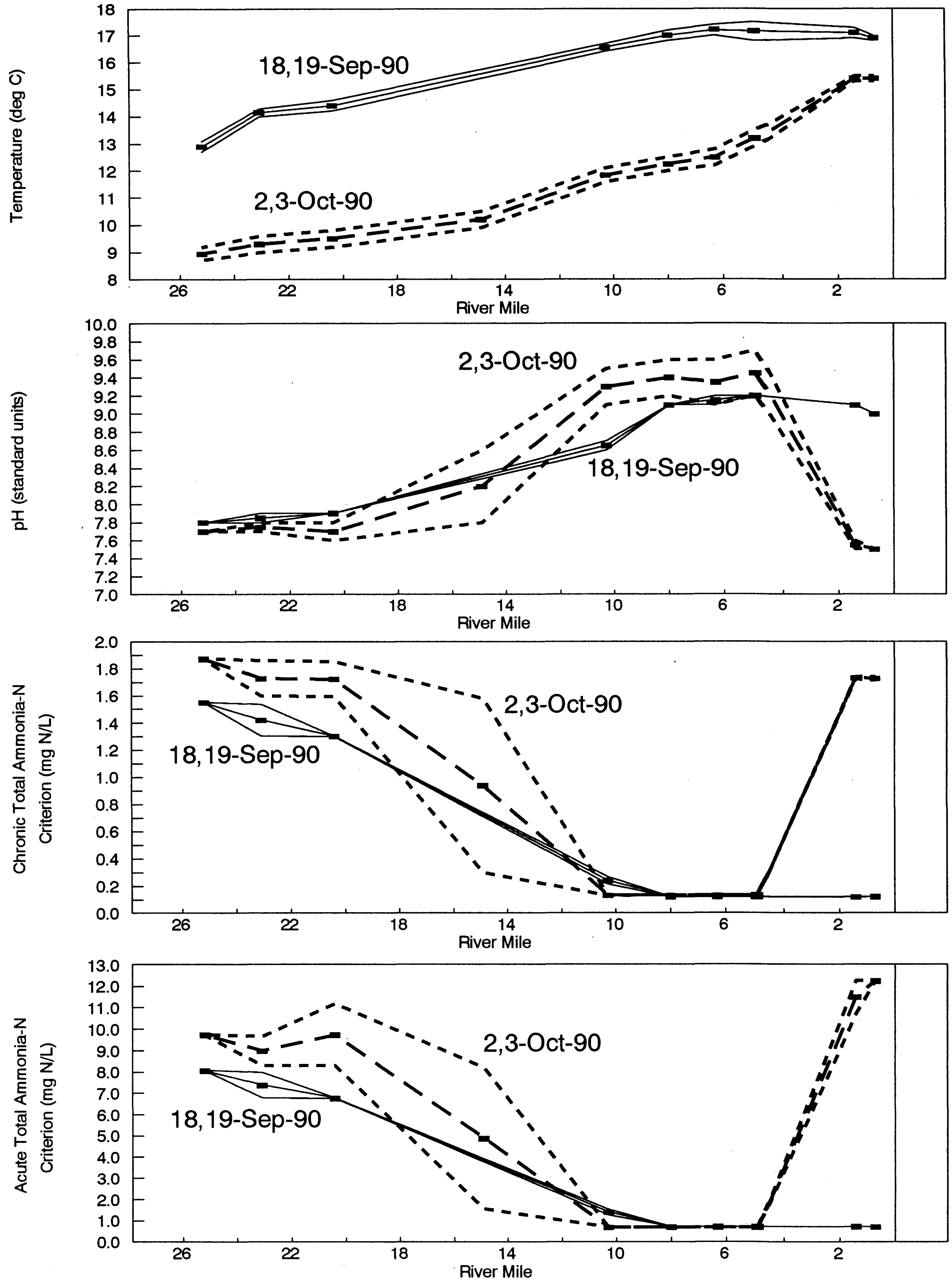


Figure 3.13. White River temperature, pH, and ammonia criteria during September and October 1990 Ecology surveys.
Plots show means +/- standard errors.

Periphyton productivity is the most likely explanation of pH and dissolved oxygen patterns in the White River. Concentrations of DIN and SRP were both in excess of limiting concentrations (greater than five times the half-saturation concentrations) immediately below WTP inputs at Enumclaw and Buckley, which indicates that productivity is probably limited mainly by light and temperature in this reach. Nitrogen limitation probably begins at some point within the reach as DIN levels are reduced from periphyton uptake, whereas SRP is in excess throughout the reach. Although periphyton productivity appears to be high, periphyton biomass levels were well below criteria for nuisance conditions (Appendix D), possibly because of scouring by relatively rapid velocities. Models of periphyton growth are presently in early stages of development and generally only address prediction of potential maximum biomass (Horner and Welch, 1981). Reliable prediction of water quality changes resulting from periphyton productivity (e.g., reduced diurnal pH ranges resulting from nutrient loading reductions) is currently not possible. Reductions in DIN loading from municipal WTPs (Enumclaw, Buckley, and Rainier School) would probably be more effective at reducing productivity than controls on phosphorus since N:P ratios indicate N limitation and natural headwater loading of total P exceeds requirements for algal growth.

Table 3.2 presents a summary of September and October 1990 intensive survey data of temperature, pH, and ammonia criteria for all surface water stations. These data were used to supplement ambient monitoring data to derive design conditions for steady-state WLA modeling of dissolved oxygen and ammonia.

3.2.2 Metals Results

Table 3.3 presents all total recoverable metals data from the September and October, 1990 surveys by Ecology. Sample observations which exceed acute and chronic water quality criteria are indicated by annotations to the right of reported values. Criteria that depended on hardness were calculated from sample hardness (EPA, 1986).

The very low hardness of surface waters in the study area results in chronic and acute criteria that are near or below the detection limit for many metals. The only metals observations that exceeded water quality criteria without qualification (*i.e.*, sample results are considered quantifiable above the detection limit) were found at Carbon RM 17.7, Government Canal, and several NPDES discharges. The major findings of total recoverable metals sampling are summarized below with respect to EPA Gold Book criteria:

- copper concentrations were greater than chronic and acute criteria at Carbon RM 17.7 and several NPDES discharges;
- lead concentrations were greater than chronic and acute criteria at Carbon RM 17.7 and greater than chronic in the Boeing cooling water discharge and Government Canal;
- silver concentrations were greater than the chronic criterion at Enumclaw and Puyallup WTPs; and

Table 3.2 Summary of September and October 1990 field measurements of temperature and pH for mainstem and large tributary stations with calculated ammonia criteria.

Waterbody	River Mile	Date	Temperature (degrees C)	pH (SU)	Acute Total Ammonia Criteria (mgN/L)	Chronic Total Ammonia Criteria (mgN/L)
Wilkeson Ck	4.0	Sep-90	13.4	7.8	8.04	1.55
		Oct-90	10.5	8.2	3.72	0.72
South Prairie Ck	7.4	Sep-90	13.6	7.4	13.97	1.80
		Oct-90	11.2	8.1	4.63	0.89
South Prairie Ck	5.8	Sep-90	13.8	7.7	9.37	1.80
		Oct-90	11.2	8.1	4.63	0.89
South Prairie Ck	1.1	Sep-90	14.2	7.7	9.35	1.80
		Oct-90	11.6	8.0	5.78	1.11
Carbon R.	17.7	Sep-90	10.6	6.9	21.65	1.83
		Oct-90	7.3	7.7	9.89	1.90
Carbon R.	6.1	Sep-90	12.5	7.5	12.48	1.81
		Oct-90	9.3	8.0	5.88	1.13
Carbon R.	2.0	Sep-90	14.3	7.6	10.80	1.79
		Oct-90	10.8	7.9	6.93	1.33
White R.	25.2	Sep-90	12.6	7.9	6.84	1.32
		Oct-90	9.6	7.9	7.00	1.35
White R.	25.1	Sep-90	12.8	7.6	10.91	1.81
White R.	23.3	Sep-90	13.2	7.9	6.82	1.31
White R.	20.4	Sep-90	13.0	8.1	4.58	0.88
		Oct-90	11.1	8.1	4.64	0.89
White R.	8.0	Sep-90	15.0	8.6	1.54	0.30
		Oct-90	12.3	8.9	0.84	0.16
White R.	4.9	Sep-90	15.0	8.5	1.90	0.37
		Oct-90	11.7	8.8	1.02	0.20
White R.	0.7	Sep-90	14.8	8.1	4.54	0.87
		Oct-90	15.3	7.8	7.95	1.53
Puyallup R.	18.0	Sep-90	13.4	7.4	13.99	1.80
		Oct-90	9.9	7.7	9.65	1.86
Puyallup R.	12.2	Sep-90	14.2	7.3	15.49	1.79
		Oct-90	10.8	7.8	8.19	1.57
Puyallup R.	8.3	Sep-90	13.9	7.9	6.79	1.31
		Oct-90	12.7	7.8	8.08	1.55
Puyallup R.	5.7	Sep-90	13.8	7.8	8.02	1.54
		Oct-90	12.2	7.5	12.51	1.82
Puyallup R.	1.5	Sep-90	14.9	7.8	7.97	1.53
		Oct-90	12.2	7.5	12.51	1.82
Puyallup R.	0.8	Sep-90	13.7	7.5	12.38	1.80
		Oct-90	11.9	7.4	14.14	1.82

Table 3.2 (cont) Summary of September and October 1990 field measurements of temperature and pH and calculated ammonia criteria for tributary stations.

Waterbody	Date	Temperature (degrees C)	pH (SU)	Acute Total Ammonia Criteria (mgN/L)	Chronic Total Ammonia Criteria (mgN/L)
Boise Ck r.m. 5.8	Sep-90	12.5	7.5	12.48	1.81
	Oct-90	11.0	7.4	14.25	1.83
Boise Ck r.m. 0.1	Sep-90	13.8	8.0	5.70	1.10
	Oct-90	11.8	7.9	6.88	1.32
Bowman Ck	Sep-90	14.9	7.9	6.75	1.30
	Oct-90	12.5	7.4	14.08	1.81
Canyon Falls Ck	Sep-90	13.8	7.8	8.02	1.54
	Oct-90	11.4	8.1	4.63	0.89
Clarks Ck	Sep-90	11.0	7.4	14.25	1.83
	Oct-90	10.8	7.4	14.27	1.83
Clear Ck	Sep-90	11.0	7.2	17.44	1.83
	Oct-90	11.0	7.6	11.06	1.84
Fennel Ck	Sep-90	12.6	7.9	6.84	1.32
	Oct-90	10.7	7.8	8.19	1.58
Government Canal	Sep-90	14.7	6.8	22.06	1.77
	Oct-90	12.9	7.0	20.01	1.80
Lily Ck	Sep-90	11.1	7.5	12.62	1.83
	Oct-90	10.3	7.5	12.71	1.84
Misc. Trib at Puyallup r.m. 13.0	Sep-90	14.4	7.5	12.32	1.79
	Oct-90	11.5	7.6	11.01	1.83
Misc. Trib at White r.m. 15	Sep-90	10.3	6.5	25.35	1.83
	Oct-90	10.3	6.0	25.35	1.83
Misc. Trib at White r.m. 1.3	Sep-90	13.6	7.0	19.91	1.79
	Oct-90	9.8	7.3	16.03	1.85
Strawberry (Salmon) Ck	Sep-90	11.5	7.5	12.58	1.83
	Oct-90	11.0	7.6	11.06	1.84
Swan Ck	Sep-90	13.3	7.6	10.87	1.81
	Oct-90	11.2	7.7	9.55	1.84
Voights Ck	Sep-90	14.1	7.5	12.35	1.79
	Oct-90	12.5	7.7	9.45	1.82

Table 3.3. Summary of total recoverable metals data for mainstem and major tributary stations.

Water Body	RM	Date	Time	TSS	Total Hardness	AG-TREC	AS-TREC	CD-TREC	CR-TREC	CU-TREC	HG-TOT	NI-TREC	PB-TREC	ZN-TREC
				mg/L	mgCaCO3/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Wilkeson Ck	4.0	18-Sep-90	1615	1	70.9	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.64 BJ	7.5 J
"	4.0	19-Sep-90	1330		50.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.3 BJ	5.3 J
"	4.0	02-Oct-90	1250	1	79.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.62 BJ	11 JB
"	4.0	03-Oct-90	1230	2	78.0	0.05 U	1 U	0.1 U	5 U	2 U	0.02 U C	10 U	1.3 JB	4.4 J
White River	25.2	18-Sep-90	1330	82	22.2	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.91 BJC	5.9 J
"	25.2	19-Sep-90	1440	72	22.2	0.05 U	1 U	0.1 U	5 U	2.4 J	0.04 U C	10 U	1.1 BJC	6 J
"	25.2	02-Oct-90	820	140	23.1	0.05 U	1 U	0.1 U	5 U	5.4 J CA	0.04 U C	10 U	1.1 BJC	6.1 JB
"	25.2	03-Oct-90	800	53	26.2	0.05 U	1.1 J	0.1 U	5 U	2 U	0.02 U C	10 U	0.62 JBC	5.3 J
"	23.3	18-Sep-90	1420	68	23.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.89 BJC	6.9 J
"	23.3	02-Oct-90	840	69	27.4	0.05 U	1 U	0.18 J	5 U	4.9 J C	0.04 U C	10 U	1.2 BJC	15 JB
"	10.3	18-Sep-90	1610	29	27.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.45 BJ	3.7 J
"	10.3	02-Oct-90	1310	11	33.2	0.05 U	1 U	0.1 U	5 U	3.2 J	0.04 U C	10 U	0.78 BJ	9.8 JB
"	4.9	18-Sep-90	1740	23	29.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.46 BJ	6.1 J
"	4.9	02-Oct-90	1840	10	33.0	0.05 U	1 U	0.1 U	5 U	2.2 J	0.04 U C	10 U	0.8 BJC	3.4 JB
"	0.7	18-Sep-90	1900	17	27.8	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.48 BJ	4.1 J
"	0.7	02-Oct-90	1450	12	22.3	0.05 U	1 U	0.1 U	5 U	4.1 J C	0.04 U C	10 U	1.3 BJC	4.6 JB
"	0.7	03-Oct-90	1530	11	23.1	0.05 U	1.2 J	0.1 U	5 U	2 U	0.02 U C	10 U	1.6 JBC	5.1 J
S. Prairie Ck	7.4	18-Sep-90	1630	1	37.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.45 BJ	3.3 J
"	7.4	19-Sep-90	1350		37.6	0.05 U	1 U	0.11 J	5 U	2 U	0.04 U C	10 U	0.2 BJ	2.9 J
"	7.4	02-Oct-90	1330	1	39.4	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.51 BJ	6.6 JB
"	7.4	03-Oct-90	1245	1	40.2	0.05 U	1 U	0.1 U	5 U	2 U	0.02 U C	10 U	0.57 JB	2.9 J
"	1.1	18-Sep-90	1700	1	50.1	0.05 U	1 U	0.01 U	5 U	2 U	0.04 U C	10 U	0.99 BJ	10 J
"	1.1	02-Oct-90	1435	2	53.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.4 BJ	2.8 JB
Puyallup R.	18.0	18-Sep-90	1800	57	25.5	0.05 U	1 U	0.1 U	5 U	2.1 J	0.11 J C	10 U	0.99 BJC	14 J
"	18.0	19-Sep-90	1605	64	24.0	0.05 U	1 U	0.19 J	5 U	6.1 J CA	0.04 U C	10 U	1.5 BJC	15 J
"	18.0	02-Oct-90	1655	55	26.5	0.05 U	1 U	0.1 U	5 U	3.5 J	0.04 U C	10 U	1.5 BJC	7.2 JB
"	18.0	03-Oct-90	1500	104	28.4	0.05 U	1 U	0.1 U	5 U	2.3 J	0.044 J C	10 U	1.1 JBC	9.5 J
"	12.2	18-Sep-90	1850	36	28.3	0.05 U	1 U	0.2 J	5 U	2 U	0.04 U C	10 U	0.98 BJC	13 J
"	12.2	02-Oct-90	1727	43	29.8	0.05 U	1 U	0.1 U	5 U	3.5 J	0.04 U C	10 U	0.83 BJC	5.3 JB
"	12.2	03-Oct-90	1520	47	34.7	0.05 U	1 U	0.1 U	5 U	11 J CA	0.036 J C	10 U	1.3 JBC	8.3 J
"	8.3	18-Sep-90	1940	30	29.5	0.079 J	1 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.87 BJC	6 J
"	8.3	02-Oct-90	1530	32	24.5	0.05 U	1 U	0.1 U	5 U	3.5 J	0.04 U C	10 U	1.2 BJC	4 JB
"	5.7	18-Sep-90	2010	28	30.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	2.64 B C	5.3 J
"	5.7	02-Oct-90	1600	34	24.7	0.05 U	1 U	0.1 U	5 U	5.6 J CA	0.08 J C	10 U	1.4 BJC	8.1 JB
"	5.7	03-Oct-90	1700	25	26.9	0.05 U	1 U	0.1 U	5 U	2 U	0.02 U C	10 U	2.3 B C	5.9 J
"	1.5	18-Sep-90	1200	52	48.1	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	3.34 B C	3.8 J
"	1.5	02-Oct-90	1640	22	60.4	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	3.77 B C	5.1 JB
"	1.5	02-Oct-90	1200	74	38.7	0.05 U	1 U	0.1 U	5 U	3.8 J	0.08 J C	10 U	1 BJC	6.2 JB
"	0.8	18-Sep-90	1120	59	179.5 J	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	1.8 BJ	10 J
"	0.8	02-Oct-90	1120	95	75.3	0.05 U	1 U	0.1 U	5 U	4.8 J	0.04 U C	10 U	1.2 BJ	6.8 JB
"	0.8	02-Oct-90	1700	20	150.0	0.05 U	1 U	0.1 U	5 U	4.7 J	0.04 U C	10 U	0.71 JB	4.1 JB
"	0.8	03-Oct-90	1145	27	54.8	0.05 U	1 U	0.1 U	5 U	2.1 J	0.042 J C	10 U	1.2 JB	5 J
"	0.8	03-Oct-90	1800	7	438.0	0.054 J	1 J	0.1 U	5 U	2 U	0.02 U C	10 U	2.3	2.2 J
Lake Tapps Outflow		18-Sep-90	1810	6	18.7	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	1 BJC	3.1 J
"		02-Oct-90	1915	4	20.1	0.05 U	1 U	0.1 U	5 U	2.7 J	0.04 U C	10 U	0.49 BJC	11 JB
"		03-Oct-90	1715	3	19.7	0.05 U	1 U	0.1 U	5 U	2 U	0.02 U C	10 U	0.57 JBC	7.5 J
Carbon River	17.7	18-Sep-90	1545	66	9.6 J	0.05 U	1 U	0.1 U	5 U	2 U CA	0.04 U C	10 U	0.59 BJC	5.2 J
"	17.7	19-Sep-90	1300	77	9.8	0.05 U	1 U	0.1 U	5 U	2.7 J CA	0.04 U C	10 U	0.89 BJC	5 J
"	17.7	02-Oct-90	1200	89	9.5	0.074 J CA	1 U	0.36 J CA	5 U	4.9 J CA	0.08 J C	10 U	0.92 BJC	4.4 JB
"	17.7	03-Oct-90	1145	3310	9.6	0.05 U	1.2 J	0.11 J	5 J	35.9 CA	0.02 U C	18 J	6.11 CA	25.2 CA
"	2.0	18-Sep-90	1735	34	26.3	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.68 BJC	2.7 J
"	2.0	02-Oct-90	1615		27.0	0.05 U	1 U	0.1 U	5 U	3.8 J	0.04 U C	10 U	0.73 BJC	4.3 JB

Table 3.3 (cont). Summary of total recoverable metals data for minor tributaries.

Water Body	Date	Time	TSS mg/L	Total Hardness mgCaCO3/L	AG-TREC ug/L	AS-TREC ug/L	CD-TREC ug/L	CR-TREC ug/L	CU-TREC ug/L	HG-TOT ug/L	NI-TREC ug/L	PB-TREC ug/L	ZN-TREC ug/L
Boise Ck	18-Sep-90	1710	3	50.1	0.05 U	1 U	0.12 J	5 U	8.5 J C	0.04 U C	10 U	1.4 BJC	16 J
"	02-Oct-90	1600	1	51.3	0.05 U	1 U	0.1 U	5 U	2.2 J	0.04 U C	10 U	0.48 BJ	6.8 JB
"	18-Sep-90	1625	1	20.0	0.05 U	1 U	0.1 U	5 U	2 U	0.11 J C	10 U	0.63 BJC	5.2 J
"	02-Oct-90	1500	11	19.6	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.32 JB	4.5 JB
Bowman Ck	18-Sep-90	1420	4	27.8	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.98 BJC	3.3 J
"	03-Oct-90	1450	1	27.8 J	0.05 U	1 U	0.1 U	5 U	3.9 J	0.02 U C	10 U	0.5 JB	8.7 J
Canyon Falls Ck	18-Sep-90	1620	2	82.3	0.05 U	1.4 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.67 BJ	4.3 J
"	02-Oct-90	1550	3	83.2	0.05 U	1.1 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.35 JB	4.7 JB
Clarks Ck	18-Sep-90	1100	3	76.9	0.05 U	1.1 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.86 BJ	2.8 J
"	02-Oct-90	1000	4	77.7	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.68 BJ	4.8 JB
Clear Ck	18-Sep-90	1000	10	77.4	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	1 BJ	3.2 J
"	02-Oct-90	915	18	79.2	0.05 U	1.2 J	0.1 U	5 U	2 U	0.04 U C	10 U	1.2 BJ	8.6 JB
Fennel Ck	19-Sep-90	1700	1	66.0	0.05 U	1 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.46 BJ	4.2 J
"	02-Oct-90	1130	2	69.0	0.05 U	1 U	0.15 J	5 U	2.7 J	0.04 U C	10 U	0.67 BJ	6.4 JB
Government Canal	18-Sep-90	1320	3	71.9	0.05 U	1 U	0.11 J	5 U	2 U	0.04 U C	10 U	0.82 BJ	15 J
"	02-Oct-90	1300	2	77.7	0.15 J C	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	5.57 C	17 JB
Lily Ck	19-Sep-90	935	1	25.8	0.05 U	1 U	0.1 U	5 U	2 U	0.11 J C	10 U	0.38 BJ	4.3 J
"	03-Oct-90	1200	1	25.8 J	0.05 U	1 U	0.1 U	5 U	2 U	0.02 U C	10 U	0.47 JB	4.4 J
Strawberry (Salmon) Ck	18-Sep-90	1245	4	71.4	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.96 BJ	2.5 J
"	02-Oct-90	1210	4	71.6	0.05 U	1 U	0.53	5 U	2 U	0.04 U C	10 U	0.9 BJ	11 JB
Swan Ck	18-Sep-90	925	22	68.0	0.05 U	1.5 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.89 BJ	5.1 J
"	02-Oct-90	830	3	67.0	0.05 U	1 U	0.1 U	5 U	3 J	0.04 U C	10 U	1 BJ	7.4 JB
Voight Ck	19-Sep-90	930	10	34.2	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	1.1 BJC	5.4 J
"	02-Oct-90	1510	2	35.9	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.38 JB	2.9 JB
Unnamed Trib @ Puy RM 13	18-Sep-90	1549	1	78.4	0.05 U	1 U	0.17 J	5 U	2 U	0.04 U C	10 U	1.5 BJ	9.4 J
"	03-Oct-90	1230	1	79.5	0.05 U	1 U	0.1 U	5 U	2 U	0.055 J C	10 U	0.8 JB	15 J
Unnamed Trib at Whi RM 1.3	18-Sep-90	1155	1	103.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.72 BJ	7 J
"	02-Oct-90	1045	2	103.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	1.2 BJ	6.7 J
Unnamed Trib at Whi RM 15	18-Sep-90	1510	1	79.9	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.5 BJ	2.1 J
"	02-Oct-90	1410	3	77.7	0.05 U	1 U	0.15 BJ	5 U	3 J	0.08 J C	10 U	1.7 BJ	11 J

QUALIFIERS:

U: analyte was not detected at or above the reported value.
B: analyte was found in the method blank indicating sample may have been contaminated.
J: analyte was positively identified and reported value is an estimate.
C: reported value exceeds EPA Gold Book criterion for chronic aquatic life protection
A: reported value exceeds EPA Gold Book criterion for acute aquatic life protection

Table 3.3 (cont). Summary of total recoverable metals data for municipal and industrial NPDES discharges.

Water Body	Date	Time	TSS mg/L	Total Hardness mgCaCO3/L	AG-TREC ug/L	AS-TREC ug/L	CD-TREC ug/L	CR-TREC ug/L	CU-TREC ug/L	HG-TOT ug/L	NI-TREC ug/L	PB-TREC ug/L	ZN-TREC ug/L
Buckley WTP	18-Sep-90	COMP	2	53.6	0.05 U	1 J	0.1 U	5 U	2 U	0.04 U C	10 U	0.75 BJ	34.6
"	19-Sep-90	COMP	1	50.0	0.05 U	2.2 J	0.1 U	5 U	2 U	0.11 J C	10 U	0.69 BJ	33.4
"	02-Oct-90	COMP	1	42.6	0.05 U	1.9 J	0.21 JB	5 U	5.7 J	0.13 J C	10 U	1 BJ	36.4
"	03-Oct-90	COMP	1	41.6	0.05 U	1.8 J	0.1 U	5 U	2 U	0.061 J C	10 U	0.95 JB	39.4
Carbonado WTP	18-Sep-90	820	23	44.3	0.05 U	1 U	0.2 J	5 U	6.4 J C	0.12 J C	10 U	3.11 B C	36.8
"	02-Oct-90	1015	29	46.2	0.05 U	1 U	0.25 JB	5 U	13.2 CA	0.08 J C	10 U	3.06 B C	51.8
Enumclaw WTP	18-Sep-90	COMP	7	101.0	0.817 C	1 U	0.19 J	5 U	42.5 CA	0.04 U C	10 U	1.6 BJ	34.1
"	19-Sep-90	COMP	8	102.0	1.19 C	1.4 J	0.19 J	5 U	49.1 CA	0.13 J C	10 U	1.6 BJ	39
"	02-Oct-90	COMP	8	98.0	0.596 C	1.2 J	0.25 JB	5 U	49.4 CA	0.11 J C	10 U	2.17 B	34.6
"	03-Oct-90	COMP	11	98.1	1.11 C	1 J	0.16 J	5 U	37.8 CA	0.065 J C	10 U	2.02 B	33
McCalder School WTP	18-Sep-90	1215	14	81.4	0.05 U	5.2	0.56	5 U	23.9 CA	0.04 U C	10 U	5.69 B C	90.7 C
"	02-Oct-90	1155	30	82.7	0.05 U	7.3	0.97 JB	5 U	14.3 C	0.04 U C	10 U	5.49 B C	70.9
Orting WTP	18-Sep-90	COMP	26	92.4	0.2 J C	2 J	0.2 J	5 U	27.9 CA	0.2 J C	10 U	6.82 B C	45.8
"	02-Oct-90	COMP	26	107.0	0.13 J C	3.1 J	0.14 JB	5 U	19.2 CA	0.14 J C	10 U	4.61 B C	29.5 B
Puyallup WTP	18-Sep-90	COMP	11	79.9	2.08 C	1.1 J	0.14 J	5 U	23.1 CA	0.15 J C	10 U	1.4 BJ	31.2
"	19-Sep-90	COMP	4	81.9	2.04 C	1.3 J	0.12 J	5 U	18 CA	0.12 J C	10 U	1 BJ	29.3
"	02-Oct-90	COMP	6	80.7	1.17 C	1 J	0.18 BJ	5 U	24.6 CA	0.16 J C	10 U	2.35 B	25.6
"	03-Oct-90	COMP	5	80.0	1.83 C	2.1 J	0.16 J	5 U	23.7 CA	0.11 J C	10 U	1.1 JB	29.9
Rainier State School WTP	18-Sep-90	COMP	5	37.6	0.4 J C	1 U	0.1 U	5 U	31 CA	0.16 J C	10 U	1.9 BJC	80.6 CA
"	02-Oct-90	COMP	11	35.2	0.12 J	1 U	0.1 U	5 U	31.6 CA	0.17 J C	10 U	2.47 B C	88.6 CA
Sumner WTP	18-Sep-90	COMP	12	96.2	0.092 J	1 U	0.11 J	5 U	12.3 C	0.11 J C	10 U	1.4 BJ	42.9
"	19-Sep-90	COMP	8	92.9	0.15 J C	1.2 J	0.14 J	5 U	16 C	0.13 J C	10 U	2.02 B	44.7
"	02-Oct-90	COMP	12	95.4	0.05 U	1.6 J	0.14 JB	5 U	12 C	0.13 J C	10 U	1.7 BJ	42.2
"	03-Oct-90	COMP	6	96.6	0.05 U	1.8 J	0.12 J	5 U	9.3 J	0.039 J C	10 U	1.6 JB	44.8
Wilkeson WTP	18-Sep-90	COMP	48	108.0	0.05 U	1 U	0.46 J	8 J	42 CA	0.48 J C	11 J	4.86 B C	103
"	02-Oct-90	COMP	55	117.0	0.057 J	1.4 J	0.46 JB	5 U	38.9 CA	0.35 J C	10 U	4.83 B C	86.7
Boeing Cooling Water	18-Sep-90	1245	1	72.4	0.05 U	1 U	0.11 J	5 U	39 CA	0.04 U C	10 U	1.4 BJ	38.4
"	02-Oct-90	1232	71	64.5	0.05 U	1.8 J	0.31 J	7 J	35.7 CA	0.08 J C	10 U	14.8 C	207 CA
Fleischmann's	18-Sep-90	1435	1	102.0	0.05 U	1 U	0.1 U	5 U	2 U	0.04 U C	10 U	0.62 BJ	3.8 J
"	02-Oct-90	1427	1	103.0	0.05 U	2.2 J	0.1 U	5 U	2.7 J	0.04 U C	10 U	0.93 BJ	5.8 J
Beatrice	18-Sep-90	COMP	41	111.0	0.05 U	1.2 J	0.1 U	5 U	5.3 J	0.11 J C	10 U	1.2 BJ	54.8
"	02-Oct-90	COMP	47	128.0	0.05 U	1 U	0.24 J	5 U	6.5 J	0.04 U C	10 U	2.42 B	76.7
National Semiconductor	18-Sep-90	COMP	4	363.0	0.05 U	1 U	0.1 J	5 U	2 U	0.2 J C	10 U	0.99 BJ	5.2 J
"	19-Sep-90	COMP	1	389.0	0.05 U	1.2 J	0.1 U	10 J	2.6 J	0.14 J C	10 U	0.81 BJ	3.4 J
"	03-Oct-90	COMP	9	338.0	0.05 U	1.6 J	0.23 J	5 U	2 U	0.044 J C	10 U	3.92 B	7.1 J
Sonoco	18-Sep-90	COMP	37	180.0 J	0.05 UJ	5.45	0.22 J	5 U	3.7 J	0.15 J C	10 U	3.07 BJ	66.6
"	19-Sep-90	COMP	160	175.0	0.05 U	4.6 J	0.6	5 U	19	0.18 J C	14 J	7.75 BJC	149
"	02-Oct-90	COMP	42	189.0	0.05 U	2.2 J	0.23 JB	6 J	5.1 J	0.04 U C	10 U	2.06 BJ	45.4
"	03-Oct-90	COMP	43	176.0	0.05 U	2.5 J	0.1 J	5 U	2 U	0.067 J C	13 J	8.39 J C	41.6
Weyerhauser	18-Sep-90	1640	3	26.7	0.05 U	2.7 J	0.1 U	5 U	2 U	0.04 U C	10 U	1.3 BJC	14 J
"	02-Oct-90	1530	2	26.4	0.084 J	2.9 J	0.1 U	5 U	2 U	0.08 J C	10 U	1.4 JBC	6.1 JB

- zinc concentrations were greater than chronic and acute criteria at Carbon RM 17.7, Rainier School, and Boeing, and greater than chronic at McAlder School WTP.

State standards for copper, lead, silver, and zinc are currently for the dissolved metal (Chapter 173-201A WAC). None of the river samples that exceeded Gold Book criteria for total recoverable metals were found to be quantifiable above state standards for dissolved metals. Dissolved metal values (Appendix A) were typically lower than the detection limit or reported as inaccurate estimates (*i.e.*, with "J" qualifiers). The relatively high total recoverable metals found at Carbon RM 17.7 all contained dissolved metals below quantifiable levels and below water quality criteria. The October 2 and 3, 1990 sampling of the Carbon River occurred during the rising limb of a storm hydrograph. Stream flow at RM 17.7 increased by 40% and total suspended solids increased from a base flow concentration of 89 mg/L to 3,300 mg/L over these two days. Therefore, relatively high total metals concentrations appear to be associated with suspended solids in the headwaters of the Carbon River.

3.3 Design Condition Summary

The major water quality design parameters for WLA modeling of dissolved oxygen and ammonia are temperature, ammonia criteria, and dissolved oxygen criteria. Ammonia criteria depend on temperature and pH. A summary of these design conditions is presented in Table 3.4 based on a composite of ambient monitoring data from Table 3.1 and intensive survey data presented in Table 3.2. Design conditions of temperature and ammonia criteria were selected as either the critical fifth percentile of ambient monitoring data or the most restrictive September or October 1990 average, whichever was more limiting. Also, the criteria for upstream reaches were assumed to be at least as limiting as downstream reaches (*i.e.*, if the criterion at a given station was less restrictive than from a downstream station, the downstream criterion was applied).

The fifth percentile from all months was chosen for the design condition of ambient water quality to represent a moderate extreme for the critical season. The tenth percentile has been commonly applied for estimating design parameters for buoyant plume modeling of ocean discharges based on a relatively arbitrary recommendation by Tetra Tech (1982), and has sometimes been applied to freshwater steady-state water quality modeling. However, for parameters with strong seasonal patterns (e.g., temperature and pH) the tenth percentile of annual data is often less restrictive than typical conditions encountered during the critical season. EPA has recommended that design values for ambient water quality in steady-state models should represent a moderate extreme of the critical season (EPA, 1980; EPA, 1985b; EPA, 1988). Therefore, the fifth percentile of data from all months was selected as a compromise between maximum values, which may be affected by outliers, and typical conditions, which would not represent a moderate "worst-case" scenario. For deriving critical conditions from data collected only during the critical season, the tenth percentile was considered to be adequately protective.

Table 3.4. Summary of model design conditions for temperature, ammonia, and dissolved oxygen criteria

	Design Temperature (degrees C)	Acute Total Ammonia Criterion (mg N/L)	Chronic Total Ammonia Criterion (mg N/L)	Dissolved Oxygen Criteria (3) (mg/L)
Puyallup River (1)				
RM 0.0 - 1.0	15	8.0 (4.2)	1.5 (0.63)	6.5(5.0)
RM 1.0 - 2.2	15	8.0 (4.2)	1.5 (0.63)	8.0(6.0)
RM 2.2 - 18.4	15	6.8	1.3	8.0
White River (1)				
RM 0.0 - 3.6	18	4.5	0.87	8.0
RM 3.6 - 24.3	18	0.84	0.16	8.0
RM 24.3 - 25.4	13	0.84	0.16	8.0
Carbon River (1)				
RM 0.0 - 2.0	15	6.8	1.3	8.0
RM 2.0 - 17.7	15	5.9	1.1	8.0
Miscellaneous Modeled Tributaries (2)				
Boise Creek	14	0.84	0.16	8.0
Canyon Falls Creek	14	4.6	0.89	8.0
Clarks Creek	11	6.8	1.3	8.0
Clear Creek	11	6.8	1.3	8.0
Diru Creek	11	6.8	1.3	8.0
South Prairie Creek	15	4.6	0.89	8.0
Swan Creek	14	6.8	1.3	8.0
Voights Creek	15	5.9	1.1	8.0
Wilkeson Creek	14	3.7	0.72	8.0

1) Critical ambient annual 5 percentile or September-October 1990 observation, whichever is more limiting. For any given segment, if criteria based on downstream stations were more restrictive, then downstream criteria were continued upstream until a more restrictive condition was encountered for ammonia criteria.
Ammonia and dissolved oxygen criteria were based on WAC 173-201A.

2) For any given tributary the ammonia criteria were assumed to be based on stations in that tributary or downstream receiving water criteria, whichever was more restrictive.
Design temperatures were based on September-October 1990 data.
Ammonia and dissolved oxygen criteria were based on WAC 173-201A.

3) Values in parentheses are marine dissolved oxygen criteria. Marine ammonia criteria are fifth percentiles of surface samples from CMB003, 1980-91.

4.0 PUYALLUP RIVER QUAL2E MODEL

4.1 Model Structure

QUAL2E is a one-dimensional, steady-state numerical model capable of simulating a variety of conservative and non-conservative water quality parameters (EPA, 1987). QUAL2E is capable of simulating up to 15 water quality constituents in any combination desired by the user. QUAL2E was calibrated to the Puyallup River system to simulate dissolved oxygen, biochemical oxygen demand, and ammonia at steady-state conditions. The major constituent interactions modeled in the Puyallup River system are shown in Figure 4.1.

The river system was divided into 47 reaches for QUAL2E modeling. Each reach was assumed to have fairly uniform hydraulic and reaction characteristics. A schematic of reaches and loading sources is presented in Figure 4.2. Each reach is further divided into computational elements with length of 0.2 miles, which have uniform steady-state concentrations of modeled constituents.

The model was calibrated using data collected during September and confirmed with data from October 1990. Comparison of model results for the September and October intensive surveys tested the validity of the model over a range of conditions since both surveys were modeled using the same reaction rate coefficient relationships. After calibration and confirmation with 1990 data, the model was run at several scenarios of low flow design conditions with various alternative point source inputs for development of WLAs.

4.2 Flow Balance for Calibration and Design

The balance of flows within the basin was determined assuming steady state using the network of USGS gaging stations and other direct measurements of sources. Tables 4.1 and 4.2 present the directly measured flows at control points in the basin. Table 4.3 presents the steady-state flows in each reach based on mass balance of flow. For the September and October 1990 survey conditions, the surface flows balanced within 2.5 percent at the downstream gage at Puyallup RM 6.6. Therefore, most inflow sources appear to be adequately accounted for by a surface water mass balance.

Low flow is the design condition for modeling dissolved oxygen and ammonia as discussed in Section 3. The occurrence of low flow is coincident with the greatest sensitivity to impacts because of seasonally high temperature and pH, and least dilution of loads. The design flow used for QUAL2E modeling was the 7-day-10-year low flow (7Q10).

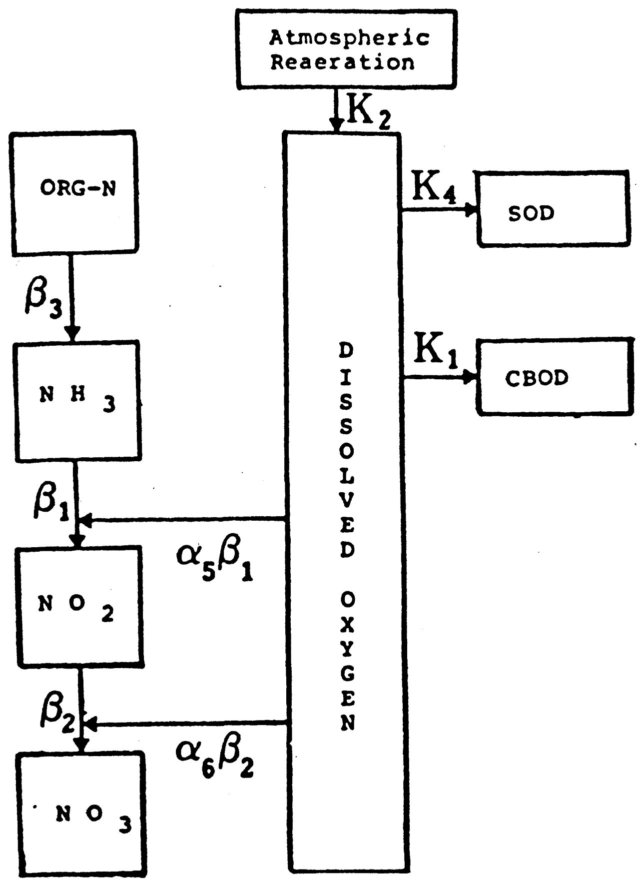


Figure 4.1. Major constituent interactions modeled in the Puyallup River system with QUAL2E.

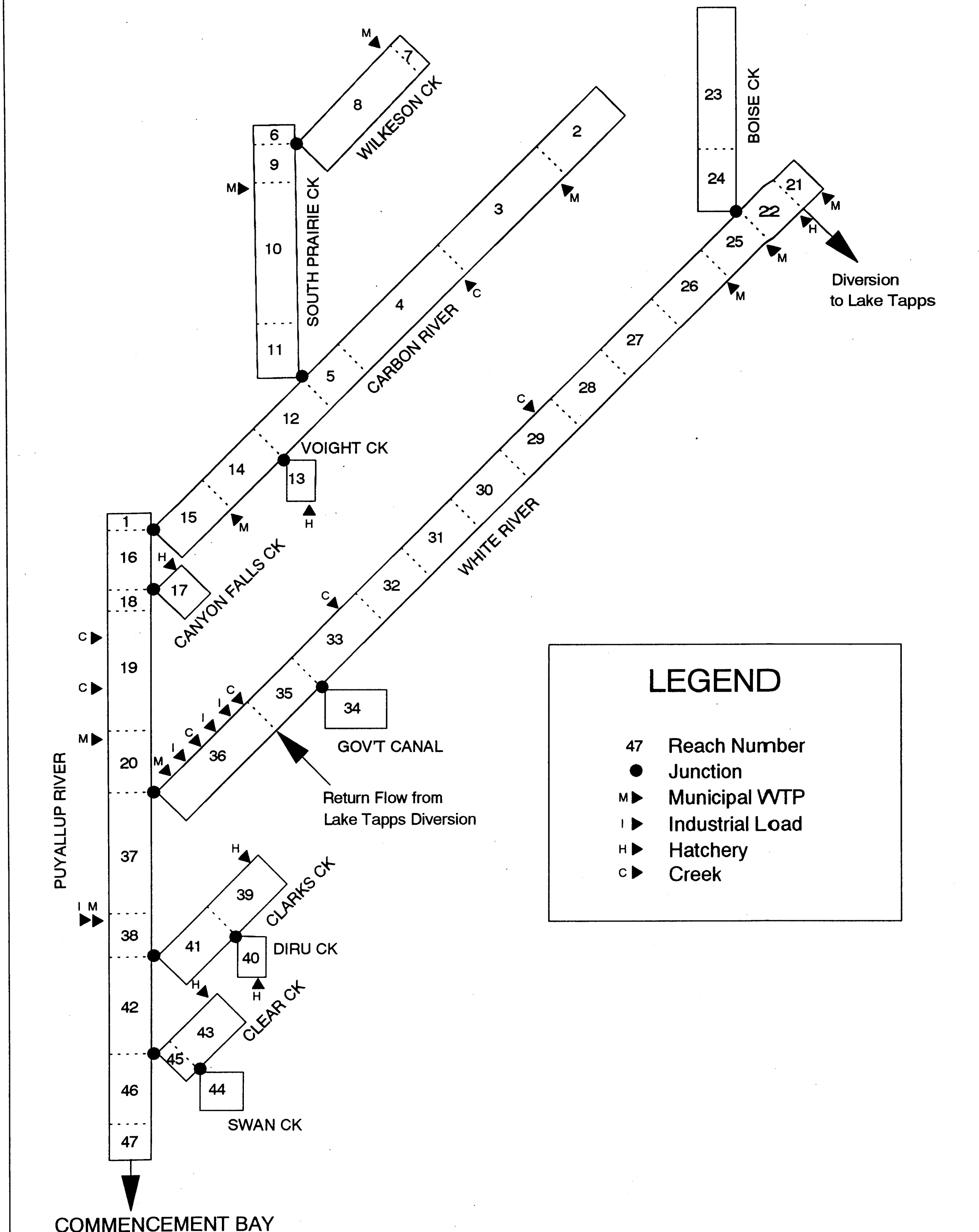


Figure 4.2. Schematic of QUAL2E model of the Puyallup River system.

Table 4.1. Gaged or estimated flow statistics at control points in the Puyallup River system.

		7Q10 (cfs)
USGS GAGES:		
USGS 12093500 Puyallup r.m. 26.4		160
USGS 12095000 S Prairie Ck		29
USGS 12096500 Puyallup r.m. 12.2		332
USGS 12098500 White r.m. 27.9		292
USGS 12099500/12099600 Boise Ck		4
USGS 12100000 White r.m. 23.1		130
USGS 12101500 Puyallup r.m. 6.6		774
MISCELLANEOUS NATURAL TRIBUTARIES/HEADWATERS:		
Bowman Ck r.m. 0.0	(See Note A)	0.3
Canyon Falls Ck r.m. 0.0	(See Note A)	8.3
Clarks Ck r.m. 0.0	(See Note B)	55
Clear Ck r.m. 0.0	(See Note B)	11
Diru Ck Headwater above Hatchery	(See Note B)	0.1
Fennel Ck r.m. 0.0	(See Note A)	6.4
Gov't Canal Headwater above Boeing	(See Note A)	0.0
Lily Ck r.m. 0.0	(See Note A)	1.1
Strawberry (Salmon) Ck r.m. 0.0	(See Note A)	6.8
Swan Ck r.m. 0.0	(See Note B)	1.4
Unnamed Trib at Puyallup r.m. 13.0	(See Note A)	3.1
Unnamed Trib at White r.m. 1.3	(See Note A)	2.6
Unnamed Trib at White r.m. 15.0	(See Note A)	0.8

Note A: 7Q10 estimated as 0.90*(Sep-Oct'90) from average ratio for Boise, Clear and Clarks Ck

Note B: 7Q10 estimated by Kresch and Prych (1989)

Table 4.2. Estimated headwater and pointload flows for 1990 surveys and existing NPDES design condition.

