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A WATER QUALITY ASSESSMENT AND RECEIVING WATER SURVEY OF THE SOUTH FORK OF THE PALOUSE RIVER AT PULLMAN, SEPTEMBER 1986

by

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ABSTRACT

A low-flow water quality survey of five miles of the South Fork of the Palouse River (SFPR) was conducted concurrently with a Class II inspection at the Pullman wastewater treatment plant (WWTP).

Physical and chemical data indicated very few improvements in water quality conditions above the WWTP since a 1978 survey, especially with fecal coliform, nutrients, and pH. However, benthic macroinvertebrate results indicated improved water quality conditions. Instream ammonia had markedly decreased with the removal of a major discharger.

The Pullman WWTP effluent was poorly diluted during the survey. Effluent quality had improved since 1978; chlorine and ammonia toxicity problems were not present. Effluent created Class A pH, temperature and dissolved oxygen (D.O.) criteria violations, and excessive nutrient loading.

A total maximum daily load (TMDL) analysis concluded: (1) the SFPR above the WWTP is at its TMDL for nutrients and bacteria, (2) the SFPR has inadequate discharge for nine months of the year to dilute the WWTP effluent to meet 20:1 dilution guidelines, (3) current and maximum permitted loads of ammonia and BOD would probably create Class A D.O., temperature, and pH violations for 1.5 to 2.5 miles below the WWTP during low-flow conditions (7Q10). Identification of fecal coliform source(s) above the WWTP; monitoring of pH, temperature, and ammonia above and below the WWTP; and consideration of seasonal effluent removal from the SFPR were recommended.

INTRODUCTION

On September 16 and 17, 1986, staff from the Water Quality Investigations Section (WQIS) of the Department of Ecology conducted a receiving water survey of the South Fork of the Palouse River (SFPR) in the vicinity of Pullman. A Class II inspection of the Pullman wastewater treatment plant (WWTP) was concurrently performed by Marc Heffner of WQIS, results of which are presented in a separate document (Heffner, 1987). The Class II and receiving water surveys were requested by Carl Nuechterlein and Larry Peterson of Ecology's Eastern Regional Office (ERO). The objectives of the receiving water survey were:

1. Assess the current water quality of the SFPR from Paradise Creek (river mile [r.m.] 23.3) to 2.5 miles below the Pullman WWTP (r.m. 18.7) during dry weather, low-flow conditions.

2. Collect water quality and benthic invertebrate samples for comparison to the 1978 survey.

3. Monitor Pullman WWTP effluent impacts with respect to NPDES permit limits, especially nitrogen and chlorine.

4. Assess current water quality effects of other sources within the study area, including those identified in the 1978 survey: Palouse Producers, Inc.; Moscow WWTP (Paradise Creek); storm drains; or other unknown sources between Thatuna Park and the Pullman WWTP.

This information will be used by the ERO staff to assess the impacts of the Pullman WWTP upgrade and to forecast the strategy for further water quality improvements in the watershed.

BACKGROUND

Site Description

The SFPR at Pullman (r.m. 22.2) drains approximately 130 mi^2 of rolling hills around Pullman and Moscow (Figure 1). The area is dominated by grain fields and pastures. Residential, commercial, and industrial developments are clustered around the two towns.

Moscow WWTP discharges approximately 2.5 MGD of effluent into Paradise Creek, a tributary to the SFPR (Figure 1). It is a trickling filter plant with dechlorination equipment (W. Chamberlain, personal conversation) serving both the city of Moscow and the University of Idaho.

The Pullman WWTP discharges at r.m. 21.3 of the SFPR in the northwest corner of town (Figure 1). It is a secondary plant that provides seasonal nitrification (Heffner, 1982). The plant serves a population of 23,800 when Washington State University (WSU) is in session. Population drops dramatically June through August. The NPDES permit limits for the plant are shown in Table 1.

Historical Water Quality Data

The SFPR is designated Class A (Table 2). However, it has consistently had the worst water quality of any monitored segment in the state based upon the Water Quality Index (WQI) (Singleton, 1980; Moore, 1984; Thielen, 1986). The major parameters leading to the poor WQI scores have been (Table 3):

- fecal coliform (bacteria index)
- nutrients (trophic index)
- turbidity (aesthetics index)
- suspended solids, conductivity (suspended solids index)
- pH

These scores are calculated using Ecology ambient monitoring network data from Station 34B110 located at r.m. 22.2 just above the Pullman WWTP outfall (Figure 2). The scores do not reflect water quality impacts of the WWTP.