	QUAL2E Headwater or Poindload Number	1990 Survey 1 Sep 18-20 (cfs)	1990 Survey 2 Oct 2-4 (cfs)	Existing Design 7Q10 (cfs)
Puyallup r.m. 18.0	HW-01	351.50	509.00	160.00
Carbon r.m. 16.1	HW-02	216.00	186.00	106.64
South Prairie Ck r.m. 7.4	HW-03	30.90	28.20	20.01
Wilkeson Ck r.m. 4.0	HW-04	8.30	5.50	8.96
Voights Ck above hatchery	HW-05	7.51	6.04	0.00
Canyon Falls Ck above hatchery	HW-06	0.00	0.00	0.00
White r.m. 25.2	HW-07	575.00	482.00	292.00
Boise Ck r.m. 5.8	HW-08	6.31	5.24	4.00
Government Canal above Boeing	HW-09	0.00	0.00	0.00
Clarks Ck above hatchery	HW-10	30.57	25.43	42.05
Diru Ck above hatchery	HW-11	0.00	0.00	0.10
Clear Ck above hatchery	HW-12	5.45	8.90	0.00
Swan Ck above Lige Dickson	HW-13	1.90	1.80	1.40
Carbonado WTP	PL-01	0.03	0.03	0.155
Lily Ck	PL-02	1.20	1.20	1.08
Wilkeson WTP	PL-03	0.03	0.04	0.108
South Praire WTP	PL-04	0.00	0.00	0.0591
Dept. of Fisheries Hatchery	PL-05	7.89	7.36	16.91
Orting WTP	PL-06	0.49	0.37	3.87
Reach 16 Dummy	PL-07	0.00	0.00	0.00
Trout Springs Hatchery	PL-08	10.05	9.60	8.33
Reach 18 Dummy	PL-09	0.00	0.00	0.00
Fennel Ck	PL-10	7.15	7.00	6.37
Reach 19 Dummy	PL-11	0.00	0.00	0.00
Unnamed Trib at Puyallup r.m. 13.0	PL-12	3.55	3.30	3.08
McAlder WTP	PL-13	0.01	0.01	0.0146
Reach 20 Dummy	PL-14	0.00	0.00	0.00
Rainier School WTP	PL-15	0.17	0.22	0.650
White River Canal Diversion	PL-16	0.00	-314.00	-175.36
Muckleshoot Tribe Hatchery	PL-17	1.95	1.60	5.00
Weyerhauser Enumclaw Mill Pond	PL-18	0.09	0.06	0.00
Enumclaw WTP	PL-19	1.12	1.08	3.71
Buckley WTP	PL-20	0.36	0.35	1.55
Unnamed Trib at White r.m. 15.0	PL-21	0.33	1.40	0.78
Bowman Ck	PL-22	0.55	0.17	0.32
Boeing Auburn Cooling Water	PL-23	0.40	0.26	0.00
Lake Tapps Diversion Outflow	PL-24	7.80	613.00	291.80
Strawberry (Salmon) Ck	PL-25	7.20	7.80	6.75
Beatrice Cheese WTP	PL-26	0.32	0.18	0.774
Sonoco WTP	PL-27	0.23	0.27	0.484
Unnamed Trib at White r.m. 1.3	PL-28	2.40	3.30	2.57
Fleischmans WTP	PL-29	1.52	1.34	1.69
Sumner WTP	PL-30	1.88	1.92	5.29
Reach 37 Dummy	PL-31	0.00	0.00	0.00
Puyallup and Matsushita WTPs	PL-32	6.65	5.80	17.67
Dept. of Wildlife Hatchery	PL-33	13.69	13.61	12.07
Puyallup Tribe Hatchery	PL-34	0.74	0.66	0.780
Troutco Hatchery	PL-35	6.85	4.50	9.60
Lige Dickson	PL-36	0.00	0.00	0.00
Reach 46 Dummy	PL-37	0.00	0.00	0.00
Reach 47 Dummy	PL-38	0.00	0.00	0.00

Table 4.3. Calculated reach flow balance for 1990 surveys and existing NPDES design condition flows.

QUAL2E Reach Identification		1990 Survey 1 Sep 18-20 (cfs)	1990 Survey 2 Oct 2-4 (cfs)	Existing Design 7Q10 (cfs)
Reach 1:	Puyallup r.m. 18.4 to 18.0	351.50	509.00	160.00
Reach 2:	Carbon r.m. 17.8 to 15.4	216.00	186.00	106.64
Reach 3:	Carbon r.m. 15.4 to 11.4	216.03	186.03	106.79
Reach 4:	Carbon r.m 11.4 to 7.4	217.23	187.23	107.87
Reach 5:	Carbon r.m. 7.4 to 6.0	217.23	187.23	107.87
Reach 6:	South Prairie Ck r.m. 7.2 to 6.8	30.90	28.20	20.01
Reach 7:	Wilkeson Ck r.m. 4.2 to 4.0	8.30	5.50	8.96
Reach 8:	Wilkeson Ck r.m. 4.0 to 0.0	8.33	5.54	9.07
Reach 9:	South Prairie Ck r.m. 6.8 to 5.6	39.23	33.74	29.08
Reach 10:	South Prairie Ck r.m. 5.6 to 1.6	39.23	33.74	29.14
Reach 11:	South Prairie Ck r.m. 1.6 to 0.0	39.23	33.74	29.14
Reach 12:	Carbon r.m. 6.0 to 4.0	256.46	220.97	137.01
Reach 13:	Voights Ck r.m. 0.8 to 0.0	15.40	13.40	16.91
Reach 14:	Carbon r.m. 4.0 to 2.0	271.86	234.37	153.91
Reach 15:	Carbon r.m. 2.0 to 0.0	272.35	234.73	157.78
Reach 16:	Puyallup r.m. 18.0 to 16.4	623.85	743.73	317.78
Reach 17:	Canyon Falls Ck r.m. 1.0 to 0.0	10.05	9.60	8.33
Reach 18:	Puyallup r.m. 16.4 to 15.6	633.90	753.33	326.11
Reach 19:	Puyallup r.m. 15.6 to 12.2	644.60	763.63	335.56
Reach 20:	Puyallup r.m. 12.2 to 10.4	644.61	763.65	335.57
Reach 21:	White r.m. 25.4 to 24.6	575.17	482.22	292.65
Reach 22:	White r.m. 24.6 to 23.4	577.12	169.82	122.29
Reach 23:	Boise Ck r.m. 5.8 to 1.8	6.40	5.30	4.00
Reach 24:	Boise Ck r.m. 1.8 to 0.0	6.40	5.30	4.00
Reach 25:	White r.m. 23.4 to 21.8	584.65	176.21	130.00
Reach 26:	White r.m. 21.8 to 19.8	585.00	176.56	131.55
Reach 27:	White r.m. 19.8 to 17.8	585.00	176.56	131.55
Reach 28:	White r.m. 17.8 to 15.8	585.00	176.56	131.55
Reach 29:	White r.m. 15.8 to 13.8	585.33	177.96	132.33
Reach 30:	White r.m. 13.8 to 11.8	585.33	177.96	132.33
Reach 31:	White r.m. 11.8 to 9.8	585.33	177.96	132.33
Reach 32:	White r.m. 9.8 to 8.0	585.33	177.96	132.33
Reach 33:	White r.m. 8.0 to 5.4	585.88	178.13	132.65
Reach 34:	Government Canal r.m. 1.8 to 0.0	0.40	0.26	0.00
Reach 35:	White r.m. 5.4 to 3.6	586.28	178.39	132.65
Reach 36:	White r.m. 3.6 to 0.0	607.62	806.20	442.00
Reach 37:	Puyallup r.m. 10.4 to 7.0	1252.24	1569.84	777.57
Reach 38:	Puyallup r.m. 7.0 to 5.8	1258.88	1575.64	795.24
Reach 39:	Clarks Ck r.m. 4.0 to 2.0	44.26	39.04	54.12
Reach 40:	Diru Ck r.m. 0.8 to 0.0	0.74	0.66	0.88
Reach 41:	Clarks Ck r.m. 2.0 to 0.0	45.00	39.70	55.00
Reach 42:	Puyallup r.m. 5.8 to 3.0	1303.88	1615.34	850.24
Reach 43:	Clear Ck r.m. 2.4 to 0.4	12.30	13.40	9.60
Reach 44:	Swan Ck r.m. 1.2 to 0.0	1.90	1.80	1.40
Reach 45:	Clear Ck r.m. 0.4 to 0.0	14.20	15.20	11.00
Reach 46:	Puyallup r.m. 3.0 to 1.0	1318.08	1630.54	861.24
Reach 47:	Puyallup r.m. 1.0 to 0.0	1318.08	1630.54	861.24

The design flow for the White River between RM 24.3 and 3.6 is not based on the 7Q10 because of control by Puget Power. An instream low flow agreement between Puget Power and the Muckleshoot Tribe requires a minimum flow of 130 cfs at USGS Station 12100000 at White RM 23.3 below the diversion. Therefore, the minimum flow agreement (130 cfs) was used as the design flow at White RM 23.3. Figure 4.3 shows that the White River minimum low flow can be expected to occur during any month of the year. Other less controlled segments of the basin may experience flows as low as the 7Q10 between the months of August and February, with lowest flows typically in September and October.

4.3 Model Calibration

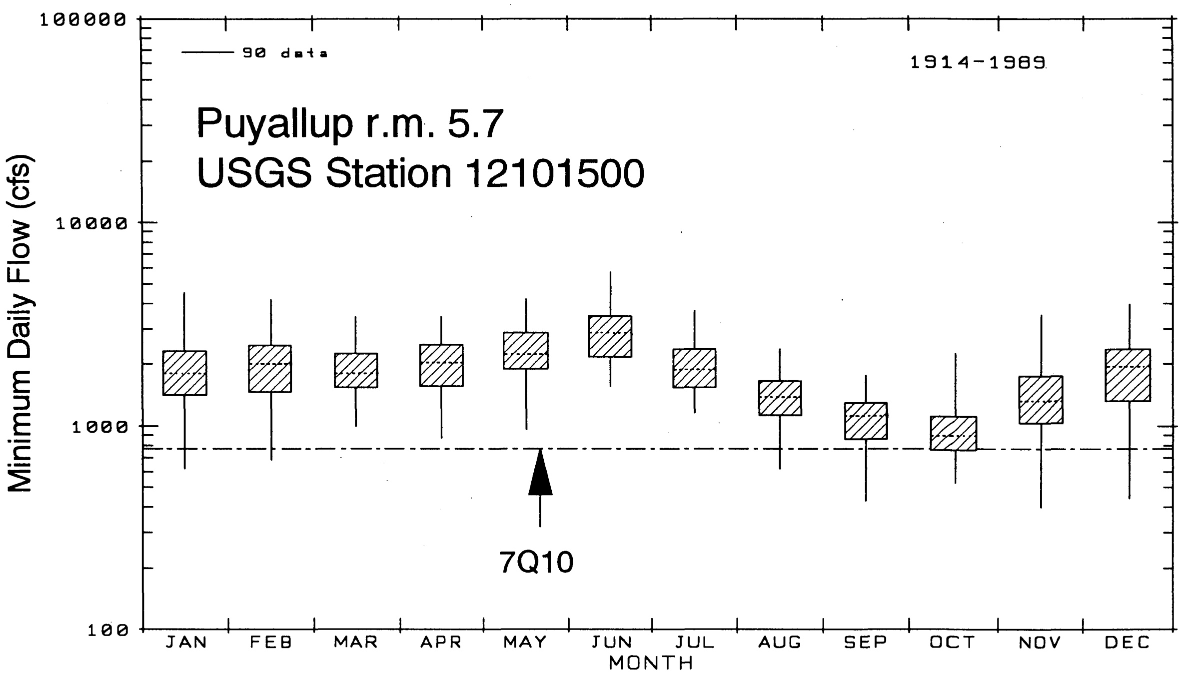
4.3.1 Velocity, Depth, and Dispersion

The methods used to estimate hydraulic characteristics were presented in Section 2 and are summarized in Table 2.6. Velocity and depth were represented in QUAL2E using power functions of flow (EPA, 1987; McCutcheon, 1989). Velocity and depth functions for all reaches (Table 4.4) were derived from HEC-2 modeling, dye studies, cross-section measurements, and the Manning equation. The travel time from the upstream boundary of the study area to the mouth of the Puyallup River is less than two days at 7Q10 flows (Figure 4.4).

Longitudinal dispersion can be included in QUAL2E, although usually it does not influence steady-state concentration profiles as much as other input variables (EPA, 1985a). Dispersion was measured in the White River using dye tracer measurements according to the procedure of the U.S. Geological Survey (USGS, 1981). Dispersion rates between White RM 23.1-8.0 and 8.0-4.9 were 576 ft^2/sec and 500 ft^2/sec, respectively on October 10, 1990. A value of 500 ft^2/sec was assumed to be representative of the White, Carbon, and Puyallup Rivers in free-flowing (non-tidal) reaches. Other tributary reaches were modeled excluding dispersion, which was considered to be an insignificant variable based on sensitivity and uncertainty analyses.

The lower Puyallup River is influenced by tidal changes in Commencement Bay. The HEC-2 model was used to estimate the upstream boundary of tidal influence on river velocity and water level by examining differences in estimated surface water profiles in the river when tidal levels are at mean higher high water (MHHW) and at mean sea level (MSL). This analysis indicated that the upstream extent of tidal influence on river water level at seasonal low flows is approximately RM 5.8. The lower three reaches of the Puyallup River between RM 5.8 and 0.0 were assumed to have double the dispersion (1000 ft^2/sec) of free-flowing reaches. This assumed dispersion rate for tidal reaches is typical of the mid range of tidally averaged values reported for other tidally influenced rivers (EPA, 1985a).

Water quality at the downstream boundary of the Puyallup River is also influenced by Commencement Bay. The effect of Commencement Bay water quality on the Puyallup River was accounted for by using the downstream boundary option of QUAL2E and assuming that Ecology Commencement Bay station CMB003 represents water quality in Commencement Bay.



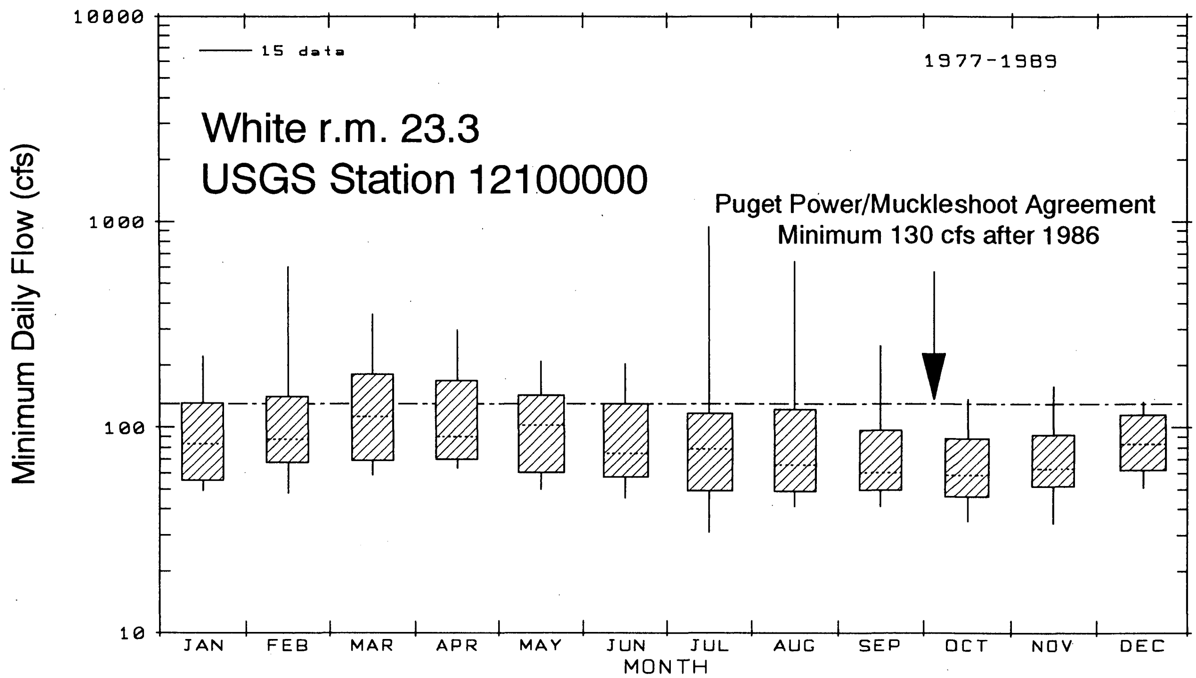


Figure 4.3. Minimum daily discharges at selected sites compared with design low flows.

Table 4.4. Summary of hydraulic coefficients for QUAL2E model of Puyallup River system reaches.

QUAL2E Reach Identification		Velocity Coefficients (1) "a"	Velocity Coefficients (1) "b"	Depth Coefficients (2) "c"	Depth Coefficients (2) "d"
Reach 1:	Puyallup r.m. 18.4 to 18.0	0.50	0.28	0.15	0.46
Reach 2:	Carbon r.m. 17.8 to 15.4	0.48	0.4	0.036	0.6
Reach 3:	Carbon r.m. 15.4 to 11.4	0.48	0.4	0.036	0.6
Reach 4:	Carbon r.m 11.4 to 7.4	0.48	0.4	0.036	0.6
Reach 5:	Carbon r.m. 7.4 to 6.0	1.0	0.23	0.19	0.29
Reach 6:	South Prairie Ck r.m. 7.2 to 6.8	0.074	0.69	0.76	0.071
Reach 7:	Wilkeson Ck r.m. 4.2 to 4.0	0.62	0.4	0.053	0.6
Reach 8:	Wilkeson Ck r.m. 4.0 to 0.0	0.62	0.4	0.053	0.6
Reach 9:	South Prairie Ck r.m. 6.8 to 5.6	0.074	0.69	0.76	0.071
Reach 10:	South Prairie Ck r.m. 5.6 to 1.6	0.074	0.69	0.76	0.071
Reach 11:	South Prairie Ck r.m. 1.6 to 0.0	0.074	0.69	0.76	0.071
Reach 12:	Carbon r.m. 6.0 to 4.0	1.1	0.22	0.22	0.31
Reach 13:	Voights Ck r.m. 0.8 to 0.0	0.52	0.4	0.073	0.6
Reach 14:	Carbon r.m. 4.0 to 2.0	0.92	0.18	0.10	0.40
Reach 15:	Carbon r.m. 2.0 to 0.0	0.44	0.32	0.13	0.40
Reach 16:	Puyallup r.m. 18.0 to 16.4	0.54	0.29	0.38	0.28
Reach 17:	Canyon Falls Ck r.m. 1.0 to 0.0	1.3	0.4	0.036	0.6
Reach 18:	Puyallup r.m. 16.4 to 15.6	0.75	0.19	0.20	0.36
Reach 19:	Puyallup r.m. 15.6 to 12.2	0.50	0.25	0.13	0.45
Reach 20:	Puyallup r.m. 12.2 to 10.4	0.26	0.35	0.16	0.41
Reach 21:	White r.m. 25.4 to 24.6	0.095	0.56	0.19	0.3
Reach 22:	White r.m. 24.6 to 23.4	0.095	0.56	0.19	0.3
Reach 23:	Boise Ck r.m. 5.8 to 1.8	0.94	0.4	0.1	0.6
Reach 24:	Boise Ck r.m. 1.8 to 0.0	0.94	0.4	0.1	0.6
Reach 25:	White r.m. 23.4 to 21.8	0.095	0.56	0.19	0.3
Reach 26:	White r.m. 21.8 to 19.8	0.095	0.56	0.19	0.3
Reach 27:	White r.m. 19.8 to 17.8	0.095	0.56	0.19	0.3
Reach 28:	White r.m. 17.8 to 15.8	0.095	0.56	0.19	0.3
Reach 29:	White r.m. 15.8 to 13.8	0.095	0.56	0.19	0.3
Reach 30:	White r.m. 13.8 to 11.8	0.095	0.56	0.19	0.3
Reach 31:	White r.m. 11.8 to 9.8	0.095	0.56	0.19	0.3
Reach 32:	White r.m. 9.8 to 8.0	0.095	0.56	0.19	0.3
Reach 33:	White r.m. 8.0 to 5.4	0.41	0.33	0.18	0.36
Reach 34:	Government Canal r.m. 1.8 to 0.0	0.3	0.4	0.28	0.6
Reach 35:	White r.m. 5.4 to 3.6	0.42	0.31	0.16	0.35
Reach 36:	White r.m. 3.6 to 0.0	0.078	0.49	0.10	0.51
Reach 37:	Puyallup r.m. 10.4 to 7.0	0.20	0.34	0.29	0.33
Reach 38:	Puyallup r.m. 7.0 to 5.8	0.18	0.36	0.063	0.54
Reach 39:	Clarks Ck r.m. 4.0 to 2.0	0.39	0.4	0.14	0.6
Reach 40:	Diru Ck r.m. 0.8 to 0.0	0.39	0.4	0.14	0.6
Reach 41:	Clarks Ck r.m. 2.0 to 0.0	0.39	0.4	0.14	0.6
Reach 42:	Puyallup r.m. 5.8 to 3.0	0.044	0.53	0.62	0.24
Reach 43:	Clear Ck r.m. 2.4 to 0.4	0.41	0.4	0.21	0.6
Reach 44:	Swan Ck r.m. 1.2 to 0.0	0.65	0.4	0.41	0.6
Reach 45:	Clear Ck r.m. 0.4 to 0.0	0.41	0.4	0.21	0.6
Reach 46:	Puyallup r.m. 3.0 to 1.0	6.8E-04	0.98	5.6	0
Reach 47:	Puyallup r.m. 1.0 to 0.0	1.3E-04	1.1	7.6	0

1) V = aQ^b where V = velocity (ft/sec) and Q = flow (cfs)
2) D = cQ^d where d = Depth (feet) and Q = flow (cfs)

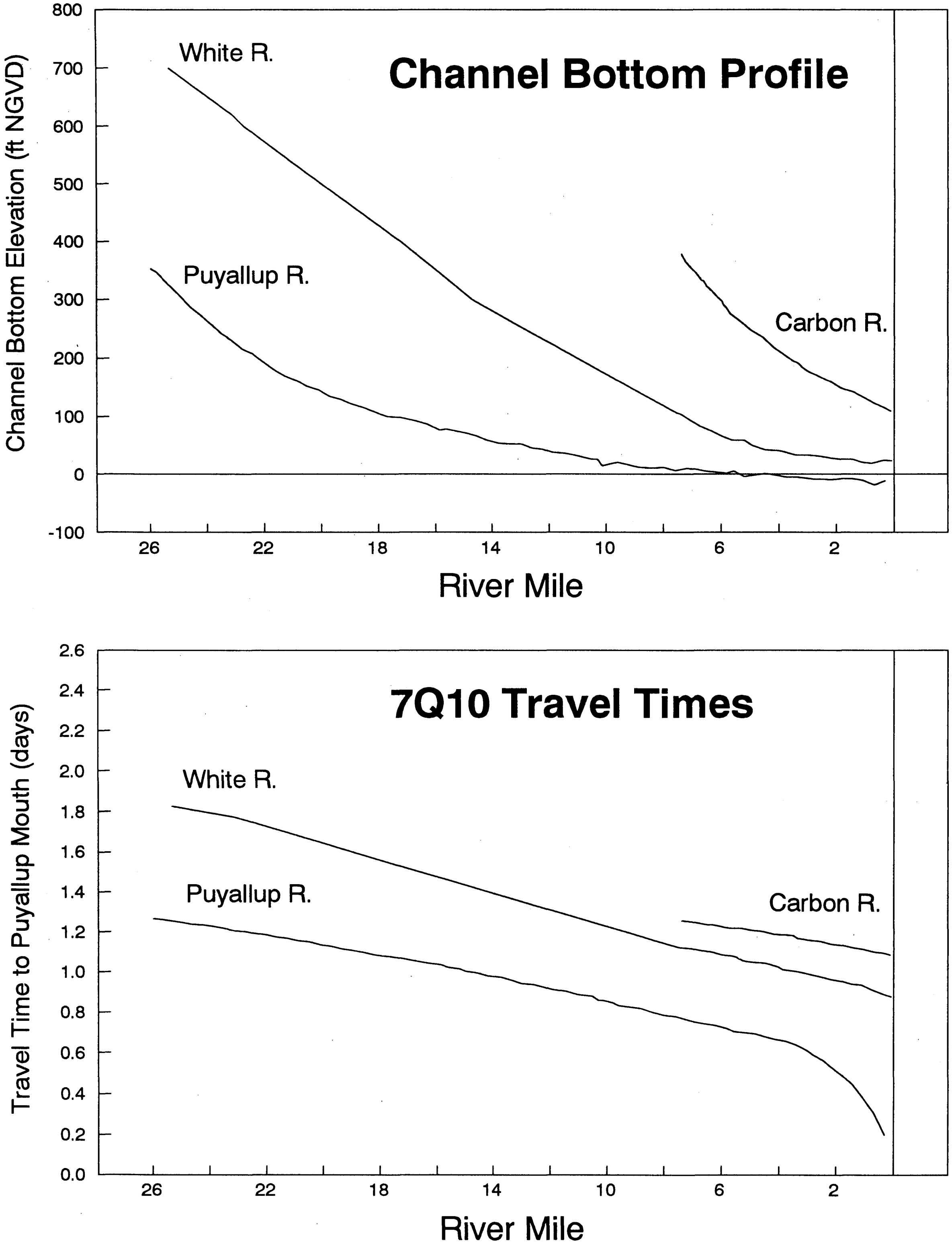


Figure 4.4. Channel bottom profiles and travel times for critical conditions in the Puyallup, White, and Carbon Rivers.

4.3.2 Calibration of QUAL2E Coefficients and Inputs

The coefficients which control constituent interactions in the Puyallup River application of QUAL2E are depicted in Figure 4.1 and described in Table 4.5. Data from the 1990 study and scientific literature were used to calibrate the QUAL2E model to the Puyallup River system. This section describes the procedure for calibration of model coefficients.

4.3.2.1 BOD Decay, Reaeration, and Benthic Oxygen Exchange

Dissolved oxygen was modeled with QUAL2E incorporating atmospheric reaeration and the demand of oxygen from carbonaceous BOD (CBOD) and nitrogenous BOD (NBOD). The net algal production or respiration of oxygen was calculated from diurnal dissolved oxygen data and included in the model using the benthic oxygen exchange term (K_4).

The rate constant for decay of CBOD in natural waters is typically greater than the laboratory "bottle" decay rate due to benthic influence on BOD decay at low stream flow. Benthic BOD decay influences the rate constant K_1 in QUAL2E, which is distinct from benthic oxygen exchange (K_4). BOD decay is modeled as a first-order decay process while benthic oxygen exchange is a zero-order rate specified for each reach (Table 4.5). EPA (1985a and 1985b) recommends the formulation of Wright and McDonnell (1979) for describing the CBOD decay rate for a range of river flows between 10 and 800 cfs:

$$K_1 = 10.3\, Q^{-0.49}$$

where K_1 is the CBOD decay rate (days^{-1} in base e at 20 degrees C) and Q is stream flow (cfs). At flows less than 10 cfs and greater than 800 cfs the decay rate is assumed to be constant at 3.3 day^{-1} and 0.39 day^{-1}, respectively. The lower decay rate at larger flows compares favorably with the measured bottle decay rate of 0.25 ± 0.48 day^{-1} (mean $\pm$ standard deviation of 137 samples) for all ultimate BOD samples analyzed during the September and October, 1990 surveys. CBOD decay rates (K_1) were calculated for each reach using the Wright and McDonnell equation.

The rate of atmospheric reaeration (K_2) was estimated from empirical equations built into QUAL2E which relate reaeration to velocity and depth or velocity and slope. Selection of appropriate reaeration equations was based on recommendations by EPA (1985a and 1991b). For reaches with stream depth less than 0.5 feet, the Tsivoglou-Wallace equation (QUAL2E option 8) was used. At depths greater than or equal to 0.5 feet, the O'Connor and Dobbins equation was used (QUAL2E option 3).

Table 4.5. Summary of QUAL2E model coefficients for dissolved oxygen and nitrogen cycle simulation.

Coefficient (Figure 4.1)	Description	Units	Value Used
α_5	O_2 uptake per unit NH_3 oxidized	mg O/mg N	3.43
α_6	O_2 uptake per unit NO_2 oxidized	mg O/mg N	1.14
β_1	rate constant for biological oxidation of NH_3 to NO_2	day^{-1}	reach spec. (1)
β_2	rate constant for biological oxidation of NO_2 to NO_3	day^{-1}	4
β_3	rate constant for hydrolysis of organic N to NH_3	day^{-1}	0.1
K_1	CBOD decay rate constant	day^{-1}	reach spec. (2)
K_2	reaeration rate constant	day^{-1}	reach spec. (3)
K_4	benthic oxygen exchange	gm O/ ft^2-d	reach spec. (4)

1) 0.2 day^{-1} for deep segments (> 2 ft); 0.45 day^{-1} for shallow.

2) Wright and McDonnell formula: $K_1 = 10.3\ Q^{-0.49}$ for Q in cfs.

3) Tsiviglou-Wallace equation for depth < 0.5 ft; O'Connor-Dobbins equation for depth ≥ 0.5 ft.

4) Calculated from diurnal oxygen range.

Net productivity or respiration was calculated as an areal net gain or loss of oxygen input to QUAL2E using the sediment oxygen demand term (QUAL2E variable K_4; also called benthic oxygen exchange). This term is expressed as an input value of mass of oxygen per unit channel bottom area per unit time. Positive values of benthic oxygen exchange represent net respiration of benthic organisms (e.g., periphyton) and negative values represent net production of oxygen. Benthic oxygen production was calculated from diurnal ranges of dissolved oxygen measured during September and October 1990, using the method of DiToro (1975) as presented by Thomann and Mueller (1987). All measurements in the Puyallup River system indicated net photosynthetic production of oxygen from benthic organisms (Table 4.6).

4.3.2.2 Nitrogen Cycle Coefficients

The rates of oxygen uptake per unit of ammonia and nitrite oxidation (α_5 and α_6) are stoichiometric constants which are assumed to pertain to all reaches (Table 4.5). The rate constant for hydrolysis of organic N to ammonia (β_3) was assumed to be 0.1 day^{-1} for all reaches, which is in the mid range of reported values in the literature (EPA, 1985a).

The rate constants for the nitrification reactions of ammonia to nitrite (β_1) and nitrite to nitrate (β_2) represent the major controlling reactions of NBOD. The rate of these reactions was assumed to be controlled by β_1 since β_2 is typically much faster (EPA, 1985a). The β_1 values selected, for all reaches except Puyallup RM 0.0 to 7.0, were based on typical values in the literature and regional experience by Ecology since nitrification rates in the river could not be directly measured at current loading levels in most reaches. A rate constant of 0.45 day^{-1} was used for shallow reaches (less than or equal to two feet deep) assuming conditions would be most favorable for nitrification. Deeper reaches were assumed to have a nitrification rate constant of 0.2 day^{-1}.

The lower Puyallup reaches (RM 0.0 to 7.0) had high enough levels of ammonia during the September 18-20 survey to allow direct estimation of nitrification rates. Nitrification rates required to explain ammonia decreases and coincident nitrate increases in this segment were estimated to be 4 day^{-1} based on regression of river concentrations versus travel time. This measured nitrification rate was used in the QUAL2E model for the Puyallup River below the Puyallup WTP (reaches 38, 42, 46 and 47). A faster rate of nitrification in the lower Puyallup compared to the rest of the system could be explained by higher ammonia concentrations in the river below the Puyallup WTP, which promote development of nitrifying bacteria populations in the river. Nitrification rates as high as 9 day^{-1} have been reported in other rivers (EPA (1985a).

4.3.2.3 Temperature Correction of Coefficients

All reaction coefficients discussed in this section are reported at 20°C. The QUAL2E model allows correction of actual reaction rates from the rate at 20°C to the ambient temperature of the river during the simulations. The temperature corrections used were the default values

Table 4.6. Summary of diurnal net oxygen production by periphyton from diurnal dissolved oxygen data

Station	Date	Temp	Diurnal Dissolved Oxygen Range	Net Oxygen Production @ ambient Temperature	Net Oxygen Production Corrected to 20°C (mg/ft2/day)	Mean	±	SD
		deg C	mg/L	mg/ft2/day		Mean	±	SD
WIL04.2	18-Sep-90	13.7	0.43	0.14	0.18			
WIL04.2	19-Sep-90	13.1	0.72	0.22	0.31			
WIL04.2	02-Oct-90	10.5	0.84	0.26	0.40	0.30	±	0.11
WHI25.2	19-Sep-90	12.6	0.27	0.07	0.10			
WHI25.2	24-Sep-90	12.6	0.01	0.00	0.00			
WHI25.2	02-Oct-90	9.6	0.69	0.18	0.28			
WHI25.1	20-Sep-90	12.8	1.05	0.27	0.37	0.19	±	0.17
WHI23.3	18-Sep-90	13.3	0.28	0.06	0.09			
WHI23.3	19-Sep-90	12.8	0.04	0.01	0.01			
WHI23.3	20-Sep-90	13.5	0.44	0.10	0.14			
WHI23.3	25-Sep-90	13.2	0.17	0.04	0.05			
WHI20.4	18-Sep-90	13.7	0.26	0.06	0.08			
WHI20.4	20-Sep-90	12.8	0.28	0.07	0.09			
WHI20.4	24-Sep-90	13.8	0.11	0.02	0.03			
WHI20.4	25-Sep-90	14.0	1.02	0.24	0.31			
WHI20.4	02-Oct-90	11.1	1.20	0.28	0.42	0.14	±	0.14
WHI08.0	18-Sep-90	15.0	0.65	0.15	0.18			
WHI08.0	19-Sep-90	15.0	0.07	0.02	0.02			
WHI08.0	02-Oct-90	11.9	2.06	0.46	0.67			
WHI04.9	18-Sep-90	15.3	0.67	0.14	0.18			
WHI04.9	20-Sep-90	14.7	1.80	0.39	0.50			
WHI04.9	24-Sep-90	13.7	1.08	0.23	0.31			
WHI04.9	25-Sep-90	15.2	1.62	0.35	0.44			
WHI04.9	02-Oct-90	11.9	1.89	0.41	0.59			
WHI03.7	27-Sep-90	13.9	1.17	0.25	0.34			
WHI03.7	28-Sep-90	13.6	1.29	0.28	0.37	0.36	±	0.20
SPR07.4	19-Sep-90	13.3	0.42	0.05	0.06			
SPR07.4	02-Oct-90	11.2	0.58	0.06	0.09			
SPR05.8	19-Sep-90	13.5	0.44	0.05	0.07			
SPR05.8	02-Oct-90	11.2	0.35	0.04	0.06			
SPR01.1	18-Sep-90	14.1	1.87	0.22	0.29			
SPR01.1	19-Sep-90	14.3	1.43	0.17	0.22			
SPR01.1	27-Sep-90	15.3	1.70	0.20	0.25			
SPR01.1	02-Oct-90	11.6	1.57	0.19	0.27	0.16	±	0.10
PUY18.0	18-Sep-90	12.6	0.99	0.16	0.23			
PUY18.0	27-Sep-90	12.5	0.65	0.11	0.15			
PUY18.0	02-Oct-90	9.9	0.27	0.04	0.07	0.15	±	0.08
PUY12.2	18-Sep-90	13.2	0.87	0.14	0.19			
PUY12.2	27-Sep-90	12.9	0.55	0.09	0.12			
PUY12.2	02-Oct-90	9.9	0.35	0.06	0.09	0.14	±	0.05
PUY08.3	18-Sep-90	14.2	0.81	0.13	0.17			
PUY08.3	20-Sep-90	13.5	1.10	0.18	0.24			
PUY08.3	02-Oct-90	12.7	1.16	0.19	0.26			
PUY05.7	20-Sep-90	14.3	1.30	0.21	0.28			
PUY05.7	27-Sep-90	14.5	1.34	0.22	0.28			
PUY05.7	02-Oct-90	12.2	-0.07	-0.01	-0.02	0.20	±	0.12
CAR16.1	18-Sep-90	11.4	0.17	0.07	0.11			
CAR16.1	19-Sep-90	9.8	-0.12	-0.05	-0.08			
CAR16.1	27-Sep-90	10.1	0.12	0.05	0.08			
CAR16.1	02-Oct-90	7.3	0.17	0.07	0.13			
CAR06.1	18-Sep-90	12.8	0.62	0.21	0.29			
CAR06.1	19-Sep-90	12.6	0.10	0.03	0.05			
CAR06.1	27-Sep-90	13.7	0.91	0.31	0.41			
CAR06.1	02-Oct-90	9.3	0.34	0.11	0.19	0.14	±	0.15
CAR02.0	18-Sep-90	13.9	1.25	0.31	0.41			
CAR02.0	19-Sep-90	14.5	0.07	0.02	0.02			
CAR02.0	27-Sep-90	14.3	0.61	0.15	0.20			
CAR02.0	02-Oct-90	10.8	0.07	0.02	0.03	0.16	±	0.18

recommended by EPA, which represent current best estimates from the scientific literature (EPA, 1991b). The benthic oxygen exchange temperature correction was assumed to equal the default correction for algae growth since this reaction represents periphyton productivity.

4.3.3 Calibration and Confirmation Results

Most of the coefficients chosen to calibrate QUAL2E to the Puyallup River system were chosen from typical literature values and are independent of model output or observed water quality. Therefore, both intensive surveys provide partially independent confirmation of the model. The only model kinetics parameters (Figure 4.1 and Table 4.5) which were derived from intensive survey data were: 1) nitrification rates below the Puyallup WTP based on the September 18-20, 1990 survey; and 2) benthic oxygen exchange based on the average of all data at each station, which were collected mainly during September 1990.

The observed dissolved oxygen profiles are compared with QUAL2E predictions for September 18-20 and October 2, 1990 in Figures 4.5 and 4.6. Both surveys show close agreement between model predictions and observed data, with concentrations generally slightly above saturation except for the lower Puyallup and White Rivers. All dissolved oxygen concentrations during September and October 1990 were well above standards.

Observed ammonia concentration profiles are compared with QUAL2E predictions for September 18-20 and October 2, 1990 in Figures 4.7 and 4.8. The QUAL2E model appears to represent the significant features of the observed ammonia profile. Ammonia concentrations were generally highest in the lower Puyallup River below the Puyallup WTP, and near the quantitation limit (0.010 mg N/L) in most of the rest of the system.

The comparison of observed mean dissolved oxygen and ammonia concentrations with QUAL2E model predictions shows that the model adequately represents these parameters for a range of low flow conditions. For example, differences in White River and lower Puyallup River water quality in September versus October surveys due to changes in Lake Tapps outflow were accurately predicted by the model. Observed and modeled dissolved oxygen and ammonia were compared using the root mean squared error (RMSE) (Reckhow, Clements, and Dodd, 1986). The purpose of calibration is to minimize differences between observed and modeled data using appropriate models. Deviations between modeled and observed dissolved oxygen (RMSE = 0.2 mg/L) and ammonia (RMSE = 0.01 mg/L as N) were less than the variability of measurements, which was dominated by natural variability (e.g. ranges of diurnal dissolved oxygen). No significant differences were observed between calibration (September 1990) and confirmation (October 1990) RMSEs. Differences between observed and modeled results were not significantly greater than 0.1 mg/L for dissolved oxygen and 0.01 mg/L for ammonia as N. The calibrated model was considered to be representative of normal ranges of summer conditions.

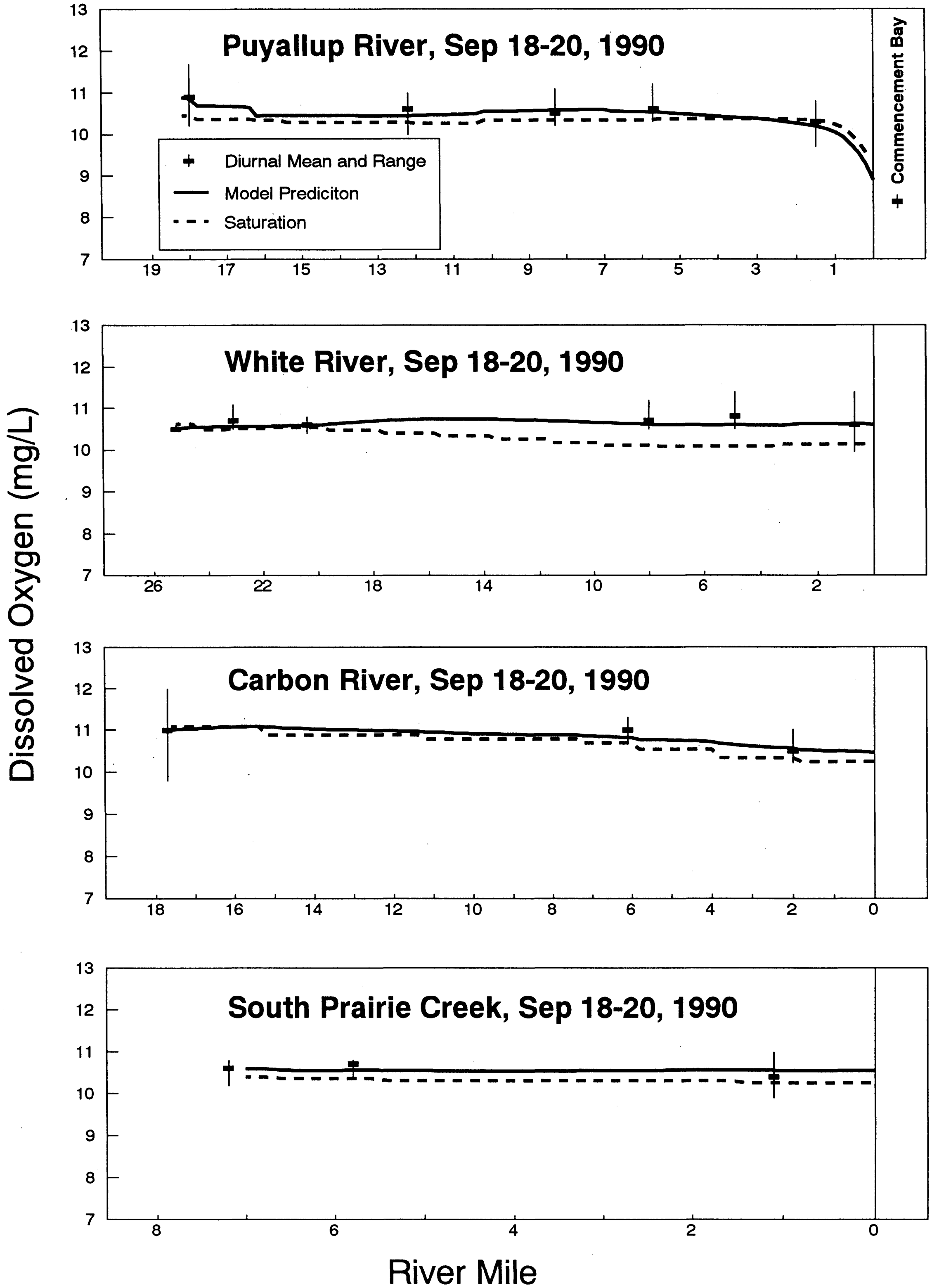


Figure 4.5. QUAL2E model calibration of dissolved oxygen for September 18-20, 1990 survey.

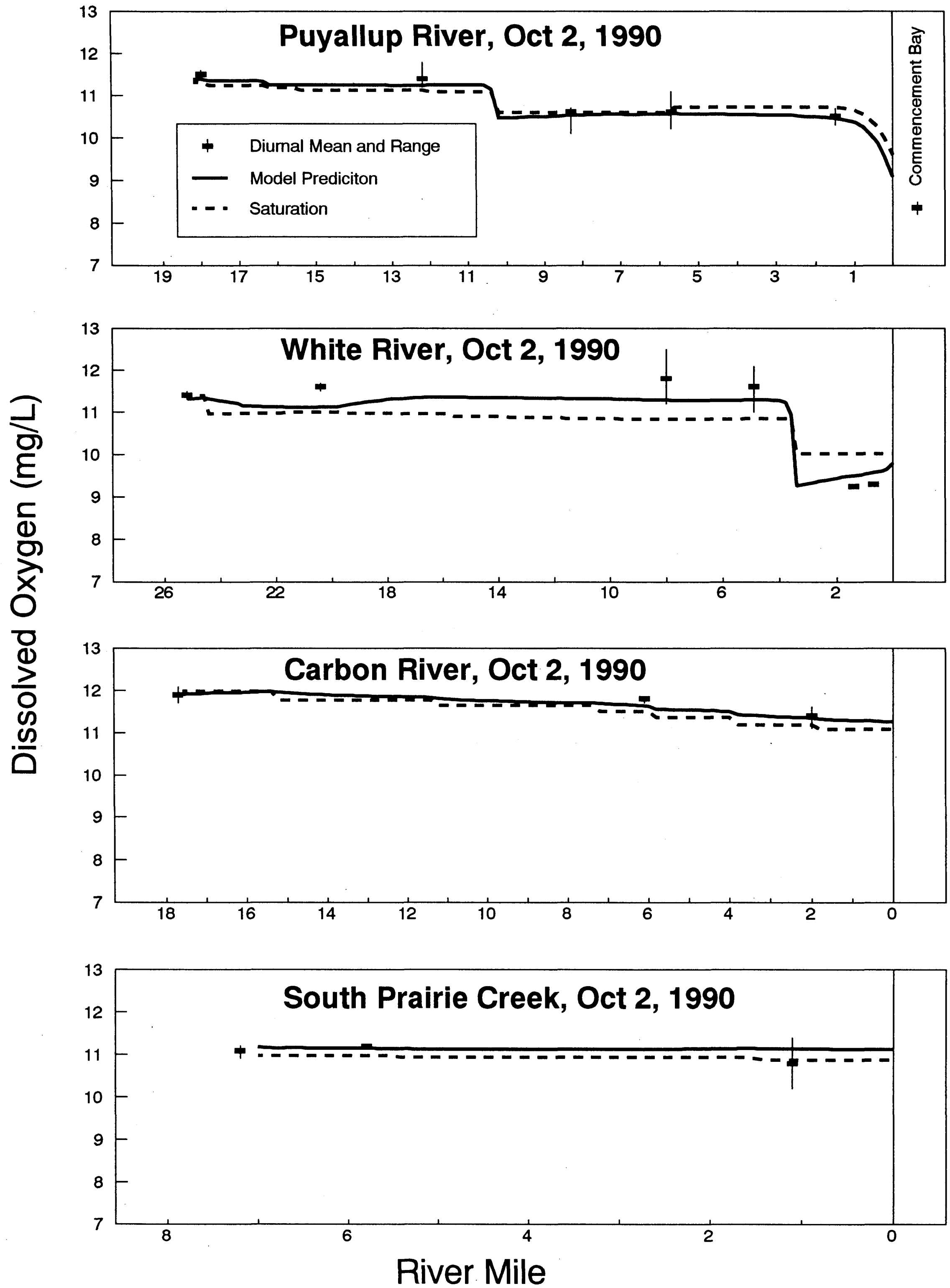


Figure 4.6. QUAL2E model calibration of dissolved oxygen for October 2, 1990 survey.

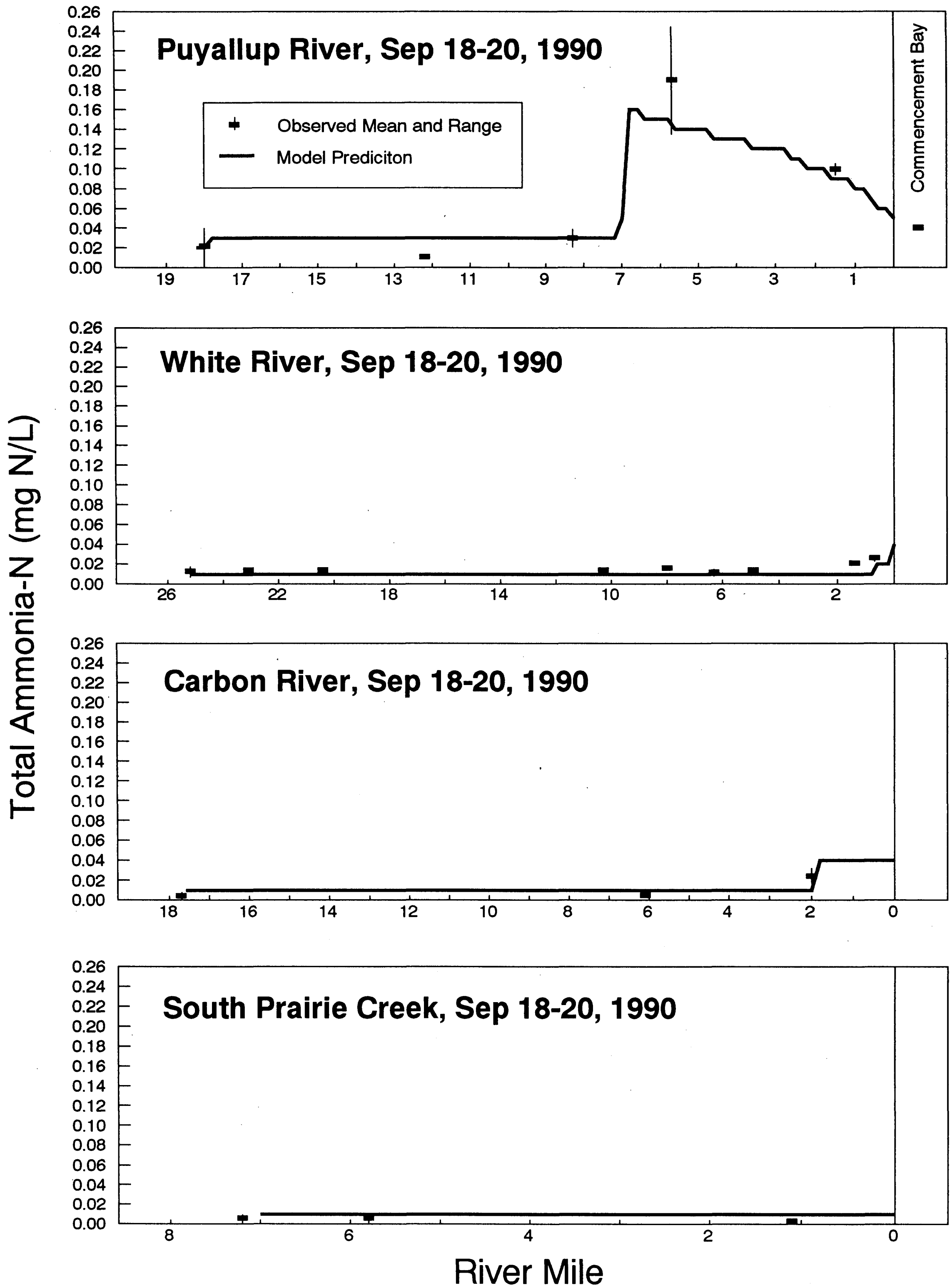


Figure 4.7. QUAL2E model calibration of total ammonia for September 18-20, 1990 survey.

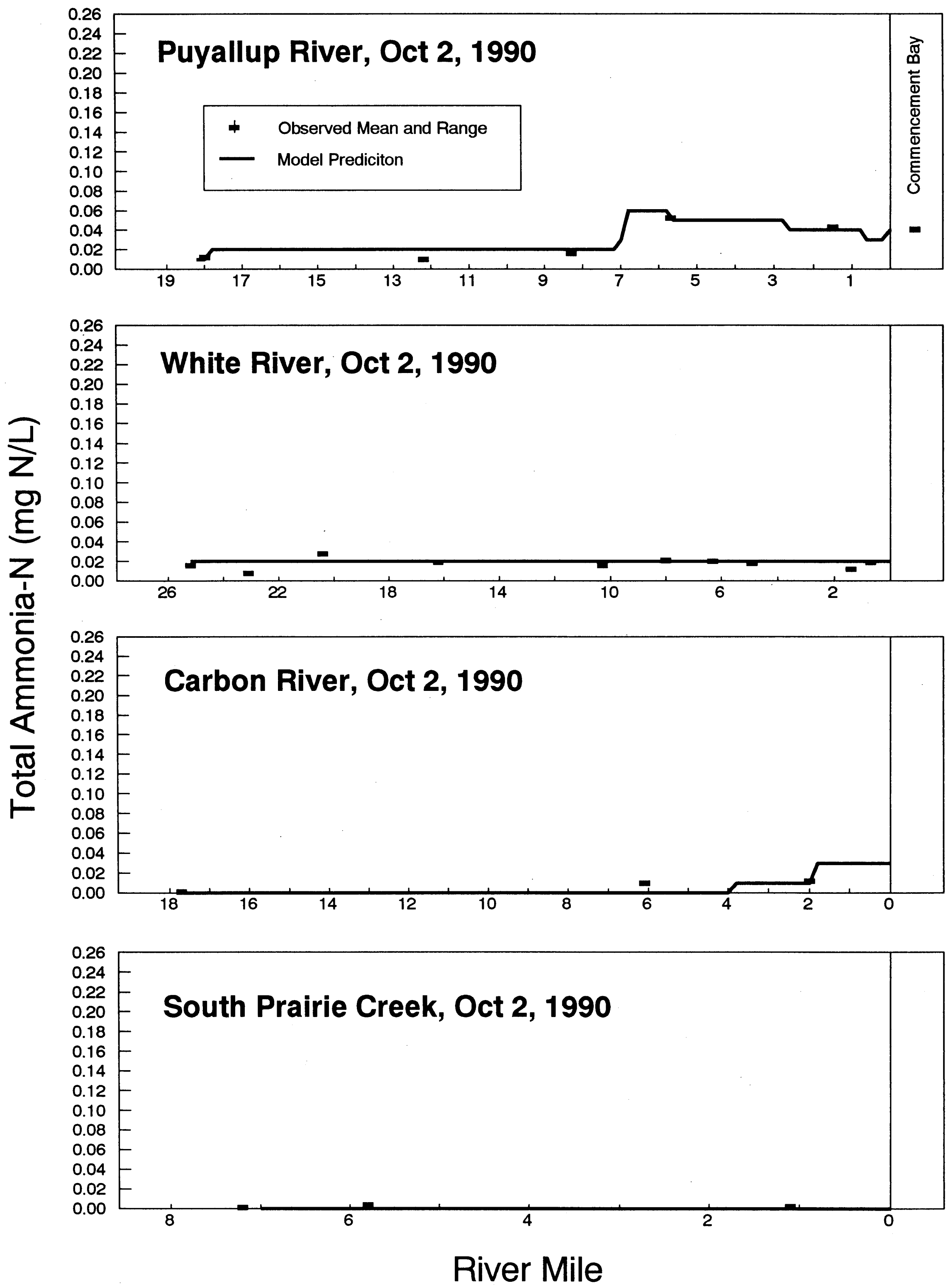


Figure 4.8. QUAL2E model calibration of total ammonia for October 2, 1990 survey.

4.3.4 Sensitivity and Uncertainty Analysis

The QUAL2E model contains a powerful uncertainty analysis option called QUAL2E-UNCAS. Uncertainty is a measure of model precision (e.g., standard deviation of predicted values). Sensitivity is a measure of how much a predicted variable would change given a unit change in an input. First order uncertainty analysis was used to evaluate both the sensitivity of model predictions of water quality to changes in input variables, and also to quantify the amount of model uncertainty due to each input variable. The QUAL2E-UNCAS output provides two major tabulations: 1) a listing of normalized sensitivity coefficients (e.g., percent change of the predicted water quality variable which would result from one percent change in each input variable); and 2) a listing of the components of total model variance at selected points in the river basin (*i.e.*, how much of the total model variance is due to each input variable).

QUAL2E-UNCAS requires specification of coefficients of variation (CVs), which are defined as the standard deviation divided by the mean value, for each input variable. Wherever possible the CVs were estimated from sampling data. CVs for velocity, ultimate BOD conversion rate constant, ammonia decay rate, and all forcing functions listed in Table 4.7 were estimated from the sampling data. For all other input variables, CVs were estimated from typical ranges reported in EPA guidance documents (EPA, 1985a; EPA, 1987).

The QUAL2E-UNCAS first-order uncertainty analysis was performed on the September 18-20, 1990 calibration model predictions. The normalized sensitivity coefficients (Table 4.8) show that dissolved oxygen predictions are most sensitive to river temperature (for example, a 1 percent increase in temperature causes a 0.63 percent decrease in dissolved oxygen at Puyallup RM 1.0). Ammonia predictions are most sensitive to headwater and point loads of ammonia, and river temperature. Perturbations of all other model input variables have relatively little influence on changes in model predictions.

The components of model uncertainty (Table 4.9) reveal that most of the dissolved oxygen prediction uncertainty is due to river temperature variability. Ammonia prediction uncertainty is explained mostly by headwater and point load ammonia concentration variability, and ammonia decay rate and temperature variability to a lesser extent. Uncertainty in all other input variables combined generally explains less than 25 percent of the total model prediction uncertainty. In general, headwater uncertainty dominates in upper areas of the river and other input variables become progressively more important downstream.

The model uncertainty for dissolved oxygen prediction (standard deviations of 0.7-0.8 mg/L) could probably not be improved significantly since natural diurnal variability in temperature accounts for the major share. Ammonia prediction variability also appears to be reasonable, with standard deviations less than 0.020 mg N/L above the Puyallup WTP and about 0.041 mg N/L at Puyallup RM 1.0.

Table 4.7. Summary of coefficients of variation for input variables.

QUAL2E Input Variable	Coefficient Of Variation (% of Mean)
HYDRAULIC DATA	
Velocity	10% (1)
Depth	10%
Dispersion	100%
REACTION COEFFICIENTS	
5-Day to Ultimate BOD Conversion Rate Constant	16% (1)
Instream CBOD Decay Rate	50%
Ammonia Oxidation Rate	50% (1)
Oxygen Uptake per Unit Ammonia and Nitrite	10%
Organic N Hydrolysis Rate	20%
Rearation Rate	15%
Temperature Correction Coefficient for Rate Constants	3%
FORCING FUNCTIONS (1)	
River Temperature	11%
Benthic Oxygen Exchange	80%
Headwater Flow	5%
Headwater CBOD	16%
Headwater Nitrogen	110%
Headwater Dissolved Oxygen	5%
Pointload Flow (2)	10%
Pointload CBOD (2)	43%
Pointload Nitrogen (2)	46%
Pointload Dissolved Oxygen (2)	5%

1) CVs were estimated from sampling data for these variables. Cvs for other variables were based on best professional judgement and typical values summarized from the literature.

2) Pointloads include NPDES discharges and tributary loads

Table 4.8. Sensitivity analysis of QUAL2E model predicitons for dissolved oxygen and ammonia. All values are normalized sensitivity coefficients (see text).

	Puyallup RM 1.0 Reach 47 Element 1	Puyallup RM 10.4 Reach 20 Element 9	White RM 3.6 Reach 35 Element 9	Carbon RM 0.2 Reach 15 Element 9
DISSOLVED OXYGEN PREDICTION SENSITIVITY				
River Temperature	-0.63	-0.60	-0.62	-0.66
All Other Input Variables (Each)	<0.10	<0.10	<0.10	<0.10
AMMONIA PREDICTION SENSITIVITY (1)				
Pointload Ammonia Concentration	0.86 (2)	0.54 (1)	0.20 (3)	0.84 (1)
Pointload Flow	0.83 (3)	0.50 (2)	0.19	0.80 (2)
Headwater Flow	-0.37	-0.49 (3)	-0.15	-0.76 (3)
River Temperature	-1.52 (1)	-0.03	-0.23 (2)	-0.02
Headwater Ammonia Concentration	0.07	0.41	0.77 (1)	0.13
Ammonia Decay Rate	-0.62	-0.04	-0.11	-0.03
Velocity	0.59	-0.01	0.07	-0.01
Mannings n	-0.05	-0.02	-0.00	0.00
Dispersion	-0.05	-0.02	-0.00	0.00
Temperature Coefficient for Ammonia Decay	0.29	0.02	0.05	0.01
Depth	-0.04	-0.02	-0.00	0.00
All Other Input Variables (Each)	<0.10	<0.10	<0.10	<0.10

1) Numbers in parentheses are ranks of sensitivity coefficients for three most sensitive inputs. Pointloads include NPDES discharges and tributary inputs.

Table 4.9. Summary of model uncertainty and components of variance for dissolved oxygen and ammonia predictions with QUAL2E for September 18-20, 1990 calibration data.

	Puyallup RM 1.0 Reach 47 Element 1	Puyallup RM 10.4 Reach 20 Element 9	White RM 3.6 Reach 35 Element 9	Carbon RM 0.2 Reach 15 Element 9
DISSOLVED OXYGEN PREDICTIONS				
Model Standard Deviation (mg/L)	0.8	0.7	0.8	0.8
COMPONENTS OF MODEL VARIANCE (% of Total)				
River Temperature	76.7%	92.8%	76.5%	96.4%
Benthic Oxygen Exchange	7.6%	6.7%	23.3%	3.4%
Dispersion	12.0%	0.0%	0.0%	0.0%
Pointload Ammonia	1.4%	0.0%	0.0%	0.0%
All Other Input Variables (Combined)	2.3%	0.5%	0.2%	0.1%
AMMONIA PREDICTIONS				
Model Standard Deviation (mg N/L)	0.041	0.017	0.012	0.015
COMPONENTS OF MODEL VARIANCE (% of Total)				
Headwater Ammonia	1.8%	74.8%	98.2%	12.1%
Pointload Ammonia	52.2%	23.1%	1.1%	82.8%
Ammonia Decay Rate	32.2%	0.1%	0.4%	0.1%
River Temperature	9.4%	0.0%	0.1%	0.0%
Pointload Flow	2.3%	0.9%	0.1%	3.6%
Velocity	1.2%	0.0%	0.0%	0.0%
Dispersion	0.7%	0.2%	0.0%	0.0%
All Other Input Variables (Combined)	0.2%	0.9%	0.1%	3.2%

Both dissolved oxygen and ammonia concentrations were found to be insensitive to dispersion except in the last two reaches of the model near the mouth of the Puyallup River. Some minor discrepancies with conservation of mass at model junctions (e.g., confluence of White and Puyallup or Carbon and Puyallup Rivers) were found to be caused by including dispersion in junction reaches. Since the complexity of the model network included many junctions, and given that dispersion had almost no effect on steady state concentrations of the upper river, dispersion was assumed to be zero in all but the lowest three reaches of the Puyallup River for design condition simulations below.

4.4 Design Condition Simulations

The cumulative water quality impact of various NPDES permit loading scenarios is explored in this section. The general approach used is outlined as follows:

- Existing and currently proposed permits were summarized;
- Load allocations for background and nonpoint sources were estimated;
- The QUAL2E model was used to evaluate cumulative water quality impacts of existing and currently proposed permits at 7Q10 river flow without regard for water quality-based limits;
- Waste load allocations (WLAs) based on maximum allowable mixing zone dilution flows for water quality-based limits were estimated for ammonia and chlorine;
- The QUAL2E model was used to evaluate cumulative water quality impacts of mixing zone WLAs at 7Q10 river flow and explore further loading reductions and provisions for future loading increases.

If the cumulative impact of mixing zone WLAs results in meeting water quality criteria, then no further loading limits would be required. Therefore, since each discharger is required to comply with mixing zone regulations, evaluation of individual mixing zone WLAs is the first step in a strategy for developing water quality-based limits.

4.4.1 Summary of Existing Permits

The existing NPDES permits for municipal and industrial discharges are listed in Table 4.10. Currently only one municipal WTP (Sumner) and two of the industrial WTPs (Matsushita and Beatrice) permits contain limits on ammonia.

Table 4.10. Summary of exisiting and proposed NPDES discharges at maximum design load of BOD and ammonia.

	Design Flow (mgd)	Design BOD5 Conc. (mg/L)	Design Total Ammonia N Conc. (mg N/L)	Design BOD5 Load (lbs/day)	Design Total Ammonia N Load (lbs/day)
MUNICIPAL NPDES PERMITS					
Buckley WTP	1.00	45	25	375	209
Carbonado WTP	0.10	45	25	38	21
Enumclaw WTP (2)	2.4	25.2	25	504	501
McAlder Elementary WTP	0.009425	45	25	3.6	2.0
Orting WTP					
Existing Permit	0.75	45	25	280	156
Approved Expansion	2.5	45	25	939	522
Puyallup WTP (2)	10.72	23.3	25	2,085	2,236
Rainier School WTP	0.42	45	25	158	88
South Prairie WTP	0.0382	30	25	9.6	8
Sumner WTP	3.42	45	13.7	1,284	391
Wilkeson WTP	0.07	45	25	26	15
INDUSTRIAL NPDES PERMITS					
Fleischmann's Yeast (3)	1.092	4.94	0.411	45	3.7
Matsushita	0.7	30	32	175	187
Beatrice Cheese	0.5	8.39	32	35	133
Sonoco Products (3)	0.313	258	0.416	673	1.1

1) Proposed new WTP at either of two potential discharge sites.

2) Puyallup and Enumclaw WTP design BOD5 concentration based on permitted maximum load and flow.

3) Design ammonia N concentration based on September - October 1990 maximum multiplied by reasonable potential factors from Table 3-2 of EPA (1991c) assuming CV=0.6. Design BOD5 for Fleischmann's was also estimated this way . BOD5 for Sonoco was based on NPDES permit.

The municipal permits represent the largest BOD_5 and ammonia loads. For the purpose of estimating a reasonable worst-case design load of ammonia from municipal discharges, an effluent concentration of 25 mg N/L was assumed based on data from a large number of similar dischargers (EPA, 1985b and Ecology unpublished summary of municipal Class 2 inspections from 1988-present). Ammonia concentrations in Puyallup WTP effluent averaged 21 mg N/L during the September-October 1990 surveys, although values as high as 42 mg N/L have been reported to Ecology (personal communication with K. Cupps, Ecology, 1991). The other municipal WTPs presently have effluent ammonia concentrations of less than 25 mg N/L, although present levels could be exceeded at any municipal WTP that is not designed to provide nitrification. Design BOD_5 loads were estimated based on the permit weekly maximum values, with the exception of Fleischmann's, which was based on the estimated 95th percentile from September and October 1990 data. Design ammonia loads for Fleischmann's and Sonoco were estimated 95th percentiles from September and October 1990 concentration data and permitted design flow.

Permitted fish hatchery loads of BOD_5 and ammonia were estimated based on regression analysis of data published by Kendra (1989) relating hatchery loading to pounds of fish on hand (Table 4.11). In general, the hatchery effluent concentrations were relatively low in comparison to municipal and industrial loads. The hatchery effluent BOD5 values were typically less than 4 mg/L and effluent ammonia N was less than 0.6 mg N/L for the design load with maximum fish on hand. Hatchery effluents are typically dilute in comparison to municipal and industrial discharges.

4.4.2 Load Allocations for Background, Nonpoint, and Hatcheries

Loading to the river system from background and nonpoint sources occurred from 27 points of input (Table 4.12). The QUAL2E model distinguishes between "headwaters" and "point loads." QUAL2E "headwaters" are defined as inputs from above the upstream boundary of the model. QUAL2E "point loads," which should not be confused with point sources, are defined as any direct inputs to or withdrawals from the model (e.g., creeks or NPDES discharges). The QUAL2E point loads include the withdrawal from the White River to Lake Tapps.

Flows for background headwaters and point loads were estimated for the 7Q10 condition as described in Section 4.2. The dissolved oxygen, ultimate carbonaceous BOD (CBODU), organic N, and most of the ammonia N concentrations for these sources were estimated based on critical tenth percentiles of concentrations from the September and October 1990 surveys. Ammonia concentration of the Puyallup River headwater (HW-01) was estimated based on the 95th percentile of all ambient monitoring data from Puyallup RM 22.2 (Table 3.1).

Fish hatcheries loads were estimated by adding the design hatchery loads from Table 4.11 with influent loads based on critical tenth percentiles of influent concentrations at each hatchery during September and October 1990. In cases where a portion of the tributary flow does not enter the hatchery influent, the bypass loads were accounted for separately (*i.e.*, headwaters 5, 6, 10, 11, and 12 in Table 4.12).

Table 4.11. Summary of net BOD5 and ammonia N loading from fish hatcheries (1).

Hatchery	Maximum Pounds of Fish on Hand	Net BOD5 Load (1) (lbs/day)	Net Ammonia N Load (1) (lbs N/day)
Dept. of Fisheries	80,000 lbs chinook	47	13
Dept. of Wildlife	59,600 lbs rainbow/steelhead/kokanee	35	9
Muckleshoot Tribe	28,300 lbs coho/chinook	17	4
Puyallup Tribe	10,000 lbs chinook/steelhead	6	2
Trout Springs	175,000 lbs rainbow trout	103	27
Troutco, Inc.	100,000 lbs rainbow trout	59	16

1) Net loads estimated based on regression analysis of Kendra (1989) data:
   0.157 ± 0.011 lbs NH_3-N/day per 1000 pounds fish on hand (mean ± std dev)
   0.589 ± 0.128 lbs BOD5/day per 1000 pounds fish on hand (mean ± std dev)

   Net loads in this table do not include load from influent to hatchery.
   Total loads in Table 4.12 include hathery influent loading and net loading from maximum fish on hand.

Table 4.12. Summary of load allocations for background/nonpoint sources and hatcheries for 7Q10 design condition for parameters that affect ammonia and dissolved oxygen mass balance in the QUAL2E model.

Source	QUAL2E Headwater or Pointload Number	Flow (cfs)	Dissolved Oxygen (mg/L)	5-day BOD5 (mg/L)	Ammonia-N (mgN/L)	Organic N (mgN/L)
QUAL2E HEADWATERS:						
Puyallup RM 18.0	HW-01	160.00	10.1	2.5	0.070	0.387
Carbon RM 16.1	HW-02	106.64	10.1	2.5	0.022	0.465
S. Prairie Ck RM 7.4	HW-03	20.01	10.1	2.7	0.027	0.309
Wilkeson Ck RM 4.0	HW-04	8.96	10.3	2.4	0.022	0.296
Voights Ck abv Hatchery	HW-05	0.00	--	--	--	--
Canyon Falls Ck abv Hatchery	HW-06	0.00	--	--	--	--
White RM 25.2	HW-07	292.00	10.5	1.7	0.049	0.268
Boise Ck RM 0.1	HW-08	4.00	8.6	2.7	0.078	0.920
Government Canal abv Boeing	HW-09	0.00	--	--	--	--
Clarks Ck abv Hatchery	HW-10	42.05	7.8	1.8	0.011	0.338
Diru C abv Hatchery	HW-11	0.10	9.2	2.2	0.054	0.081
Clear Ck abv Hatchery	HW-12	0.00	--	--	--	--
Swan Ck	HW-13	1.40	8.9	1.7	0.089	0.556
QUAL2E POINTLOADS:						
Lily Ck	PL-02	1.08	7.6	3.4	0.046	0.331
Dept of Fisheries Hatchery	PL-05	16.91	8.2	3.7	0.165	0.614
Trout Springs Hatchery	PL-08	8.33	8.6	4.8	0.612	1.260
Fennel Ck	PL-10	6.37	9.2	2.0	0.024	0.645
Unnamed Puyallup Trib at RM 13.0	PL-12	3.08	8.2	2.1	0.086	2.230
White River Canal Diversion	PL-16	-175.36	--	--	--	--
Muckleshoot Tribe Hatchery	PL-17	5.00	9.6	3.1	0.170	0.473
Unnamed White R Trib at RM 15.0	PL-21	0.78	7.7	2.2	0.023	0.748
Bowman Ck	PL-22	0.32	8.2	1.9	0.055	0.576
Lake Tapps Outflow to White River	PL-24	291.80	8.0	1.7	0.049	0.187
Strawberry (Salmon) Ck	PL-25	6.75	8.5	1.7	0.032	0.195
Unnamed White R Trib at RM 1.3	PL-28	2.57	2.9	1.7	0.096	1.139
Dept of Wildlife Hatchery	PL-33	12.07	7.7	2.3	0.149	0.876
Puyallup Tribe Hatchery	PL-34	0.78	8.9	3.6	0.530	0.291
Troutco Hatchery	PL-35	9.60	7.7	3.6	0.325	2.670
TOTAL HATCHERY WASTE LOAD ALLOCATION (lbs/day) (1):				994	76	322
BACKGROUND/NONPOINT LOAD ALLOCATION (lbs/day) (2):				10,058	241	1,554

1) Includes load from maximum fish on hand plus 90th percentile of hatchery influent load.

2) Includes all headwaters and tributaries excluding hatchery effluent.

4.4.3 QUAL2E Model of NPDES Alternatives

Four alternatives of existing and proposed NPDES loading were examined (Table 4.13). Alternative 1 represents the base condition of existing permittees discharging at WTP design flows and loads at 7Q10. Alternative 2 increases municipal and industrial NPDES loads by 50 percent over Alternative 1 to evaluate effects of growth without consideration of water quality. Alternative 3 is the same as Alternative 1 except WLAs based on maximum allowable dilution flows in mixing zones were used for NPDES ammonia and chlorine loads unless technology-based limits were more restrictive. Alternative 4 is the same as Alternative 3 except all municipal and industrial design flows of WTPs were increased by 50 percent and mixing zone WLAs were recalculated accordingly.

Results of QUAL2E runs for the four NPDES loading alternatives are presented in Figures 4.9 to 4.14, which show the following specific areas of concern for dissolved oxygen, ammonia, and chlorine:

- Dissolved oxygen in the lower Puyallup is predicted to violate the water quality standard above Puyallup RM 1.0 for Alternatives 1 (freshwater) and 2 (freshwater and marine). Puyallup RM 1.0 to 2.2 was found to be the critical segment within the basin for compliance with dissolved oxygen standards.

- Ammonia in the Puyallup River is expected to exceed chronic toxicity criteria under Alternative 2.

- Ammonia in the White River is expected to exceed chronic toxicity criteria under Alternatives 1 and 2.

- The Carbon River and South Prairie Creek appear to meet dissolved oxygen and ammonia criteria under all evaluated alternatives. However, ammonia concentrations in the lower Carbon river are predicted to approach chronic criteria under Alternative 2.

- Cumulative concentrations of chlorine are predicted to be well below criteria in all modeled segments if mixing zone WLAs are applied to all dischargers (Alternative 3).

The existing permits may be inadequate for protection of water quality standards for dissolved oxygen and ammonia at critical points in the White and Puyallup Rivers. The following section presents a strategy for establishing WLAs.

4.4.4 Mixing Zone Waste Load Allocations

Chapter 173-201A WAC contains requirements for limiting mixing zones for NPDES dischargers. Separate chronic and acute points of compliance are recognized as follows:

Table 4.13. Summary of alternative design loading scenarios for existing permits and proposed future loads at 7Q10 river flow.

Design Loading Alternative	Description
1	Existing NPDES permits design condition: - River flows at 7-day-10-year low flow (7Q10) - All existing permits at maximum allowable limits - Municipal WTP effluent ammonia N of 25 mg N/L - Municipal and Industrial BOD limits at daily or weekly max - Orting WTP at approved 2.5 mgd design flow - Lake Tapps outflow dissolved oxygen at 8 mg/L (1)
2	Future NPDES discharges without water quality-based limits - River flows at 7Q10 - Increase all municipal and industrial loads by 50 percent over Alternative 1
3	Existing NPDES discharges with mixing zone WLAs - River flows at 7Q10 - Implement mixing zone WLAs from Table 4.15 and 4.16 - McAlder, S. Prairie, and Carbonado WTP ammonia assumed to be potential maximum of 25 mgN/L - Fleischmann's and Sonoco ammonia at reasonable potential max - Beatrice at current permit ammonia which is more limiting than proposed WLA.
4	Same as Alternative 3 except: - Increase all municipal and industrial flows by 50 percent - recalculate mixing zone WLAs based on increased design flows

1) Dissolved oxygen of 8 mg/L was assumed to be the minimum required to maintain the Class A standard in the mixing zone for the power flume where it enters the White River. Application of this criterion may be a consideration for Puget Power operations. Available data show the potential for less than 8 mg/L in the Lake Tapps outflow.

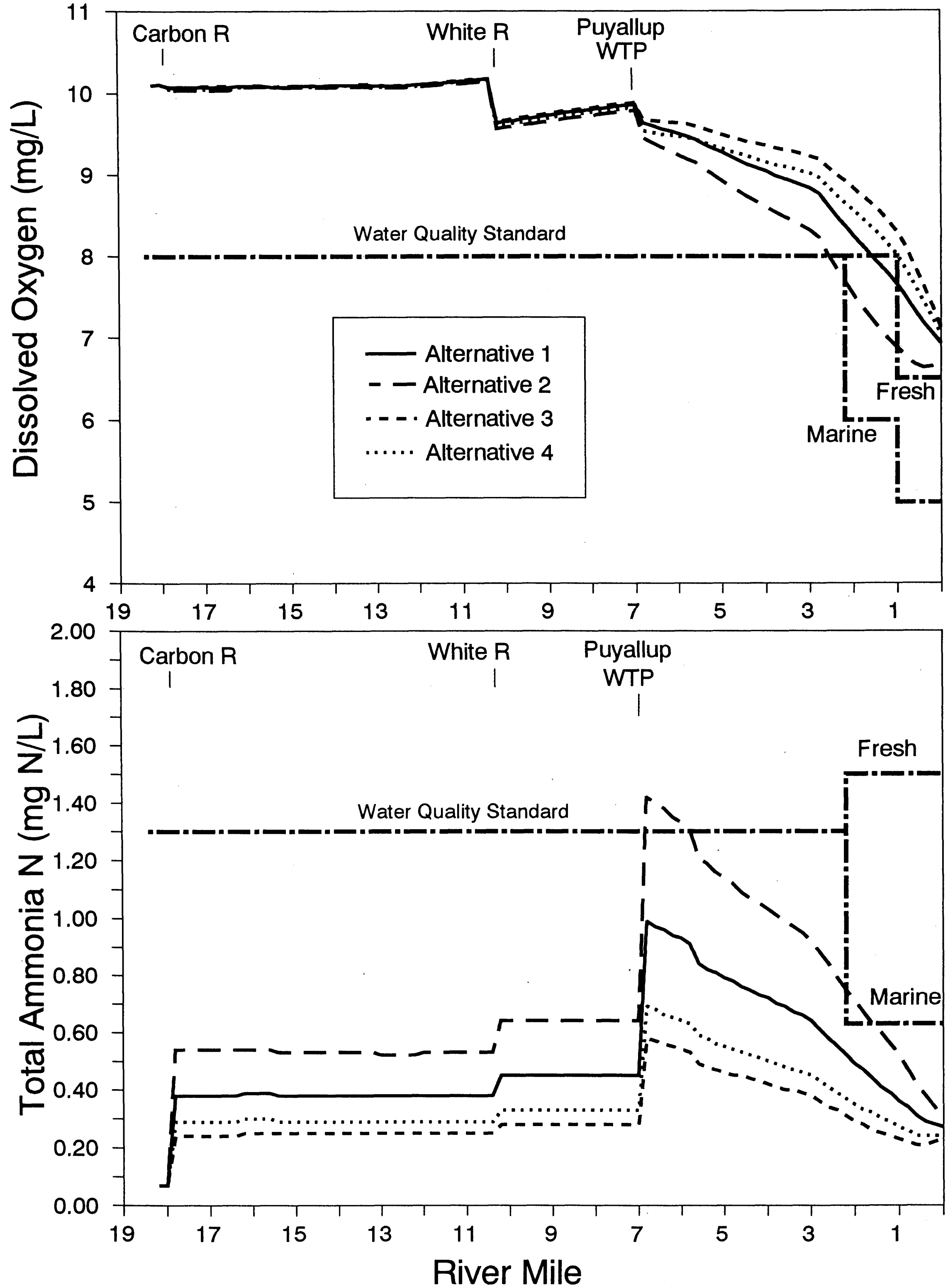


Figure 4.9. 7Q10 model predictions for the Puyallup River at alternative point load conditions.

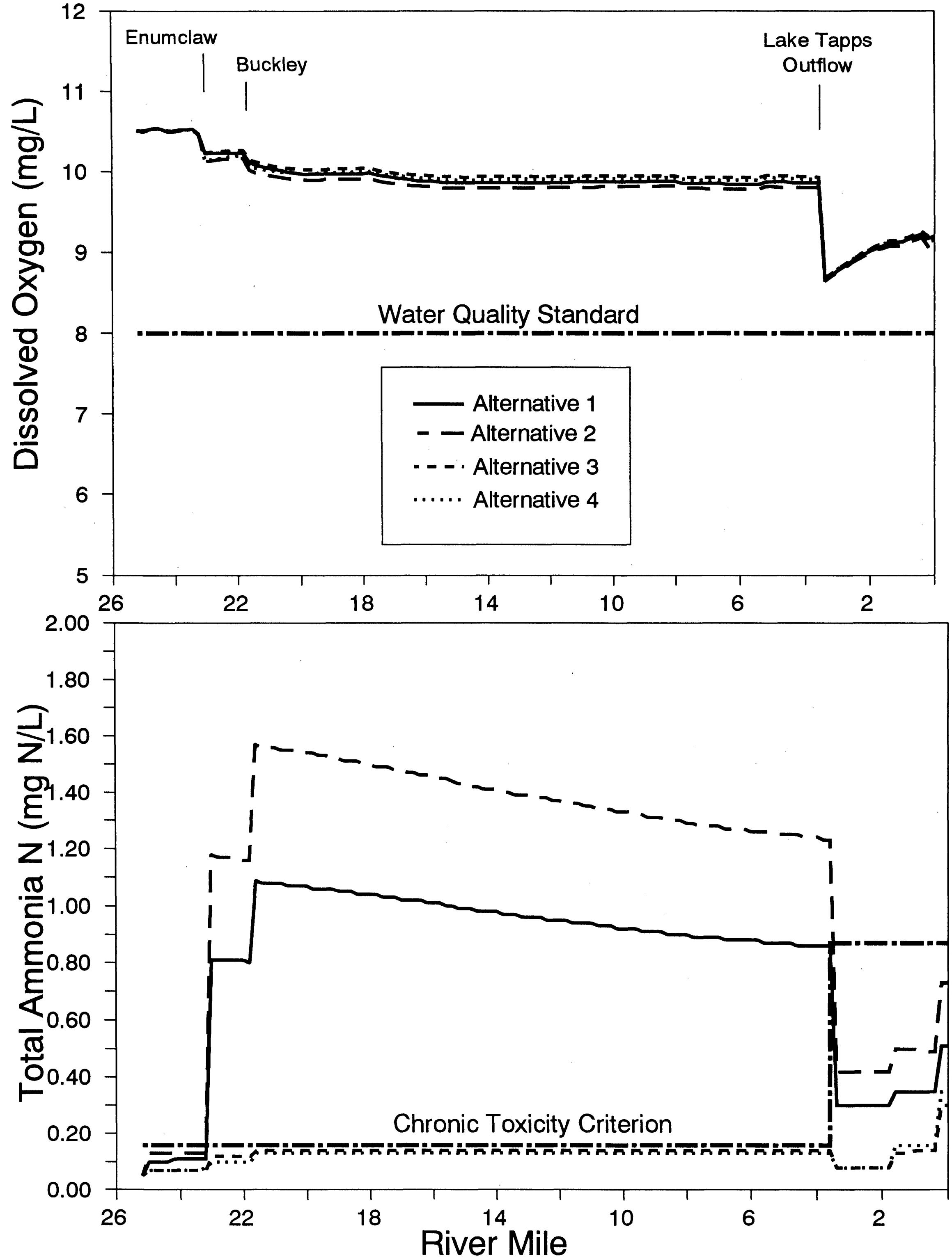


Figure 4.10. 7Q10 model predictions for the White River at alternative point load conditions.

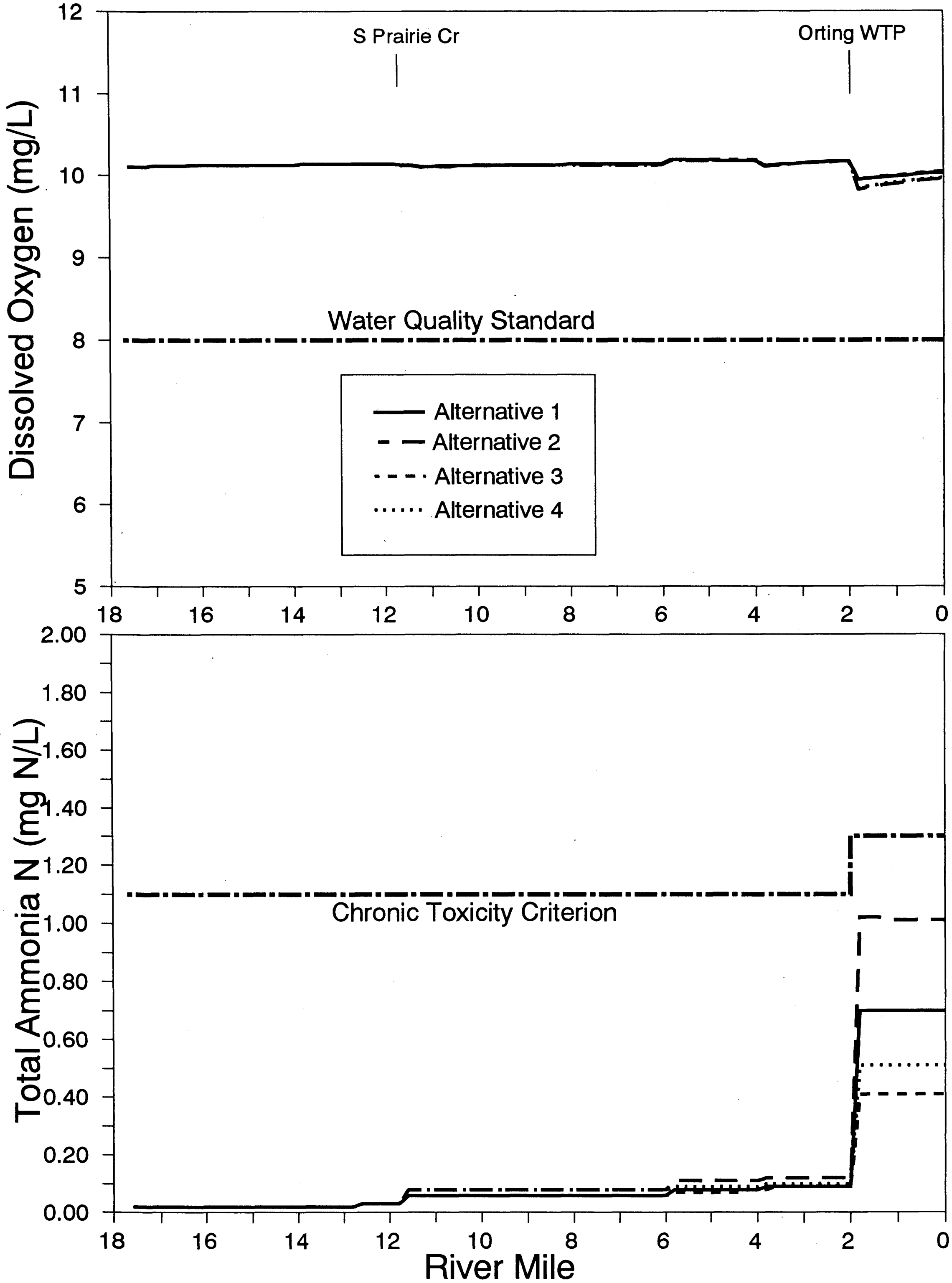


Figure 4.11. 7Q10 model predictions for the Carbon River at alternative point load conditions.

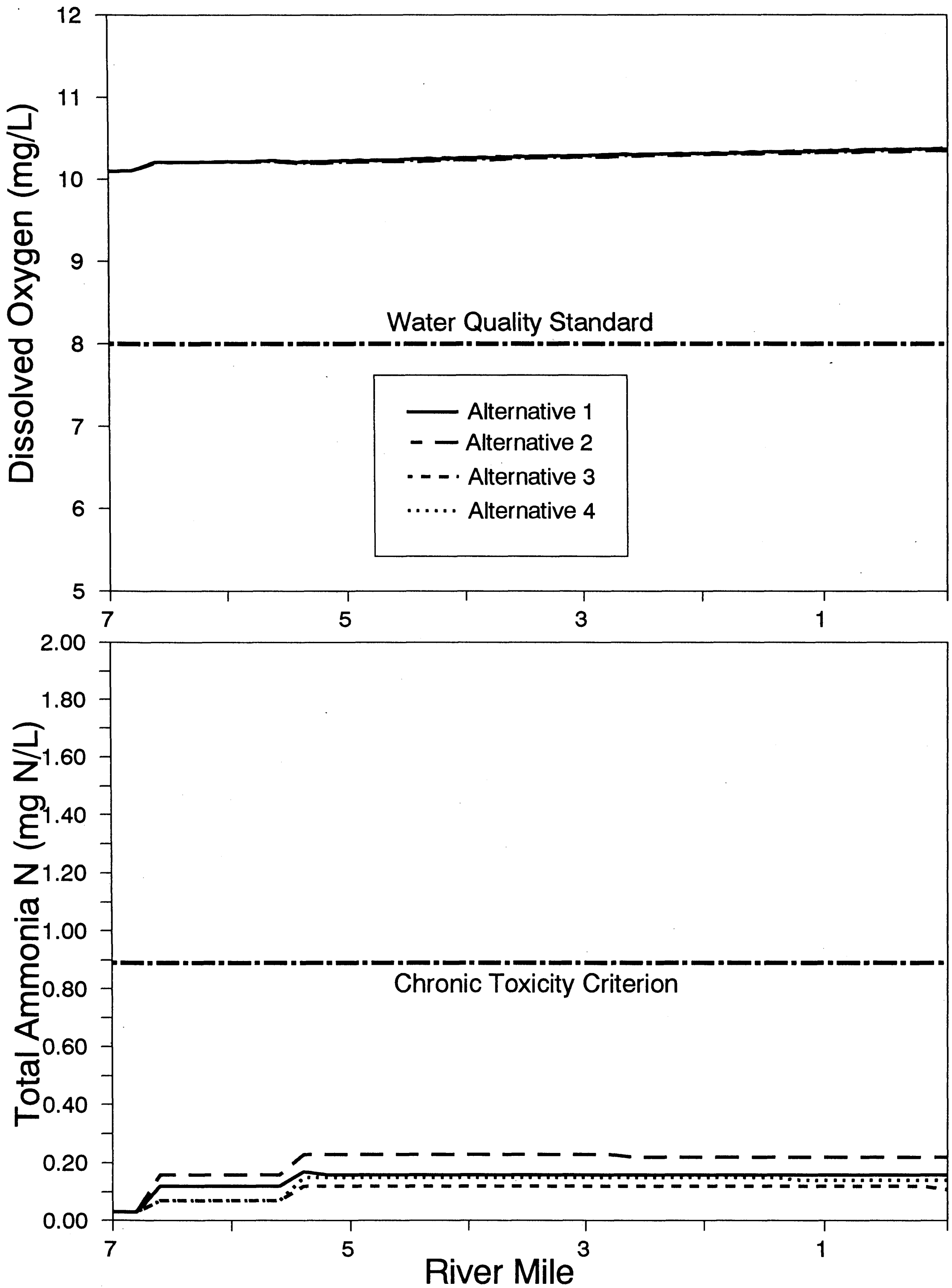


Figure 4.12. 7Q10 model predictions for South Prairie Creek at alternative point load conditions.