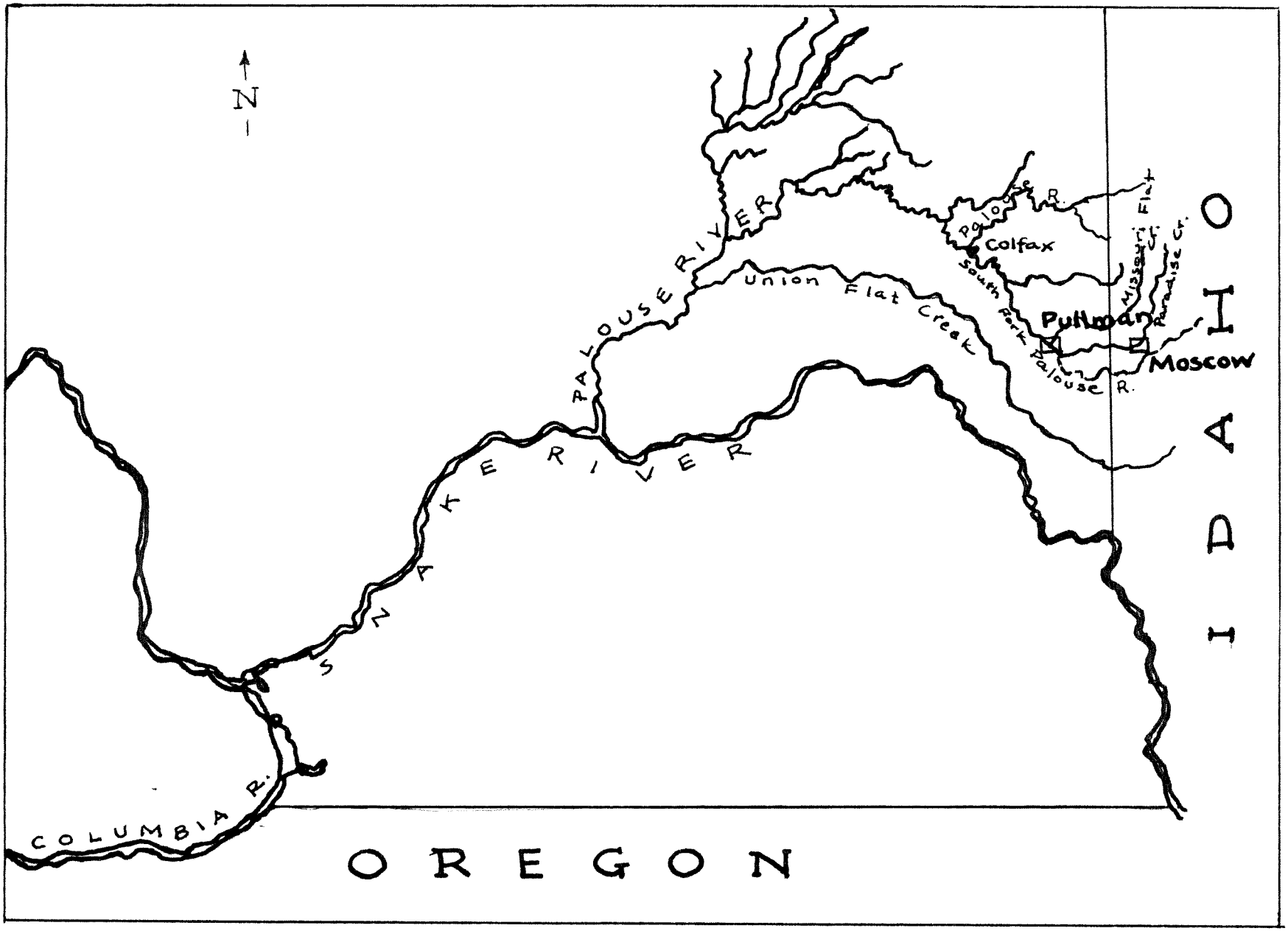


Figure 1. Area drainage map - SFPR, 1986.

Table 1. NPDES permit limits for the Pullman wastewater treatment plant discharge (Permit no. WA-004465-2) SFPR, September 1986.