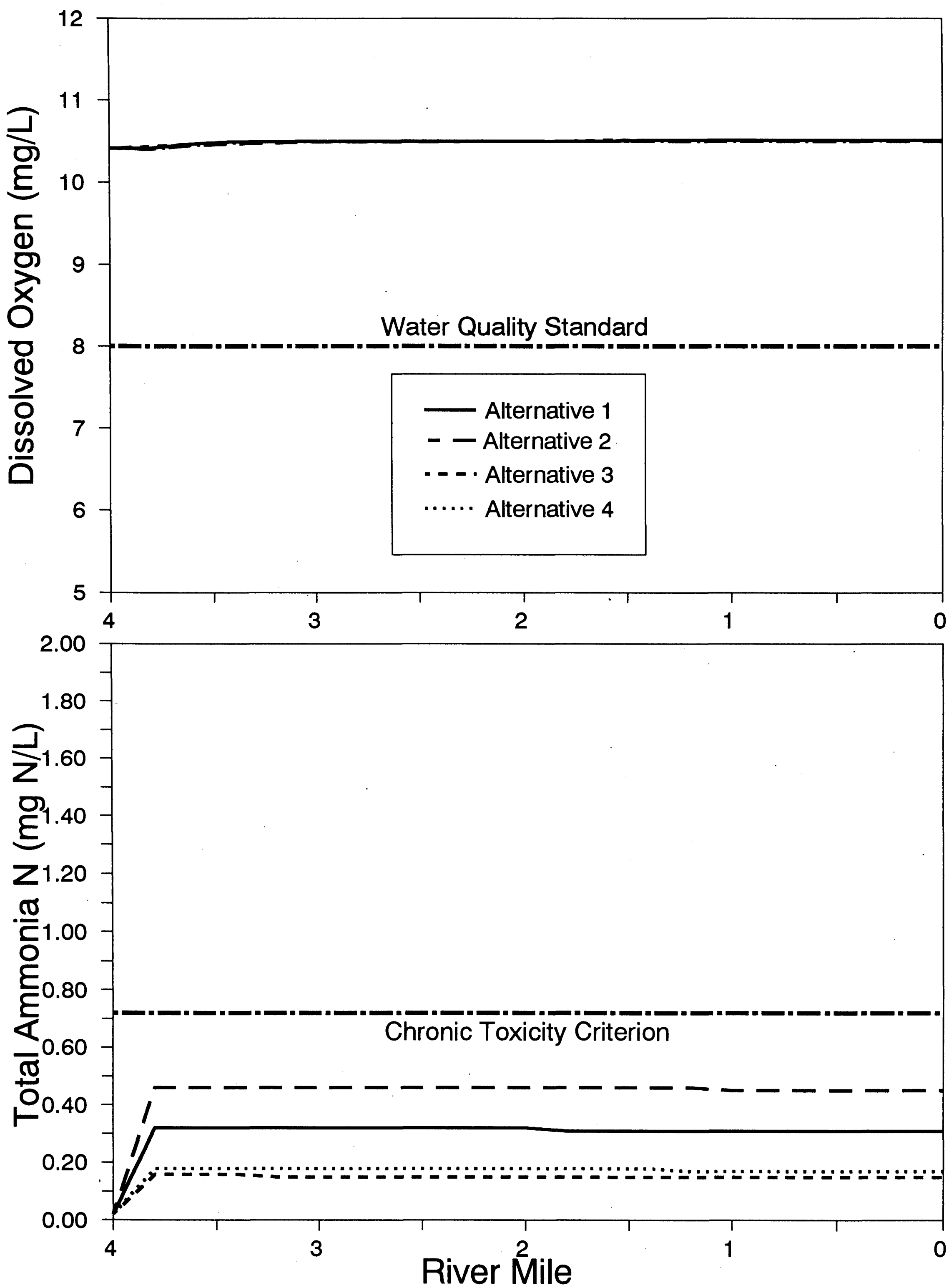


Figure 4.13. 7Q10 model predictions for Wilkeson Creek at alternative point load conditions.

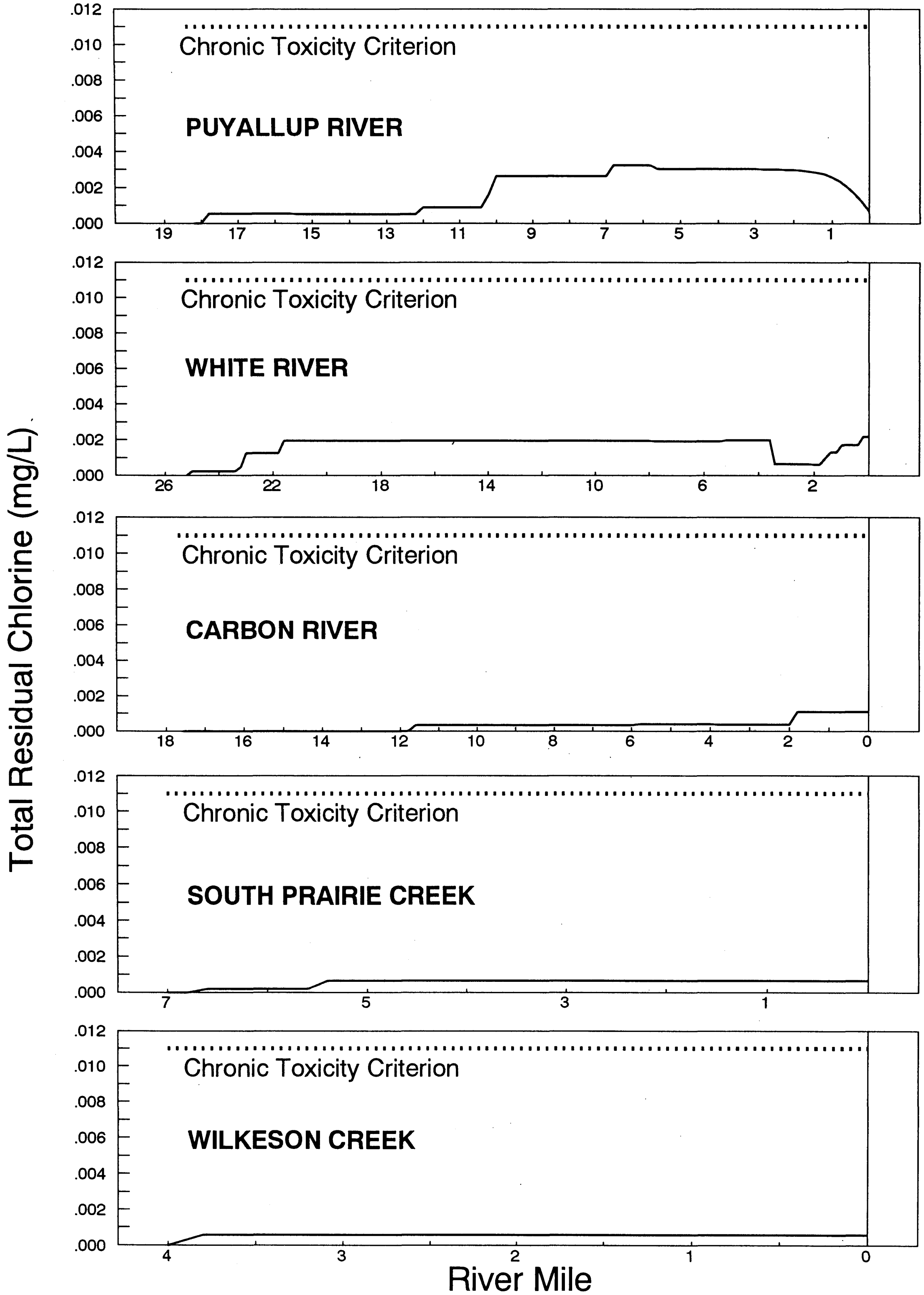


Figure 4.14. Total residual chlorine predictions for Alternative 3 at 7Q10 with mixing zone WLAs and assuming chlorine is conservative.

- In no case shall the zone of chronic criteria excursion in rivers be greater than the most restrictive combination of the following:
  - shall not utilize more than 25% of the river flow or occupy greater than 25% of the width of the channel;
  - shall not extend in the downstream direction more than 300 feet plus the depth of water over the diffuser;
  - shall not extend upstream more than 100 feet.
- In no case shall the acute criteria excursion in rivers be greater than the most restrictive of the following:
  - shall not utilize more than 2.5 percent of the flow;
  - shall extend no more than 10 percent of the distance from the edge of the outfall structure to the upstream and downstream boundaries of an authorized mixing zone;
  - shall not occupy more than 25 percent of the width of the waterbody.

Dilution factors (DF) based on allowable dilution flows were calculated from discharger design flow (Q_{NPDES} based on maximum monthly average design flow) and river flow (7Q10). The dilution factors, using percentages of river flows allowed in WAC 173-201A, were calculated as follows:

$$\text{Chronic DF} = (Q_{NPDES} + (.25 * 7Q10)) / (Q_{NPDES})$$

$$\text{Acute DF} = (Q_{NPDES} + (.025 * 7Q10)) / (Q_{NPDES})$$

These dilution factors (Table 4.14) are intended for calculating maximum allowable effluent loads if mixing zone regulations are implemented. These dilution factors in combination with water quality criteria provide a basis for allocating loads basin wide. Individual NPDES discharges may require lower dilution factors for developing permit limits, depending on diffuser performance evaluations, which are beyond the scope of this analysis. If a site specific analysis (e.g. dilution modeling or dye study) of diffuser performance shows that a discharger actually should be allowed less dilution than that presented in Table 4.14, then the lower value should be used for permit limit development.

WLAs for individual dischargers were calculated based on the dilution factors in Table 4.14 using a simple mass balance equation. Each mixing zone WLA (acute and chronic) was calculated from water quality standards (acute and chronic WQS), background ambient constituent concentrations (CA), and dilution factors (acute and chronic DF) as follows:

Table 4.14. Dilution factors (1) based on maximum allowable dilution flows for mixing zone WLA calculations for municipal and industrial NPDES discharges.

	Design Flow (mgd)	7Q10 Upstream Flow (cfs)	Chronic Dilution Factor @ 25% 7Q10 (unitless)	Acute Dilution Factor @ 2.5% 7Q10 (unitless)
MUNICIPAL NPDES PERMITS				
Buckley WTP	1.0	130	22.0	3.10
Carbonado WTP	0.10	107	174	18.3
Enumclaw WTP	2.4	126	9.5	1.85
McAlder Elementary WTP	0.009425	336	5,760	577
Orting WTP				
Existing Permit	0.75	154	34.2	4.32
Approved Expansion	2.5	154	11.0	2.00
Puyallup WTP (2)	10.72	778	12.0	2.10
Rainier School WTP	0.42	292	113	12.2
South Prairie WTP	0.0382	29	124	13.3
Sumner WTP	3.42	437	21.6	3.06
Wilkeson WTP	0.07	9.0	21.8	3.08
INDUSTRIAL NPDES PERMITS				
Fleischmann's Yeast	1.092	435	65.4	7.44
Matsushita (2)	0.7	778	12.0	2.10
Beatrice Cheese	0.5	431	140	14.9
Sonoco Products	0.313	432	224	23.3

1) Chronic dilution factor = (Qnpdes + (.25 * 7Q10)) / (Qnpdes)
Acute dilution factor = (Qnpdes + (.025 * 7Q10)) / (Qnpdes)

where: Qnpdes = design flow from NPDES discharge
7Q10 = 7-day-10-year low flow in river upstream from NPDES discharge

2) Puyallup WTP and Matsushita share same outfall. The maximum allowable dilution factor and subsequent WLAs were calculated based on the combined discharge.

$$\text{Mixing Zone WLA} = (\text{WQS} * \text{DF}) - (\text{CA} * (\text{DF} - 1))$$

The mixing zone WLAs for ammonia and total residual chlorine are presented in Tables 4.15 and 4.16. The acute and chronic WLAs were compared for each discharge to determine which would be more limiting by back calculating the long-term average (LTA) effluent concentration which would be required to meet the WLA (EPA, 1991c). In general the acute WLAs required lower LTAs than chronic WLAs, even when acute WLAs were slightly higher than chronic WLAs. Therefore, acute WLAs were typically more limiting than chronic.

The acute WLAs were not very sensitive to the assumed background ambient concentration since the acute water quality criteria values were much higher than expected background concentrations. In general, the WLA decreases as background concentration increases. The sensitivity of the acute WLA to background concentration was tested by varying the assumed background concentration. As presented above, the design condition for background ammonia in the Puyallup, White, and Carbon Rivers was estimated as the 95th percentile of ambient monitoring data at Puyallup RM 22.2. However, as waste loads discharge to the river downstream from the headwater, the background concentration for successive discharges increases. The maximum allowable background concentration for the acute WLAs was assumed to be the chronic criterion (i.e. the cumulative effect of numerous discharges would not be allowed to raise the whole river above the chronic criterion). Increasing the assumed background concentration to the chronic criterion resulted in less than a 10 percent decrease in the acute WLA compared with the WLA derived using the design condition background based on the 95 percentile.

4.4.5 Cumulative Effect of Mixing Zone WLAs

Dissolved oxygen in the lower Puyallup River was predicted to be more sensitive to changes in NBOD loading than CBOD. If the proposed mixing zone WLAs are adopted for all existing discharges there will be a surplus amount of dissolved oxygen throughout the river system compared with state standards, including at Puyallup RM 1.0. The surplus dissolved oxygen could be reserved for water quality protection or allocated to additional future NBOD and CBOD discharges as long as water quality standards are met. It is probably reasonable to allocate the entire surplus to future loading, with respect to the freshwater criteria, considering that:

- The salt wedge of the Puyallup River estuary extends upstream to RM 2.2. Therefore, marine dissolved oxygen criteria, which are less restrictive than freshwater criteria, should also be considered applicable when salinity is in excess of 1 ppt. Application of freshwater criteria to RM 1.0 conservatively protects marine criteria in the lower 2.2 miles of the Puyallup River.

- The spatial extent of potentially impacted water quality is relatively short. All segments of the basin, except for the vicinity of Puyallup RM 1.0, are predicted to meet the freshwater quality criteria for dissolved oxygen under all alternatives involving mixing zone WLAs.

Table 4.15. Mixing zone WLAs (1) for total ammonia N for municipal and industrial discharges.

	Chronic Total Ammonia Criterion (mgN/L)	Acute Total Ammonia Criterion (mgN/L)	Chronic Total Ammonia WLA (mgN/L)	Acute Total Ammonia WLA (mgN/L)	Most Limiting Criterion (2)	Mass Load of Limiting WLA (lbs N/day)
MUNICIPAL NPDES PERMITS						
Buckley WTP	0.16	0.84	2.1	2.5	Acute	21
Carbonado WTP (3)	1.1	5.9	179	107	Acute	89
Enumclaw WTP	0.16	0.84	0.9	1.5	Acute	30
McAlder Elementary WTP (3)	1.3	6.8	7,080	3,880	Acute	--
Orting WTP						
Existing Permit	1.3	6.8	42.1	29.1	Acute	182
Approved Expansion	1.3	6.8	13.5	13.5	Acute	282
Puyallup WTP (4)	1.3	6.8	14.8	14.2	Acute	1,271
Rainier School WTP	0.16	0.84	10.3	9.5	Acute	33
South Prairie WTP (3)	0.89	4.6	101	60.2	Acute	19
Sumner WTP	0.87	4.5	17.4	13.6	Acute	389
Wilkeson WTP	0.72	3.7	14.2	11.2	Acute	7
INDUSTRIAL NPDES PERMITS						
Fleischmann's Yeast (3)	0.87	4.5	52.4	33.0	Acute	--
Matsushita (4)	1.3	6.8	14.8	14.2	Acute	83
Beatrice Cheese (3)	0.87	4.5	112	66.2	Acute	276
Sonoco Products (3)	0.87	4.5	179	103	Acute	--

1) Waste load allocation WLA = (WQS * DF) - (CA * (DF - 1))
where: WQS = water quality standard,
DF = the dilution factor
CA = background ambient total ammonia concentration (0.07 mg N/L)

2) Most limiting criterion for long-term average (LTA; not shown) effluent concentration required to meet WLA.

3) Water quality-based WLA is much greater than actual effluent concentrations. Therefore, WLA does not apply and technology-based limit should be applied (existing limit should be applied for Beatrice).

4) WLA calculated for mixed concentration of combined flow of Puyallup WTP and Matsushita.

Table 4.16. Mixing zone WLAs (1) for chlorine.

	Total Residual Chlorine: Chronic Chlorine WLA (mg/L)	Total Residual Chlorine: Acute Chlorine WLA (mg/L)	Total Residual Chlorine: Most Limiting Criterion (3)
MUNICIPAL NPDES PERMITS			
Buckley WTP	0.24	0.06	Acute
Carbonado WTP	1.91	0.35	Acute
Enumclaw WTP	0.10	0.04	Acute
McAlder Elementary WTP (4)	63.4	11.0	Acute
Orting WTP			
Existing Permit	0.38	0.08	Acute
Approved Expansion	0.12	0.04	Acute
Puyallup WTP (5)	0.13	0.04	Acute
Rainier School WTP	1.25	0.23	Acute
South Prairie WTP	1.36	0.25	Acute
Sumner WTP	0.24	0.06	Acute
Wilkeson WTP	0.24	0.06	Acute
INDUSTRIAL NPDES PERMITS			
Fleischmann's Yeast	0.72	0.14	Acute
Matsushita (5)	0.13	0.04	Acute
Beatrice Cheese (4)	1.54	0.28	Acute
Sonoco Products (4)	2.46	0.44	Acute

1) Waste load allocation WLA = (WQS * DF) - (CA * (DF - 1))
where: WQS = water quality standard
= 0.019 and 0.011 mg/L for chlorine acute and chronic
DF = dilution factor,
CA = background ambient concentration (assumed 0).

3) Most limiting criterion for back-calclated long-term average (LTA) effluent concentration required to meet WLA.

4) Water quality-based WLA is much greater than actual effluent concentrations. Therefore WLA does not apply.

5) WLA calculated for mixed concentration of combined flow of Puyallup WTP and Matsushita.

- Puyallup RM 1.0 is a transition zone between Class A and Class B water quality standard designation. Depletion of dissolved oxygen to the Class A standard is limited to the immediate vicinity of this transition area.

- Model design conditions already conservatively reflect input uncertainty (e.g. the cumulative probability of all critical design assumptions occurring at the same time is relatively low).

- Most of the model uncertainty for dissolved oxygen is explained by actual variability in the river and the model probably provides an accurate estimate of the average dissolved oxygen for the design condition (e.g. model variability is largely caused by diurnal variations in temperature and dissolved oxygen saturation). Differences between diurnal minimum and average dissolved oxygen concentrations are generally less than the difference between freshwater and marine criteria.

- The Class A criterion is well above EPA Gold Book (EPA, 1986) criteria for cold water species protection from water column exposure. Dissolved oxygen criteria above 8 mg/L are protective of sufficient inter-gravel conditions for early life stages of salmonids. EPA criteria for early life stages are intended to apply only where and when these stages occur.

The anti-degradation policy of the state of Washington is described in Chapter 173-201A-070. Briefly, applicable sections of the policy are as follows:

- existing beneficial uses shall be maintained;

- whenever waters are of higher quality than assigned criteria, existing water quality shall be protected, except where:

    - after satisfactory public and intergovernmental participation, overriding consideration of the public interest will be served;

    - NPDES permits shall require all known, available, and reasonable methods of prevention, control, and treatment;

    - all known, available, and reasonable best management practices shall be used to control nonpoint sources of pollution; and

    - when lowering of water quality in high quality waters is authorized, the lower quality shall still support all existing beneficial uses.

The surplus loading capacity (WLA for growth or reserve) should be allocated for new or expanded point sources only after consideration of the anti-degradation policy.

Any combination of additional CBOD and NBOD loading that meets the freshwater dissolved oxygen standard at Puyallup RM 1.0 would be acceptable provided that mixing zone WLAs are not exceeded. The estimated WLAs for future growth are presented in Table 4.17 using a method outlined by EPA (1983b). The maximum amount of additional ammonia loading, assuming existing discharges are at mixing zone WLAs and no additional CBOD is introduced, is 880 lbs/day as N. Similarly, the maximum amount of additional CBOD loading, assuming no additional NBOD loading, is 12,000 lbs/day as BOD_5. If future loading sources discharge to the river at the same ratio of BOD_5/ammonia as mixing zone WLAs, then an additional 730 lbs/day of ammonia as N and 2,100 lbs/day of BOD_5 could be assimilated. However, other combinations would be acceptable as described in Table 4.17.

Worst-case predictions of cumulative impacts of mixing zone WLAs for total residual chlorine are presented in Figure 4.14. The QUAL2E analysis assumed that chlorine would be conservative in the river (*i.e.* no chemical reactions). Therefore, the predictions are considered to be a conservative estimate of the actual cumulative effects. The river concentrations of chlorine are expected to remain below water quality criteria in all river segments if mixing zone WLAs are implemented.

The total residual chlorine WLAs (Table 4.16) generally maintain river concentrations below 50 percent of the water quality criteria for chronic toxicity in all modeled segments. Therefore, the existing discharges only use less than 50 percent of the loading capacity if mixing zone WLAs are implemented. The remainder of the loading capacity could be reserved for future growth or water quality protection.

4.5 Recommended Waste Load Allocations

The preceding analysis indicates that mixing zone WLAs alone are sufficient for dissolved oxygen and ammonia criteria protection. Table 4.18 summarizes the recommended total maximum daily loads (TMDLs) and waste load allocations (WLAs) for BOD_5, ammonia, and total residual chlorine. The design condition for the TMDL is the 7-day-10-year low river flow. The proposed TMDL for CBOD, expressed as BOD_5 is 19,500 lbs/day. The proposed TMDL for ammonia is 3,330 lbs/day as N and for total residual chlorine is 45.9 lbs/day.

Carbonaceous BOD is assumed to be estimated by BOD_5. If BOD5 tests for a given discharger are influenced by nitrogenous BOD in the BOD_5 test, then laboratory protocols that measure the carbonaceous BOD_5 may be specified (e.g., through direct measurement and subtraction of nitrification in the BOD incubation or use of nitrification inhibitors). From a regulatory standpoint, the use of the standard BOD_5 test would provide a conservative estimate of carbonaceous BOD. The substitution of 5-day carbonaceous BOD ($CBOD_5$) for BOD_5 may be made at the option of the NPDES permit manager (40 CFR Part 133; Metcalf and Eddy, 1991). However, national standards for secondary treatment effluent $CBOD_5$ are more stringent than for BOD_5 (effluent $CBOD_5$ not to exceed monthly average of 25 mg/L and weekly average of 40 mg/L).

Table 4.17. Estimation of WLAs for future growth in total ammonia N and BOD5 loading assuming exisiting discharges have mixing zone WLAs in place for ammonia.

1. Estimate allocatable excess dissolved oxygen at Puyallup RM 1.0 from comparison of model simulation for existing discharges (with mixing zone WLAs for ammonia) and water quality standard.

DO at Puyallup RM 1.0 with existing discharges at mixing zone WLAs (Alternative 5):	8.30 mg/L
Water Quality Standard for Dissolved Oxygen:	8.00 mg/L
Allocatable excess DO:	0.30 mg/L

2. Allocate excess DO to alternative combinations of future BOD5 and ammonia N loads assuming sensitivity of Puyallup RM 1.0 dissolved oxygen from QUAL2E model:

DO response to increased ammonia N load:	0.34 mg/L per 1000 lbs NH3-N/day
DO response to increased BOD5 load:	0.025 mg/L per 1000 lbs BOD5/day

Any combination of additional ammonia N and BOD5 loads is acceptable if the following condition is met:

[0.34 * (added NH3-N load in 1000 lbs N/day)] + [0.025 * (added BOD5 load in 1000 lbs/day)] <= 0.30

Alternative acceptable combinations of future growth WLAs for ammonia N and BOD5:

Future Growth Ammonia N WLA (lbs N/day)	Future Growth BOD5 WLA (lbs BOD5/day)	
0	12,000	
200	9,300	
400	6,600	
730	2,100	<-- Same ratio of BOD5/NH3N as existing discharges mixing zone WLAs
880	0	

Table 4.18. Summary of recommended TMDLs and WLAs for water quality-based permit limit development.

	5-Day BOD		Total Ammonia N		Total Residual Chlorine	
	(lbs/day)	(mg/L)	(lbsN/day)	(mgN/L)	(lbs/day)	(mg/L)
MUNICIPAL NPDES PERMITS						
Buckley WTP	375	45	21	2.5	0.49	0.059
Carbonado WTP (1)	38	45	21	25	0.29	0.35
Enumclaw WTP	504	45	30	1.5	0.70	0.035
McAlder Elementary WTP (1)	3.6	45	2.0	25	0.86	11.0
Orting WTP						
Existing Permit	135	45	156	25	0.51	0.082
Approved Expansion	939	45	282	13.5	0.79	0.038
Puyallup WTP (2)	2,085	45	1,271	14.2	3.6	0.040
Rainier School WTP	158	45	33	9.5	0.81	0.23
South Prairie WTP (1)	9.5	30	8.0	25	0.080	0.25
Sumner WTP	1,284	45	389	13.6	1.7	0.058
Wilkeson WTP	26	45	6.6	11.2	0.034	0.058
INDUSTRIAL NPDES PERMITS						
Fleischmann's Yeast (1)	45	--	3.7	0.41	1.3	0.14
Matsushita (2)	175	30	83	14.2	0.23	0.040
Beatrice Cheese	35	--	134	32	1.2	0.28
Sonoco Products (1)	673	--	1.1	0.42	1.2	0.44
TOTAL FISH HATCHERY WLA (3)	994	--	76	--	0.0	--
BACKGROUND/NONPOINT LA (3)	10,100	--	241	--	0.0	--
WLA FOR FUTURE GROWTH (4)	2,100	--	730	--	32.6	--
TOTAL MAXIMUM DAILY LOAD (5)	19,500	--	3,330	--	45.9	--

1) Waste load allocations based on water quality considerations are less limiting than technology-based limits. Technology-based limits should be developed following effluent characterization.
2) WLAs may apportioned in any combination between Puyallup WTP and Matsushita provided the sum of loads from the two facilities does not exceed the sum of both WLA loads.
3) From Table 4.12.
4) See Table 4.17 for other acceptable combinations of future growth BOD5 and ammonia N loading.
5) TMDL estimated as the sum of all WLAs (municipal, industrial, future growth) plus background/nonpoint LA. Orting WTP was assumed to discharge at future expansion load for TMDL estimation. Chlorine TMDL estimated as 7Q10 at USGS station 12101500 multiplied by chronic criterion of 11 ug/L.

Ammonia WLAs proposed for municipal discharges range between 1.5 and 25 mg/L as N at WTP design flows. Three minor municipal WTP discharges -- Carbonado, McAlder Elementary School, and South Prairie -- are not expected to require more advanced treatment processes than are currently designed. Ammonia limits for these three facilities should be based on the performance of the existing treatment processes (*i.e.* technology-based).

Ammonia limits for the other seven municipal WTPs are likely to require some degree of nitrification in the treatment process. The most restrictive ammonia limits are proposed for Enumclaw, Buckley, and Rainier School WTPs (ammonia limits of 1.5, 2.5, and 9.5 mg/L as N at WTP design flows). Ammonia WLAs proposed for the Orting, Puyallup, Sumner, and Wilkeson WTPs are between 10 and 25 mg/L, which may require operational changes or improvements to provide for nitrification at design flows. All of the ammonia WLAs recommended are within the range of technological feasibility for biological treatment processes (Metcalf and Eddy, 1991).

Existing ammonia limits for the Sumner and Beatrice discharges meet the proposed WLAs. The Matsushita discharge uses the same outfall as the Puyallup WTP. Therefore, the Matsushita and Puyallup WTP ammonia WLAs may be apportioned in any combination provided that the sum of both permit loads does not exceed the total for both in Table 4.18 (*i.e.* the total ammonia load from both facilities should not exceed 1,354 lbs/day as N). The Fleischmann's and Sonoco ammonia loads are relatively minor. Therefore, ammonia limits based on existing loading (*i.e.* technology-based) are recommended for these two facilities.

Allocations for fish hatcheries and background/nonpoint sources were set at conservatively high estimates for existing conditions. If nonpoint sources are significantly reduced through future controls, then additional loading capacity may become available. A reasonable approach to including hatcheries and background/nonpoint sources in the present WLA would be to allocate nonpoint loading at the current loading levels, since they are dominated by headwater background loads. However, if loading from these categories increases (e.g., through addition or expansion of hatcheries), then the increased load should be subtracted from the WLA for future growth presented in Table 4.18.

NPDES limits on effluent concentration are not needed to protect ammonia criteria in the entire river from cumulative effects of all dischargers provided permits contain limits on loading. Concentration limits may be needed to satisfy mixing zone requirements. Since the major objective of the TMDL is to prevent cumulative water quality violations in the entire river, an acceptable approach to implementing the TMDLs in this report in NPDES permits would be to include the WLA loads in Table 4.18 in permits. Concentration limits could be evaluated on a case-by-case basis to consider site-specific conditions (e.g., diffuser performance and seasonal effluent flows). NPDES permit limits on concentration could be more or less restrictive than WLA concentrations provided that WLA loads in Table 4.18 are not exceeded.

Proposed WLAs for ammonia will prevent violations of un-ionized ammonia criteria in the White River, but the high pH from algal productivity will probably continue. Water quality criteria for nutrient concentrations in rivers are currently not developed. Control of both N and P is probably not needed if either could be reduced to concentrations that limit productivity. Available data suggest that reduction of DIN concentrations would be more effective than reduced SRP. A restrictive target of 0.10 mg/L of DIN would probably not achieve compliance with pH criteria since the DIN in the White River averaged 0.10 mg/L during September-October 1990 and pH criteria were still exceeded. Enumclaw and Buckley WTPs combined would be limited to less than 20 lbs/day of DIN or 8 lbs/day of SRP and Rainier School WTP would be limited to less than 3 lbs/day of DIN or 1 lb/day of SRP if White River nutrients are to be maintained below concentrations that limit algal growth (approximately 0.10 mg/L DIN or 0.025 mg/L SRP).

The recommended strategy for managing Enumclaw, Buckley, and Rainier School permits is to proceed with limits on effluent ammonia to achieve proposed WLAs. A feasibility analysis of reducing nutrient loads should also be performed. A phased approach of implementing feasible nutrient reductions and measuring response of river pH may be appropriate to achieve Class A standards for pH. A phased TMDL for nutrients in the White River (RM 4 to 24) should probably include the following elements: detailed analysis of pH response to nutrient loading and concentration; feasibility analysis of reducing nutrient loading from Rainier School, Enumclaw, and Buckley WTPs, and nonpoint sources; preliminary nutrient TMDLs (N or P); implementation of cost-effective loading reductions if appropriate; measurement of response of White River pH to reduced nutrient loads; and reassessment of loading capacity for nutrients in the White River. Available data shows that the target for ambient nutrient concentration should limit algal productivity (less than 0.10 mg/L DIN or 0.025 mg/L SRP) to meet pH criteria.

The recommended strategy for determining WLAs for parameters other than those considered in this study (e.g., metals), which could potentially exceed aquatic life criteria, is to first estimate the WLAs based on the maximum allowable dilution flows in the mixing zone (Table 4.14). If no background concentration data are available, development of WLAs should be preceded by background characterization, unless the background can be assumed to be insignificant. After mixing zone WLAs are estimated, the cumulative effect of multiple discharges could be evaluated using a conservative mass balance model. If the cumulative impact based on a conservative model maintains the water quality criteria throughout the river, then the mixing zone WLAs would be adequate for water quality-based permitting.

5.0 MONITORING

A summary of current permittee monitoring requirements for selected parameters in existing NPDES permits is presented in Table 5.1. Effluent quality will need to be characterized for the following minimum parameters in order to evaluate compliance or reasonable potential to exceed the recommended WLAs:

Flow
5-day BOD
Total Ammonia N
Total residual chlorine

Existing NPDES permits typically require testing for BOD_5 and total residual chlorine, but not for ammonia. Selection of parameters to test at specific facilities depends on several factors, including: mixing zone WLAs; type of municipal WTP; type of industry; and history of compliance problems.

The method of total residual chlorine determination is a consideration since the recommended WLAs for chlorine are less than the detection limit of the tests typically used. For effluent chlorine WLAs less than 0.2 mg/L, method 4500 Cl E from the 18th edition of Standard Methods (APHA *et al.*, 1992) should be used. This test has a detection limit of 0.01 mg/L.

Table 5.2 presents suggestions for the minimum amount of additional monitoring that should be required by permittees for reissuance of NPDES permits or establishment of new permits. The testing schedule in Table 5.2 is suggested as a framework for a minimum level of effort in consideration of monitoring that is already required by some permittees and similarity of discharges and receiving waters. Modifications of the schedule may be appropriate, especially if Ecology policies change before testing is required.

Water quality conditions in surface waters of the basin are presently monitored monthly by Ecology (Puyallup RM 8.3 and 22; White RM 0.7) and quarterly by USGS (Puyallup RM 5.7). No significant tributaries, with the exception of the Puyallup WTP, enter the Puyallup River between the USGS station (Puyallup RM 5.7) and the Ecology station at Puyallup RM 8.3. Therefore, if the resources used for sampling one of these stations were used at a different location in the basin, more information could be gained for the same cost. Possible locations for additional ambient monitoring stations would include monitoring within the White River upstream from the Lake Tapps outflow at Dieringer, and in the headwaters of the White and Carbon Rivers. A detailed study of pH response to nutrients in the White River (RM 4 to 24) is warranted if the possibility of reducing ambient pH through reductions in nutrient loading is pursued. Other possibilities for expanded ambient monitoring could include metals sampling to address the issue of possible water quality limitation. At a minimum, the existing Ecology ambient monitoring network should be maintained.

Table 5.1 Summary of NPDES permittee effluent monitoring requirements for selected parameters.

Permittee	Flow Monitoring Loc-Frq-Typ	BOD5 Sampling Loc-Frq-Typ	Chlorine Sampling Loc-Frq-Typ	Ammonia Sampling Loc-Frq-Typ	Temperature Sampling Loc-Frq-Typ	DO Sampling Loc-Frq-Typ	Industrial Discharge Type	Permit Expiration Date
MUNICIPAL								
Puyallup, City of (WTP)	E-D-C	E-3/W-24C	E-D-G	NM	I-PC-G	E-PC-G	-	7/94
Sumner, City of (WTP)	I-D-C	E-3/W-24C	E-D-G	E-2/W-G	E-D-G	NM	-	9/97
Buckley, City of (WTP)	E-D-C	E-W-24C	E-D-G	NM	I-D-G	E-PC-G	-	8/85
Enumclaw, Town of (WTP) *	E-D-C	E-2/W-24C	E-D-G	E-3/W-G	I-D-G	E-D-G	-	7/95
Rainier State School (WTP)	E-D-C	E-W-24C	E-D-G	NM	I-D-G	E-5/W-G	-	2/85
McAlder Elementary (WTP)	E-D-C	E-W-8C	E-5/W-G	NM	NM	NM	-	8/95
Orting, Town of (WTP)	IorE-D-C	E-2/W-24C	E-D-G	E-2/W-G	E-D-G	E-2/W-G	-	1/94
South Prairie, Town of (WTP)	E-D-C	E-M-16C	NM	E-2/M-G	E-M-G	NM	-	2/97
Wilkeson, Town of (WTP)	E-D-C	E-M-10C	E-5/W-G	NM	P-W-G	P-2/W-G	-	4/85
Carbonado, Town of (WTP)	E-D-C	E-M-10C	E-5/W-G	NM	P-W-G	P-2/W-G	-	2/85
INDUSTRIAL								
Matsushita Semiconductor	E-D-C	E-W-24C	NM	E-W-24C	E-W-G	NM	Process Wastewater	6/96
Fleischmann's Yeast Co.	E-Q-EST	NM	E-M-G	NM	E-Q-G	NM	Non-Contact Cooling	5/82
Sonoco	E-C-C	E-3/W-24C	NM	NM	E-C-C	NM	Treated Process	10/95
Beatrice Cheese Co.	E-D-D	E-3/W-24C	NM	E-W-G	E-D-G	NM	Treated Process	4/94
FISH HATCHERY								
Troutco, Inc.	E-W-?	NM	NM	NM	NM	NM	100,000 # Rainbow	1/83
Puyallup Tribe Hatchery	NM	NM	NM	NM	NM	NM	-	NA
Puyallup Trout Hatchery (WDW)	E-W-D	NM	NM	NM	NM	NM	59,600 # RB/SH/Kok	1/86
Muckleshoot Tribe Hatchery	NM	NM	NM	NM	NM	NM	-	NA
Trout Springs, Inc.	E-W-?	NM	NM	NM	NM	NM	175,000 # Rainbow	1/83
Puyallup Fish Hatchery (WDF)	E-W-D	NM	NM	NM	NM	NM	80,000 # Coho/Chinook	5/86

* Enumclaw WTP also is required to monitor effluent CBOD5 and CBOD ultimate in monthly composite samples.

Loc-Frq-Typ = Code for sample location (Loc), frequency of sampling (Frq), and sample type (Typ); (NM = measurement not required).

Location (Loc) Codes: IorE = influent or effluent; I = influent (effluent not sampled); E = final effluent; SE = secondary effluent (final effluent not sampled); P = process stream (effluent not sampled)

Frequency (Frq) Codes: D = daily; W = weekly; 2/W = 2/week; 3/W = 3/week; 5/W = 5/week; PC = Process Control; M = monthly; 2/M = 2/month; Q = quarterly; I = intermittant; C = continuous; 6/D = 6/day

Sample Type (Typ) Codes: C = continuous; G = grab; ; 24C = 24 hr composite; 6C = 6 hr composite; 10C = 10 hr composite; D = daily average (flow); EST = estimate.

Table 5.2. Suggested minimum permittee monitoring in addition to existing NPDES requirements.

Permittee	Flow Monitoring Loc-Frq-Typ	BOD5 Sampling Loc-Frq-Typ	Chlorine Sampling Loc-Frq-Typ	Ammonia Sampling Loc-Frq-Typ	Temperature Sampling Loc-Frq-Typ	DO Sampling Loc-Frq-Typ
MUNICIPAL						
Puyallup, City of (WTP)	E-D-C	E-3/W-24C	E-D-G	E-2/W-G	I-PC-G	E-PC-G
Sumner, City of (WTP)	I-D-C	E-3/W-24C	E-D-G	E-2/W-G	E-D-G	NM
Buckley, City of (WTP)	E-D-C	E-W-24C	E-D-G	E-2/W-G	I-D-G	E-PC-G
Enumclaw, Town of (WTP)	E-D-C	E-2/W-24C	E-D-G	E-3/W-G	I-D-G	E-D-G
Rainier State School (WTP)	E-D-C	E-W-24C	E-D-G	E-2/W-G	I-D-G	E-5/W-G
McAlder Elementary (WTP)	E-D-C	E-W-8C	E-5/W-G	NM	NM	NM
Orting, Town of (WTP)	IorE-D-C	E-2/W-24C	E-D-G	E-2/W-G	E-D-G	E-2/W-G
South Prairie, Town of (WTP)	E-D-C	E-M-16C	E-5/W-G	E-2/M-G	E-M-G	NM
Wilkeson, Town of (WTP)	E-D-C	E-M-10C	E-5/W-G	E-2/M-G	P-W-G	P-2/W-G
Carbonado, Town of (WTP)	E-D-C	E-M-10C	E-5/W-G	E-2/M-G	P-W-G	P-2/W-G
INDUSTRIAL						
Matsushita Semiconductor	E-D-C	E-W-24C	NM	E-W-24C	E-W-G	NM
Fleischmann's Yeast Co.	E-Q-EST	NM	E-M-G	NM	E-Q-G	NM
Sonoco	E-C-C	E-3/W-24C	NM	E-W-G	E-C-C	NM
Beatrice Cheese Co.	E-D-D	E-3/W-24C	NM	E-W-G	E-D-G	NM

Loc-Frq-Typ = Code for sample location (Loc), frequency of sampling (Frq), and sample type (Typ);
(NM = measurement not required).

Location (Loc) Codes:
IorE = influent or effluent; I = influent (effluent not sampled); E = final effluent;
SE = secondary effluent (final effluent not sampled); P = process stream (effluent not sampled)

Frequency (Frq) Codes:
D = daily; W = weekly; 2/W = 2/week; 3/W = 3/week; 5/W = 5/week; PC = Process Control;
M = monthly; 2/M = 2/month; Q = quarterly; I = intermittant; C = continuous; 6/D = 6/day

Sample Type (Typ) Codes:
C = continuous; G = grab; ; 24C = 24 hr composite; 6C = 6 hr composite; 10C = 10 hr composite;
D = daily average (flow); EST = estimate.

6.0 CONCLUSIONS AND RECOMMENDATIONS

- Dissolved oxygen in the lower Puyallup River is expected to violate freshwater quality standards if existing NPDES facilities reach their design capacity. Less restrictive marine dissolved oxygen criteria would be met in the lower Puyallup when existing dischargers reach design capacities. However, marine criteria would be violated if design NPDES loads are increased substantially (e.g., by 50 percent). Reductions in ammonia (NBOD) loading were found to have greater potential to improve dissolved oxygen than reductions of CBOD.

- Implementation of ammonia WLAs based on mixing zone regulations would suffice to protect dissolved oxygen standards.

- Ammonia criteria in the White River are likely to be exceeded under existing NPDES permits. Ammonia loads which are currently not regulated by NPDES permits are potentially in excess of proposed mixing zone WLAs for most municipal discharges.

- Implementation of mixing zone ammonia and chlorine WLAs for existing discharges is expected to protect the aquatic life criteria for these parameters in all segments of the Puyallup River basin. Conservative far-field modeling of toxic parameters shows that WLAs based on mixing zones would not result in cumulative excess of water quality criteria by the existing dischargers.

- A TMDL is recommended for the entire basin to prevent violation of water quality criteria for dissolved oxygen, unionized ammonia, and total residual chlorine. The TMDL represents the sum of all permitted NPDES loads (WLAs) plus conservative assumptions for nonpoint and natural background loading (LAs), as well as a reserve for future growth or water quality protection. The design condition for the TMDL is the 7-day-10-year low river flow. The proposed TMDLs are as follows: 19,500 lbs/day for BOD_5; 3,330 lbs/day for total ammonia as N; and 45.9 lbs/day for total residual chlorine.

- WLAs and LAs were proposed to meet the TMDLs and protect water quality standards. WLAs for BOD_5 were based on existing WTP design loads. WLAs for ammonia and chlorine were based on mixing zone regulations for maximum volumes of river flow available or reasonable potential for maximum loading from existing effluents, depending on whichever was more restrictive. LAs for nonpoint and background sources were based on reasonable potential for maximum loading at design conditions.

  Proposed WLAs and LAs for municipal and industrial dischargers, fish hatcheries, background/nonpoint sources, and future growth/reserve are as follows for BOD_5, total ammonia as N, and total residual chlorine in lbs/day:

TMDLs, WLAs and LAs in lbs/day			
	BOD_5	Ammonia-N	Chlorine
MUNICIPAL WLAs			
Buckley	375	21	0.49
Carbonado	38	21	0.29
Enumclaw	504	30	0.70
McAlder School	3.6	2.0	0.86
Orting	939	282	0.79
Puyallup	2085	1271	3.6
Rainier School	158	33	0.81
South Prairie	9.5	8.0	0.080
Sumner	1284	389	1.7
Wilkeson	26	6.6	0.034
INDUSTRIAL WLAs			
Beatrice	35	134	1.2
Fleischmann's	45	3.7	1.3
Matsushita	175	83	0.23
Sonoco	673	1.1	1.2
HATCHERY, NONPOINT, BACKGROUND, AND RESERVE WLA/LA			
Fish Hatchery WLA	994	76	0.0
Nonpoint/Background LA	10,100	241	0.0
WLA for Growth/Reserve	2,100	730	32.6
TMDLs	19,500	3,330	45.9

- If the proposed WLAs are implemented in NPDES permits, then a surplus of loading capacity will be available for either future growth or water quality protection. The surplus WLA would be 2,100 lbs/day of BOD_5, 730 lbs/day of ammonia as N, and 32.6 lbs/day of total residual chlorine for new sources, expansion of existing sources, or set-aside for water quality protection.

- The WLAs proposed in this report can be adjusted for each discharger provided that the TMDLs are not exceeded and regulations in WAC 173-201A are followed.