The monthly average quantity of effluent discharge shall not exceed 4.3 MGD.

Parameter	EFFLUENT LIMITATIONS	
	Monthly Average	Weekly Average
Biochemical Oxygen Demand* (5-day)	30 mg/L, 900 lbs/day	45 mg/L, 1350 lbs/day
Suspended Solids*	30 mg/L, 915 lbs/day	45 mg/L, 1373 lbs/day
Fecal Coliform Bacteria	200/100 mL	400/100 mL
Total Ammonia Nitrogen (NH_3-N)	No limitation (Dec. 1 - Mar. 30) 5 mg/L (Apr. 1 - Apr. 30) 1 mg/L (May 1 - Oct. 30) 5 mg/L (Nov. 1 - Nov. 30)	
Chlorine Residual**	No detectable residual	
pH	Shall not be outside the range 6.0 to 9.0	

The monthly and weekly averages for BOD_5, Suspended Solids and Total Ammonia Nitrogen are based on the arithmetic mean of the samples taken. The averages for Fecal Coliform are based on the geometric mean of the samples taken.

*The monthly average effluent concentration limitations for BOD_5 and Suspended Solids shall not exceed 30 mg/L or 15% of the respective influent concentrations, whichever is more stringent.

**The permittee shall operate dechlorination equipment continuously, unless high stream flow requires the use of effluent pumping. During effluent pumping, chlorine residual shall be maintained between 0.1 mg/L and 0.5 mg/L. Periods of effluent pumping will be noted on the Discharge Monitoring Report. No detectable residual in this permit shall mean less than 0.02 mg/L.

Table 2. Class A (excellent) freshwater quality standards (WAC 173-201-045) and characteristic uses - SFPR, September 1986.

CLASS A	
Characteristics shall meet exceed requirements for all or substantially all uses:	Domestic, industrial, and agricultural or water supply, wildlife habitat; livestock watering; general recreation and aesthetic enjoyment; commerce and navigation; salmonid and other fish reproduction, migration, rearing, and harvesting.
Water Quality Criteria	
Fecal coliform:	Geometric mean not to exceed 100 organisms/100 mLs with not more than 10 percent of samples exceeding 200 organisms/100 mLs.
Dissolved oxygen:	Shall exceed 8 mg/L.
Total dissolved gas:	Shall not exceed 110 percent saturation.
Temperature:	Shall not exceed $18^{o}C$ due to human activity. Increases shall not, at any time, exceed $t = 28(T+7)$; or where temperature exceeds $18^{o}C$ naturally, no increase greater than $0.3^{o}C$. t = allowable temperature increase across dilution zone, and T = highest temperature outside the dilution zone. Increases from non-point sources shall not exceed $2.8^{o}C$.
pH:	Shall be within the range of 6.5 to 8.5, with man-caused variation within a range of less than 0.5 unit.
Turbidity:	Shall not exceed 5 NTU over background when background is 50 NTU or less, or cause 10 percent increase in turbidity over background when background is greater than 50 NTU.
Toxic, radioactive, or deleterious materials:	Shall be below concentrations of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.
Aesthetic values:	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

Table 3. Water quality index (WQI) scores for the South Fork of the Palouse River above river mile 22.2*, September 1986.

Year	Temperature	Oxygen	pH	Bacteria	Trophic	Aesthetics	Solids	Ammonia	Overall
1980	11	11	16	65	100	70	(81)	12	98
1981	11	12	16	77	100	63	73	9	100
1984	20	8	16	62	100	59	34	11	94
1986	25	7	27	63	100	55	28	18	97

*Scores are calculated by comparing Class A water quality criteria to ambient monitoring data collected monthly at Station 34B110. Data that were evaluated include those collected for the five years previous to the WQI date. WQI scores falling between 0 - 20 meet "fishable, swimmable" water quality goals. Those between 20 - 60 are marginal; above 60 are considered poor or unacceptable. Scores reported in: Singleton, 1980; Singleton and Joy, 1981; Moore, 1984; and Thielen, 1986.

( ) = Value not used to calculate overall WQI score.

The raw monthly data from 1971 to 1986 were reviewed for more specific information on water quality (Appendix I). Turbidity and suspended solids concentrations are generally higher in the winter and spring months.