- The recommended strategy for managing Enumclaw, Buckley, and Rainier School permits for nutrient loading is to proceed with limits on effluent ammonia to achieve proposed ammonia WLAs. A feasibility analysis of reducing N or P loads should also be performed. A phased approach of implementing feasible nutrient reductions and measuring response of river pH may be appropriate to achieve class A standards for pH. However, target nutrient concentrations should be less than the amount which can limit productivity (less than 0.10 mg/L DIN or 0.025 mg/L SRP) to meet pH criteria.

- The recommended strategy for determining WLAs for other toxic parameters (e.g., metals) which could potentially exceed aquatic life criteria is to first estimate the WLAs based on maximum allowable dilution factors in the mixing zone. If background concentration is appreciable or unknown, development of WLAs should be preceded by background characterization. After mixing zone WLAs are estimated, the cumulative effect of multiple discharges could be evaluated using a conservative mass balance model. If the cumulative impact based on a conservative model maintains the water quality criteria throughout the river, then the mixing zone WLAs would be adequate for water quality-based permitting.

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Appendix A. Database for intensive survey results

Sample Number	Station Name (See Table 2.3)	Date	Time	FLow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite-N mgN/L	Ammonia-N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
388400	PUY18.0	18-Sep-90	1800	999999	15.4	7.2	10.2	0.010	0.004	0.057	0.012	0.107	17.5	26	999999	34	66	1.07	57
388401	PUY12.2	18-Sep-90	1850	999999	15.8	7.4	10.3	0.102	0.012	0.161	0.014	0.079	26.4	31	17	23.5	74	1.31	36
388402	PUY08.3	18-Sep-90	1940	999999	15.6	8.1	10.5	0.096	0.021	0.207	0.038	0.094	27.8	690	70	19	83	2.1	30
388403	PUY05.7	18-Sep-90	2010	999999	15.2	7.8	10.6	0.116	0.245	0.471	999999	0.137	31.4	999999	999999	20	88	2.34	28
388404	PUY01.5	18-Sep-90	1200	999999	13.3	7.6	10.3	0.164	0.094	0.347	0.041	0.125	999999	900	15	20.5	309	6.54	52
388405	PUY00.8	18-Sep-90	1120	999999	13.3	7.5	10.0	0.207	0.065	0.356	999999	0.119	999999	1900	999999	20	822	202	59
388406	CAR17.7	18-Sep-90	1545	999999	15.3	7.1	9.8	0.022	0.001	0.040	0.017	0.098	12	3 U	999999	32	28	0.66	66
388407	CAR06.1	18-Sep-90	1715	999999	13.5	7.3	10.7	0.030	0.002	0.063	999999	0.104	999999	999999	999999	999999	50	0.91	999999
388408	CAR02.0	18-Sep-90	1735	999999	15.9	7.5	10.2	0.081	0.017	0.142	0.012	0.062	29.7	20	999999	20.5	68	1.21	34
388409	WIL04.2	18-Sep-90	1615	999999	15.3	7.9	10.2	0.083	0.003	0.152	0.002	0.009	74.2	92	999999	1 U	169	1.57	1
388410	SPR07.2	18-Sep-90	1630	999999	14.8	7.5	10.2	0.172	0.002	0.293	0.001	0.008	39.1	23	999999	1 U	96	2.13	1
388411	SPR05.8	18-Sep-90	1645	999999	15.1	7.7	10.4	0.180	0.002	0.296	999999	0.012	999999	999999	999999	999999	109	2.09	999999
388412	SPR01.1	18-Sep-90	1700	999999	15.9	7.6	10.4	0.318	0.001	0.407	0.004	0.012	50.3	53 S	999999	1 U	118	2.34	1 UJ
388413	WHI25.2	18-Sep-90	1330	999999	13.1	7.8	10.6	0.041	0.018	0.065	0.012	0.108	21	6	BDL	35	67	1.56	82
388415	WHI23.1	18-Sep-90	1420	999999	14	7.9	10.5	0.040	0.011	0.073	0.013	0.103	22	14	50	32	69	1.62	68
388416	WHI20.4	18-Sep-90	1500	999999	14.6	7.9	10.4	0.074	0.014	0.113	999999	0.111	999999	11	999999	32.5	74	2.29	61
388418	WHI10.3	18-Sep-90	1610	999999	16.7	8.7	10.4	0.025	0.012	0.075	0.027	0.078	25.4	999999	BDL	19	83	2.61	29
388419	WHI08.0	18-Sep-90	1650	999999	17.2	9.1	10.5	0.018	0.017	0.092	999999	0.074	999999	3 U	999999	20	83	2.57	24
388420	WHI06.3	18-Sep-90	1720	999999	17.4	9.2	10.5	0.016	0.015	0.072	999999	0.076	999999	11	999999	18	83	2.51	44
388421	WHI04.9	18-Sep-90	1740	999999	17.5	9.2	10.5	0.008	0.013	0.061	0.028	0.073	25.8	6	BDL	17	83	2.51	23
388422	LTD03.6	18-Sep-90	1810	999999	12.7	7	9.6	0.027	0.012	0.091	0.002	0.021	20	6	50	8.2	56	1.02	6
388423	WHI01.4	18-Sep-90	1840	999999	17.3	9.1	10.5	0.014	0.019	0.074	999999	0.061	999999	49	999999	14.5	83	2.27	15
388424	WHI00.7	18-Sep-90	1900	999999	17	9	10.5	0.021	0.023	0.093	0.038	0.080	27.9	270	89	14	86	2.57	17
388425	CLEAR	18-Sep-90	1000	14.2	11	7.2	8.9	1.813	0.083	2.118	0.043	0.084	71.1	110 S	999999	2.8	192	6.1	10
388426	SWAN	18-Sep-90	925	2.2	12.2	7.3	10.0	1.339	0.009	1.420	0.048	0.077	58.3	100	999999	4.5 J	167	5.62	22
388427	CLARKS	18-Sep-90	1100	42.8	10.5	7.1	7.9	1.510	0.018	1.598	0.033	0.066	74.9	140	999999	1.2	185	5.05	3
388428	FENNEL	19-Sep-90	1700	7	12.8	7.93	10.2	1.081	0.001	1.119	0.040	0.052	999999	43	999999	1 U	158	3.32	1
388429	CANYONFA	18-Sep-90	1620	9.2	13.8	7.6	10.3	2.167	0.102	2.428	0.127	0.153	999999	84	999999	1 U	189	3.68	2
388430	VOIGHT	19-Sep-90	930	16.4	13.2	7.5	9.3	0.105	0.105	0.388	0.039	0.070	999999	77	999999	2 J	91	2.06	10 J
388432	STRAWBER	18-Sep-90	1245	6.6	11.3	7.4	9.3	0.530	0.012	0.615	0.033	0.053	73	120	999999	1	165	3.15	4
388433	BOWMAN	18-Sep-90	1420	0.55	14.9	7.9	9.6	0.052	0.012	0.191	0.011	0.022	26.9	46	999999	1.8 J	70	1.13	4
388434	BOI00.1	18-Sep-90	1710	6.4	15.2	7.6	9.5	0.281	0.029	0.664	0.023	0.047	53.3	830	999999	2	114	1.9	3
388435	PTR13.0	18-Sep-90	1549	3.6	14.5	7.2	10.1	1.866	0.017	2.072	0.023	0.051	999999	20 S	999999	1.3	189	4.74	1
388436	WTR15.0	18-Sep-90	1510	0.33	10.3	6.5	8.8	7.508	0.005	7.595	0.043	0.058	46.1	3	999999	1 U	208	9.74	1 U
388437	WTR01.3	18-Sep-90	1155	1.4	13.2	6.8	3.5	0.267	0.029	0.652	0.030	0.057	117	11	999999	1.7	256	6.54	1
388438	PUYALLUP	18-Sep-90	COMP	5.8	999999	999999	999999	2.870	25.610	33.110	5.465	6.667	205	220	999999	8.5	630	40.7	11
388439	SUMNER	18-Sep-90	COMP	1.9	999999	999999	999999	17.390	1.698	22.700	7.030	7.314	96.8	3 U	999999	4.7	680	73.4	12
388440	BUCKLEY	18-Sep-90	COMP	0.35	999999	999999	999999	0.183	0.624	1.663	6.591	6.633	110	3	999999	1.4	736	32.9	2
388441	ENUMCLAW	18-Sep-90	COMP	1.1	999999	999999	999999	14.820	0.608	16.780	5.696	6.440	114	700 H	999999	4.9	894	149	7
388442	RAINSCH	18-Sep-90	COMP	0.17	999999	999999	999999	3.751	4.923	9.570	0.111	3.064	72	2900 H	999999	6.7 J	274	15.4	5
388443	MCCALDER	18-Sep-90	1215	0.012	17.1	7.5	8.1	5.021	5.461	14.420	2.895	3.685	107	2600	999999	5.5	352	21.2	14
388444	ORTING	18-Sep-90	COMP	0.51	999999	999999	999999	0.314	15.790	20.020	3.201	4.689	185	280000 P	999999	27	490	24.2	26
388445	WILKESON	18-Sep-90	COMP	0.035	999999	999999	999999	20.310	0.196	23.660	8.036	8.270	104	49 H	999999	18	578	41.7	48
388446	CARBONADO	18-Sep-90	820	0.025	17.8	7.1	2.2	2.193	0.584	7.248	7.658	8.342	88.4	6 H	999999	11	412	40.4	23
388448	NASEMI	18-Sep-90	COMP	0.86	999999	999999	999999	5.725	6.298	12.140	2.150	2.266	14	1 U	999999	1.3	1011	34.6	4
388449	FLEISCHMA	18-Sep-90	1435	1.3	25	8.1	6.2	0.028	0.139	0.242	0.207	0.230	134	240 J	999999	1 U	274	6.3	1
388450	SONOCO	18-Sep-90	COMP	0.21	999999	999999	999999	0.005	0.125	3.656	2.222	2.120	630	15000	47	32.5	1275	31.5	37
388451	MAZZA	18-Sep-90	COMP	0.26	999999	999999	999999	4.000	1.618	11.820	17.920	18.850	436	140000 PJ	999999	5.8	2088	377	41
388452	BOEING2	18-Sep-90	1245	0.50	17.1	7.4	8.1	1.793	0.017	1.633	0.302	0.062	65.2	34 J	999999	2.6	183	3.96	1 U
388453	GOVT CANAL	18-Sep-90	1320	0.48	14.6	6.6	6.1	0.447	0.015	0.602	0.024	0.032	61.9	240	999999	1 U	180	3.31	3
388454	BOI05.8	18-Sep-90	1625	1.8	12.9	7.3	9.8	0.278	0.004	0.331	0.011	0.012	22.8	29	89	1 U	54	1.66	1 U

Sample Number	Station Name (See Table 2.3)	Date	Time	Flow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite-N mgN/L	Ammonia-N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
388455	WEYCO EFF	18-Sep-90	1640	0.094	19	6.7	5.8	0.030	0.113	0.484	0.012	0.059	31.7	3	BDL	11.5	69	1.38	3
388456	TRTCOIN	18-Sep-90	1040	999999	10.7	7.9	11.2	2.604	0.005	2.474	999999	0.035	71.3	999999	999999	1 U	197	7.07	1 U
388457	TRTCOEFF	18-Sep-90	1100	7	11	7.8	8.7	2.483	0.246	2.889	0.062	0.090	71.7	999999	999999	1.1	201	7.3	2
388458	PUYTRBIN	18-Sep-90	1205	999999	11.8	8.1	10.7	0.005	0.020	0.044	999999	0.172	66.7	999999	999999	1 U	137	2.72	1
388459	PUYTRBEFF	18-Sep-90	1235	0.74	11.7	7.9	9.6	0.014	0.097	0.161	0.172	0.193	67.1	999999	999999	1 U	137	2.14	1
388460	DOWIN	18-Sep-90	1320	999999	13.5	7.2	9.0	1.881	0.002	1.853	999999	0.042	70.8	999999	999999	1 U	180	5.12	1
388461	DOWEFF	18-Sep-90	1355	14.5	12.7	7.1	8.8	1.840	0.149	2.181	0.090	0.109	71.9	999999	999999	1 U	180	5.14	3
388462	MUCTRBIN	19-Sep-90	1110	999999	10.9	6.8	5.1	0.242	0.002	0.260	999999	0.012	30.2	999999	999999	1 U	95	1.65	1 U
388463	MUCTRBEFF	19-Sep-90	1125	1.9	11.5	7.5	10.8	0.224	0.099	0.451	0.026	0.038	31.1	999999	999999	1 U	95	1.75	1
388464	TRTSPRIN	18-Sep-90	845	999999	9.5	7.7	9.7	1.885	0.001	1.885	999999	0.028	76.2	999999	999999	1 U	186	3.59	1
388465	TRTSPREFF	18-Sep-90	905	9.1	10.2	7.7	9.8	1.869	0.302	2.383	0.135	0.162	78.2	999999	999999	1 U	191	3.76	2
388466	DOFIN	19-Sep-90	840	999999	12.9	7.6	10.6	0.099	0.007	0.180	999999	0.020	40.4	999999	999999	1 U	88	2.07	1
388467	DOFEFF	19-Sep-90	910	9.3	13	7.5	9.5	0.104	0.110	0.402	0.044	0.080	41.3	999999	999999	1.2	90	2.03	5
388474	BLANK-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	0.004	999999	999999	999999	999999	999999	999999	999999	999999
388475	BLANK-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	0.882	999999	999999	999999	999999	999999	999999	999999	999999
388476	X-ORT	18-Sep-90		999999	999999	999999	999999	0.007	1.582	1.866	999999	0.579	999999	14	999999	999999	999999	999999	999999
388490	SRPQA-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	-0.002	999999	999999	999999	999999	999999	999999	999999	999999
388491	SRPQA-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	-0.002	999999	999999	999999	999999	999999	999999	999999	999999
388500	PUY18.0	19-Sep-90	1605	999999	15.3	7.2	10.6	0.018	0.040	0.207	999999	0.125	16.8	999999	999999	42	64	1.16	64
388501	PUY12.2	19-Sep-90	1630	999999	15.7	7.4	10.7	0.099	0.010	0.175	999999	0.128	25.4	999999	999999	999999	73	999999	63
388502	PUY08.3	19-Sep-90	1100	999999	13.3	7.6	10.6	0.105	0.039	0.174	999999	0.089	999999	999999	999999	999999	81	999999	34
388503	PUY05.7	19-Sep-90	1330	999999	14.3	7.5	10.7	0.137	0.135	0.363	0.061	0.134	28.3	84	BDL	999999	84	999999	35
388504	PUY01.5	19-Sep-90	1230	999999	14.7	7.6	10.4	0.160	0.106	0.356	999999	0.124	999999	999999	999999	999999	238	999999	54
388505	PUY00.8	19-Sep-90	1200	999999	14.1	7.5	10.2	0.186	0.076	0.357	999999	0.122	999999	999999	999999	999999	610	999999	54
388506	CAR17.7	19-Sep-90	1300	999999	12.3	7	10.5	0.024	0.008	0.073	999999	0.108	12.6	999999	999999	32.5	27	0.69	77
388507	CAR06.1	19-Sep-90	1510	999999	13.6	7.4	10.9	0.031	0.008	0.057	999999	0.096	999999	999999	999999	999999	48	999999	999999
388508	CAR02.0	19-Sep-90	1535	999999	16	7.6	10.4	0.083	0.032	0.149	999999	0.061	29.6	999999	999999	21	66	1.26	33
388509	WIL04.2	19-Sep-90	1330	999999	14.2	8	10.7	0.080	0.008	0.202	999999	0.009	77.3	999999	999999	999999	175	1.63	999999
388510	SPR07.2	19-Sep-90	1350	999999	14.2	7.6	10.7	0.174	0.010	0.243	999999	0.008	39.3	999999	999999	999999	96	2.21	999999
388511	SPR05.8	19-Sep-90	1410	999999	14.4	7.8	10.7	0.186	0.010	0.260	999999	0.012	999999	999999	999999	999999	111	999999	999999
388512	SPR01.1	19-Sep-90	1450	999999	15.7	7.8	11.0	0.326	0.006	0.430	999999	0.013	50.2	999999	999999	999999	122	999999	999999
388513	WHI25.2	19-Sep-90	1440	999999	12.7	7.8	10.6	0.033	0.007	0.060	999999	0.114	20.6	999999	999999	35	66	1.59	72
388515	WHI23.1	19-Sep-90	1510	999999	14.3	7.8	10.5	0.042	0.016	0.083	999999	0.109	23	999999	999999	999999	68	999999	68
388516	WHI20.4	19-Sep-90	1540	999999	14.2	7.9	10.5	0.074	0.013	0.104	999999	0.112	999999	999999	999999	999999	73	999999	59
388518	WHI10.3	19-Sep-90	1640	999999	16.4	8.6	10.5	0.021	0.016	0.068	999999	0.083	25.4	999999	999999	999999	84	999999	24
388519	WHI08.0	19-Sep-90	1700	999999	16.8	9.1	10.5	0.017	0.015	0.065	999999	0.079	999999	999999	999999	999999	83	999999	24
388520	WHI06.3	19-Sep-90	1730	999999	17	9.1	10.6	0.010	0.008	0.061	999999	0.076	999999	999999	999999	999999	83	999999	26
388521	WHI04.9	19-Sep-90	1750	999999	16.8	9.2	10.5	0.003	0.014	0.056	0.028	0.068	25.6	6	BDL	999999	84	999999	23
388522	LTD03.6	19-Sep-90	1135	999999	13.3	6.9	11.0	0.018	0.018	0.064	999999	0.018	20.7	999999	999999	999999	57	999999	1
388523	WHI01.4	19-Sep-90	1830	999999	16.9	9.1	10.7	0.011	0.023	0.111	999999	0.063	999999	999999	999999	999999	84	999999	10
388524	WHI00.7	19-Sep-90	1850	999999	16.8	9	10.6	0.016	0.029	0.055	999999	0.014	27.6	999999	999999	999999	86	999999	15
388526	SWAN	19-Sep-90	1605	1.52	14.3	7.9	9.8	1.283	0.033	1.530	999999	0.115	999999	999999	999999	999999	164	999999	8
388527	CLARKS	19-Sep-90	1500	47.1	11.5	7.7	9.1	1.513	0.020	0.609	999999	0.084	999999	999999	999999	999999	188	999999	10
388528	FENNEL	20-Sep-90	1645	7.3	12.4	7.8	10.4	1.105	0.007	1.135	999999	0.044	999999	999999	999999	999999	158	999999	4
388529	CANYONFA	19-Sep-90	1630	9.5	13.7	8	10.3	2.194	0.127	2.593	999999	0.162	999999	999999	999999	999999	191	999999	1 U
388530	VOIGHT	20-Sep-90	1550	14.4	15	7.5	8.6	0.091	0.136	0.463	999999	0.086	999999	999999	999999	999999	93	999999	12
388531	LILY	19-Sep-90	935	1.2	11.1	7.5	9.8	0.058	0.010	0.144	999999	0.033	999999	34	999999	1 U	74	1.72	1 U
388532	STRAWBER	19-Sep-90	1330	7.8	11.6	7.6	9.8	0.516	0.012	0.603	999999	0.061	999999	999999	999999	999999	165	999999	3
388534	BOI00.1	19-Sep-90	1025	6.4	12.4	8.36	10.4	0.247	0.010	0.338	999999	0.033	999999	999999	999999	999999	116	999999	1 U
388535	PTR13.0	19-Sep-90	1545	3.5	14.3	7.7	9.8	1.956	0.017	1.991	999999	0.054	999999	999999	999999	999999	191	999999	1 U
388537	WTR01.3	19-Sep-90	1415	3.3	13.9	7.2	3.3	0.263	0.022	0.622	999999	0.062	999999	999999	999999	999999	256	999999	1 U

Sample Number	Station Name (See Table 2.3)	Date	Time	FLow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite-N mgN/L	Ammonia-N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
388538	PUYALLUP	19-Sep-90	COMP	5.7	999999	999999	999999	2.984	30.720	37.390	999999	6.854	219	999999	999999	999999	655	999999	4
388539	SUMNER	19-Sep-90	COMP	1.9	999999	999999	999999	22.780	0.786	24.490	999999	7.363	83.5	999999	999999	999999	692	999999	8
388540	BUCKLEY	19-Sep-90	COMP	0.36	999999	999999	999999	0.186	0.381	1.434	999999	5.851	106	999999	999999	999999	397	999999	1 U
388541	ENUMCLAW	19-Sep-90	COMP	1.12	999999	999999	999999	15.880	0.477	18.210	999999	6.511	105	999999	999999	999999	1132	999999	8
388542	RAINSCH	19-Sep-90	COMP	0.17	999999	999999	999999	3.294	4.557	9.347	999999	2.849	65.4	999999	999999	999999	252	999999	6
388543	MCCALDER	19-Sep-90	1140	0.012	17.2	7.9	8	4.630	7.661	19.600	999999	4.530	121	999999	999999	999999	389	999999	17
388544	ORTING	19-Sep-90	COMP	0.48	999999	999999	999999	0.031	13.240	20.530	999999	4.502	182	999999	999999	999999	480	999999	30
388545	WILKESON	19-Sep-90	COMP	0.027	999999	999999	999999	20.280	0.141	25.160	999999	8.501	102	999999	999999	999999	572	999999	33
388546	CARBONADO	19-Sep-90	810	0.025	18.1	7.2	2.3	2.136	0.422	6.169	999999	8.409	88.1	999999	999999	999999	416	999999	5
388548	NASEMI	19-Sep-90	COMP	0.88	999999	999999	999999	2.248	7.552	9.000	999999	1.330	15.5	999999	999999	999999	912	999999	1
388549	FLEISCHMA	19-Sep-90	1425	1.7	20.9	8.1	8.2	0.014	0.112	0.204	999999	0.312	134	999999	999999	999999	284	999999	1 U
388550	SONOCO	19-Sep-90	COMP	0.24	999999	999999	999999	0.013	0.063	1.434	999999	4.988	653	999999	999999	999999	1322	999999	160
388551	MAZZA	19-Sep-90	COMP	0.38	999999	999999	999999	3.440	1.645	16.040	999999	15.910	373	999999	999999	999999	1894	999999	10
388552	BOEING2	19-Sep-90	1215	0.70	19	9.1	7.6	0.932	0.054	1.424	999999	0.107	61.4	999999	999999	999999	167	999999	1 U
388553	GOVT CANAL	19-Sep-90	1300	0.32	14.8	6.97	6.4	0.481	0.012	0.671	999999	0.027	999999	999999	999999	999999	176	999999	1 U
388554	BOI05.8	19-Sep-90	1130	2.3	12	7.6	9.6	0.295	0.005	0.334	999999	0.012	999999	999999	999999	999999	53	999999	1
388555	WEYCO EFF	19-Sep-90	1200	0.084	18.4	7.1	5.7	0.030	0.135	0.453	999999	0.052	999999	999999	999999	999999	69	999999	1 U
388556	TRTCOIN	20-Sep-90	1115	999999	10.5	7.1	999999	2.371	0.006	2.196	999999	0.039	70	999999	999999	999999	200	999999	1
388557	TRTCOEFF	20-Sep-90	1130	6.7	11.9	7.1	9.6	1.545	0.384	2.957	999999	0.119	72.2	999999	999999	999999	204	999999	4
388558	PUYTRBIN	19-Sep-90	1255	999999	13.6	8	10.6	0.003	0.018	0.022	999999	0.173	66.4	999999	999999	999999	137	999999	1 U
388559	PUYTRBEFF	19-Sep-90	1310	0.74	12.1	7.9	10.1	0.003	0.109	0.224	999999	0.223	66.7	999999	999999	999999	138	999999	1
388560	DOWIN	19-Sep-90	1340	999999	10.2	7.45	9.2	1.889	0.004	1.848	999999	0.041	70	999999	999999	999999	179	999999	1
388561	DOWEFF	19-Sep-90	1420	12.9	11.8	7.52	8.5	1.888	0.121	2.208	999999	0.297	71.2	999999	999999	999999	183	999999	7
388562	MUCTRBIN	20-Sep-90	1325	999999	10.9	6.8	999999	0.246	0.008	0.256	999999	0.010	30.3	999999	999999	999999	94	999999	1 U
388563	MUCTRBEFF	20-Sep-90	1400	2	12	7.5	10.6	0.232	0.127	0.473	999999	0.029	30.9	999999	999999	999999	96	999999	1
388564	TRTSPRIN	20-Sep-90	910	999999	9.1	7.9	999999	1.914	0.004	1.900	999999	0.028	75.9	999999	999999	999999	186	999999	2
388565	TRTSPREFF	20-Sep-90	930	11	9.2	7.2	9.9	1.910	0.366	2.566	999999	0.189	77.4	999999	999999	999999	189	999999	2
388566	DOFIN	20-Sep-90	1450	999999	14	7.8	999999	0.083	0.008	0.183	999999	0.019	40.6	999999	999999	999999	88	999999	1
388567	DOFEFF	20-Sep-90	1510	6.5	14.4	7.5	9.0	0.089	0.206	0.531	999999	0.123	41.8	999999	999999	999999	92	999999	5
388570	PUYALLUP	19-Sep-90	COMP	5.7	999999	999999	999999	3.180	31.280	38.640	999999	6.528	999999	999999	999999	999999	999999	999999	999999
388571	SUMNER	19-Sep-90	COMP	1.9	999999	999999	999999	20.110	0.021	23.520	999999	7.053	999999	999999	999999	999999	999999	999999	999999
388572	BUCKLEY	19-Sep-90	COMP	0.36	999999	999999	999999	0.480	0.016	1.153	999999	6.243	999999	999999	999999	999999	999999	999999	999999
388573	ENUMCLAW	19-Sep-90	COMP	1.1	999999	999999	999999	15.130	0.309	17.160	999999	7.258	999999	999999	999999	999999	999999	999999	999999
408400	PUY18.0	02-Oct-90	1655	999999	11.1	7.8	11.4	0.015	0.012	0.061	0.009	0.094	20	6	0	32	71.7	1.22	55
408401	PUY12.2	02-Oct-90	1727	999999	11.7	7.8	11.2	0.112	0.010	0.172	0.014	0.083	26	17	0	27.5	77.4	1.41	43
408402	PUY08.3	02-Oct-90	1530	999999	14	7.7	10.1	0.072	0.016	0.150	0.016	0.066	24	120	13	17	68.8	1.5	32
408403	PUY05.7	02-Oct-90	1600	999999	14	7.6	10.2	0.104	0.052	0.228	0.029	0.088	999999	100	8	17.5	71.2	1.65	34
408404	PUY01.5	02-Oct-90	1200	999999	11.3	7.5	10.7	0.180	0.043	0.313	999999	0.146	32	700	80	28	187	26.1	74
408405	PUY00.8	02-Oct-90	1120	999999	10.9	7.5	10.7	0.224	0.038	0.344	999999	0.175	999999	660	75	31.5	583	131	95
408406	CAR17.7	02-Oct-90	1200	999999	8.2	7.8	11.7	0.033	0.001	0.055	0.012	0.117	12	1	999999	33.5	28.8	0.71	89
408407	CAR06.1	02-Oct-90	1520	999999	10.1	8	11.7	0.037	0.010	0.060	999999	0.109	999999	999999	999999	1 U	127	2.51	75
408408	CAR02.0	02-Oct-90	1615	999999	11.9	8	11.0	0.096	0.012	0.151	0.012	0.084	30	41	6	24.5	70.7	1.3	999999
408409	WIL04.2	02-Oct-90	1250	999999	10.9	8.3	11.4	0.049	-0.002	0.153	0.001	0.024	80	92	999999	1 U	183	1.7	1
408410	SPR07.2	02-Oct-90	1330	999999	11.7	8.1	11.2	0.173	0.001	0.240	0.001	0.010	50	42	999999	1 U	100	2.3	1
408411	SPR05.8	02-Oct-90	1355	999999	11.9	8.3	11.2	0.173	0.004	0.234	0.006	0.016	999999	999999	999999	999999	999999	999999	999999
408412	SPR01.1	02-Oct-90	1435	999999	12.3	8.1	11.4	0.339	0.002	0.425	999999	0.022	48	77	999999	1 U	127	2.52	2
408413	WHI25.2	02-Oct-90	820	999999	8.7	7.7	11.3	0.040	0.016	0.064	0.014	0.161	21	3	0	51.5	70.5	1.73	140
408415	WHI23.1	02-Oct-90	840	999999	9	7.8	11.4	0.045	0.008	0.088	0.015	0.106	26	34 S	0	38	77.2	1.82	69
408416	WHI20.4	02-Oct-90	920	999999	9.2	7.8	11.5	0.082	0.028	0.110	0.042	0.100	999999	38	999999	27	85.4	2.38	28
408417	WHI14.9	02-Oct-90	1020	999999	9.9	8.6	12.3	0.110	0.019	0.155	999999	0.087	999999	35	999999	24.5	91.8	2.43	14

Sample Number	Station Name (See Table 2.3)	Date	Time	FLow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite- N mgN/L	Ammonia- N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
408418	WHI10.3	02-Oct-90	1310	999999	11.6	9.5	13.4	0.042	0.016	0.117	0.043	0.086	28	5	20	19	92.2	2.5	11
408419	WHI08.0	02-Oct-90	1340	999999	12	9.6	12.4	0.041	0.021	0.111	999999	0.086	999999	3	999999	19.5	92.3	2.54	11
408420	WHI06.3	02-Oct-90	1400	999999	12.2	9.6	12.3	0.039	0.020	0.110	999999	0.088	999999	3	999999	20	92.3	2.54	10
408421	WHI04.9	02-Oct-90	1840	999999	12.9	9.7	11.0	0.012	0.018	0.093	0.041	0.075	30	4	0	19.5	93.6	2.42	10
408422	LTD03.6	02-Oct-90	1915	999999	15.9	7.8	8.4	0.007	0.013	0.070	-0.001	0.022	46	17	0	9.2	58	1.08	4
408423	WHI01.4	02-Oct-90	1430	999999	15.5	7.6	9.3	0.016	0.012	0.091	999999	0.031	999999	35	42	8.8	63.5	1.38	10
408424	WHI00.7	02-Oct-90	1450	999999	15.5	7.5	9.3	0.021	0.019	0.102	0.008	0.038	22	38	80	11	64.5	1.43	12
408425	CLEAR	02-Oct-90	915	15.2	10.3	7.6	6.6	1.673	0.084	1.864	0.038	0.106	999999	88	999999	3.7	190	5.97	18
408426	SWAN	02-Oct-90	830	1.8	10.8	7.5	10.1	1.128	0.004	1.252	0.035	0.059	999999	51	999999	1 U	167	5.47	3
408427	CLARKS	02-Oct-90	1000	39.7	9.8	7.4	7.5	1.502	0.019	1.667	0.035	0.066	999999	180	999999	1	185	5.12	4
408428	FENNEL	02-Oct-90	1130	7	10.6	8	10.9	1.001	0.009	1.258	0.038	0.049	999999	31	999999	1 U	158	3.28	2
408429	CANYONFA	04-Oct-90	1230	9.1	11.7	8	10.7	2.223	0.212	2.658	999999	0.177	999999	6	999999	999999	193	999999	2
408430	VOIGHT	03-Oct-90	930	13	12	7.6	9.0	0.075	0.124	0.402	999999	0.073	999999	130	999999	999999	94.7	999999	3
408432	STRAWBER	02-Oct-90	1210	7.8	9.6	7.7	9.3	0.553	0.010	0.612	0.029	0.054	999999	80 S	999999	1.1	167	2.95	4
408434	BOI00.1	02-Oct-90	1600	5.3	11.4	7.9	10.4	0.219	0.006	0.331	0.015	0.027	999999	260	999999	1 U	117	1.71	1
408436	WTR15.0	02-Oct-90	1410	1.4	10.3	6	9.5	7.331	0.003	7.508	0.038	0.064	999999	1	999999	1 U	209	8.92	3
408437	WTR01.3	02-Oct-90	1045	3.3	9.8	7.3	4.5	0.405	0.018	0.698	0.029	0.055	999999	76	999999	2.2	248	6.08	2
408438	PUYALLUP	02-Oct-90	COMP	4.9	999999	999999	999999	7.596	11.650	22.060	5.482	5.439	130	17	999999	5.8	524	32.1	6
408439	SUMNER	02-Oct-90	COMP	1.9	999999	999999	999999	20.650	0.552	23.450	6.949	6.607	86	210	999999	2.5 J	655	56.1	12
408440	BUCKLEY	02-Oct-90	COMP	0.35	999999	999999	999999	1.455	0.212	3.600	6.424	6.680	90	3	999999	1 U	391	33.4	1
408441	ENUMCLAW	02-Oct-90	COMP	1.1	999999	999999	999999	15.500	1.154	18.880	7.743	7.729	999999	110	999999	4.2 J	739	99.4	8
408442	RAINSCH	02-Oct-90	COMP	0.22	999999	999999	999999	3.201	4.527	9.803	2.737	3.099	60	100	999999	7.1 J	262	15.7	11
408443	MCCALDER	02-Oct-90	1155	0.012	15.2	7.6	8.1	3.558	9.298	17.320	3.173	3.911	57	4600	999999	9.2	373	21.6	30
408444	ORTING	02-Oct-90	COMP	0.37	999999	999999	999999	0.066	13.140	17.020	2.968	3.796	170	440000	999999	19	475	23	26
408445	WILKESON	02-Oct-90	COMP	0.036	999999	999999	999999	21.780	0.066	24.830	8.127	8.341	999999	430	999999	15	597	45	55
408446	CARBONADO	02-Oct-90	1015	999999	16.1	7.1	2.1	0.978	7.056	3.231	8.709	8.520	110	1	999999	12.5	443	38.3	29
408448	NASEMI	02-Oct-90	COMP	0.90	999999	999999	999999	5.457	6.067	11.910	0.648	0.720	10	1 U	999999	1	897	28.8	4
408449	FLEISCHMA	02-Oct-90	1427	1.3	22	8.2	8.6	0.020	0.124	0.219	0.304	0.274	130	3 U	999999	1 U	289	8.1	1
408450	SONOCO	02-Oct-90	COMP	0.27	999999	999999	999999	0.186	0.160	4.300	0.022	0.405	570	50000 X	100	14.5	1190	30	42
408451	MAZZA	02-Oct-90	COMP	0.18	999999	999999	999999	19.160	0.107	25.750	17.970	17.210	450	55000	100	6.6	2100	351	47
408452	BOEING2	02-Oct-90	1232	0.50	16.4	7.5	9.6	1.220	0.043	1.445	0.026	0.183	40	140 X	999999	28.5	157	3.39	71
408453	GOVT CANAL	02-Oct-90	1300	0.26	11.8	7.1	5.9	0.632	0.011	0.799	0.027	0.037	999999	900	999999	1 U	194	4.27	2
408454	BOI05.8	02-Oct-90	1500	1.6	10.6	6.9	10.8	0.282	0.004	0.332	0.017	0.013	999999	5	33	1 U	54.9	1.74	11
408455	WEYCO EFF	02-Oct-90	1530	0.061	15.6	7.1	6.6	0.040	0.157	0.516	0.017	0.049	999999	21	0	12.5	68.6	1.42	2
408456	TRTCOIN	04-Oct-90	950	999999	10.5	7.8	999999	2.283	0.002	2.681	999999	0.035	64	999999	999999	999999	198	999999	1 U
408457	TRTCOEFF	04-Oct-90	1005	6.4	11.4	7.5	8.5	2.264	0.318	2.981	999999	0.118	70	999999	999999	999999	204	999999	2
408458	PUYTRBIN	04-Oct-90	1125	999999	11.5	8.1	999999	0.003	0.018	0.052	999999	0.169	63	999999	999999	999999	137	999999	1 U
408459	PUYTRBEFF	04-Oct-90	1140	0.73	12	7.6	9.8	0.003	0.111	0.188	999999	0.189	64	999999	999999	999999	138	999999	1 U
408460	DOWIN	03-Oct-90	1305	999999	9.8	7.5	999999	1.849	0.004	1.983	999999	0.047	68	999999	999999	999999	179	999999	3
408461	DOWEFF	03-Oct-90	1335	3.2	10.1	7.4	9.0	1.762	0.085	2.184	999999	0.092	70	999999	999999	999999	181	999999	1
408462	MUCTRBIN	04-Oct-90	1320	999999	10.8	6.8	999999	0.266	0.002	0.287	999999	0.011	30	999999	999999	999999	101	999999	1 U
408463	MUCTRBEFF	04-Oct-90	1340	1.9	11.1	7.4	10.9	0.256	0.097	0.535	999999	0.046	34	999999	999999	999999	102	999999	1
408464	TRTSPRIN	04-Oct-90	825	999999	9.9	7.6	999999	1.888	0.001	2.075	999999	0.032	72	999999	999999	999999	188	999999	1 U
408465	TRTSPREFF	04-Oct-90	845	8.8	10.5	7.6	9.4	1.869	0.411	2.764	999999	0.173	76	999999	999999	999999	193	999999	1 U
408466	DOFIN	03-Oct-90	845	999999	11.7	7.9	999999	0.078	0.002	0.181	999999	0.027	40	999999	999999	999999	90.5	999999	9
408467	DOFEFF	03-Oct-90	905	6	11.7	7.5	9.0	0.074	0.127	0.430	999999	0.080	42	999999	999999	999999	94.5	999999	5
408470	BLANK T-1	02-Oct-90		999999	999999	999999	999999	0.031	0.003	0.068	999999	0.001	999999	999999	999999	999999	999999	999999	999999
408471	BLANK T-2	02-Oct-90		999999	999999	999999	999999	0.008	0.001	0.042	999999	0.000	999999	999999	999999	999999	999999	999999	999999
408472	FLTR B-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	0.000	999999	999999	999999	999999	999999	999999	999999	999999
408473	FLTR B-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	0.152	999999	999999	999999	999999	999999	999999	999999	999999
408474	ENUM OUT	02-Oct-90	835	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	120	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	FLow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite-N mgN/L	Ammonia-N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
408475	ORT-OUT	02-Oct-90		999999	999999	999999	999999	0.020	1.126	1.762	999999	0.526	999999	150	999999	999999	999999	999999	999999
408476	FLTR B-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	0.113	999999	999999	999999	999999	999999	999999	999999	999999
408480	PUY01.5	02-Oct-90	1640	999999	13	7.5	10.3	0.161	0.043	0.277	999999	0.089	28	160	63	19	433	98.5	22
408481	PUY00.8	02-Oct-90	1700	999999	12.8	7.2	10.3	0.217	0.060	0.330	999999	0.093	999999	160	57	18.5	1390	345	20
408490	SRPQA-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	-0.001	999999	999999	999999	999999	999999	999999	999999	999999
408491	SRPQA-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	0.000	999999	999999	999999	999999	999999	999999	999999	999999
408492	SRPQA-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	-0.001	999999	999999	999999	999999	999999	999999	999999	999999
408493	SRPQA-4	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	0.000	999999	999999	999999	999999	999999	999999	999999	999999
408500	PUY18.0	03-Oct-90	1500	999999	10.6	7.7	11.8	0.017	0.004	0.144	999999	0.121	18	64	0	28	77.7	1.48	104
408501	PUY12.2	03-Oct-90	1520	999999	11.7	7.8	11.3	0.118	0.026	0.202	999999	0.075	28	120 S	11	19	87.7	1.66	47
408502	PUY08.3	03-Oct-90	1630	999999	14.2	7.6	9.9	0.151	0.034	0.296	999999	0.064	26	120	7	999999	75.6	999999	29
408503	PUY05.7	03-Oct-90	1700	999999	14.2	7.6	10.1	0.082	0.023	0.176	999999	0.057	26	96	4	999999	75.5	1.79	25
408504	PUY01.5	03-Oct-90	1230	999999	14	7.5	9.8	0.121	0.040	0.246	999999	0.076	999999	120	8	999999	153	999999	30
408505	PUY00.8	03-Oct-90	1145	999999	13.7	7.4	9.7	0.153	0.038	0.293	999999	0.074	999999	230	9	999999	439	999999	27
408506	CAR17.7	03-Oct-90	1145	999999	8.5	7.5	11.4	0.044	0.005	0.228	999999	1.810	10	48	999999	150 J	28.4	0.69	3310 J
408507	CAR06.1	03-Oct-90	1350	999999	10.5	7.8	11.3	0.062	0.007	0.195	999999	0.632	999999	999999	999999	999999	999999	999999	999999
408508	CAR02.0	03-Oct-90	1440	999999	11.9	8	11.1	0.101	0.007	0.187	999999	0.133	34	100 S	32	20	76.7	999999	111
408509	WIL04.2	03-Oct-90	1230	999999	11.7	8.1	10.7	0.072	0.008	0.172	999999	0.018	999999	3400 J	999999	2.5	181	999999	2
408510	SPR07.2	03-Oct-90	1245	999999	11.7	7.9	11.0	0.188	0.006	0.278	999999	0.013	38	65	999999	1 U	100	999999	1
408511	SPR05.8	03-Oct-90	1255	999999	11.9	8	10.8	0.185	0.004	0.273	999999	0.016	999999	999999	999999	999999	999999	999999	999999
408512	SPR01.1	03-Oct-90	1330	999999	12	7.8	10.4	0.372	0.006	0.469	999999	0.020	52	230 S	999999	1 U	129	999999	2
408513	WHI25.2	03-Oct-90	800	999999	9.2	7.7	11.1	0.043	0.012	0.158	999999	0.078	22	17	6	22	78.3	1.78	53
408515	WHI23.1	03-Oct-90	830	999999	9.6	7.7	11.1	0.062	0.018	0.121	999999	0.056	26	52	3	999999	82.6	999999	29
408516	WHI20.4	03-Oct-90	900	999999	9.8	7.6	11.0	0.102	0.013	0.268	999999	0.081	999999	43	999999	999999	88.8	999999	19
408517	WHI14.9	03-Oct-90	1000	999999	10.5	7.8	11.2	0.162	-0.001	0.248	999999	0.085	999999	16	999999	999999	97.2	999999	13
408518	WHI10.3	03-Oct-90	1345	999999	12.1	9.1	12.3	0.071	0.001	0.153	999999	0.071	30	10	10	999999	96.9	999999	10
408519	WHI08.0	03-Oct-90	1415	999999	12.5	9.2	12.1	0.063	0.003	0.141	999999	0.078	999999	16	999999	999999	97.1	999999	10
408520	WHI06.3	03-Oct-90	1430	999999	12.8	9.1	11.6	0.051	0.013	0.124	999999	0.072	999999	40	999999	999999	97.4	999999	10
408521	WHI04.9	03-Oct-90	1645	999999	13.5	9.2	11.3	0.046	0.009	0.156	999999	0.070	32	24	0	14	97.7	999999	11
408522	LTD03.6	03-Oct-90	1715	999999	16.5	7.7	8.7	0.002	0.007	0.081	999999	0.012	20	3	0	7	57.6	1.21	3
408523	WHI01.4	03-Oct-90	1500	999999	15.3	7.5	9.2	0.013	0.006	0.187	999999	0.023	999999	52	0	999999	64.8	999999	9
408524	WHI00.7	03-Oct-90	1530	999999	15.3	7.5	9.2	0.019	0.004	0.097	999999	0.030	22	42	20	999999	65.7	1.53	11
408525	CLEAR	03-Oct-90	930	14.3	11.6	7.5	8.6	1.630	0.098	1.904	999999	0.097	999999	270	999999	3.2	191	999999	25
408526	SWAN	03-Oct-90	900	1.7	11.6	7.8	10.2	1.137	-0.001	1.231	999999	0.054	999999	40	999999	1 U	166	999999	1
408527	CLARKS	03-Oct-90	1000	40.7	11.7	7.3	7.1	1.492	0.006	1.546	999999	0.064	999999	190	999999	1.1	185	999999	4
408528	FENNEL	03-Oct-90	1100	7.4	10.8	7.6	10.1	0.957	-0.003	1.084	999999	0.054	999999	65	999999	1 U	159	999999	3
408529	CANYONFA	02-Oct-90	1550	9.1	11	8.2	10.9	2.122	0.164	2.489	0.132	0.159	999999	17	999999	1 U	190	3.72	3
408530	VOIGHT	02-Oct-90	1510	13.4	12.9	7.7	9.5	0.059	0.009	0.338	0.041	0.063	999999	230	999999	1 U	93.4	2.16	2
408531	LILY	03-Oct-90	1200	1.2	10.3	7.5	8.7	0.040	0.001	0.118	0.009	0.027	999999	44	999999	1 U	76.1	999999	1
408532	STRAWBER	03-Oct-90	1600	8	12.4	7.5	9.3	0.564	0.004	0.636	999999	0.049	999999	310	999999	1 U	169	999999	4
408533	BOWMAN	03-Oct-90	1450	0.17	12.5	7.4	9.4	0.068	0.004	0.206	0.006	0.015	999999	96	999999	1 U	92.4	999999	1
408534	BOI00.1	03-Oct-90	1245	8.1	12.1	7.8	9.7	0.257	0.003	0.404	999999	0.032	999999	800	999999	1	120	999999	3
408535	PTR13.0	03-Oct-90	1230	3.3	11.5	7.6	9.2	1.845	0.026	2.568	0.024	0.047	999999	6000 J	999999	1.3	191	5.41	1
408538	PUYALLUP	03-Oct-90	COMP	4.5	999999	999999	999999	8.591	13.870	26.140	999999	5.638	140	9	999999	999999	533	999999	5
408539	SUMNER	03-Oct-90	COMP	1.8	999999	999999	999999	21.820	0.162	24.380	999999	6.392	80	63	999999	999999	688	999999	6
408540	BUCKLEY	03-Oct-90	COMP	0.34	999999	999999	999999	2.916	0.124	3.706	999999	6.397	88	3	999999	999999	390	999999	1
408541	ENUMCLAW	03-Oct-90	COMP	1.1	999999	999999	999999	14.740	0.233	17.060	999999	7.173	96	3000 J	999999	999999	1030	999999	11
408542	RAINSCH	03-Oct-90	COMP	0.13	999999	999999	999999	3.368	4.828	10.620	999999	3.723	68	170	999999	999999	268	999999	8
408543	MCCALDER	03-Oct-90	1120	0.012	16.4	7.5	7.8	3.705	12.250	20.840	999999	4.151	130	16000	999999	999999	436	999999	44
408544	ORTING	03-Oct-90	COMP	0.44	999999	999999	999999	0.062	14.390	18.270	999999	4.267	190	460000	999999	999999	495	999999	23
408545	WILKESON	03-Oct-90	COMP	0.032	999999	999999	999999	21.260	0.062	22.910	999999	8.498	94	220	999999	999999	595	999999	54

Sample Number	Station Name (See Table 2.3)	Date	Time	FLow cfs	Temp-erature degC	pH S.U.	Diss. Oxygen mg/L	Nitrate+ Nitrite- N mgN/L	Ammonia- N mgN/L	Total Persulf. N mgN/L	Soluble Reactive P mgP/L	Total P mgP/L	Alka-linity mgCaCO3/L	Fecal Coliform #/100mL	Klebs-iella % of FC	Turb-idity NTU	Specific Conduc-tance um/cm25C	Chlor-ide mg/L	Total Susp. Solids mg/L
408546	CARBONADO	03-Oct-90	942	999999	15.9	7.2	2.1	0.808	5.557	9.879	999999	8.823	120	1700 J	999999	999999	453	999999	22
408548	NASEMI	03-Oct-90	COMP	0.88	999999	999999	999999	4.521	7.763	14.560	999999	0.680	130	1 U	999999	999999	1050	999999	9
408549	FLEISCHMA	03-Oct-90	1415	0.60	999999	999999	999999	0.034	0.158	0.258	999999	0.254	18	180	999999	999999	281	999999	1
408550	SONOCO	03-Oct-90	COMP	0.21	999999	999999	999999	0.153	0.136	3.556	999999	0.285	550	1800 X	47	999999	1190	999999	43
408551	MAZZA	03-Oct-90	COMP	0.21	999999	999999	999999	19.470	0.069	41.020	999999	18.600	420	15000	100	999999	2200	999999	62
408552	BOEING2	03-Oct-90	1215	1.5	999999	999999	999999	1.931	0.884	3.730	999999	0.111	34	6100 J	999999	999999	143	999999	33
408553	GOVT CANAL	03-Oct-90	1520	1	13.9	6.9	4.8	1.123	0.017	1.765	999999	0.070	999999	730	999999	1 U	203	999999	2
408554	BOI05.8	03-Oct-90	1330	4.2	11.3	7.8	10.7	0.266	0.003	0.327	999999	0.023	999999	170 S	0	3.6	54.5	999999	4
408555	WEYCO EFF	03-Oct-90	1400	0.12	18.8	7.9	6.7	0.036	0.153	0.465	999999	0.047	999999	14	33	12.5	68	999999	4
408556	TRTCOIN	02-Oct-90	1035	999999	9.7	7.7	999999	2.258	0.004	2.318	999999	0.032	70	999999	999999	1 U	197	6.94	1
408557	TRTCOEFF	02-Oct-90	1055	4.5	10.3	7.5	9.8	2.146	0.211	2.559	0.064	0.094	66	999999	999999	1.9	200	7.12	4
408558	PUYTRBIN	02-Oct-90	1145	999999	11.4	8.1	999999	0.001	0.014	0.011	999999	0.168	65	999999	999999	1 U	136	2.18	1 U
408559	PUYTRBEFF	02-Oct-90	1200	0.66	11.6	7.9	9.9	0.001	0.034	0.067	0.167	0.187	64	999999	999999	1 U	135	1.99	1
408560	DOWIN	02-Oct-90	1220	999999	9.7	7.3	999999	1.816	-0.002	1.741	999999	0.045	68	999999	999999	1 U	178	5.24	4
408561	DOWEFF	02-Oct-90	1255	13.6	10.2	7.3	9.2	1.799	0.088	1.907	0.066	0.097	68	999999	999999	1 U	180	5.06	2
408562	MUCTRBIN	03-Oct-90	1040	999999	10.7	7	999999	0.254	-0.002	0.221	999999	0.007	32	999999	999999	1 U	100	1.6	1 U
408563	MUCTRBEFF	03-Oct-90	1105	1.6	11.1	7.6	10.9	0.235	0.062	0.383	0.018	0.029	30	999999	999999	1 U	101	1.85	1 U
408564	TRTSPRIN	02-Oct-90	835	999999	9.3	7.4	999999	1.847	-0.001	1.642	999999	0.028	72	999999	999999	1 U	186	3.43	1
408565	TRTSPREFF	02-Oct-90	900	9.6	9.2	7.5	10.0	1.825	0.343	2.435	0.128	0.158	72	999999	999999	1 U	192	3.59	2
408566	DOFIN	02-Oct-90	1410	999999	12.2	7.8	999999	0.056	-0.001	0.102	999999	0.018	40	999999	999999	1 U	89.5	2.03	2
408567	DOFEFF	02-Oct-90	1425	7.4	12.6	7.7	9.7	0.059	0.128	0.358	0.047	0.070	41	999999	999999	1 U	93	2.13	2
408574	ENUM-OUT	03-Oct-90	825	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	980	999999	999999	999999	999999	999999
408575	ORT-OUT	03-Oct-90	1050	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	3800 J	999999	999999	999999	999999	999999
408580	PUY01.5	03-Oct-90	1745	999999	14.3	7.5	9.6	0.135	0.038	0.203	999999	0.052	999999	88	9	999999	2980	999999	7
408581	PUY00.8	03-Oct-90	1800	999999	14.2	7.3	9.7	0.144	0.037	0.245	999999	0.054	999999	88	0	999999	4300	999999	7
408582	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	100	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chlorophyll A µg/L	Pheo-pigments µg/L	Carbon-aceous BOD5 mg/L	Carbon-aceous BODU mg/L
388400	PUY18.0	18-Sep-90	1800	2.78	0.51	0.48	0.9	2.0
388401	PUY12.2	18-Sep-90	1850	3.28	1.24	1.64	1.5	2.0
388402	PUY08.3	18-Sep-90	1940	3.55	0.93	1.01	0.8	1.6
388403	PUY05.7	18-Sep-90	2010	2.86	999999	999999	0.8	3.8
388404	PUY01.5	18-Sep-90	1200	4.39	1.35	1.31	0.8	1.8
388405	PUY00.8	18-Sep-90	1120	4.1	999999	999999	1.8	2.9
388406	CAR17.7	18-Sep-90	1545	1.65	999999	999999	1.4	1.9
388407	CAR06.1	18-Sep-90	1715	2.49	999999	999999	0.6	1.6
388408	CAR02.0	18-Sep-90	1735	3.95	1.47	1.67	0.4	0.9
388409	WIL04.2	18-Sep-90	1615	6.31	999999	999999	2	2.8
388410	SPR07.2	18-Sep-90	1630	5.26	999999	999999	1.8	2.3
388411	SPR05.8	18-Sep-90	1645	5.3	999999	999999	0.8	1.6
388412	SPR01.1	18-Sep-90	1700	7.1	999999	999999	1.4	2.5
388413	WHI25.2	18-Sep-90	1330	2.89	0.63	0.91	1.2	1.8
388415	WHI23.1	18-Sep-90	1420	2.67	999999	999999	0.7	1.4
388416	WHI20.4	18-Sep-90	1500	2.86	999999	999999	1	1.7
388418	WHI10.3	18-Sep-90	1610	2.84	999999	999999	0.6	1.5
388419	WHI08.0	18-Sep-90	1650	2.76	999999	999999	0.5	1.6
388420	WHI06.3	18-Sep-90	1720	2.11	999999	999999	1	1.6
388421	WHI04.9	18-Sep-90	1740	1.56	5.87	5.32	0.5	1.1
388422	LTD03.6	18-Sep-90	1810	2.13	0.34	0.49	0.6	1.6
388423	WHI01.4	18-Sep-90	1840	2.89	999999	999999	0.4	1.2
388424	WHI00.7	18-Sep-90	1900	3.19	1.96	1.71	1	1.7
388425	CLEAR	18-Sep-90	1000	3.29	999999	999999	1.6	2.3
388426	SWAN	18-Sep-90	925	2.73	999999	999999	0.6	2.5
388427	CLARKS	18-Sep-90	1100	5.1	999999	999999	1.1	1.8
388428	FENNEL	19-Sep-90	1700	7.5	999999	999999	999999	999999
388429	CANYONFA	18-Sep-90	1620	3.88	999999	999999	2.3	3.5
388430	VOIGHT	19-Sep-90	930	NAR	999999	999999	2.2	999999
388432	STRAWBER	18-Sep-90	1245	7.42	999999	999999	0.9	1.5
388433	BOWMAN	18-Sep-90	1420	7.85	999999	999999	0.9	2.0
388434	BOI00.1	18-Sep-90	1710	3.63	999999	999999	1.4	2.4
388435	PTR13.0	18-Sep-90	1549	3.1	999999	999999	2	2.8
388436	WTR15.0	18-Sep-90	1510	5.57	999999	999999	1.3	1.8
388437	WTR01.3	18-Sep-90	1155	14.3	999999	999999	1.1	1.9
388438	PUYALLUP	18-Sep-90	COMP	33.9	999999	999999	18.3	17.3
388439	SUMNER	18-Sep-90	COMP	19.9	999999	999999	4.7	28.6
388440	BUCKLEY	18-Sep-90	COMP	13.6	999999	999999	1.7 J	6.7
388441	ENUMCLAW	18-Sep-90	COMP	21.9	999999	999999	6.3	19.5
388442	RAINSCH	18-Sep-90	COMP	27.6	999999	999999	12.9	19.7
388443	MCCALDER	18-Sep-90	1215	17	999999	999999	5	17.2
388444	ORTING	18-Sep-90	COMP	40.1	999999	999999	7 J	77.3
388445	WILKESON	18-Sep-90	COMP	29.8	999999	999999	26.4 J	25.6
388446	CARBONADO	18-Sep-90	820	35	999999	999999	7.9 J	36.5
388448	NASEMI	18-Sep-90	COMP	3.97	999999	999999	PNQ	999999
388449	FLEISCHMA	18-Sep-90	1435	8.08	999999	999999	0.4 J	1.4
388450	SONOCO	18-Sep-90	COMP	85.1	999999	999999	29.4	39.0
388451	MAZZA	18-Sep-90	COMP	42.4	999999	999999	12.1 J	19.2
388452	BOEING2	18-Sep-90	1245	13.1	999999	999999	1.1 J	3.7
388453	GOVT CANAL	18-Sep-90	1320	5.32	999999	999999	1	1.6
388454	BOI05.8	18-Sep-90	1625	2.56	999999	999999	0.5	1.5

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chlorophyll A µg/L	Pheopigments µg/L	Carbonaceous BOD5 mg/L	Carbonaceous BODU mg/L
388455	WEYCO EFF	18-Sep-90	1640	10.9	999999	999999	1.4	7.4
388456	TRTCOIN	18-Sep-90	1040	5.44	999999	999999	0.2	0.9
388457	TRTCOEFF	18-Sep-90	1100	4.7	999999	999999	0.7	2.3
388458	PUYTRBIN	18-Sep-90	1205	39.6	999999	999999	1	1.4
388459	PUYTRBEFF	18-Sep-90	1235	7.09	999999	999999	1.6	2.1
388460	DOWIN	18-Sep-90	1320	7.13	999999	999999	1.1	1.5
388461	DOWEFF	18-Sep-90	1355	6.19	999999	999999	2.5	3.5
388462	MUCTRBIN	19-Sep-90	1110	4.68	999999	999999	1.8	999999
388463	MUCTRBEFF	19-Sep-90	1125	4.22	999999	999999	2.8	999999
388464	TRTSPRIN	18-Sep-90	845	5.1	999999	999999	0.8	1.3
388465	TRTSPREFF	18-Sep-90	905	7.51	999999	999999	2.1	3.3
388466	DOFIN	19-Sep-90	840	3.78	999999	999999	2.3	999999
388467	DOFEFF	19-Sep-90	910	3.98	999999	999999	2.7	999999
388474	BLANK-1	18-Sep-90		999999	999999	999999	999999	999999
388475	BLANK-2	18-Sep-90		999999	999999	999999	999999	999999
388476	X-ORT	18-Sep-90		999999	999999	999999	999999	999999
388490	SRPQA-1	18-Sep-90		999999	999999	999999	999999	999999
388491	SRPQA-2	18-Sep-90		999999	999999	999999	999999	999999
388500	PUY18.0	19-Sep-90	1605	2.92	999999	999999	1.1	999999
388501	PUY12.2	19-Sep-90	1630	3.19	999999	999999	1	999999
388502	PUY08.3	19-Sep-90	1100	3.31	999999	999999	1.4	999999
388503	PUY05.7	19-Sep-90	1330	3.56	1.24	1	1.5	999999
388504	PUY01.5	19-Sep-90	1230	7	999999	999999	1.1	999999
388505	PUY00.8	19-Sep-90	1200	6.9	999999	999999	1.2	999999
388506	CAR17.7	19-Sep-90	1300	2.18	999999	999999	1.5	999999
388507	CAR06.1	19-Sep-90	1510	2.33	999999	999999	2.2	999999
388508	CAR02.0	19-Sep-90	1535	2.83	999999	999999	1	999999
388509	WIL04.2	19-Sep-90	1330	5.13	999999	999999	1.3	999999
388510	SPR07.2	19-Sep-90	1350	3.44	999999	999999	1.3	999999
388511	SPR05.8	19-Sep-90	1410	3.18	999999	999999	1.7	999999
388512	SPR01.1	19-Sep-90	1450	4.71	999999	999999	2.1	999999
388513	WHI25.2	19-Sep-90	1440	2.61	999999	999999	1	999999
388515	WHI23.1	19-Sep-90	1510	2.65	999999	999999	0.8	999999
388516	WHI20.4	19-Sep-90	1540	2.13	999999	999999	0.8	999999
388518	WHI10.3	19-Sep-90	1640	2.79	999999	999999	0.7	999999
388519	WHI08.0	19-Sep-90	1700	2.49	999999	999999	0.9	999999
388520	WHI06.3	19-Sep-90	1730	2.11	999999	999999	1.1	999999
388521	WHI04.9	19-Sep-90	1750	2.03	2.85 J	2.54 J	0.8	999999
388522	LTD03.6	19-Sep-90	1135	3.13	999999	999999	2	999999
388523	WHI01.4	19-Sep-90	1830	2.78	999999	999999	0.8	999999
388524	WHI00.7	19-Sep-90	1850	3.13	999999	999999	1	999999
388526	SWAN	19-Sep-90	1605	3.34	999999	999999	1	999999
388527	CLARKS	19-Sep-90	1500	4.72	999999	999999	1.3	999999
388528	FENNEL	20-Sep-90	1645	6.41	999999	999999	0.8	1.9
388529	CANYONFA	19-Sep-90	1630	4.91	999999	999999	2	999999
388530	VOIGHT	20-Sep-90	1550	6.18	999999	999999	4.5	3.7
388531	LILY	19-Sep-90	935	5.48	999999	999999	2	999999
388532	STRAWBER	19-Sep-90	1330	5.22	999999	999999	1.2	999999
388534	BOI00.1	19-Sep-90	1025	3.98	999999	999999	1.9	999999
388535	PTR13.0	19-Sep-90	1545	3.51	999999	999999	1.4	999999
388537	WTR01.3	19-Sep-90	1415	9.44	999999	999999	1	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chloro-phyll A µg/L	Pheo-pigments µg/L	Carbon-aceous BOD5 mg/L	Carbon-aceous BODU mg/L
388538	PUYALLUP	19-Sep-90	COMP	29.4	999999	999999	17.3	999999
388539	SUMNER	19-Sep-90	COMP	16.4	999999	999999	6.1	999999
388540	BUCKLEY	19-Sep-90	COMP	11.7	999999	999999	1.7 J	999999
388541	ENUMCLAW	19-Sep-90	COMP	20.6	999999	999999	6.3	999999
388542	RAINSCH	19-Sep-90	COMP	20.7	999999	999999	9.2	999999
388543	MCCALDER	19-Sep-90	1140	18.6	999999	999999	7.1	999999
388544	ORTING	19-Sep-90	COMP	24.8	999999	999999	22.5	999999
388545	WILKESON	19-Sep-90	COMP	20.8	999999	999999	12.7	999999
388546	CARBONADO	19-Sep-90	810	33.6	999999	999999	8.5	999999
388548	NASEMI	19-Sep-90	COMP	4.84	999999	999999	PNQ	999999
388549	FLEISCHMA	19-Sep-90	1425	4.56	999999	999999	1.9	999999
388550	SONOCO	19-Sep-90	COMP	182	999999	999999	69.9	999999
388551	MAZZA	19-Sep-90	COMP	43	999999	999999	12.2	999999
388552	BOEING2	19-Sep-90	1215	10.9	999999	999999	6.2	999999
388553	GOVT CANAL	19-Sep-90	1300	6.31	999999	999999	1.4	999999
388554	BOI05.8	19-Sep-90	1130	3.11	999999	999999	1	999999
388555	WEYCO EFF	19-Sep-90	1200	11.1	999999	999999	1 J	999999
388556	TRTCOIN	20-Sep-90	1115	4.49	999999	999999	1.6	1.9
388557	TRTCOEFF	20-Sep-90	1130	6.85	999999	999999	3.1	3.8
388558	PUYTRBIN	19-Sep-90	1255	4.59	999999	999999	1	999999
388559	PUYTRBEFF	19-Sep-90	1310	4.19	999999	999999	2	999999
388560	DOWIN	19-Sep-90	1340	4.07	999999	999999	1.1	999999
388561	DOWEFF	19-Sep-90	1420	5.26	999999	999999	4.6	999999
388562	MUCTRBIN	20-Sep-90	1325	3.79	999999	999999	1	1.3
388563	MUCTRBEFF	20-Sep-90	1400	3.72	999999	999999	2.3	3.1
388564	TRTSPRIN	20-Sep-90	910	5.68	999999	999999	1.8	2.0
388565	TRTSPREFF	20-Sep-90	930	5.54	999999	999999	3.9	5.2
388566	DOFIN	20-Sep-90	1450	5.23	999999	999999	2.2	2.9
388567	DOFEFF	20-Sep-90	1510	6.62	999999	999999	2.2	3.4
388570	PUYALLUP	19-Sep-90	COMP	999999	999999	999999	999999	999999
388571	SUMNER	19-Sep-90	COMP	999999	999999	999999	999999	999999
388572	BUCKLEY	19-Sep-90	COMP	999999	999999	999999	999999	999999
388573	ENUMCLAW	19-Sep-90	COMP	999999	999999	999999	999999	999999
408400	PUY18.0	02-Oct-90	1655	3.49	0.56	0.5	1.8	2.2
408401	PUY12.2	02-Oct-90	1727	3.34	0.7	0.63	1.5	2.1
408402	PUY08.3	02-Oct-90	1530	3.47	0.96	0.8	999999	999999
408403	PUY05.7	02-Oct-90	1600	3.89	1.31	2.43	1.4	2.4
408404	PUY01.5	02-Oct-90	1200	4.63	999999	999999	999999	999999
408405	PUY00.8	02-Oct-90	1120	3.88	999999	999999	1.6	2.9
408406	CAR17.7	02-Oct-90	1200	2.71	999999	999999	1.8	3.2
408407	CAR06.1	02-Oct-90	1520	3.04	999999	999999	999999	999999
408408	CAR02.0	02-Oct-90	1615	4.21	0.41	0.4	1.8	2.4
408409	WIL04.2	02-Oct-90	1250	7.57	999999	999999	1.7	3.2
408410	SPR07.2	02-Oct-90	1330	4.66	999999	999999	1.5	2.7
408411	SPR05.8	02-Oct-90	1355	4.82	999999	999999	999999	999999
408412	SPR01.1	02-Oct-90	1435	3.3	999999	999999	999999	999999
408413	WHI25.2	02-Oct-90	820	2.02	0.44	0.41	1.1	1.8
408415	WHI23.1	02-Oct-90	840	3.42	999999	999999	0.9	1.8
408416	WHI20.4	02-Oct-90	920	2.95	999999	999999	0.5	2.5
408417	WHI14.9	02-Oct-90	1020	3.87	999999	999999	0.9	1.8