Phosphorus loads are lowest in June through August, and increase in September even while streamflows remain low (Figure 3). The total inorganic nitrogen and phosphorus loads and concentrations both show a definite increase between August and September (the median monthly values are significantly different, as illustrated in the notched box and whisker plots) (Figure 4). This suggests a possible change in Moscow WWTP or other point source loads rather than nonpoint source problems. Both Moscow and Pullman wastewater and collection systems are heavily influenced by the fluctuating student populations at the University of Idaho and Washington State University. Students arrive in August and September and leave in May and June. Ammonia and fecal coliform do not show these increased loads, and so their loads may be related to nonpoint or intermittent discharge sources.

The last 13 years of ambient data for the low-flow months of July through October were reviewed for significant changes. Most data contained too much monthly variation to detect a trend over the 13-year period. A major change was observed in pH data (Figure 5). The significant drop in pH values in 1979 to 1981 was first thought to be related to a change in sample collection times; however, prior to 1979, pHs were measured at approximately the same time of day as in 1979-1981. Since the median pH values from 1971 to 1978 do not appear significantly different than 1982 to 1986, the pH drop is probably related to personnel or instrumentation changes. Samples taken since 1982 have been collected an average of four hours later than previous samples, which may account for a wider variation of pH values, especially toward higher pH values (Figure 5). The elevated 1986 WQI score for pH reflected these changes in personnel and sampling time (Table 3).

In past years, the ERO has conducted enforcement actions and requested investigations of the SFPR at Pullman in recognition of its poor water quality. In 1978, Bernhardt and Yake (1979) of WQIS performed a Class II and receiving water survey of the SFPR. Their findings were:

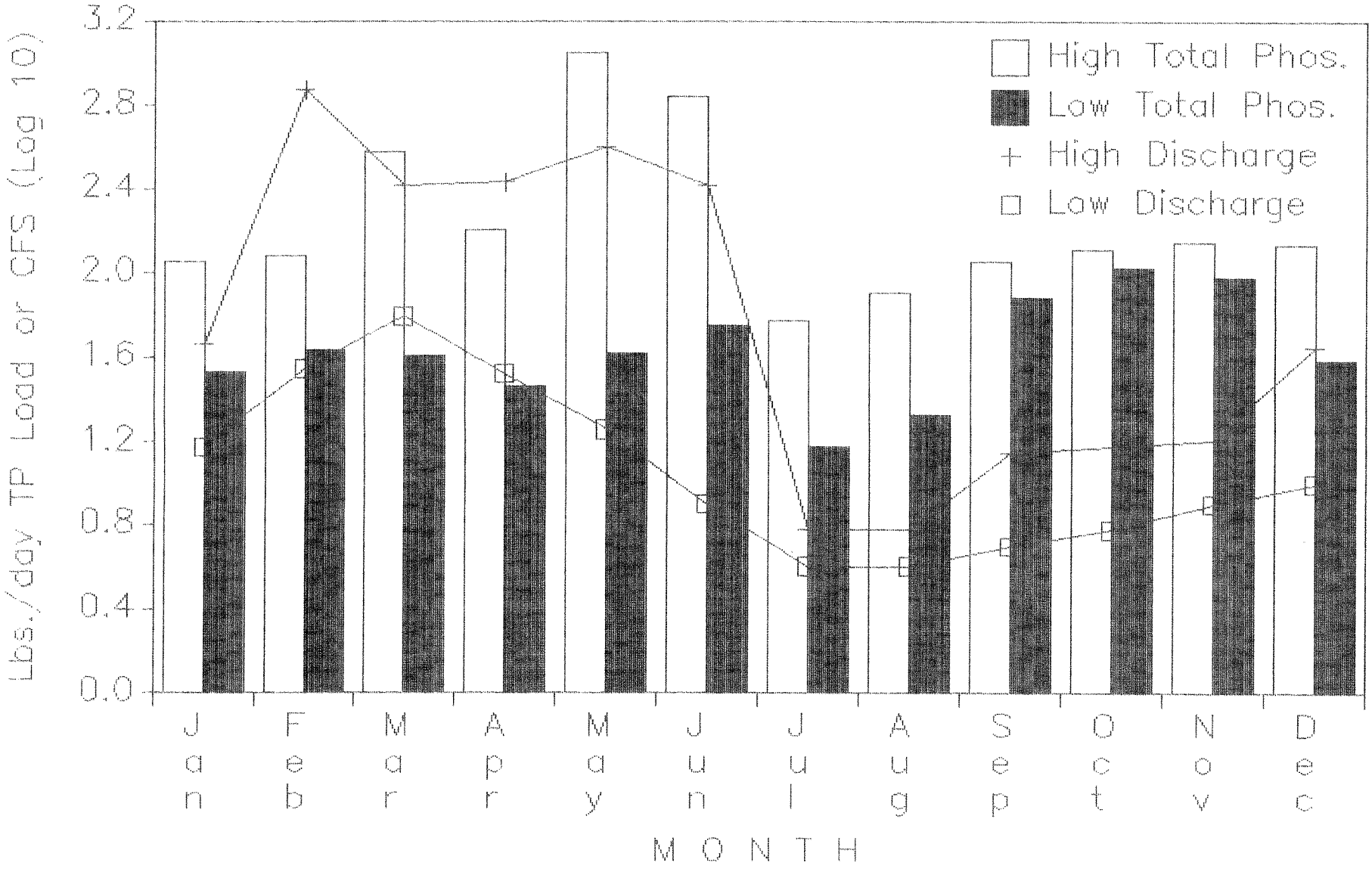
1. The SFPR within the study area was moderately to severely polluted.