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chloro-phyll A µg/L	Pheo-pigments µg/L	Carbon-aceous BOD5 mg/L	Carbon-aceous BODU mg/L
408418	WHI10.3	02-Oct-90	1310	3.12	999999	999999	1.1	1.9
408419	WHI08.0	02-Oct-90	1340	3.54	999999	999999	999999	999999
408420	WHI06.3	02-Oct-90	1400	3.14	999999	999999	999999	999999
408421	WHI04.9	02-Oct-90	1840	3.14	1.67	2.75	1.5	3.1
408422	LTD03.6	02-Oct-90	1915	2.81	1.09	0.72	1.1	1.8
408423	WHI01.4	02-Oct-90	1430	3.6	999999	999999	999999	999999
408424	WHI00.7	02-Oct-90	1450	3.25	0.91	0.8	0.9	1.5
408425	CLEAR	02-Oct-90	915	5.03	999999	999999	1.3	2.6
408426	SWAN	02-Oct-90	830	3.75	999999	999999	1.1	1.9
408427	CLARKS	02-Oct-90	1000	7.26	999999	999999	0.9	1.8
408428	FENNEL	02-Oct-90	1130	4.79	999999	999999	1.3	1.9
408429	CANYONFA	04-Oct-90	1230	8.91	999999	999999	1.8	2.7
408430	VOIGHT	03-Oct-90	930	6.54	999999	999999	2	3.2
408432	STRAWBER	02-Oct-90	1210	3.06	999999	999999	1.2	1.7
408434	BOI00.1	02-Oct-90	1600	2.32	999999	999999	1.2	2.2
408436	WTR15.0	02-Oct-90	1410	4.87	999999	999999	0.9	1.4
408437	WTR01.3	02-Oct-90	1045	10.5	999999	999999	1	1.7
408438	PUYALLUP	02-Oct-90	COMP	6.64	999999	999999	8.6	21.3
408439	SUMNER	02-Oct-90	COMP	18.9	999999	999999	5.6	13.3
408440	BUCKLEY	02-Oct-90	COMP	13.1	999999	999999	1.8	2.8
408441	ENUMCLAW	02-Oct-90	COMP	22.9	999999	999999	7.9	17.0
408442	RAINSCH	02-Oct-90	COMP	26.6	999999	999999	10.4	18.0
408443	MCCALDER	02-Oct-90	1155	20.5	999999	999999	7	19.4
408444	ORTING	02-Oct-90	COMP	36	999999	999999	5.2 J	50.8
408445	WILKESON	02-Oct-90	COMP	29.1	999999	999999	10.7	34.6
408446	CARBONADO	02-Oct-90	1015	36.7	999999	999999	2.4 J	26.8
408448	NASEMI	02-Oct-90	COMP	5	999999	999999	PNQ	999999
408449	FLEISCHMA	02-Oct-90	1427	10	999999	999999	0.6 J	1.4
408450	SONOCO	02-Oct-90	COMP	129	999999	999999	48.6 J	59.4
408451	MAZZA	02-Oct-90	COMP	36.8	999999	999999	13.7 J	22.9
408452	BOEING2	02-Oct-90	1232	6.9	999999	999999	2.2 J	4.4
408453	GOVT CANAL	02-Oct-90	1300	6.21	999999	999999	1.2	8.3
408454	BOI05.8	02-Oct-90	1500	1.77	999999	999999	1.1	4.0
408455	WEYCO EFF	02-Oct-90	1530	9.84	999999	999999	0.9	11.2
408456	TRTCOIN	04-Oct-90	950	5.34	999999	999999	1.4	3.2
408457	TRTCOEFF	04-Oct-90	1005	3.71	999999	999999	2	2.7
408458	PUYTRBIN	04-Oct-90	1125	1.99	999999	999999	0.8	1.3
408459	PUYTRBEFF	04-Oct-90	1140	6.47	999999	999999	1.5	1.8
408460	DOWIN	03-Oct-90	1305	6.51	999999	999999	1.3	1.4
408461	DOWEFF	03-Oct-90	1335	4.99	999999	999999	1.8	2.8
408462	MUCTRBIN	04-Oct-90	1320	4.11	999999	999999	0.7	0.9
408463	MUCTRBEFF	04-Oct-90	1340	2.67	999999	999999	1.7	3.4
408464	TRTSPRIN	04-Oct-90	825	2.41	999999	999999	1.4	2.7
408465	TRTSPREFF	04-Oct-90	845	7.09	999999	999999	2.9	3.9
408466	DOFIN	03-Oct-90	845	5.35	999999	999999	1.4	2.0
408467	DOFEFF	03-Oct-90	905	5.02	999999	999999	1.5	4.1
408470	BLANK T-1	02-Oct-90		999999	999999	999999	999999	999999
408471	BLANK T-2	02-Oct-90		999999	999999	999999	999999	999999
408472	FLTR B-1	02-Oct-90		999999	999999	999999	999999	999999
408473	FLTR B-2	02-Oct-90		999999	999999	999999	999999	999999
408474	ENUM OUT	02-Oct-90	835	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chloro-phyll A µg/L	Pheo-pigments µg/L	Carbon-aceous BOD5 mg/L	Carbon-aceous BODU mg/L
408475	ORT-OUT	02-Oct-90		999999	999999	999999	999999	999999
408476	FLTR B-3	02-Oct-90		999999	999999	999999	999999	999999
408480	PUY01.5	02-Oct-90	1640	2.63	999999	999999	999999	999999
408481	PUY00.8	02-Oct-90	1700	3.44	999999	999999	0.8	4.0
408490	SRPQA-1	02-Oct-90		999999	999999	999999	999999	999999
408491	SRPQA-2	02-Oct-90		999999	999999	999999	999999	999999
408492	SRPQA-3	02-Oct-90		999999	999999	999999	999999	999999
408493	SRPQA-4	02-Oct-90		999999	999999	999999	999999	999999
408500	PUY18.0	03-Oct-90	1500	3.04	999999	999999	1.4	999999
408501	PUY12.2	03-Oct-90	1520	3.12	999999	999999	1.3	999999
408502	PUY08.3	03-Oct-90	1630	3.53	999999	999999	999999	999999
408503	PUY05.7	03-Oct-90	1700	3.12	0.99	0.94	1.3	999999
408504	PUY01.5	03-Oct-90	1230	3.77	999999	999999	999999	999999
408505	PUY00.8	03-Oct-90	1145	3.56	999999	999999	1.3	999999
408506	CAR17.7	03-Oct-90	1145	4.19	999999	999999	1.5	999999
408507	CAR06.1	03-Oct-90	1350	2.6	999999	999999	999999	999999
408508	CAR02.0	03-Oct-90	1440	3.18	999999	999999	999999	999999
408509	WIL04.2	03-Oct-90	1230	5.13	999999	999999	1.5	999999
408510	SPR07.2	03-Oct-90	1245	4.23	999999	999999	1.9	999999
408511	SPR05.8	03-Oct-90	1255	4.5	999999	999999	999999	999999
408512	SPR01.1	03-Oct-90	1330	3.4	999999	999999	999999	999999
408513	WHI25.2	03-Oct-90	800	1.88	999999	999999	1	999999
408515	WHI23.1	03-Oct-90	830	2.62	999999	999999	0.7	999999
408516	WHI20.4	03-Oct-90	900	2.52	999999	999999	1	999999
408517	WHI14.9	03-Oct-90	1000	2.93	999999	999999	0.8	999999
408518	WHI10.3	03-Oct-90	1345	2.89	999999	999999	1	999999
408519	WHI08.0	03-Oct-90	1415	3.18	999999	999999	999999	999999
408520	WHI06.3	03-Oct-90	1430	2.9	999999	999999	999999	999999
408521	WHI04.9	03-Oct-90	1645	3.12	2.44 J	4.12	1.4	999999
408522	LTD03.6	03-Oct-90	1715	3.59	999999	999999	1.2	999999
408523	WHI01.4	03-Oct-90	1500	3.14	999999	999999	999999	999999
408524	WHI00.7	03-Oct-90	1530	2.64	999999	999999	0.8	999999
408525	CLEAR	03-Oct-90	930	6.88	999999	999999	1.4	999999
408526	SWAN	03-Oct-90	900	4.78	999999	999999	1.2	999999
408527	CLARKS	03-Oct-90	1000	6.49	999999	999999	1.6	999999
408528	FENNEL	03-Oct-90	1100	3.97	999999	999999	1.1	999999
408529	CANYONFA	02-Oct-90	1550	4.32	999999	999999	2.1	3.3
408530	VOIGHT	02-Oct-90	1510	4.72	999999	999999	1.6	2.6
408531	LILY	03-Oct-90	1200	6.52	999999	999999	1.1	999999
408532	STRAWBER	03-Oct-90	1600	4.44	999999	999999	0.7	999999
408533	BOWMAN	03-Oct-90	1450	4.7	999999	999999	1.1	999999
408534	BOI00.1	03-Oct-90	1245	5.55	999999	999999	1.7	999999
408535	PTR13.0	03-Oct-90	1230	5.79	999999	999999	0.9	999999
408538	PUYALLUP	03-Oct-90	COMP	21.6	999999	999999	9.5	999999
408539	SUMNER	03-Oct-90	COMP	14.5	999999	999999	5.7	999999
408540	BUCKLEY	03-Oct-90	COMP	8.02	999999	999999	1.5 J	999999
408541	ENUMCLAW	03-Oct-90	COMP	10.9	999999	999999	8.2	999999
408542	RAINSCH	03-Oct-90	COMP	26.3	999999	999999	10.1	999999
408543	MCCALDER	03-Oct-90	1120	19.2	999999	999999	10.4	999999
408544	ORTING	03-Oct-90	COMP	26.5	999999	999999	8 J	999999
408545	WILKESON	03-Oct-90	COMP	24.6	999999	999999	4.8 J	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Total Organic Carbon mg/L	Chlorophyll A µg/L	Pheo-pigments µg/L	Carbon-aceous BOD5 mg/L	Carbon-aceous BODU mg/L
408546	CARBONADO	03-Oct-90	942	36.7	999999	999999	14.8 J	999999
408548	NASEMI	03-Oct-90	COMP	3.83	999999	999999	PNQ	999999
408549	FLEISCHMA	03-Oct-90	1415	2.68	999999	999999	0.4	999999
408550	SONOCO	03-Oct-90	COMP	104	999999	999999	46.3	999999
408551	MAZZA	03-Oct-90	COMP	37.7	999999	999999	15.8	999999
408552	BOEING2	03-Oct-90	1215	16.7	999999	999999	5.3	999999
408553	GOVT CANAL	03-Oct-90	1520	10.2	999999	999999	1.3	999999
408554	BOI05.8	03-Oct-90	1330	2.89	999999	999999	999999	999999
408555	WEYCO EFF	03-Oct-90	1400	7.26	999999	999999	0.6	999999
408556	TRTCOIN	02-Oct-90	1035	4.39	999999	999999	1.8	2.4
408557	TRTCOEFF	02-Oct-90	1055	4.23	999999	999999	1.7	2.5
408558	PUYTRBIN	02-Oct-90	1145	4.02	999999	999999	1.6	1.9
408559	PUYTRBEFF	02-Oct-90	1200	3.13	999999	999999	1.6	2.2
408560	DOWIN	02-Oct-90	1220	2.66	999999	999999	1.3	1.8
408561	DOWEFF	02-Oct-90	1255	3.99	999999	999999	2.6	3.4
408562	MUCTRBIN	03-Oct-90	1040	4.35	999999	999999	0.9	1.1
408563	MUCTRBEFF	03-Oct-90	1105	2.99	999999	999999	1.2	2.7
408564	TRTSPRIN	02-Oct-90	835	3.82	999999	999999	1.6	2.1
408565	TRTSPREFF	02-Oct-90	900	3.38	999999	999999	2.6	3.8
408566	DOFIN	02-Oct-90	1410	3.47	999999	999999	1.6	2.5
408567	DOFEFF	02-Oct-90	1425	4.55	999999	999999	1.5	2.4
408574	ENUM-OUT	03-Oct-90	825	999999	999999	999999	999999	999999
408575	ORT-OUT	03-Oct-90	1050	999999	999999	999999	999999	999999
408580	PUY01.5	03-Oct-90	1745	2.89	999999	999999	999999	999999
408581	PUY00.8	03-Oct-90	1800	3.01	999999	999999	0.3	1.6
408582	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
388400	PUY18.0	18-Sep-90	1800	25.5	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388401	PUY12.2	18-Sep-90	1850	28.3	0.05 U	0.11 J	1 U	1 U	0.2 J	0.1 U	5 U	5 U
388402	PUY08.3	18-Sep-90	1940	29.5	0.079 J	0.05 U	1 J	1 U	0.1 U	0.1 U	5 U	5 U
388403	PUY05.7	18-Sep-90	2010	30.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388404	PUY01.5	18-Sep-90	1200	48.1	0.05 U	0.06 J	1 U	1 U	0.1 U	0.17 JB	5 U	5 U
388405	PUY00.8	18-Sep-90	1120	999999	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388406	CAR17.7	18-Sep-90	1545	999999	0.05 U	0.05 U	1 U	1 U	0.1 U	0.16 JB	5 U	8 J
388407	CAR06.1	18-Sep-90	1715	999999	999999	999999	999999	999999	999999	999999	999999	999999
388408	CAR02.0	18-Sep-90	1735	26.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.16 JB	5 U	5 U
388409	WIL04.2	18-Sep-90	1615	70.9	0.05 U	0.05 U	1 U	1 U	0.1 U	0.13 JB	5 U	5 U
388410	SPR07.2	18-Sep-90	1630	37	0.05 U	0.05 U	1 U	1 U	0.1 U	0.22 JB	5 U	5 U
388411	SPR05.8	18-Sep-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999
388412	SPR01.1	18-Sep-90	1700	50.1	0.05 U	0.05 U	1 U	1 U	0.01 U	0.1 U	5 U	5 U
388413	WHI25.2	18-Sep-90	1330	22.2	0.05 U	0.05 U	1 U	1 U	0.1 U	0.23 JB	5 U	5 U
388415	WHI23.1	18-Sep-90	1420	23.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388416	WHI20.4	18-Sep-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999
388418	WHI10.3	18-Sep-90	1610	27.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388419	WHI08.0	18-Sep-90	1650	999999	999999	999999	999999	999999	999999	999999	999999	999999
388420	WHI06.3	18-Sep-90	1720	999999	999999	999999	999999	999999	999999	999999	999999	999999
388421	WHI04.9	18-Sep-90	1740	29	0.05 U	0.13 J	1 U	1 J	0.1 U	0.14 JB	5 U	5 U
388422	LTD03.6	18-Sep-90	1810	18.7	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388423	WHI01.4	18-Sep-90	1840	999999	999999	999999	999999	999999	999999	999999	999999	999999
388424	WHI00.7	18-Sep-90	1900	27.8	0.05 U	0.05 U	1 U	1 U	0.1 U	0.22 JB	5 U	5 U
388425	CLEAR	18-Sep-90	1000	77.4	0.05 U	0.05 U	1 U	1 U	0.1 U	0.14 JB	5 U	5 U
388426	SWAN	18-Sep-90	925	68	0.05 U	0.05 U	1.5 J	1.4 J	0.1 U	0.1 U	5 U	5 U
388427	CLARKS	18-Sep-90	1100	76.9	0.05 U	0.05 U	1.1 J	1.5 J	0.1 U	0.1 U	5 U	5 U
388428	FENNEL	19-Sep-90	1700	66	0.05 U	0.05 U	1 J	1.3 J	0.1 U	0.1 U	5 U	5 U
388429	CANYONFA	18-Sep-90	1620	82.3	0.05 U	0.05 U	1.4 J	1.8 J	0.1 U	0.1 U	5 U	5 U
388430	VOIGHT	19-Sep-90	930	34.2	0.05 U	0.273	1 U	1.6 JB	0.1 U	0.1 U	5 U	5 U
388432	STRAWBER	18-Sep-90	1245	71.4	0.05 U	0.204	1 U	1.3 JB	0.1 U	0.1 U	5 U	5 U
388433	BOWMAN	18-Sep-90	1420	27.8	0.05 U	0.05 U	1 U	1.1 JB	0.1 U	3.6	5 U	5 U
388434	BOI00.1	18-Sep-90	1710	50.1	0.05 U	0.05 U	1 U	1 U	0.12 J	0.2 J	5 U	5 U
388435	PTR13.0	18-Sep-90	1549	78.4	0.05 U	0.05 U	1 U	1 U	0.17 J	0.1 U	5 U	5 U
388436	WTR15.0	18-Sep-90	1510	79.9	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388437	WTR01.3	18-Sep-90	1155	103	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388438	PUYALLUP	18-Sep-90	COMP	79.9	2.08	999999	1.1 J	999999	0.14 J	999999	5 U	999999
388439	SUMNER	18-Sep-90	COMP	96.2	0.092 J	999999	1 U	999999	0.11 J	999999	5 U	999999
388440	BUCKLEY	18-Sep-90	COMP	53.6	0.05 U	999999	1 J	999999	0.1 U	999999	5 U	999999
388441	ENUMCLAW	18-Sep-90	COMP	101	0.817	999999	1 U	999999	0.19 J	999999	5 U	999999
388442	RAINSCH	18-Sep-90	COMP	37.6	0.4 J	999999	1 U	999999	0.1 U	999999	5 U	999999
388443	MCCALDER	18-Sep-90	1215	81.4	0.05 U	999999	5.2	999999	0.56	999999	5 U	999999
388444	ORTING	18-Sep-90	COMP	92.4	0.2 J	999999	2 J	999999	0.2 J	999999	5 U	999999
388445	WILKESON	18-Sep-90	COMP	108	0.05 U	999999	1 U	999999	0.46 J	999999	8 J	999999
388446	CARBONADO	18-Sep-90	820	44.3	0.05 U	999999	1 U	999999	0.2 J	999999	5 U	999999
388448	NASEMI	18-Sep-90	COMP	363	0.05 U	999999	1 U	999999	0.1 J	999999	5 U	999999
388449	FLEISCHMA	18-Sep-90	1435	102	0.05 U	999999	1 U	999999	0.1 U	999999	5 U	999999
388450	SONOCO	18-Sep-90	COMP	50 J	0.05 UJ	999999	5.45	999999	0.22 J	999999	5 U	999999
388451	MAZZA	18-Sep-90	COMP	111	0.05 U	999999	1.2 J	999999	0.1 U	999999	5 U	999999
388452	BOEING2	18-Sep-90	1245	72.4	0.05 U	999999	1 U	999999	0.11 J	999999	5 U	999999
388453	GOVT CANAL	18-Sep-90	1320	71.9	0.05 U	999999	1 U	999999	0.11 J	999999	5 U	999999
388454	BOI05.8	18-Sep-90	1625	20	0.05 U	999999	1 U	999999	0.1 U	999999	5 U	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
388455	WEYCO EFF	18-Sep-90	1640	26.7	0.05 U	999999	2.7 J	999999	0.1 U	999999	5 U	999999
388456	TRTCOIN	18-Sep-90	1040	999999	999999	999999	999999	999999	999999	999999	999999	999999
388457	TRTCOEFF	18-Sep-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999
388458	PUYTRBIN	18-Sep-90	1205	999999	999999	999999	999999	999999	999999	999999	999999	999999
388459	PUYTRBEFF	18-Sep-90	1235	999999	999999	999999	999999	999999	999999	999999	999999	999999
388460	DOWIN	18-Sep-90	1320	999999	999999	999999	999999	999999	999999	999999	999999	999999
388461	DOWEFF	18-Sep-90	1355	999999	999999	999999	999999	999999	999999	999999	999999	999999
388462	MUCTRBIN	19-Sep-90	1110	999999	999999	999999	999999	999999	999999	999999	999999	999999
388463	MUCTRBEFF	19-Sep-90	1125	999999	999999	999999	999999	999999	999999	999999	999999	999999
388464	TRTSPRIN	18-Sep-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999
388465	TRTSPREFF	18-Sep-90	905	999999	999999	999999	999999	999999	999999	999999	999999	999999
388466	DOFIN	19-Sep-90	840	999999	999999	999999	999999	999999	999999	999999	999999	999999
388467	DOFEFF	19-Sep-90	910	999999	999999	999999	999999	999999	999999	999999	999999	999999
388474	BLANK-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
388475	BLANK-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
388476	X-ORT	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
388490	SRPQA-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
388491	SRPQA-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
388500	PUY18.0	19-Sep-90	1605	24	0.05 U	0.05 U	1 U	1 U	0.19 J	0.1 U	5 U	5 U
388501	PUY12.2	19-Sep-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999
388502	PUY08.3	19-Sep-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999
388503	PUY05.7	19-Sep-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999
388504	PUY01.5	19-Sep-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999
388505	PUY00.8	19-Sep-90	1200	999999	999999	999999	999999	999999	999999	999999	999999	999999
388506	CAR17.7	19-Sep-90	1300	9.79	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388507	CAR06.1	19-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999
388508	CAR02.0	19-Sep-90	1535	999999	999999	999999	999999	999999	999999	999999	999999	999999
388509	WIL04.2	19-Sep-90	1330	50	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388510	SPR07.2	19-Sep-90	1350	37.6	0.05 U	0.05 U	1 U	1 U	0.11 J	0.1 JB	5 U	5 U
388511	SPR05.8	19-Sep-90	1410	999999	999999	999999	999999	999999	999999	999999	999999	999999
388512	SPR01.1	19-Sep-90	1450	999999	999999	999999	999999	999999	999999	999999	999999	999999
388513	WHI25.2	19-Sep-90	1440	22.2	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388515	WHI23.1	19-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999
388516	WHI20.4	19-Sep-90	1540	999999	999999	999999	999999	999999	999999	999999	999999	999999
388518	WHI10.3	19-Sep-90	1640	999999	999999	999999	999999	999999	999999	999999	999999	999999
388519	WHI08.0	19-Sep-90	1700	999999	999999	999999	999999	999999	999999	999999	999999	999999
388520	WHI06.3	19-Sep-90	1730	999999	999999	999999	999999	999999	999999	999999	999999	999999
388521	WHI04.9	19-Sep-90	1750	999999	999999	999999	999999	999999	999999	999999	999999	999999
388522	LTD03.6	19-Sep-90	1135	19.2	999999	999999	999999	999999	999999	999999	999999	999999
388523	WHI01.4	19-Sep-90	1830	999999	999999	999999	999999	999999	999999	999999	999999	999999
388524	WHI00.7	19-Sep-90	1850	999999	999999	999999	999999	999999	999999	999999	999999	999999
388526	SWAN	19-Sep-90	1605	999999	999999	999999	999999	999999	999999	999999	999999	999999
388527	CLARKS	19-Sep-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999
388528	FENNEL	20-Sep-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999
388529	CANYONFA	19-Sep-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999
388530	VOIGHT	20-Sep-90	1550	999999	999999	999999	999999	999999	999999	999999	999999	999999
388531	LILY	19-Sep-90	935	25.8	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
388532	STRAWBER	19-Sep-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999
388534	BOI00.1	19-Sep-90	1025	999999	999999	999999	999999	999999	999999	999999	999999	999999
388535	PTR13.0	19-Sep-90	1545	999999	999999	999999	999999	999999	999999	999999	999999	999999
388537	WTR01.3	19-Sep-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
388538	PUYALLUP	19-Sep-90	COMP	81.9	2.04	999999	1.3 J	999999	0.12 J	999999	5 U	999999
388539	SUMNER	19-Sep-90	COMP	92.9	0.15 J	999999	1.2 J	999999	0.14 J	999999	5 U	999999
388540	BUCKLEY	19-Sep-90	COMP	50	0.05 U	999999	2.2 J	999999	0.1 U	999999	5 U	999999
388541	ENUMCLAW	19-Sep-90	COMP	102	1.19	999999	1.4 J	999999	0.19 J	999999	5 U	999999
388542	RAINSCH	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388543	MCCALDER	19-Sep-90	1140	999999	999999	999999	999999	999999	999999	999999	999999	999999
388544	ORTING	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388545	WILKESON	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388546	CARBONADO	19-Sep-90	810	999999	999999	999999	999999	999999	999999	999999	999999	999999
388548	NASEMI	19-Sep-90	COMP	389	0.05 U	999999	1.2 J	999999	0.1 U	999999	10 J	999999
388549	FLEISCHMA	19-Sep-90	1425	999999	999999	999999	999999	999999	999999	999999	999999	999999
388550	SONOCO	19-Sep-90	COMP	175	0.05 U	999999	4.6 J	999999	0.6	999999	5 U	999999
388551	MAZZA	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388552	BOEING2	19-Sep-90	1215	999999	999999	999999	999999	999999	999999	999999	999999	999999
388553	GOVT CANAL	19-Sep-90	1300	999999	999999	999999	999999	999999	999999	999999	999999	999999
388554	BOI05.8	19-Sep-90	1130	999999	999999	999999	999999	999999	999999	999999	999999	999999
388555	WEYCO EFF	19-Sep-90	1200	999999	999999	999999	999999	999999	0.1 U	999999	999999	999999
388556	TRTCOIN	20-Sep-90	1115	999999	999999	999999	999999	999999	999999	999999	999999	999999
388557	TRTCOEFF	20-Sep-90	1130	999999	999999	999999	999999	999999	999999	999999	999999	999999
388558	PUYTRBIN	19-Sep-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999
388559	PUYTRBEFF	19-Sep-90	1310	999999	999999	999999	999999	999999	999999	999999	999999	999999
388560	DOWIN	19-Sep-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999
388561	DOWEFF	19-Sep-90	1420	999999	999999	999999	999999	999999	999999	999999	999999	999999
388562	MUCTRBIN	20-Sep-90	1325	999999	999999	999999	999999	999999	999999	999999	999999	999999
388563	MUCTRBEFF	20-Sep-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999
388564	TRTSPRIN	20-Sep-90	910	999999	999999	999999	999999	999999	999999	999999	999999	999999
388565	TRTSPREFF	20-Sep-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999
388566	DOFIN	20-Sep-90	1450	999999	999999	999999	999999	999999	999999	999999	999999	999999
388567	DOFEFF	20-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999
388570	PUYALLUP	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388571	SUMNER	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388572	BUCKLEY	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
388573	ENUMCLAW	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
408400	PUY18.0	02-Oct-90	1655	26.5	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408401	PUY12.2	02-Oct-90	1727	29.8	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408402	PUY08.3	02-Oct-90	1530	24.5	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408403	PUY05.7	02-Oct-90	1600	24.7	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408404	PUY01.5	02-Oct-90	1200	38.7	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408405	PUY00.8	02-Oct-90	1120	75.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408406	CAR17.7	02-Oct-90	1200	9.5	0.074 J	0.05 U	1 U	1 U	0.36 J	0.1 U	5 U	5 U
408407	CAR06.1	02-Oct-90	1520	53.5	999999	999999	999999	999999	999999	999999	999999	999999
408408	CAR02.0	02-Oct-90	1615	27	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408409	WIL04.2	02-Oct-90	1250	79.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408410	SPR07.2	02-Oct-90	1330	39.4	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408411	SPR05.8	02-Oct-90	1355	999999	999999	999999	999999	999999	999999	999999	999999	999999
408412	SPR01.1	02-Oct-90	1435	53.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408413	WHI25.2	02-Oct-90	820	23.1	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408415	WHI23.1	02-Oct-90	840	27.4	0.05 U	0.05 U	1 U	1 U	0.18 J	0.1 U	5 U	5 U
408416	WHI20.4	02-Oct-90	920	999999	999999	999999	999999	999999	999999	999999	999999	999999
408417	WHI14.9	02-Oct-90	1020	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
408418	WHI10.3	02-Oct-90	1310	33.2	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408419	WHI08.0	02-Oct-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999
408420	WHI06.3	02-Oct-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999
408421	WHI04.9	02-Oct-90	1840	33	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408422	LTD03.6	02-Oct-90	1915	20.1	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408423	WHI01.4	02-Oct-90	1430	999999	999999	999999	999999	999999	999999	999999	999999	999999
408424	WHI00.7	02-Oct-90	1450	22.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408425	CLEAR	02-Oct-90	915	79.2	0.05 U	0.05 U	1.2 J	1 U	0.1 U	0.1 U	5 U	5 U
408426	SWAN	02-Oct-90	830	67	0.05 U	0.05 U	1 U	1.1 J	0.1 U	0.1 U	5 U	5 U
408427	CLARKS	02-Oct-90	1000	77.7	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408428	FENNEL	02-Oct-90	1130	69	0.05 U	0.05 U	1 U	1.3 J	0.15 J	0.1 U	5 U	5 U
408429	CANYONFA	04-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999
408430	VOIGHT	03-Oct-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999
408432	STRAWBER	02-Oct-90	1210	71.6	0.05 U	0.05 U	1 U	1 U	0.53	0.1 U	5 U	5 U
408434	BOI00.1	02-Oct-90	1600	51.3	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408436	WTR15.0	02-Oct-90	1410	77.7	0.05 U	0.05 U	1 U	1 U	0.15 BJ	0.1 U	5 U	5 U
408437	WTR01.3	02-Oct-90	1045	103	0.05 U	2.51 *	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408438	PUYALLUP	02-Oct-90	COMP	80.7	1.17	999999	1 J	999999	0.18 BJ	999999	5 U	999999
408439	SUMNER	02-Oct-90	COMP	95.4	0.05 U	999999	1.6 J	999999	0.14 JB	999999	5 U	999999
408440	BUCKLEY	02-Oct-90	COMP	42.6	0.05 U	999999	1.9 J	999999	0.21 JB	999999	5 U	999999
408441	ENUMCLAW	02-Oct-90	COMP	98	0.596	999999	1.2 J	999999	0.25 JB	999999	5 U	999999
408442	RAINSCH	02-Oct-90	COMP	35.2	0.12 J	999999	1 U	999999	0.1 U	999999	5 U	999999
408443	MCCALDER	02-Oct-90	1155	82.7	0.05 U	999999	7.3	999999	0.97 JB	999999	5 U	999999
408444	ORTING	02-Oct-90	COMP	107	0.13 J	999999	3.1 J	999999	0.14 JB	999999	5 U	999999
408445	WILKESON	02-Oct-90	COMP	117	0.057 J	999999	1.4 J	999999	0.46 JB	999999	5 U	999999
408446	CARBONADO	02-Oct-90	1015	46.2	0.05 U	999999	1 U	999999	0.25 JB	999999	5 U	999999
408448	NASEMI	02-Oct-90	COMP	366	999999	999999	999999	999999	999999	999999	999999	999999
408449	FLEISCHMA	02-Oct-90	1427	103	0.05 U	999999	2.2 J	999999	0.1 U	999999	5 U	999999
408450	SONOCO	02-Oct-90	COMP	189	0.05 U	999999	2.2 J	999999	0.23 JB	999999	6 J	999999
408451	MAZZA	02-Oct-90	COMP	128	0.05 U	999999	1 U	999999	0.24 J	999999	5 U	999999
408452	BOEING2	02-Oct-90	1232	64.5	0.05 U	999999	1.8 J	999999	0.31 J	999999	7 J	999999
408453	GOVT CANAL	02-Oct-90	1300	77.7	0.15 J	999999	1 U	999999	0.1 U	999999	5 U	999999
408454	BOI05.8	02-Oct-90	1500	19.6	0.05 U	999999	1 U	999999	0.1 U	999999	5 U	999999
408455	WEYCO EFF	02-Oct-90	1530	26.4	0.084 J	999999	2.9 J	999999	0.1 U	999999	5 U	999999
408456	TRTCOIN	04-Oct-90	950	999999	999999	999999	999999	999999	999999	999999	999999	999999
408457	TRTCOEFF	04-Oct-90	1005	999999	999999	999999	999999	999999	999999	999999	999999	999999
408458	PUYTRBIN	04-Oct-90	1125	999999	999999	999999	999999	999999	999999	999999	999999	999999
408459	PUYTRBEFF	04-Oct-90	1140	999999	999999	999999	999999	999999	999999	999999	999999	999999
408460	DOWIN	03-Oct-90	1305	999999	999999	999999	999999	999999	999999	999999	999999	999999
408461	DOWEFF	03-Oct-90	1335	999999	999999	999999	999999	999999	999999	999999	999999	999999
408462	MUCTRBIN	04-Oct-90	1320	999999	999999	999999	999999	999999	999999	999999	999999	999999
408463	MUCTRBEFF	04-Oct-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999
408464	TRTSPRIN	04-Oct-90	825	999999	999999	999999	999999	999999	999999	999999	999999	999999
408465	TRTSPREFF	04-Oct-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999
408466	DOFIN	03-Oct-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999
408467	DOFEFF	03-Oct-90	905	999999	999999	999999	999999	999999	999999	999999	999999	999999
408470	BLANK T-1	02-Oct-90		999999	0.085 J	999999	1 U	999999	0.1 U	999999	5 U	999999
408471	BLANK T-2	02-Oct-90		999999	0.05 U	999999	1 U	999999	0.15 J	999999	5 U	999999
408472	FLTR B-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408473	FLTR B-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408474	ENUM OUT	02-Oct-90	835	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
408475	ORT-OUT	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408476	FLTR B-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408480	PUY01.5	02-Oct-90	1640	60.4	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408481	PUY00.8	02-Oct-90	1700	150	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408490	SRPQA-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408491	SRPQA-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408492	SRPQA-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408493	SRPQA-4	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999
408500	PUY18.0	03-Oct-90	1500	28.4	0.05 U	0.05 U	1 U	1 U	0.1 U	0.11 J	5 U	5 U
408501	PUY12.2	03-Oct-90	1520	34.7	0.05 U	0.05 U	1 U	1 U	0.1 U	0.11 J	5 U	5 U
408502	PUY08.3	03-Oct-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999
408503	PUY05.7	03-Oct-90	1700	26.9	0.05 U	0.053 J	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408504	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999
408505	PUY00.8	03-Oct-90	1145	54.8	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408506	CAR17.7	03-Oct-90	1145	9.6	0.05 U	0.05 U	1.2 J	1 U	0.11 J	0.1 U	5 J	5 U
408507	CAR06.1	03-Oct-90	1350	999999	999999	999999	999999	999999	999999	999999	999999	999999
408508	CAR02.0	03-Oct-90	1440	999999	999999	999999	999999	999999	999999	999999	999999	999999
408509	WIL04.2	03-Oct-90	1230	78	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408510	SPR07.2	03-Oct-90	1245	40.2	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408511	SPR05.8	03-Oct-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999
408512	SPR01.1	03-Oct-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999
408513	WHI25.2	03-Oct-90	800	26.2	0.05 U	0.05 U	1.1 J	1 U	0.1 U	0.12 J	5 U	5 U
408515	WHI23.1	03-Oct-90	830	999999	999999	999999	999999	999999	999999	999999	999999	999999
408516	WHI20.4	03-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999
408517	WHI14.9	03-Oct-90	1000	999999	999999	999999	999999	999999	999999	999999	999999	999999
408518	WHI10.3	03-Oct-90	1345	999999	999999	999999	999999	999999	999999	999999	999999	999999
408519	WHI08.0	03-Oct-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999
408520	WHI06.3	03-Oct-90	1430	999999	999999	999999	999999	999999	999999	999999	999999	999999
408521	WHI04.9	03-Oct-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999
408522	LTD03.6	03-Oct-90	1715	19.7	0.05 U	0.23 J	1 U	1 U	0.1 U	0.13 J	5 U	5 U
408523	WHI01.4	03-Oct-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999
408524	WHI00.7	03-Oct-90	1530	23.1	0.05 U	0.05 U	1.2 J	1 U	0.1 U	0.1 U	5 U	5 U
408525	CLEAR	03-Oct-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999
408526	SWAN	03-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999
408527	CLARKS	03-Oct-90	1000	999999	999999	999999	999999	999999	999999	999999	999999	999999
408528	FENNEL	03-Oct-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999
408529	CANYONFA	02-Oct-90	1550	83.2	0.05 U	0.05 U	1.1 J	1 U	0.1 U	0.1 U	5 U	5 U
408530	VOIGHT	02-Oct-90	1510	35.9	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408531	LILY	03-Oct-90	1200	999999	0.05 U	0.16 J	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408532	STRAWBER	03-Oct-90	1600	999999	999999	999999	999999	999999	999999	999999	999999	999999
408533	BOWMAN	03-Oct-90	1450	999999	0.05 U	0.05 U	1 U	1 U	0.1 U	0.11 J	5 U	5 U
408534	BOI00.1	03-Oct-90	1245	999999	999999	999999	999999	999999	999999	999999	999999	999999
408535	PTR13.0	03-Oct-90	1230	79.5	0.05 U	0.05 U	1 U	1 U	0.1 U	0.1 U	5 U	5 U
408538	PUYALLUP	03-Oct-90	COMP	80	1.83	999999	2.1 J	999999	0.16 J	999999	5 U	999999
408539	SUMNER	03-Oct-90	COMP	96.6	0.05 U	999999	1.8 J	999999	0.12 J	999999	5 U	999999
408540	BUCKLEY	03-Oct-90	COMP	41.6	0.05 U	999999	1.8 J	999999	0.1 U	999999	5 U	999999
408541	ENUMCLAW	03-Oct-90	COMP	98.1	1.11	999999	1 J	999999	0.16 J	999999	5 U	999999
408542	RAINSCH	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
408543	MCCALDER	03-Oct-90	1120	999999	999999	999999	999999	999999	999999	999999	999999	999999
408544	ORTING	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
408545	WILKESON	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Ag µg/L	Diss-olved Ag µg/L	Total Recov. As µg/L	Diss-olved As µg/L	Total Recov. Cd µg/L	Diss-olved Cd µg/L	Total Recov. Cr µg/L	Diss-olved Cr µg/L
408546	CARBONADO	03-Oct-90	942	999999	999999	999999	999999	999999	999999	999999	999999	999999
408548	NASEMI	03-Oct-90	COMP	338	0.05 U	999999	1.6 J	999999	0.23 J	999999	5 U	999999
408549	FLEISCHMA	03-Oct-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999
408550	SONOCO	03-Oct-90	COMP	176	0.05 U	999999	2.5 J	999999	0.1 J	999999	5 U	999999
408551	MAZZA	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999
408552	BOEING2	03-Oct-90	1215	999999	999999	999999	999999	999999	999999	999999	999999	999999
408553	GOVT CANAL	03-Oct-90	1520	999999	999999	999999	999999	999999	999999	999999	999999	999999
408554	BOI05.8	03-Oct-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999
408555	WEYCO EFF	03-Oct-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999
408556	TRTCOIN	02-Oct-90	1035	999999	999999	999999	999999	999999	999999	999999	999999	999999
408557	TRTCOEFF	02-Oct-90	1055	999999	999999	999999	999999	999999	999999	999999	999999	999999
408558	PUYTRBIN	02-Oct-90	1145	999999	999999	999999	999999	999999	999999	999999	999999	999999
408559	PUYTRBEFF	02-Oct-90	1200	999999	999999	999999	999999	999999	999999	999999	999999	999999
408560	DOWIN	02-Oct-90	1220	999999	999999	999999	999999	999999	999999	999999	999999	999999
408561	DOWEFF	02-Oct-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999
408562	MUCTRBIN	03-Oct-90	1040	999999	999999	999999	999999	999999	999999	999999	999999	999999
408563	MUCTRBEFF	03-Oct-90	1105	999999	999999	999999	999999	999999	999999	999999	999999	999999
408564	TRTSPRIN	02-Oct-90	835	999999	999999	999999	999999	999999	999999	999999	999999	999999
408565	TRTSPREFF	02-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999
408566	DOFIN	02-Oct-90	1410	999999	999999	999999	999999	999999	999999	999999	999999	999999
408567	DOFEFF	02-Oct-90	1425	999999	999999	999999	999999	999999	999999	999999	999999	999999
408574	ENUM-OUT	03-Oct-90	825	999999	999999	999999	999999	999999	999999	999999	999999	999999
408575	ORT-OUT	03-Oct-90	1050	999999	999999	999999	999999	999999	999999	999999	999999	999999
408580	PUY01.5	03-Oct-90	1745	999999	999999	999999	999999	999999	999999	999999	999999	999999
408581	PUY00.8	03-Oct-90	1800	438	0.054 J	0.05 U	1 J	1 U	0.1 U	0.1 U	5 U	5 U
408582	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
388400	PUY18.0	18-Sep-90	1800	25.5	2.1 J	1 U	0.11 J	0.04 J	10 U	10 U	0.99 BJ	1.1 BJ	14 J	8.1 JB
388401	PUY12.2	18-Sep-90	1850	28.3	2 U	2.1 J	0.04 U	0.02 U	10 U	10 U	0.98 BJ	1.2 JB	13 J	6.6 JB
388402	PUY08.3	18-Sep-90	1940	29.5	2 U	2.9 J	0.04 U	0.045 J	10 U	10 U	0.87 BJ	1.3 JB	6 J	6 JB
388403	PUY05.7	18-Sep-90	2010	30.3	2 U	2.8 J	0.04 U	0.046 J	10 U	10 U	2.64 B	0.95 JB	5.3 J	117
388404	PUY01.5	18-Sep-90	1200	48.1	2 U	2.7 J	0.04 U	0.02 U	10 U	10 U	3.34 B	0.2 U	3.8 J	16 JB
388405	PUY00.8	18-Sep-90	1120	999999	2 U	3 J	0.04 U	0.02 U	10 U	10 U	1.8 BJ	0.2 U	10 J	7.7 JB
388406	CAR17.7	18-Sep-90	1545	999999	2 U	2.1 J	0.04 U	0.02 U	10 U	10 U	0.59 BJ	0.77 JB	5.2 J	5.4 JB
388407	CAR06.1	18-Sep-90	1715	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388408	CAR02.0	18-Sep-90	1735	26.3	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.68 BJ	0.65 JB	2.7 J	2.7 JB
388409	WIL04.2	18-Sep-90	1615	70.9	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.64 BJ	0.2 U	7.5 J	2.9 JB
388410	SPR07.2	18-Sep-90	1630	37	2 U	1 U	0.04 U	0.049 J	10 U	10 U	0.45 BJ	2.34 B	3.3 J	2.3 JB
388411	SPR05.8	18-Sep-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388412	SPR01.1	18-Sep-90	1700	50.1	2 U	1 U	0.04 U	0.04 U	10 U	10 U	0.99 BJ	0.39 JB	10 J	1.9 J
388413	WHI25.2	18-Sep-90	1330	22.2	2 U	1 U	0.04 U	0.04 U	10 U	10 U	0.91 BJ	3.02 B	5.9 J	3.4 JB
388415	WHI23.1	18-Sep-90	1420	23.3	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.89 BJ	1 JB	6.9 J	12 JB
388416	WHI20.4	18-Sep-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388418	WHI10.3	18-Sep-90	1610	27.3	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.45 BJ	0.71 JB	3.7 J	3 JB
388419	WHI08.0	18-Sep-90	1650	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388420	WHI06.3	18-Sep-90	1720	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388421	WHI04.9	18-Sep-90	1740	29	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.46 BJ	0.2 U	6.1 J	6.8 JB
388422	LTD03.6	18-Sep-90	1810	18.7	2 U	1.1 J	0.04 U	0.048 J	10 U	10 U	1 BJ	1.1 JB	3.1 J	4.5 JB
388423	WHI01.4	18-Sep-90	1840	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388424	WHI00.7	18-Sep-90	1900	27.8	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.48 BJ	7.05 B	4.1 J	126
388425	CLEAR	18-Sep-90	1000	77.4	2 U	1 U	0.04 U	0.02 U	10 U	10 U	1 BJ	0.57 JB	3.2 J	4.4 JB
388426	SWAN	18-Sep-90	925	68	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.89 BJ	1 JB	5.1 J	5.1 JB
388427	CLARKS	18-Sep-90	1100	76.9	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.86 BJ	0.2 U	2.8 J	23.4
388428	FENNEL	19-Sep-90	1700	66	2 U	1 U	0.04 U	0.039 J	10 U	10 U	0.46 BJ	0.58 JB	4.2 J	5 JB
388429	CANYONFA	18-Sep-90	1620	82.3	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.67 BJ	0.56 JB	4.3 J	10 JB
388430	VOIGHT	19-Sep-90	930	34.2	2 U	2 U	0.04 U	0.02 U	10 U	10 U	1.1 BJ	29	5.4 J	382
388432	STRAWBER	18-Sep-90	1245	71.4	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.96 BJ	0.38 J	2.5 J	10 JB
388433	BOWMAN	18-Sep-90	1420	27.8	2 U	2 U	0.04 U	0.037 J	10 U	10 U	0.98 BJ	0.69 J	3.3 J	7.4 JB
388434	BOI00.1	18-Sep-90	1710	50.1	8.5 J	3 J	0.04 U	0.02 U	10 U	10 U	1.4 BJ	0.36 J	16 J	6.6 JB
388435	PTR13.0	18-Sep-90	1549	78.4	2 U	1 U	0.04 U	0.02 U	10 U	10 U	1.5 BJ	0.2 U	9.4 J	5.6 JB
388436	WTR15.0	18-Sep-90	1510	79.9	2 U	1.2 J	0.04 U	0.02 U	10 U	10 U	0.5 BJ	0.2 U	2.1 J	6 JB
388437	WTR01.3	18-Sep-90	1155	103	2 U	2.3 J	0.04 U	0.043 J	10 U	10 U	0.72 BJ	1.9 JB	7 J	8.4 JB
388438	PUYALLUP	18-Sep-90	COMP	79.9	23.1	999999	0.15 J	999999	10 U	999999	1.4 BJ	999999	31.2	999999
388439	SUMNER	18-Sep-90	COMP	96.2	12.3	999999	0.11 J	999999	10 U	999999	1.4 BJ	999999	42.9	999999
388440	BUCKLEY	18-Sep-90	COMP	53.6	2 U	999999	0.04 U	999999	10 U	999999	0.75 BJ	999999	34.6	999999
388441	ENUMCLAW	18-Sep-90	COMP	101	42.5	999999	0.04 U	999999	10 U	999999	1.6 BJ	999999	34.1	999999
388442	RAINSCH	18-Sep-90	COMP	37.6	31	999999	0.16 J	999999	10 U	999999	1.9 BJ	999999	80.6	999999
388443	MCCALDER	18-Sep-90	1215	81.4	23.9	999999	0.04 U	999999	10 U	999999	5.69 B	999999	90.7	999999
388444	ORTING	18-Sep-90	COMP	92.4	27.9	999999	0.2 J	999999	10 U	999999	6.82 B	999999	45.8	999999
388445	WILKESON	18-Sep-90	COMP	108	42	999999	0.48 J	999999	11 J	999999	4.86 B	999999	103	999999
388446	CARBONADO	18-Sep-90	820	44.3	6.4 J	999999	0.12 J	999999	10 U	999999	3.11 B	999999	36.8	999999
388448	NASEMI	18-Sep-90	COMP	363	2 U	999999	0.2 J	999999	10 U	999999	0.99 BJ	999999	5.2 J	999999
388449	FLEISCHMA	18-Sep-90	1435	102	2 U	999999	0.04 U	999999	10 U	999999	0.62 BJ	999999	3.8 J	999999
388450	SONOCO	18-Sep-90	COMP	50 J	3.7 J	999999	0.15 J	999999	10 U	999999	3.07 BJ	999999	66.6	999999
388451	MAZZA	18-Sep-90	COMP	111	5.3 J	999999	0.11 J	999999	10 U	999999	1.2 BJ	999999	54.8	999999
388452	BOEING2	18-Sep-90	1245	72.4	39	999999	0.04 U	999999	10 U	999999	1.4 BJ	999999	38.4	999999
388453	GOVT CANAL	18-Sep-90	1320	71.9	2 U	999999	0.04 U	999999	10 U	999999	0.82 BJ	999999	15 J	999999
388454	BOI05.8	18-Sep-90	1625	20	2 U	999999	0.11 J	999999	10 U	999999	0.63 BJ	999999	5.2 J	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
388455	WEYCO EFF	18-Sep-90	1640	26.7	2 U	999999	0.04 U	999999	10 U	999999	1.3 BJ	999999	14 J	999999
388456	TRTCOIN	18-Sep-90	1040	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388457	TRTCOEFF	18-Sep-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388458	PUYTRBIN	18-Sep-90	1205	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388459	PUYTRBEFF	18-Sep-90	1235	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388460	DOWIN	18-Sep-90	1320	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388461	DOWEFF	18-Sep-90	1355	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388462	MUCTRBIN	19-Sep-90	1110	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388463	MUCTRBEFF	19-Sep-90	1125	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388464	TRTSPRIN	18-Sep-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388465	TRTSPREFF	18-Sep-90	905	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388466	DOFIN	19-Sep-90	840	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388467	DOFEFF	19-Sep-90	910	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388474	BLANK-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388475	BLANK-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388476	X-ORT	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388490	SRPQA-1	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388491	SRPQA-2	18-Sep-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388500	PUY18.0	19-Sep-90	1605	24	6.1 J	2.3 J	0.04 U	0.02 U	10 U	10 U	1.5 BJ	0.39 JB	15 J	312
388501	PUY12.2	19-Sep-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388502	PUY08.3	19-Sep-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388503	PUY05.7	19-Sep-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388504	PUY01.5	19-Sep-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388505	PUY00.8	19-Sep-90	1200	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388506	CAR17.7	19-Sep-90	1300	9.79	2.7 J	1 U	0.04 U	0.02 U	10 U	10 U	0.89 BJ	3.41 B	5 J	3.8 JB
388507	CAR06.1	19-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388508	CAR02.0	19-Sep-90	1535	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388509	WIL04.2	19-Sep-90	1330	50	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.3 BJ	0.2 U	5.3 J	6.4 JB
388510	SPR07.2	19-Sep-90	1350	37.6	2 U	1 U	0.04 U	0.02 U	10 U	10 U	0.2 BJ	0.22 JB	2.9 J	3.6 JB
388511	SPR05.8	19-Sep-90	1410	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388512	SPR01.1	19-Sep-90	1450	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388513	WHI25.2	19-Sep-90	1440	22.2	2.4 J	1 U	0.04 U	0.02 U	10 U	10 U	1.1 BJ	0.36 JB	6 J	5.8 JB
388515	WHI23.1	19-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388516	WHI20.4	19-Sep-90	1540	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388518	WHI10.3	19-Sep-90	1640	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388519	WHI08.0	19-Sep-90	1700	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388520	WHI06.3	19-Sep-90	1730	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388521	WHI04.9	19-Sep-90	1750	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388522	LTD03.6	19-Sep-90	1135	19.2	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388523	WHI01.4	19-Sep-90	1830	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388524	WHI00.7	19-Sep-90	1850	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388526	SWAN	19-Sep-90	1605	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388527	CLARKS	19-Sep-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388528	FENNEL	20-Sep-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388529	CANYONFA	19-Sep-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388530	VOIGHT	20-Sep-90	1550	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388531	LILY	19-Sep-90	935	25.8	2 U	2 U	0.11 J	0.02 U	10 U	10 U	0.38 BJ	0.78 J	4.3 J	40.5
388532	STRAWBER	19-Sep-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388534	BOI00.1	19-Sep-90	1025	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388535	PTR13.0	19-Sep-90	1545	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388537	WTR01.3	19-Sep-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
388538	PUYALLUP	19-Sep-90	COMP	81.9	18	999999	0.12 J	999999	10 U	999999	1 BJ	999999	29.3	999999
388539	SUMNER	19-Sep-90	COMP	92.9	16	999999	0.13 J	999999	10 U	999999	2.02 B	999999	44.7	999999
388540	BUCKLEY	19-Sep-90	COMP	50	2 U	999999	0.11 J	999999	10 U	999999	0.69 BJ	999999	33.4	999999
388541	ENUMCLAW	19-Sep-90	COMP	102	49.1	999999	0.13 J	999999	10 U	999999	1.6 BJ	999999	39	999999
388542	RAINSCH	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388543	MCCALDER	19-Sep-90	1140	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388544	ORTING	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388545	WILKESON	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388546	CARBONADO	19-Sep-90	810	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388548	NASEMI	19-Sep-90	COMP	389	2.6 J	999999	0.14 J	999999	10 U	999999	0.81 BJ	999999	3.4 J	999999
388549	FLEISCHMA	19-Sep-90	1425	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388550	SONOCO	19-Sep-90	COMP	175	19	999999	0.18 J	999999	14 J	999999	7.75 BJ	999999	149	999999
388551	MAZZA	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388552	BOEING2	19-Sep-90	1215	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388553	GOVT CANAL	19-Sep-90	1300	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388554	BOI05.8	19-Sep-90	1130	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388555	WEYCO EFF	19-Sep-90	1200	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388556	TRTCOIN	20-Sep-90	1115	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388557	TRTCOEFF	20-Sep-90	1130	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388558	PUYTRBIN	19-Sep-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388559	PUYTRBEFF	19-Sep-90	1310	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388560	DOWIN	19-Sep-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388561	DOWEFF	19-Sep-90	1420	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388562	MUCTRBIN	20-Sep-90	1325	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388563	MUCTRBEFF	20-Sep-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388564	TRTSPRIN	20-Sep-90	910	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388565	TRTSPREFF	20-Sep-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388566	DOFIN	20-Sep-90	1450	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388567	DOFEFF	20-Sep-90	1510	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388570	PUYALLUP	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388571	SUMNER	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388572	BUCKLEY	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
388573	ENUMCLAW	19-Sep-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408400	PUY18.0	02-Oct-90	1655	26.5	3.5 J	2 U	0.04 U	0.02 U	10 U	10 U	1.5 BJ	0.3 JB	7.2 JB	3 J
408401	PUY12.2	02-Oct-90	1727	29.8	3.5 J	2 U	0.04 U	0.02 U	10 U	10 U	0.83 BJ	0.49 JB	5.3 JB	41.9 *
408402	PUY08.3	02-Oct-90	1530	24.5	3.5 J	2 U	0.04 U	0.02 U	10 U	10 U	1.2 BJ	0.32 JB	4 JB	3.7 J
408403	PUY05.7	02-Oct-90	1600	24.7	5.6 J	2 U	0.08 J	0.02 U	10 U	10 U	1.4 BJ	0.79 JB	8.1 JB	3.6 J
408404	PUY01.5	02-Oct-90	1200	38.7	3.8 J	2 U	0.08 J	0.02 U	10 U	10 U	1 BJ	0.92 JB	6.2 JB	4.2 J
408405	PUY00.8	02-Oct-90	1120	75.3	4.8 J	2 U	0.04 U	0.02 U	10 U	10 U	1.2 BJ	1.3 JB	6.8 JB	4.3 J
408406	CAR17.7	02-Oct-90	1200	9.5	4.9 J	2 U	0.08 J	0.02 U	10 U	10 U	0.92 BJ	0.85 JB	4.4 JB	6.7 J
408407	CAR06.1	02-Oct-90	1520	53.5	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408408	CAR02.0	02-Oct-90	1615	27	3.8 J	2 U	0.04 U	0.02 U	10 U	10 U	0.73 BJ	1.3 JB	4.3 JB	3.6 J
408409	WIL04.2	02-Oct-90	1250	79.3	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.62 BJ	0.84 JB	11 JB	5.5 J
408410	SPR07.2	02-Oct-90	1330	39.4	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.51 BJ	0.75 JB	6.6 JB	3.4 J
408411	SPR05.8	02-Oct-90	1355	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408412	SPR01.1	02-Oct-90	1435	53.3	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.4 BJ	0.68 JB	2.8 JB	2.1 J
408413	WHI25.2	02-Oct-90	820	23.1	5.4 J	2.8 J	0.04 U	0.02 U	10 U	10 U	1.1 BJ	1.1 JB	6.1 JB	8.8 J
408415	WHI23.1	02-Oct-90	840	27.4	4.9 J	2 U	0.04 U	0.02 U	10 U	10 U	1.2 BJ	0.83 JB	15 JB	10 J
408416	WHI20.4	02-Oct-90	920	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408417	WHI14.9	02-Oct-90	1020	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
408418	WHI10.3	02-Oct-90	1310	33.2	3.2 J	2 U	0.04 U	0.02 U	10 U	10 U	0.78 BJ	0.49 JB	9.8 JB	2 U
408419	WHI08.0	02-Oct-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408420	WHI06.3	02-Oct-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408421	WHI04.9	02-Oct-90	1840	33	2.2 J	2 U	0.04 U	0.02 U	10 U	10 U	0.8 BJ	0.44 JB	3.4 JB	2.4 J
408422	LTD03.6	02-Oct-90	1915	20.1	2.7 J	2 U	0.04 U	0.02 U	10 U	10 U	0.49 BJ	3.8 B	11 JB	5.3 J
408423	WHI01.4	02-Oct-90	1430	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408424	WHI00.7	02-Oct-90	1450	22.3	4.1 J	2 U	0.04 U	0.02 U	10 U	10 U	1.3 BJ	0.61 JB	4.6 JB	7.6 J
408425	CLEAR	02-Oct-90	915	79.2	2 U	2.2 J	0.04 U	0.02 U	10 U	10 U	1.2 BJ	0.92 JB	8.6 JB	2.1 J
408426	SWAN	02-Oct-90	830	67	3 J	2.2 J	0.04 U	0.02 U	10 U	10 U	1 BJ	1 JB	7.4 JB	5.1 J
408427	CLARKS	02-Oct-90	1000	77.7	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.68 BJ	1.5 JB	4.8 JB	5.4 J
408428	FENNEL	02-Oct-90	1130	69	2.7 J	2 U	0.04 U	0.02 U	10 U	10 U	0.67 BJ	2.3 B	6.4 JB	3.9 J
408429	CANYONFA	04-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408430	VOIGHT	03-Oct-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408432	STRAWBER	02-Oct-90	1210	71.6	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.9 BJ	0.66 JB	11 JB	2.8 J
408434	BOI00.1	02-Oct-90	1600	51.3	2.2 J	2 U	0.04 U	0.02 U	10 U	10 U	0.48 BJ	0.34 JB	6.8 JB	2.5 J
408436	WTR15.0	02-Oct-90	1410	77.7	3 J	2 U	0.08 J	0.02 U	10 U	10 U	1.7 BJ	0.72 JB	11 J	2.2 J
408437	WTR01.3	02-Oct-90	1045	103	2 U	2 U	0.04 U	0.02 U	10 U	10 U	1.2 BJ	1.2 JB	6.7 J	3.3 J
408438	PUYALLUP	02-Oct-90	COMP	80.7	24.6	999999	0.16 J	999999	10 U	999999	2.35 B	999999	25.6	999999
408439	SUMNER	02-Oct-90	COMP	95.4	12	999999	0.13 J	999999	10 U	999999	1.7 BJ	999999	42.2	999999
408440	BUCKLEY	02-Oct-90	COMP	42.6	5.7 J	999999	0.13 J	999999	10 U	999999	1 BJ	999999	36.4	999999
408441	ENUMCLAW	02-Oct-90	COMP	98	49.4	999999	0.11 J	999999	10 U	999999	2.17 B	999999	34.6	999999
408442	RAINSCH	02-Oct-90	COMP	35.2	31.6	999999	0.17 J	999999	10 U	999999	2.47 B	999999	88.6	999999
408443	MCCALDER	02-Oct-90	1155	82.7	14.3	999999	0.04 U	999999	10 U	999999	5.49 B	999999	70.9	999999
408444	ORTING	02-Oct-90	COMP	107	19.2	999999	0.14 J	999999	10 U	999999	4.61 B	999999	29.5 B	999999
408445	WILKESON	02-Oct-90	COMP	117	38.9	999999	0.35 J	999999	10 U	999999	4.83 B	999999	86.7	999999
408446	CARBONADO	02-Oct-90	1015	46.2	13.2	999999	0.08 J	999999	10 U	999999	3.06 B	999999	51.8	999999
408448	NASEMI	02-Oct-90	COMP	366	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408449	FLEISCHMA	02-Oct-90	1427	103	2.7 J	999999	0.04 U	999999	10 U	999999	0.93 BJ	999999	5.8 J	999999
408450	SONOCO	02-Oct-90	COMP	189	5.1 J	999999	0.04 U	999999	10 U	999999	2.06 BJ	999999	45.4	999999
408451	MAZZA	02-Oct-90	COMP	128	6.5 J	999999	0.04 U	999999	10 U	999999	2.42 B	999999	76.7	999999
408452	BOEING2	02-Oct-90	1232	64.5	35.7	999999	0.08 J	999999	10 U	999999	14.8	999999	207	999999
408453	GOVT CANAL	02-Oct-90	1300	77.7	2 U	999999	0.04 U	999999	10 U	999999	5.57	999999	17 JB	999999
408454	BOI05.8	02-Oct-90	1500	19.6	2 U	999999	0.04 U	999999	10 U	999999	0.32 JB	999999	4.5 JB	999999
408455	WEYCO EFF	02-Oct-90	1530	26.4	2 U	999999	0.08 J	999999	10 U	999999	1.4 JB	999999	6.1 JB	999999
408456	TRTCOIN	04-Oct-90	950	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408457	TRTCOEFF	04-Oct-90	1005	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408458	PUYTRBIN	04-Oct-90	1125	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408459	PUYTRBEFF	04-Oct-90	1140	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408460	DOWIN	03-Oct-90	1305	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408461	DOWEFF	03-Oct-90	1335	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408462	MUCTRBIN	04-Oct-90	1320	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408463	MUCTRBEFF	04-Oct-90	1340	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408464	TRTSPRIN	04-Oct-90	825	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408465	TRTSPREFF	04-Oct-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408466	DOFIN	03-Oct-90	845	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408467	DOFEFF	03-Oct-90	905	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408470	BLANK T-1	02-Oct-90		999999	2 U	999999	0.08 J	999999	10 U	999999	0.38 JB	999999	2 U	999999
408471	BLANK T-2	02-Oct-90		999999	2 U	999999	0.08 J	999999	10 U	999999	0.59 JB	999999	6.9 JB	999999
408472	FLTR B-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408473	FLTR B-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408474	ENUM OUT	02-Oct-90	835	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
408475	ORT-OUT	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408476	FLTR B-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408480	PUY01.5	02-Oct-90	1640	60.4	2 U	2 U	0.04 U	0.02 U	10 U	10 U	3.77 B	0.42 JB	5.1 JB	2.5 J
408481	PUY00.8	02-Oct-90	1700	150	4.7 J	2 U	0.04 U	0.02 U	10 U	10 U	0.71 JB	1.1 JB	4.1 JB	4.4 J
408490	SRPQA-1	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408491	SRPQA-2	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408492	SRPQA-3	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408493	SRPQA-4	02-Oct-90		999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408500	PUY18.0	03-Oct-90	1500	28.4	2.3 J	2.6 J	0.044 J	0.02 U	10 U	10 U	1.1 JB	0.86 B	9.5 J	4.5 JB
408501	PUY12.2	03-Oct-90	1520	34.7	11 J	2 U	0.036 J	0.02 U	10 U	10 U	1.3 JB	0.7 JB	8.3 J	6.9 JB
408502	PUY08.3	03-Oct-90	1630	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408503	PUY05.7	03-Oct-90	1700	26.9	2 U	2 U	0.02 U	0.02 U	10 U	10 U	2.3 B	1 JB	5.9 J	5.5 JB
408504	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408505	PUY00.8	03-Oct-90	1145	54.8	2.1 J	2.1 J	0.042 J	0.02 U	10 U	10 U	1.2 JB	0.57 JB	5 J	4.6 JB
408506	CAR17.7	03-Oct-90	1145	9.6	35.9	2 U	0.02 U	0.02 U	18 J	10 U	6.11	0.81 JB	25.2	2 U
408507	CAR06.1	03-Oct-90	1350	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408508	CAR02.0	03-Oct-90	1440	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408509	WIL04.2	03-Oct-90	1230	78	2 U	2 U	0.02 U	0.02 U	10 U	10 U	1.3 JB	1.3 JB	4.4 J	13 JB
408510	SPR07.2	03-Oct-90	1245	40.2	2 U	3.7 J	0.02 U	0.02 U	10 U	10 U	0.57 JB	0.55 JB	2.9 J	11 JB
408511	SPR05.8	03-Oct-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408512	SPR01.1	03-Oct-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408513	WHI25.2	03-Oct-90	800	26.2	2 U	2.4 J	0.02 U	0.02 U	10 U	10 U	0.62 JB	1.7 JB	5.3 J	6.7 JB
408515	WHI23.1	03-Oct-90	830	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408516	WHI20.4	03-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408517	WHI14.9	03-Oct-90	1000	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408518	WHI10.3	03-Oct-90	1345	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408519	WHI08.0	03-Oct-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408520	WHI06.3	03-Oct-90	1430	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408521	WHI04.9	03-Oct-90	1645	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408522	LTD03.6	03-Oct-90	1715	19.7	2 U	2 U	0.02 U	0.02 U	10 U	10 U	0.57 JB	1.3 JB	7.5 J	6.7 JB
408523	WHI01.4	03-Oct-90	1500	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408524	WHI00.7	03-Oct-90	1530	23.1	2 U	2 U	0.02 U	0.02 U	10 U	10 U	1.6 JB	0.44 JB	5.1 J	7.4 JB
408525	CLEAR	03-Oct-90	930	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408526	SWAN	03-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408527	CLARKS	03-Oct-90	1000	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408528	FENNEL	03-Oct-90	1100	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408529	CANYONFA	02-Oct-90	1550	83.2	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.35 JB	0.4 JB	4.7 JB	3.4 J
408530	VOIGHT	02-Oct-90	1510	35.9	2 U	2 U	0.04 U	0.02 U	10 U	10 U	0.38 JB	0.71 JB	2.9 JB	4.8 J
408531	LILY	03-Oct-90	1200	999999	2 U	2 U	0.02 U	0.02 U	10 U	10 U	0.47 JB	0.61 JB	4.4 J	2 U
408532	STRAWBER	03-Oct-90	1600	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408533	BOWMAN	03-Oct-90	1450	999999	3.9 J	2 U	0.02 U	0.021 J	10 U	10 U	0.5 JB	0.68 JB	8.7 J	6.6 JB
408534	BOI00.1	03-Oct-90	1245	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408535	PTR13.0	03-Oct-90	1230	79.5	2 U	2 U	0.055 J	0.02 U	10 U	10 U	0.8 JB	2.78 B	15 J	15 JB
408538	PUYALLUP	03-Oct-90	COMP	80	23.7	999999	0.11 J	999999	10 U	999999	1.1 JB	999999	29.9	999999
408539	SUMNER	03-Oct-90	COMP	96.6	9.3 J	999999	0.039 J	999999	10 U	999999	1.6 JB	999999	44.8	999999
408540	BUCKLEY	03-Oct-90	COMP	41.6	2 U	999999	0.061 J	999999	10 U	999999	0.95 JB	999999	39.4	999999
408541	ENUMCLAW	03-Oct-90	COMP	98.1	37.8	999999	0.065 J	999999	10 U	999999	2.02 B	999999	33	999999
408542	RAINSCH	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408543	MCCALDER	03-Oct-90	1120	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408544	ORTING	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408545	WILKESON	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

Sample Number	Station Name (See Table 2.3)	Date	Time	Hardness mgCaCO3/L	Total Recov. Cu µg/L	Diss-olved Cu µg/L	Total Hg µg/L	Diss-olved Hg µg/L	Total Recov. Ni µg/L	Diss-olved Ni µg/L	Total Recov. Pb µg/L	Diss-olved Pb µg/L	Total Recov. Zn µg/L	Diss-olved Zn µg/L
408546	CARBONADO	03-Oct-90	942	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408548	NASEMI	03-Oct-90	COMP	338	2 U	999999	0.044 J	999999	10 U	999999	3.92 B	999999	7.1 J	999999
408549	FLEISCHMA	03-Oct-90	1415	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408550	SONOCO	03-Oct-90	COMP	176	2 U	999999	0.067 J	999999	13 J	999999	8.39 J	999999	41.6	999999
408551	MAZZA	03-Oct-90	COMP	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408552	BOEING2	03-Oct-90	1215	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408553	GOVT CANAL	03-Oct-90	1520	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408554	BOI05.8	03-Oct-90	1330	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408555	WEYCO EFF	03-Oct-90	1400	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408556	TRTCOIN	02-Oct-90	1035	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408557	TRTCOEFF	02-Oct-90	1055	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408558	PUYTRBIN	02-Oct-90	1145	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408559	PUYTRBEFF	02-Oct-90	1200	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408560	DOWIN	02-Oct-90	1220	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408561	DOWEFF	02-Oct-90	1255	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408562	MUCTRBIN	03-Oct-90	1040	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408563	MUCTRBEFF	03-Oct-90	1105	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408564	TRTSPRIN	02-Oct-90	835	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408565	TRTSPREFF	02-Oct-90	900	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408566	DOFIN	02-Oct-90	1410	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408567	DOFEFF	02-Oct-90	1425	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408574	ENUM-OUT	03-Oct-90	825	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408575	ORT-OUT	03-Oct-90	1050	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408580	PUY01.5	03-Oct-90	1745	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
408581	PUY00.8	03-Oct-90	1800	438	2 U	2 U	0.02 U	0.023 J	10 U	10 U	2.3	0.35 JB	2.2 J	2 U
408582	PUY01.5	03-Oct-90	1230	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

Codes:

999999	=	Missing data or not sampled.
U or K	=	The analyte was not detected at or above the reported result.
J	=	The analyte was positively identified. The reported value is an estimate.
UJ	=	The analyte was not detected at or above the reported estimate result.
E	=	The reported result is an estimate because of the presence of interference.
B	=	Analyte was also found in the analytical method blank indicating the sample may have been contaminated.
P	=	The analyte was detected above the instrument detection limit but below the established minimum quantitation limit.

Appendix B. Field measurements database

Station	River Mile	Date	Time	Temp-erature degC	pH S.U.	Diss-olved Oxygen mg/L	Total Ammonia Acute Criteria (mgN/L)	Total Ammonia Chronic Criteria (mgN/L)
WIL04.2	-4.2	18-Sep-90	955	12.1	7.7	10.5	9.48	1.82
WIL04.2	-4.2	18-Sep-90	1615	15.3	7.9	10.2	6.74	1.30
WIL04.2	-4.2	19-Sep-90	855	12.0	7.7	10.5	9.49	1.82
WIL04.2	-4.2	19-Sep-90	1330	14.2	8.0	10.7	5.69	1.09
WIL04.2	-4.2	02-Oct-90	805	10.0	8.1	10.8	4.67	0.90
WIL04.2	-4.2	02-Oct-90	1250	10.9	8.3	11.4	2.97	0.57
WIL04.2	-4.2	03-Oct-90	800	10.7	8.0	10.7	5.82	1.12
WIL04.2	-4.2	03-Oct-90	1230	11.7	8.1	10.7	4.62	0.89
WHI25.2	-25.2	18-Sep-90	725	12.3		10.5		
WHI25.2	-25.2	18-Sep-90	1323	13.1	7.8	10.6	8.05	1.55
WHI25.2	-25.2	19-Sep-90	1422	12.8	7.8	10.6	8.07	1.55
WHI25.2	-25.2	24-Sep-90	1605	12.2	8.0	10.7	5.39	1.04
WHI25.2	-25.2	25-Sep-90	740	13.0	7.9	10.5	6.60	1.27
WHI25.2	-25.2	02-Oct-90	816	8.7	7.7	11.3	9.75	1.88
WHI25.2	-25.2	02-Oct-90	1350	10.4	8.0	11.5	5.71	1.10
WHI25.2	-25.2	03-Oct-90	800	9.2	7.7	11.1	9.71	1.87
WHI25.2	-25.2	04-Oct-90	1335	10.9	8.1	10.9	4.97	0.96
WHI25.1	-25.1	20-Sep-90	720	11.5	7.6	9.7	11.01	1.83
WHI25.1	-25.1	20-Sep-90	1335	14.0	7.6	10.1	11.58	1.79
WHI25.1	-25.1	21-Sep-90	1045	12.3	7.3	10.0	15.22	1.81
WHI23.1	-23.1	18-Sep-90	756	12.6		10.5		
WHI23.1	-23.1	18-Sep-90	1409	14.0	7.9	10.5	6.79	1.30
WHI23.1	-23.1	19-Sep-90	910	12.4	7.7	10.7	9.46	1.82
WHI23.1	-23.1	19-Sep-90	1503	13.2	7.8	10.5	8.05	1.55
WHI23.1	-23.1	20-Sep-90	655	12.0	8.1	11.1	4.22	0.81
WHI23.1	-23.1	20-Sep-90	1400	15.0	7.8	10.9	7.84	1.51
WHI23.1	-23.1	21-Sep-90	950	12.1	7.8	10.9	7.98	1.53
WHI23.1	-23.1	24-Sep-90	1550	12.7	8.3	10.9	3.01	0.58
WHI23.1	-23.1	25-Sep-90	720	13.7	8.2	10.5	4.00	0.77
WHI23.1	-23.1	02-Oct-90	841	9.0	7.8	11.4	8.31	1.60
WHI23.1	-23.1	03-Oct-90	828	9.6	7.7	11.1	9.67	1.86
WHI20.4	-20.4	18-Sep-90	816	12.8		10.5		
WHI20.4	-20.4	18-Sep-90	1448	14.6	7.9	10.4	6.76	1.30
WHI20.4	-20.4	19-Sep-90	1531	12.6	7.9	10.5	6.84	1.32
WHI20.4	-20.4	20-Sep-90	630	12.1	8.3	10.8	2.70	0.52
WHI20.4	-20.4	20-Sep-90	1420	13.5	7.8	10.7	7.65	1.47
WHI20.4	-20.4	21-Sep-90	910	12.2	7.8	12.0	8.10	1.56
WHI20.4	-20.4	24-Sep-90	1635	14.2	7.7	10.0	9.35	1.80
WHI20.4	-20.4	25-Sep-90	800	13.3	7.6	10.1	10.42	1.81
WHI20.4	-20.4	25-Sep-90	1400	14.7	8.2	10.8	3.72	0.72
WHI20.4	-20.4	02-Oct-90	913	9.2	7.8	11.5	8.30	1.60
WHI20.4	-20.4	02-Oct-90	1410	13.0	8.4	11.7	2.31	0.44
WHI20.4	-20.4	03-Oct-90	859	9.8	7.6	11.0	11.17	1.86
WHI20.4	-20.4	04-Oct-90	1400	12.2	8.8	10.8	0.94	0.18
WHI14.9	-14.9	02-Oct-90	1014	9.9	8.6	12.3	1.55	0.30
WHI14.9	-14.9	03-Oct-90	1003	10.5	7.8	11.2	8.21	1.58
WHI10.3	-10.3	18-Sep-90	1605	16.6	8.7	10.4	1.26	0.24
WHI10.3	-10.3	19-Sep-90	1630	16.2	8.6	10.5	1.54	0.30
WHI10.3	-10.3	25-Sep-90	1405		9.3	12.2	0.70	0.14
WHI10.3	-10.3	25-Sep-90	1405	14.1	9.1	12.1	0.70	0.13
WHI10.3	-10.3	02-Oct-90	1303	11.6	9.5	13.4	0.69	0.13
WHI10.3	-10.3	03-Oct-90	1341	12.1	9.1	12.3	0.69	0.13
WHI08.0	-8.0	18-Sep-90	907	12.8		10.8		
WHI08.0	-8.0	18-Sep-90	1638	17.2	9.1	10.5	0.72	0.14
WHI08.0	-8.0	19-Sep-90	952	13.2	8.0	11.2	5.72	1.10
WHI08.0	-8.0	19-Sep-90	1654	16.8	9.1	10.5	0.72	0.14
WHI08.0	-8.0	24-Sep-90	1510	14.9	8.8	11.0	1.11	0.21

Station	River Mile	Date	Time	Temp-erature degC	pH S.U.	Diss-olved Oxygen mg/L	Total Ammonia Acute Criteria (mgN/L)	Total Ammonia Chronic Criteria (mgN/L)
WHI08.0	-8.0	25-Sep-90	655	13.7	8.0	10.4	5.71	1.10
WHI08.0	-8.0	02-Oct-90	650	10.2	8.5	11.2	1.84	0.35
WHI08.0	-8.0	02-Oct-90	1336	12.0	9.6	12.4	0.69	0.13
WHI08.0	-8.0	02-Oct-90	1500	13.5	9.6	12.5	0.69	0.13
WHI08.0	-8.0	03-Oct-90	1408	12.5	9.2	12.1	0.69	0.13
WHI08.0	-8.0	04-Oct-90	650	12.9	8.3	10.4	3.07	0.59
WHI08.0	-8.0	04-Oct-90	1450	14.5	8.1	10.7	4.45	0.86
WHI06.3	-6.3	18-Sep-90	1710	17.4	9.2	10.5	0.72	0.14
WHI06.3	-6.3	19-Sep-90	1718	17.0	9.1	10.6	0.72	0.14
WHI06.3	-6.3	03-Oct-90	1435	12.8	9.1	11.6	0.69	0.13
WHI04.9	-4.9	18-Sep-90	925	13.0		10.8		
WHI04.9	-4.9	18-Sep-90	1728	17.5	9.2	10.5	0.72	0.14
WHI04.9	-4.9	19-Sep-90	1743	16.8	9.2	10.5	0.72	0.14
WHI04.9	-4.9	20-Sep-90	1545	17.8	9.5		0.73	0.14
WHI04.9	-4.9	20-Sep-90	1545	17.2	9.5	11.4	0.72	0.14
WHI04.9	-4.9	21-Sep-90	730	12.2	7.7	10.7	9.19	1.77
WHI04.9	-4.9	24-Sep-90	1445	15.1	8.1	11.0	4.44	0.85
WHI04.9	-4.9	25-Sep-90	630	14.3	7.1	10.1	18.46	1.78
WHI04.9	-4.9	25-Sep-90	1645	16.0	9.0	11.4	0.71	0.14
WHI04.9	-4.9	28-Sep-90	1045	13.3	8.0	11.5	5.93	1.14
WHI04.9	-4.9	02-Oct-90	705	10.4	7.9	11.0	7.32	1.41
WHI04.9	-4.9	02-Oct-90	1000	10.5	8.0	11.9	5.83	1.12
WHI04.9	-4.9	02-Oct-90	1515	13.4	9.5	12.1	0.69	0.13
WHI04.9	-4.9	02-Oct-90	1840	12.9	9.7	11.0	0.69	0.13
WHI04.9	-4.9	03-Oct-90	950	10.9	7.7	11.0	9.57	1.84
WHI04.9	-4.9	03-Oct-90	1645	13.5	9.2	11.3	0.69	0.13
WHI04.9	-4.9	04-Oct-90	710	13.0	7.7	10.3	9.14	1.76
WHI04.9	-4.9	04-Oct-90	1505	15.2	8.2	11.0	3.40	0.65
WHI03.7	-3.7	27-Sep-90	1135	14.5	7.7	10.9	9.19	1.77
WHI03.7	-3.7	28-Sep-90	745	13.3	7.5	10.0	11.94	1.80
WHI03.7	-3.7	28-Sep-90	1120	13.9	7.9	11.2	7.02	1.35
LTD03.6		18-Sep-90	1804	12.7	7.0	9.6	20.04	1.80
LTD03.6		19-Sep-90	1135	13.3	6.9	11.0	21.18	1.79
LTD03.6		02-Oct-90	720	15.9	7.9	8.7	6.84	1.31
LTD03.6		02-Oct-90	1010	16.2	7.5	8.0	12.19	1.77
LTD03.6		02-Oct-90	1915	15.9	7.8	8.4	7.93	1.52
LTD03.6		03-Oct-90	1000	16.2	7.5	9.0	12.19	1.77
LTD03.6		03-Oct-90	1715	16.5	7.7	8.7	9.23	1.78
LTD03.6		04-Oct-90	720	16.1	7.8	8.9	7.55	1.45
WHI03.5	-3.5	20-Sep-90	1530	16.4	9.0	11.7	0.71	0.14
WHI03.5	-3.5	21-Sep-90	715	12.3	7.8	10.2	8.77	1.69
WHI03.5	-3.5	25-Sep-90	1605	17.0	8.0	8.8	6.04	1.16
WHI01.4	-1.4	18-Sep-90	1833	17.3	9.1	10.5	0.72	0.14
WHI01.4	-1.4	19-Sep-90	1817	16.9	9.1	10.7	0.72	0.14
WHI01.4	-1.4	02-Oct-90	1426	15.5	7.6	9.3	10.72	1.78
WHI01.4	-1.4	03-Oct-90	1506	15.3	7.5	9.2	12.26	1.78
WHI00.7	-0.7	18-Sep-90	947	13.2		10.3		
WHI00.7	-0.7	18-Sep-90	1851	17.0	9.0	10.5	0.72	0.14
WHI00.7	-0.7	19-Sep-90	1018	13.3	7.6	10.6	10.87	1.81
WHI00.7	-0.7	19-Sep-90	1843	16.8	9.0	10.6	0.72	0.14
WHI00.7	-0.7	20-Sep-90	1515	15.3	7.9	11.4	6.51	1.25
WHI00.7	-0.7	21-Sep-90	650	13.2	7.5	10.0	13.21	1.80
WHI00.7	-0.7	25-Sep-90	1620	16.9	7.6	9.1	10.21	1.77
WHI00.7	-0.7	28-Sep-90	725	13.6	7.5	9.2	13.02	1.80
WHI00.7	-0.7	28-Sep-90	1250	16.4	7.6	9.2	10.23	1.77
WHI00.7	-0.7	01-Oct-90	1315	16.2	7.3	9.3	14.84	1.76
WHI00.7	-0.7	02-Oct-90	740	14.6	7.7	9.3	9.47	1.79
WHI00.7	-0.7	02-Oct-90	1448	15.5	7.5	9.3	12.24	1.78

Station	River Mile	Date	Time	Temp-erature degC	pH S.U.	Diss-olved Oxygen mg/L	Total Ammonia Acute Criteria (mgN/L)	Total Ammonia Chronic Criteria (mgN/L)
WHI00.7	-0.7	02-Oct-90	1535	16.0	7.8	11.0	7.43	1.43
WHI00.7	-0.7	03-Oct-90	1530	15.3	7.5	9.2	12.26	1.78
WHI00.7	-0.7	04-Oct-90	735	15.7	7.7	9.0	8.86	1.70
WHI00.7	-0.7	04-Oct-90	1520	15.7	8.2	9.4	3.40	0.65
SPR07.2	-7.2	18-Sep-90	1030	13.0	7.2	10.8	17.16	1.80
SPR07.2	-7.2	18-Sep-90	1630	14.8	7.5	10.2	12.29	1.78
SPR07.2	-7.2	19-Sep-90	910	12.4	7.4	10.7	14.09	1.81
SPR07.2	-7.2	19-Sep-90	1350	14.2	7.6	10.7	10.80	1.79
SPR07.2	-7.2	02-Oct-90	820	10.6	8.0	10.9	5.82	1.12
SPR07.2	-7.2	02-Oct-90	1330	11.7	8.1	11.2	4.62	0.89
SPR07.2	-7.2	03-Oct-90	810	11.2	7.7	10.5	9.55	1.84
SPR07.2	-7.2	03-Oct-90	1245	11.7	7.9	11.0	6.89	1.32
SPR05.8	-5.8	18-Sep-90	1045	13.1	7.6	10.8	10.88	1.81
SPR05.8	-5.8	18-Sep-90	1645	15.1	7.7	10.4	9.30	1.79
SPR05.8	-5.8	19-Sep-90	918	12.5	7.5	10.7	12.48	1.81
SPR05.8	-5.8	19-Sep-90	1410	14.4	7.8	10.7	7.99	1.54
SPR05.8	-5.8	02-Oct-90	830	10.5	7.9	11.2	6.95	1.34
SPR05.8	-5.8	02-Oct-90	1355	11.9	8.3	11.2	2.96	0.57
SPR05.8	-5.8	03-Oct-90	820	11.3	7.8	10.5	8.16	1.57
SPR05.8	-5.8	03-Oct-90	1255	11.9	8.0	10.8	5.77	1.11
SPR01.1	-1.1	18-Sep-90	735	12.4	7.8	9.9	8.62	1.66
SPR01.1	-1.1	18-Sep-90	1120	14.3	7.5	10.7	12.33	1.79
SPR01.1	-1.1	18-Sep-90	1400	15.8	8.1	11.0	4.23	0.81
SPR01.1	-1.1	18-Sep-90	1700	15.9	7.6	10.4	10.70	1.78
SPR01.1	-1.1	19-Sep-90	930	12.9	7.5	10.2	12.45	1.81
SPR01.1	-1.1	19-Sep-90	1450	15.7	7.8	11.0	7.94	1.53
SPR01.1	-1.1	27-Sep-90	730	14.1	7.7	9.6	9.50	1.80
SPR01.1	-1.1	27-Sep-90	1420	16.4	7.7	10.8	8.69	1.67
SPR01.1	-1.1	02-Oct-90	840	10.8	7.8	10.2	8.19	1.57
SPR01.1	-1.1	02-Oct-90	1435	12.3	8.1	11.4	4.60	0.88
SPR01.1	-1.1	03-Oct-90	830	11.5	7.7	10.0	9.52	1.83
SPR01.1	-1.1	03-Oct-90	1330	12.0	7.8	10.4	8.11	1.56
PUY18.0	-18.0	18-Sep-90	645	11.0	8.0	11.4	5.56	1.07
PUY18.0	-18.0	18-Sep-90	1305	13.3	7.1	11.2	18.59	1.79
PUY18.0	-18.0	18-Sep-90	1427	14.1	7.9	11.7	7.13	1.37
PUY18.0	-18.0	18-Sep-90	1800	15.4	7.2	10.2	16.89	1.77
PUY18.0	-18.0	19-Sep-90	1020	11.7	7.0	11.2	20.20	1.81
PUY18.0	-18.0	19-Sep-90	1605	15.3	7.2	10.6	16.90	1.77
PUY18.0	-18.0	27-Sep-90	645	11.1	7.8	11.3	7.78	1.50
PUY18.0	-18.0	27-Sep-90	1525	13.8	7.7	11.3	9.66	1.80
PUY18.0	-18.0	02-Oct-90	930	8.6	7.6	11.8	11.29	1.88
PUY18.0	-18.0	02-Oct-90	1655	11.1	7.8	11.4	8.17	1.57
PUY18.0	-18.0	03-Oct-90	910	9.8	7.6	11.3	11.17	1.86
PUY18.0	-18.0	03-Oct-90	1500	10.6	7.7	11.8	9.59	1.84
PUY12.2	-12.2	18-Sep-90	620	12.3	7.3	10.6	15.38	1.81
PUY12.2	-12.2	18-Sep-90	1400	14.2	7.4	10.0	13.91	1.79
PUY12.2	-12.2	18-Sep-90	1415	14.1	7.2	11.0	17.33	1.78
PUY12.2	-12.2	18-Sep-90	1850	15.8	7.4	10.3	13.78	1.77
PUY12.2	-12.2	19-Sep-90	1030	12.9	7.2	10.9	17.18	1.80
PUY12.2	-12.2	19-Sep-90	1630	15.7	7.4	10.7	13.78	1.77
PUY12.2	-12.2	27-Sep-90	625	12.0	8.4	10.9	2.65	0.51
PUY12.2	-12.2	27-Sep-90	1540	13.7	7.6	11.0	11.60	1.80
PUY12.2	-12.2	01-Oct-90	1225	10.5	8.0	12.0	5.83	1.12
PUY12.2	-12.2	02-Oct-90	940	9.8	7.7	11.5	9.66	1.86
PUY12.2	-12.2	02-Oct-90	1230	10.0	8.1	11.8	4.67	0.90
PUY12.2	-12.2	02-Oct-90	1727	11.7	7.8	11.2	8.13	1.56
PUY12.2	-12.2	03-Oct-90	925	10.5	7.7	11.0	9.60	1.85
PUY12.2	-12.2	03-Oct-90	1520	11.7	7.8	11.3	8.13	1.56
PUY10.7	-10.7	18-Sep-90	1815	16.5	7.4	10.3	13.72	1.76

Station	River Mile	Date	Time	Temp-erature degC	pH S.U.	Diss-olved Oxygen mg/L	Total Ammonia Acute Criteria (mgN/L)	Total Ammonia Chronic Criteria (mgN/L)
PUY08.3	-8.3	18-Sep-90	1008	12.7		10.4		
PUY08.3	-8.3	18-Sep-90	1927	15.6	8.1	10.5	4.53	0.87
PUY08.3	-8.3	19-Sep-90	1046	13.3	7.6	10.2	10.87	1.81
PUY08.3	-8.3	20-Sep-90	1605	14.1	8.2	11.1	3.57	0.69
PUY08.3	-8.3	21-Sep-90	630	12.8	7.8	10.3	7.56	1.45
PUY08.3	-8.3	28-Sep-90	710	12.3	7.7	10.3	9.61	1.82
PUY08.3	-8.3	01-Oct-90	1425	14.2	7.2	10.3	17.02	1.78
PUY08.3	-8.3	02-Oct-90	750	10.9	7.7	10.4	9.00	1.73
PUY08.3	-8.3	02-Oct-90	1528	14.0	7.7	10.1	9.36	1.80
PUY08.3	-8.3	02-Oct-90	1610	14.5	7.9	10.7	6.77	1.30
PUY08.3	-8.3	03-Oct-90	1623	14.2	7.6	9.9	10.80	1.79
PUY08.3	-8.3	04-Oct-90	745	12.3	7.9	10.5	7.46	1.43
PUY08.3	-8.3	04-Oct-90	1555	13.2	7.6	10.4	11.64	1.80
PUY08.3	-8.3	05-Oct-90	900	10.6	8.3	10.4	3.04	0.59
PUY05.7	-5.7	18-Sep-90	1025	12.9	7.7	10.4	9.43	1.81
PUY05.7	-5.7	18-Sep-90	2000	15.2	7.8	10.6	7.96	1.53
PUY05.7	-5.7	19-Sep-90	1316	14.3	7.5	10.7	12.33	1.79
PUY05.7	-5.7	20-Sep-90	1620	14.2	8.0	11.2	5.69	1.09
PUY05.7	-5.7	21-Sep-90	615	12.7	7.9	10.3	7.08	1.36
PUY05.7	-5.7	27-Sep-90	1635	16.4	7.5	10.8	12.80	1.77
PUY05.7	-5.7	28-Sep-90	650	12.6	7.6	10.3	11.07	1.81
PUY05.7	-5.7	02-Oct-90	810	10.4	7.5	11.1	13.02	1.84
PUY05.7	-5.7	02-Oct-90	1558	14.0	7.6	10.2	10.82	1.80
PUY05.7	-5.7	03-Oct-90	1651	14.2	7.6	10.1	10.80	1.79
PUY05.7	-5.7	04-Oct-90	800	12.2	7.8	10.7	7.72	1.48
PUY05.7	-5.7	04-Oct-90	955	12.6	7.8	10.1	7.95	1.53
PUY05.7	-5.7	04-Oct-90	1605	12.7	7.9	10.6	7.08	1.36
PUY05.7	-5.7	05-Oct-90	930	10.2	7.6	10.9	10.67	1.85
PUY01.5	-1.5	18-Sep-90	1152	13.3	7.6	10.3	10.87	1.81
PUY01.5	-1.5	19-Sep-90	1225	14.7	7.6	10.4	10.77	1.79
PUY01.5	-1.5	20-Sep-90	1645	17.8	7.7	10.8	9.46	1.77
PUY01.5	-1.5	21-Sep-90	600	13.9	8.3	9.7	3.00	0.58
PUY01.5	-1.5	27-Sep-90	1700	15.9	7.2	10.2	16.84	1.76
PUY01.5	-1.5	28-Sep-90	630	13.6	8.1	9.7	5.11	0.98
PUY01.5	-1.5	02-Oct-90	1155	11.3	7.5	10.7	12.60	1.83
PUY01.5	-1.5	02-Oct-90	1637	13.0	7.5	10.3	12.44	1.81
PUY01.5	-1.5	03-Oct-90	1235	14.0	7.5	9.8	12.35	1.79
PUY01.5	-1.5	03-Oct-90	1740	14.3	7.5	9.6	12.33	1.79
PUY00.8	-0.8	18-Sep-90	1118	13.3	7.5	10.0	12.41	1.80
PUY00.8	-0.8	19-Sep-90	1148	14.1	7.5	10.6	12.35	1.79
PUY00.8	-0.8	02-Oct-90	1116	10.9	7.5	10.7	12.64	1.83
PUY00.8	-0.8	02-Oct-90	1702	12.8	7.2	10.3	17.19	1.80
PUY00.8	-0.8	03-Oct-90	1140	13.7	7.4	9.7	13.96	1.79
PUY00.8	-0.8	03-Oct-90	1801	14.2	7.3	9.7	15.49	1.79
PUY00.8	-0.8	04-Oct-90	1055	11.8	7.7	10.4	10.08	1.83
PUY00.8	-0.8	05-Oct-90	1020	10.8	7.2	10.5	18.08	1.83
CAR17.7	-17.7	18-Sep-90	910	7.5	6.7	11.6	24.47	1.89
CAR17.7	-17.7	18-Sep-90	1545	15.3	7.1	9.8	18.34	1.77
CAR17.7	-17.7	19-Sep-90	830	7.2	6.8	12.0	23.54	1.89
CAR17.7	-17.7	19-Sep-90	1300	12.3	7.0	10.5	20.10	1.81
CAR17.7	-17.7	27-Sep-90	810	7.9	7.8	11.8	8.40	1.62
CAR17.7	-17.7	27-Sep-90	1335	12.3	8.4	10.7	2.27	0.44
CAR17.7	-17.7	02-Oct-90	735	6.3	7.6	12.1	11.56	1.92
CAR17.7	-17.7	02-Oct-90	1200	8.2	7.8	11.7	8.38	1.61
CAR17.7	-17.7	03-Oct-90	735	8.3	7.4	11.4	14.60	1.88
CAR17.7	-17.7	03-Oct-90	1145	8.5	7.5	11.4	12.92	1.87
CAR06.1	-6.1	18-Sep-90	715	11.4	8.0	10.9	5.42	1.04
CAR06.1	-6.1	18-Sep-90	1155	13.5	7.3	11.0	15.56	1.79
CAR06.1	-6.1	18-Sep-90	1345	14.2	8.2	10.9	4.08	0.78

Station	River Mile	Date	Time	Temp- erature degC	pH S.U.	Diss- olved Oxygen mg/L	Total Ammonia Acute Criteria (mgN/L)	Total Ammonia Chronic Criteria (mgN/L)
CAR06.1	-6.1	18-Sep-90	1715	13.5	7.3	10.7	15.56	1.79
CAR06.1	-6.1	19-Sep-90	942	11.5	7.3	11.3	15.80	1.82
CAR06.1	-6.1	19-Sep-90	1510	13.6	7.4	10.9	13.97	1.80
CAR06.1	-6.1	27-Sep-90	720	11.6	7.8	11.0	8.81	1.69
CAR06.1	-6.1	27-Sep-90	1545	15.8	7.8	10.9	8.32	1.60
CAR06.1	-6.1	02-Oct-90	855	8.5	7.9	11.8	7.07	1.36
CAR06.1	-6.1	02-Oct-90	1520	10.1	8.0	11.7	5.85	1.12
CAR06.1	-6.1	03-Oct-90	840	9.8	7.9	11.3	6.99	1.34
CAR06.1	-6.1	03-Oct-90	1350	10.5	7.8	11.3	8.21	1.58
CAR02.0	-2.0	18-Sep-90	700	12.1	8.0	10.5	6.08	1.17
CAR02.0	-2.0	18-Sep-90	1245	15.6	7.5	10.9	12.23	1.78
CAR02.0	-2.0	18-Sep-90	1530	16.6	7.7	10.4	9.09	1.75
CAR02.0	-2.0	18-Sep-90	1735	15.9	7.5	10.2	12.21	1.77
CAR02.0	-2.0	19-Sep-90	1000	13.0	7.4	11.0	14.03	1.80
CAR02.0	-2.0	19-Sep-90	1535	16.0	7.6	10.4	10.69	1.78
CAR02.0	-2.0	27-Sep-90	700	13.0	7.7	10.6	9.28	1.78
CAR02.0	-2.0	27-Sep-90	1510	15.5	7.9	10.6	6.51	1.25
CAR02.0	-2.0	02-Oct-90	910	9.7	7.8	11.6	8.26	1.59
CAR02.0	-2.0	02-Oct-90	1615	11.9	8.0	11.1	5.77	1.11
CAR02.0	-2.0	03-Oct-90	900	10.8	7.8	11.0	8.19	1.57
CAR02.0	-2.0	03-Oct-90	1440	11.9	8.0	11.1	5.77	1.11

Appendix C. Composite and grab samples from NPDES discharges

PUYALLUP TMDL 9/18/90

Station	Sample type	Time	Temp °C	pH S.U.	Cond mmho/cm	Field Measurements DO mg/L	Chlorine mg/L Free		Chlorine mg/L Total		Composite Period 9/17/90	to 9/18/90	Flow – 24 hr ave MGD	
Carbonado	grab	0820	17.8	7.13	410	2.2	0.1	U	1.5				0.0163	(a)
													NA	
Wilkeson	grab	0840	16.2	7.18	528	5.2	0.1	U	0.8					
	composite	0845	3.9	7.51			0.1	U	0.2		0815	0745	0.0225	
Rainier St School	grab	0926	18.5	6.88	228	4.9	0.1	U	0.1	U				
	composite	0930	5.4	7.24			0.1	U	0.1	U	0845	0815	0.1127	
Enumclaw	grab	1000	20.6	7.20	1235	6.8	0.1		0.4					
	composite	1005	5.5	7.47			0.1	U	0.4		0920	0850	0.7265	
Buckley	grab	1030	19.2	7.33	401	6.5	0.1	U	0.5					
	composite	1035	5.4	7.60			0.1		0.6		0945	0915	0.2280	
Orting	grab	1130	15.6	7.37	471	1.9	0.1	U	1.5					
	composite	1135	4.9	7.73			0.5		0.5		1035	1005	0.3279	(b)
	CCC outlet	1140	11.5	7.24	238	7.8	0.1	U	0.1	U				
McAlder Elem	grab	1215	17.1	7.49	311	8.1	0.4		1.0				0.008	
Boeing #2	grab	1245	17.1	7.39	170	8.1	0.1	U	0.1	U			0.325	(a)
Mazza	grab	1330	19.8	7.90	3000	7.9	0.1	U	0.1	U				
	composite	1335	4.9	8.20			0.1	U	0.1	U	1120	1050	0.1709	
Sonoco	grab	1400	23.8	7.86	1400	6.2	0.1	U	0.1	U				
	composite	1405	7.5	8.11			0.1	U	0.1	U	1155	1125	0.1372	
Fleischman's	grab	1435	25.0	8.09	275	6.2	0.1	U	0.1	U			0.883	(a)
													0.804	
Sumner	grab	1515	19.9	6.86	654	3.3	0.1	U	1.8					
	composite	1520	7.3	7.06			0.1	U	1.5		1310	1440	1.223	
Nat'l Semi	grab	1710	21.6	8.27	987	9.8	0.1	U	1.7					
	composite	1715	9.7	8.40			0.2		4.0		1410	1340	0.5532	
Puyallup	grab	1615	20.9	7.34	676	2.6	0.1		0.4					
	composite	1620	7.6	7.78			0.1	U	0.1	U	1445	1415	3.7572	

U – Undetected at detection limit shown

(a) Instantaneous flow reading near time that grab sample was taken

(b) Flow is from effluent lagoon only. Groundwater addition to CCC prior to discharge to river estimated at 1.3 to 2.6 MGD

PUYALLUP TMDL 9/19/90

Station	Sample type	Time	Temp °C	pH S.U.	Cond mmho/cm	Field Measurements DO mg/L	Chlorine mg/L Free	Chlorine mg/L Total	Composite Period 9/18/90	to 9/19/90	Flow – 24 hr ave MGD
Carbonado	grab	0810	18.1	7.24	399	2.3	0.1 U	1.6			0.0163 (a) NA
Wilkeson	grab	0830	16.4	7.44	515	5.0	0.1 U	0.9			
	composite	0835	4.6	7.69			0.1 U	0.6	0900	0830	0.0175
Rainier St School	grab	0900	18.6	7.19	231	4.9	0.1 U	0.1 U			
	composite	0905	5.4	7.44			0.1 U	0.1 U	0940	0840	0.1098
Enumclaw	grab	0930	20.4	7.47	1610	7.2	0.1 U	0.5			
	composite	0935	6.4	7.65			0.1	0.5	1015	0915	0.7271
Buckley	grab	1000	18.9	7.63	378	6.8	0.1 U	0.4			
	composite	1005	5.4	7.73			0.1 U	0.5	1055	0955	0.2321
Orting	grab	1100	16.6	7.78	591	0.3	0.1 U	0.1 U			
	composite	1105	5.0	8.15			0.6	0.6	1155	1055	0.3108 (b)
	CCC outlet	1110	12.0	7.60	241 (c)	8.0					
McAlder Elem	grab	1140	17.2	7.91	375	8.0	0.5	0.6			0.008
Boeing #2	grab	1215	19.0	9.06	158	7.6	0.1 U	0.5			0.452 (a)
Mazza	grab	1300	20.8	8.14	2500	4.0	0.1 U	0.1 U			
	composite	1305	7.9	8.54			0.1 U	0.1 U	1345	1245	0.2441
Sonoco	grab	1325	23.8	8.20	1334	6.6	0.1 U	0.1 U			
	composite	1330	9.7	8.44			0.1 U	0.1 U	1420	1320	0.1539
Fleischman's	grab	1425	20.9	8.11	274	8.2	0.1 U	0.3			1.391 (a) 0.852
Sumner	grab	1350	20.3	7.07	694	3.4	0.1	0.1			
	composite	1355	8.6	7.11			0.1	0.5	1540	1340	1.201
Nat'l Semi	grab	1605	21.1	8.70	935	9.4	0.3	5.0			
	composite	1610	9.0	8.79			0.1 U	0.1 U	1730	1600	0.5689
Puyallup	grab	1510	20.7	7.44	618	2.9	0.1 U	0.4			
	composite	1515	9.6	7.75			0.1 U	0.1 U	1630	1500	3.7112

U – Undetected at detection limit shown
(a) Instantaneous flow reading near time that grab sample was taken
(b) Flow is from effluent lagoon only. Groundwater addition to CCC prior to discharge to river estimated at 1.3 to 2.6 MGD
(c) Conductivity of added groundwater 245 mmho/cm

PUYALLUP TMDL 10/2/90

Station	Sample type	Time	Temp °C	pH S.U.	Cond mmho/cm	Field Measurements DO mg/L	Chlorine mg/L Free	Chlorine mg/L Total	Composite Period 10/1/90	to 10/2/90	Flow – 24 hr ave MGD
Carbonado	grab	1015	16.1	7.09	430	2.1	0.1 U	3.0			NA
											NA
Wilkeson	grab	1035	14.3	7.28	558	5.0 (d)	0.1 U	0.5			
	composite	1040	3.0	7.61	566		0.1 U	0.4	0915	0845	0.0233
Rainier St School	grab	0925	17.4	6.91	235	5.5	0.1 U	0.2			
	composite	0930	3.2	7.35	240		0.1	0.1	0845	0815	0.1452
Enumclaw	grab	0800	18.9	7.15	905	5.8	0.1 U	0.6			
	outfall grab	0835	18.7	7.43	885	9.2	0.1 U	0.1			0.7000
	composite	0810	5.7	7.66	699		0.1 U	0.1	0800	0730	
Buckley	grab	0850	17.2	7.18	381	7.1	0.1 U	0.1			
	composite	0900	3.1	7.50	358		0.1 U	0.1	0820	0750	0.2265
Orting	grab	1115	15.0	7.44	657	0.6	0.1 U	0.1 U			
	composite	1125	3.8	7.55	441		0.1 U	1.8	0955	1025	0.2373 (b)
	CCC outlet	1130	11.3	7.20	251	7.5	0.1 U	0.1 U			
McAlder Elem	grab	1155	15.2	7.56	366	8.1	0.6	0.9			0.008
Boeing #2	grab	1230	16.4	7.52	154	9.6	0.1 U	0.1 U			0.325 (a)
Mazza	grab	1330	15.8	7.94	1875	6.5	0.1 U	0.1 U			
	composite	1335	3.7	8.16	1940		0.1 U	0.1 U	1030	1000	0.1165
Sonoco	grab	1400	21.3	7.76	1150	9.3	0.1 U	0.1 U			
	composite	1405	5.0	8.00	1070		0.1 U	0.1 U	1050	1020	0.1734
Fleischman's	grab	1425	22.0	8.19	270	8.6	0.1 U	0.6			0.868 (a)
											0.8611
Sumner	grab	1500	17.7	7.04	675	3.3	0.1 U	0.1 U			
	composite	1505	3.6	7.24	618		0.1 U	0.1	1110	1040	1.242
Nat'l Semi	grab	1650	19.5	8.58	692	10.0	0.3	3.5			
	composite	1655	3.8	8.15	855		0.6	4.0	1320	1250	0.5789
Puyallup	grab	1605	19.9	7.16	531	3.4	0.1 U	0.3			
	composite	1610	4.5	7.55	492		0.1 U	0.2	1230	1200	3.1676

U – Undetected at detection limit shown
(a) Instantaneous flow reading near time that grab sample was taken
(b) Flow is from effluent lagoon only. Groundwater addition to CCC prior to discharge to river estimated at 1.3 to 2.6 MGD
(d) DO variable, 5.0 – 6.0 mg/L, meter wouldn't settle

PUYALLUP TMDL 10/3/90

Field Measurements

Station	Sample type	Time	Temp °C	pH S.U.	Cond mmho/cm	DO mg/L	Chlorine mg/L Free	Chlorine mg/L Total	Composite Period 10/2/90	to 10/3/90	Flow - 24 hr ave MGD
Carbonado	grab	0940	15.9	7.23	443	2.05	0.1 U	0.8			NA
											NA
Wilkeson	grab	1000	14.0	7.38	570	5.0 (g)	0.1 U	0.6			
	composite	1005	4.2	7.62	580		0.1 U	0.2	1040	0940	0.0210
Rainier St School	grab	0905	18.3	7.12	220	6.3	0.1 U	0.3			
	composite	0910	3.8	7.41	246		0.1 U	0.1 U	0940	0840	0.0861
Enumclaw	grab	0805	18.6	7.23	942	5.7 (e)	0.1 U	0.2			
	outfall grab	0825	18.3	7.45	949	9.2	0.1 U	0.1 U			
	composite	0810	6.0	7.59	993		0.1 U	0.1 U	0800	0730	0.7000
Buckley	grab	0845	17.2	7.41	353	7.6 (f)	0.1	0.4			
	composite	0845	4.2	7.53	368		0.1 U	0.1 U	0905	0835	0.2199
Orting	grab	1045	15.3	7.48	653	0.35	0.1 U	0.1 U			
	composite	1050	5.6	7.65	440		0.6	0.8	1130	1030	0.2828
McAlder Elem	grab	1120	16.4	7.54	385	7.8	0.1 U	0.1 U			0.008
Boeing #2	grab	1215	16.2	7.90	122	10.5	0.1 U	0.1 U			0.969 (a)
Mazza	grab	1245	17.0	8.25	2240	4.7	0.1 U	0.1 U			
	composite	1250	6.1	8.26	2040		0.1 U	0.1 U	1340	1240	0.1386
Sonoco	grab	1305	21.0	8.04	1120	9.2 (h)	0.1 U	0.1 U			
	composite	1310	7.8	8.28	1020		0.1 U	0.1 U	1410	1310	0.1369
Fleischman's	grab	1415	22.9	8.32	283	7.5	0.1 U	0.1 U			0.389 (a)
											0.3624
Sumner	grab	1330	17.9	7.42	610	2.8	0.1 U	0.1			
	composite	1330	5.5	7.84	660		0.1 U	0.1 U	1510	1310	1.134
Nat'l Semi	grab	1515	19.9	8.41	834	9.8	0.5	5.8			
	composite	1520	7.2	7.57	1019		0.1 U	1.5	1700	1500	0.5659
Puyallup	grab	1445	20.3	7.33	518	3.0	0.1 U	0.4			
	composite	1450	6.6	7.28	543		0.1 U	0.1	1615	1445	2.9096

U - Undetected at detection limit shown
(a) Instantaneous flow reading near time that grab sample was taken
(b) Flow is from effluent lagoon only. Groundwater addition to CCC prior to discharge to river estimated at 1.3 to 2.6 MGD
(e) DO 7.1 mg/L after CCC weir, vertical drop of about 4 ft. from weir to channel below
(f) DO 5.3 mg/L before CCC weir, vertical drop of about 3 ft. from weir to channel below
(g) DO variable, 4.5 - 5.5 mg/L, meter wouldn't settle
(h) DO 6.2 mg/L before flume, vertical drop of about 7 ft. from flume to channel below

Appendix D. Periphyton sampling

PUYALLUP RIVER PERIPHYTON SUMMARY

METHODS

Evaluation of periphyton communities can often provide a reliable indicator of water quality. The objective of this study was to characterize the biomass and distribution of periphyton communities in the Puyallup River system, particularly in areas associated with high productivity. Periphyton samples were collected on September 25 and October 1 and 2 at four sites on the White River (RM 25.2, 23.3, 20.4, and 8.0), RM 2.0 on the Carbon River, and RM 18.0 and 12.2 on the Puyallup River. Riffle areas with similar habitat types (i.e. depth, velocity, substrate, and shading) were selected so that comparisons between sites could be made. Depth and flow were measured with a Swoffer current meter.

Five rocks were selected at each site. Periphyton inside a 12.6 cm^2 plexiglass circular sampler was scrubbed from each rock with a stiff bristled brush and composited into a one liter sample bottle. The periphyton slurry was diluted to a volume of one liter using deionized water. The composite was homogenized by vigorous shaking and then separated into appropriate sample containers. A replicate composite sample was taken at each site. This survey was intended to be semi-qualitative because sample sizes were small relative to those normally required to reliably assess periphyton biomass levels.

Samples for laboratory analysis were stored on ice and delivered to the Ecology\Environmental Protection Agency (EPA) Laboratory in Manchester, Washington, within 24 hours. Laboratory analyses were performed as per EPA (1983), APHA et al. (1989), and Huntamer and Smith (1986). Analytical measurements included total organic carbon (TOC), total phosphorus (TP), total nitrogen (TN), chlorophyll a (chl. a), and pheophytin. Results were converted from volumetric to areal measurements by dividing volumetric results by the area of the sample collected.

RESULTS AND DISCUSSION

A summary of periphyton data is presented in Table 1. The complete set of raw data can be found in Appendix A. Periphyton standing crop expressed as chl. a was highest in the White River at RM 23.3 and RM 20.4 (50.6 and 47.8 mg/M^2, respectively). The next highest chl. a (47.1 mg/M^2) was measured at RM 2.0 on the Carbon River. Lowest chl. a (14.2 mg/M^2) was measured on the White River at RM 25.2, upstream of the Rainier School WTP outfall. Variability between replicate samples was high for some samples which is not unusual given the large spatial variability characteristics found in of most periphyton communities.

It was not surprising that highest periphyton biomass was measured at RM 23.3 and 20.4 on the White River. This is below an area where a large portion of the White River is diverted into Lake Tapps. Lower flows in this reach probably result in less scouring and better periphyton growth. Higher nutrient levels from several WTP dischargers probably also foster greater plant growth in this area.

Table 1. Summary of periphyton data collected in the Puyallup River drainage (9/25/91–10/2/91).

Sampling Site	River Mile	Date	Depth (ft) Mean	± S.D.	Flow (fps) Mean	± S.D.	TOC (mg/M^2) Mean	± S.D.	TP (mg/M^2) Mean	± S.D.	TN (mg/M^2) Mean	± S.D.	TN/TP Ratio	Chl. a (mg/M^2) Mean	± S.D.
White River	25.2	9/25/91	1.1	0.1	0.99	0.22	1,563	56	941	126	142	6	0.15	14.2	0.5
White River	23.3	9/25/91	0.9	0.1	1.22	0.29	2,984	314	426	32	510	39	1.20	50.6	12.3
White River	20.4	9/25/91	1.2	0.2	0.93	0.26	1,873	337	335	103	231	102	0.69	47.8	21.8
White River	8.0	10/1/91	0.9	0.1	1.16	0.24	3,904	336	275	0	889	45	3.24	18.5	7.7
Carbon River	2.0	10/2/91	1.0	0.1	1.27	0.35	1,817	123	169	3	385	17	2.28	47.1	0.1
Puyallup River	18.0	10/2/91	0.9	0.1	1.19	0.30	1,611	122	444	32	196	10	0.44	16.3	—
Puyallup River	12.2	10/2/91	1.0	0.1	1.12	0.23	1,992	78	234	12	336	14	1.43	23.6	18.9

Periphyton standing crop above a critical range of 100-150 mg chl. a/M^2 has been considered representative of nuisance conditions by some investigators (Horner et al. 1983; Welch et al. 1988). Biomass in this range has been associated with dense filamentous coverage which produces an adverse aesthetic effect. All samples collected during this survey were well below nuisance levels (Table 1). Biomass of chl. a from this survey appear to be in the lower range of values reported by other investigators in the Pacific Northwest (Table 2). It is highly probable that the naturally high turbidity levels found in the Puyallup system limit light penetration through the water column and subsequently inhibit periphyton growth. Additionally 1990 was an unusually high flow water year. During a more typical year periphyton growth could be considerably greater.

Periphyton samples were analyzed for TN and TP (essential nutrients for plant growth) to help assess the nutritional content of periphyton tissues relative to supplies available in the environment. According to Healey and Hendzel (1980) when the ratio of TN/TP in plant tissue exceeds 10 then moderate phosphorus deficiency is likely. If TN/TP is less than 10 then nitrogen deficiency is probable. All the TN/TP ratios found in periphyton tissue from this survey were relatively low (averaging 1.3) giving the indication of nitrogen limitation.

Table 2. Chlorophyll a biomass in the Puyallup survey compared to other Washington rivers and streams.

Location	N	Chl. a (mg/M²) Mean	Max	Range
Upper Spokane River (Patmont et al. 1987)	5	-	-	3-34
Lower Spokane River (Patmont et al. 1987)	21	-	-	61-600
Raging River (Horner et al. 1986)	10	55	92	-
Issaquah Creek (Horner et al. 1986)	10	166	267	-
S.F. Snoqualmie River (Joy et al. 1991)	8	83	156	29-156
Snoqualmie River (Joy et al. 1991)	11	39	66	9-66
White River (present study)	6	38	63	13-63
Carbon River (present study)	2	47	47	-
Puyallup River (present study)	4	20	37	10-37

N = sample size

Appendix A. Results of periphyton surveys conducted 9/25/91-10/2/91.

Sampling Site	River Mile	Date	Depth (ft)	Flow (fps)	TOC (mg/L)	TP (mg/L)	TN (mg/L)	Chl. a (ug/L)
White River	25.2	9/25/91	1.1	1.02	10.1	5.37	0.87	87.3
		Repl.	1.1	0.96	9.6	6.49	0.92	91.9
White River	23.3	9/25/91	0.9	1.18	20.2	2.54	3.39	374.0
		Repl.	0.9	1.25	17.4	2.83	3.04	264.0
White River	20.4	9/25/91	1.2	0.93	10.3	2.57	1.00	204.0
		Repl.	1.2	0.92	13.3	1.65	1.91	398.0
White River	8.0	10/1/91	0.9	1.14	26.1	1.73	5.80	82.5
		Repl.	0.9	1.18	23.1	1.73	5.40	151.0
Carbon River	2.0	10/2/91	1.0	1.40	10.9	1.05	2.35	296.0
		Repl.	1.0	1.14	12.0	1.08	2.50	297.0
Puyallup River	18.0	10/2/91	0.9	1.18	9.6	2.94	1.28	LAC
		Repl.	1.0	1.19	10.7	2.65	1.19	103.0
Puyallup River	12.2	10/2/91	1.0	0.95	12.9	1.42	2.05	233.0
		Repl.	1.0	1.28	12.2	1.53	2.18	64.9

Repl = Replicate sample
LAC = Laboratory accident