2. Temperature, pH, D.O., and fecal coliform bacteria violated water quality standards. Nutrient enrichment was evident throughout the entire area.

3. Four toxic pollutant sources were identified: (a) Palouse Producers - ammonia; (b) Pullman WWTP - total residual chlorine and ammonia; (c) Paradise Creek-Moscow WWTP - nitrite; and (d) Missouri Flat Creek - nitrite.

4. No water quality improvements were observed since the last assessment in 1970. There was some evidence of greater fecal contamination and a less benthic invertebrate diversity since surveys in 1969-1971 by Yake (1971).

Figure 3. Comparison of discharge and total phosphorus load SFPR - 1982-1986



Data collected at Ecology Sta. 348110

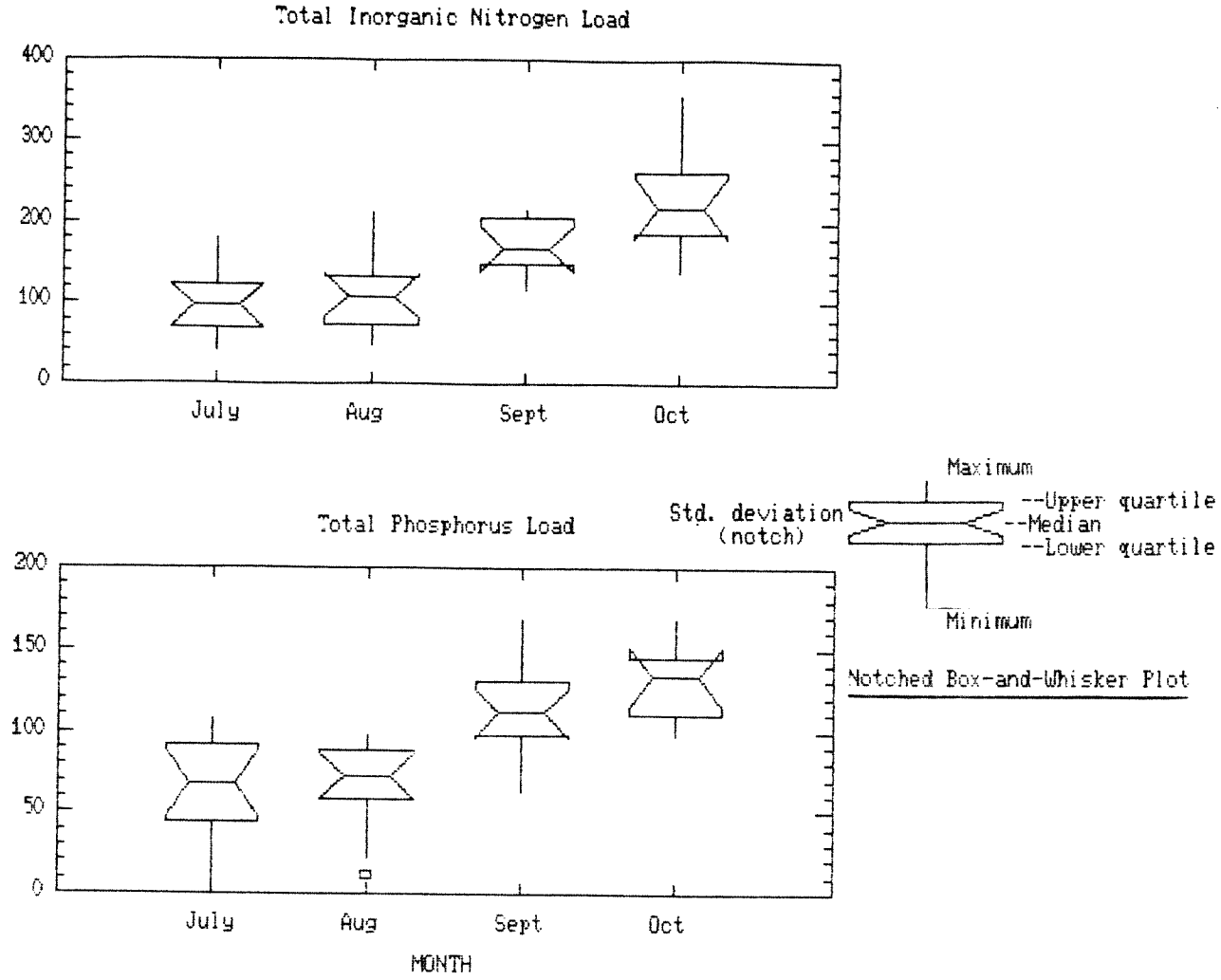


Figure 4. Distribution of 1971-1986 total inorganic nitrogen (TIN) and total phosphorus (TP) load data (lbs/day) at Ecology Station 34B110 - SFPR, 1986.

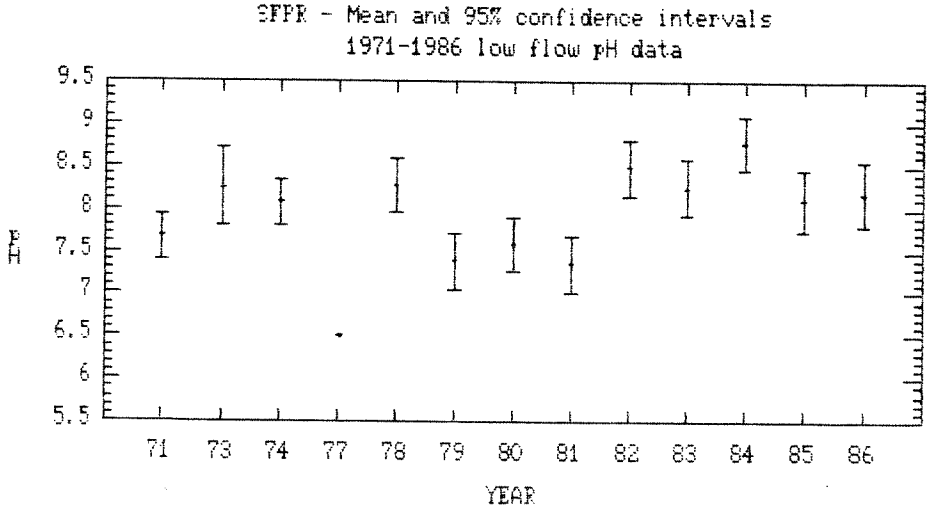


Figure 5. Seasonal low-flow pH data (July-October) at Ecology Station 34B110 - SFPR, 1986.

5. Pullman WWTP was operating well in terms of BOD and TSS removal; however, the dilution ratio was very poor. Total residual chlorine (TRC) and ammonia concentrations in the effluent were creating toxic conditions for aquatic life.

6. Palouse Producers, Inc. was having a substantial impact on SFPR water quality. Ammonia concentrations were 21 mg/L below the discharge (and above the Pullman WWTP): approximately 400 times the 1979 ammonia criterion.

7. Several sources of fecal waste were suspected within Pullman, above the WWTP.

Since that survey, the ERO staff have been able to eliminate the Palouse Producers' discharge and facilitate the Pullman WWTP upgrade. The Palouse Producers site now houses a fertilizer equipment rental operation. The Pullman WWTP upgrade in 1983-85 included:

- addition of a biotower and sludge dewatering equipment
- general improvements in existing equipment and structures
- addition of dechlorination equipment

METHODS

Descriptions and field/laboratory activities for individual stations are listed in Table 4. Station locations are shown in Figure 2.

Field analyses included: temperature by mercury thermometer, D.O. by Winkler-azide modified titration, pH and conductivity by field meters, and total residual chlorine (TRC) by DPD ferrous titrametric method (APHA-AWWA-WPCF, 1985). Stream discharge was calculated at selected sites using data obtained from cross-sectional stream and velocity measurements by either a magnetic or propeller flow meter.

Grab samples collected for laboratory analysis were stored in the dark on ice and received via air freight by the Ecology/USEPA Manchester Environmental Laboratory within 24 hours. All analyses were performed using approved procedures (USEPA, 1983; APHA-AWWA-WPCF, 1985).

Benthic invertebrate samples were collected at or near selected stations at the head of riffle areas. Specific collection sites were chosen because of similarities in water velocity and depth, and lighting characteristics. At each site a rock of four- to six-inch diameter was randomly selected from mid-channel, right channel, and left channel. Organisms were picked, scraped, and rinsed off each rock into a jar containing a 70 percent alcohol solution. Organisms were enumerated and identified to at least family level using standard texts: Merritt and Cummins (1976), Pennak (1953), and Usinger (1973).

Table 4. Station descriptions and monitoring activities for a water quality survey at the South fork of the Palouse River at Pullman, September 16-17, 1986.

Station	Mile	Station Description	Field/Laboratory Activities	Benthic Invertebrate Sample
1	23.5	South fork of the Palouse River (SFPR) approx. 1100' above confluence with Paradise Cr.,at bridge to business park.	Discharge, temperature, pH, conductivity, dissolved oxygen / F.C., COD, nutrients (4), chloride, total suspended solids	No
Paradise Cr.	0.1	Approx. 400' from confluence with SFPR (rm 23.4) at bridge in front of motel	Same as Station 1 / Same as Station 1	No
2	22.9	At Thatuna Park, 10' downstream of foot-bridge in mid-stream	Same as Station 1 / Same as Station 1	Yes
Thatuna Park	22.8	Draintile at rt. bank directly in front of fieldhouse	--/fecal coliform	No
WSU Boiler	22.6	Drain outfall at rt. bank 20' above bridge at Reany Park below WSU campus	Discharge, temperature, pH, conductivity / COD nutrients (4), chloride, total susp. solids	No
3	22.5	Approx. 50' below bridge at Reany Park, mid-stream on piling dam	Temperature, pH, conductivity, dissolved oxygen / fecal coliform, COD, nutrients (4), chloride, total susp. solids	No
Storm Drain	22.4	Grand Ave. storm drain at mouth, left bank, at Grand Ave. bridge	Same as Station 1 / Same as Station 1	No
Standard Lumber Drain	22.3	Drain from left bank behind Standard Lumber Co.	Temperature, pH, conductivity / Same as Station 1	No
4	22.2	Approx. 10' below State Street at mid-stream: Ecology & USGS monitoring site	Same as Station 1 / Same as Station 1	Yes
Missouri Flat Creek	22.1	Water quality samples taken at mouth; discharge at State St.: USGS gage site	Same as Station 1 / Same as Station 1	No
5	21.4	At southwest corner of Pullman WWTP site mid-stream in riffle, approx. 1000' up from WWTP outfall	Discharge, temperature, pH, conductivity, dissolved oxygen / fecal coliform, COD, BOD, nutrients (5), chloride, total susp. solids, enterococcus	Yes
Pullman WWTP	21.3	Dechlorinated samples from effluent line as stated in Heffner, 1987	Same as Station 5 + total residual chlorine / Same as Station 5	No
6	21.2	Approx. 600' below the WWTP outfall at Old City Dump Rd., mid-stream	Same as Pullman WWTP / Same as Station 5	Yes
7	20.9	Through field at bend and swale on Old City Dump Rd., midstream at riffle	Temperature,pH,conductivity,dissolved oxygen / Same as Station 5-no enterococcus	No
8	20.6	Through thicket at end of Old City Dump Rd., midstream at riffle	Discharge, temperature, pH, conductivity, dissolved oxygen / fecal coliform, COD, nutrients (5), chloride, total susp. solids	Yes
9	19.5	Approx. 25' upstream of wood bridge to farmhouse with silo on Albion Rd., mid-stream in riffle	Same as Station 8 / Same as Station 8	Yes
10	18.7	Approx. 50' downstream from Armstrong Rd. bridge, in horse pasture, mid-stream in riffle	Same as Station 1 / Same as Station 1	Yes

RESULTS AND DISCUSSION

Discharge

Instantaneous discharge measurements indicated the South Fork of the Palouse River (SFPR) undergoes a wide daily fluctuation (Table 5). The SFPR fluctuation may be common during low-flow periods when the Moscow WWTP and Pullman WWTP greatly influence SFPR discharge. Paradise Creek discharge, which is dominated by the Moscow WWTP, varied by 2.5 cfs (Table 5). Heffner (1987) recorded up to 4 cfs difference between instantaneous effluent discharge measurements at the Pullman WWTP during the Class II survey (Table 6). Irrigation withdrawals from Paradise Creek and the SFPR may also contribute to the variability.

The flow measured at Station 4 (the USGS gaging station and Ecology monitoring station) and Missouri Creek (another former USGS gaging station) were normal for September. Some statistics for these stations have been summarized in Table 7. The confluence of Missouri Creek and the SFPR is just upstream of the Pullman WWTP so that dilution water statistics for the WWTP are roughly the sum of the statistics of the two stations. For example:

- The 7-day, 10-year low flow (7Q10): (Missouri Creek 7Q10: 0.1 cfs) + (SFPR 7Q10: 0.6 cfs) = 0.7cfs

- Similarly, the mean monthly discharge for September equals 3.3 cfs

Pullman WWTP effluent discharge equaled or exceeded the SFPR discharge during the two-day survey (Table 5). Two sets of instantaneous flow measurements at the WWTP outfall (Stations 5 and 6) showed 1:1 and 0.9:1 receiving-water-to-effluent dilution ratios.

Only one set of flow data was collected below r.m. 21.2 (Stations 7 through 10). The 4.9 cfs increase in discharge between r.m. 21.1 and r.m. 18.7 could have been from WWTP discharge variability or additional ground water and/or surface water. Surface water tributaries were not evident while conducting the survey, although a comprehensive stream-walk was not performed.

Bernhardt and Yake (1979) measured slightly higher discharges during their survey (Table 8). However, their 1.3:1 dilution ratio was very similar to this survey.

Water Quality Upstream of the Pullman WWTP

Water quality data were collected at five instream stations and six point source stations above the Pullman WWTP (Figure 2). Several water quality problems were detected both in the SFPR and at the point sources. Some of the problems and sources were also identified by Bernhardt and Yake (1979). A brief description of the 1986 survey data for the point source stations follows:

Table 5. Water quality data, South Fork of the Palouse River, September 1986. All values are mg/L unless otherwise specified. Pullman WWTP results from Class 2 report by Heffner, 1987.

			Field Data								Laboratory Data																	
River Mile	Station Number	Date	Time	Discharge (cfs)	Temp. (°C)	pH (S.U.)	Spec. Cond. (umhos/cm)	Diss. Oxygen	Diss. Oxygen Percent Sat.	T. Resid. Chlor.	Fecal Coliform (#/100 mL)	Enterococci (#/100 mL)	BOD_5	COD	NH_3-N	NH_3-N*	NO_3 + NO_2	NO_3-N	NO_2-N	T. Inorganic Nitrogen	O-PO_4-P	Total P	pH (S.U.)	Spec. Cond. (umhos/cm)	Cl^-	Total Suspended Solids
23.5	1	9/16	1517	2.1	15.3	7.8	300	8.35	82.8		300			20	0.06	0.001	1.30			1.36		0.36	7.8	322	8	72
		9/17	1105	2.1	12.3	7.7	310				270			20	0.02	0.001	1.10			1.12		0.28	7.7	323	10	48
23.4	Paradise Cr.	9/16	1510	4.7	15.2	8.5	620	10.80	106.8		43			36	0.03	0.002	11.00			11.03		4.80	8.7	678	69	7
		9/17	1055	2.4	12.7	8.0	600				80			12	0.09	0.002	9.80			9.89		4.70	8.2	639	55	9
22.9	2	9/16	1500	6.0	15.6	8.5	490	11.60	115.7		3300			20	0.04	0.003	3.10			3.14		3.10	8.7	521	36	16
		9/17	1045	4.5	13.3	8.1	500				770			24	0.11	0.003	6.10			6.21		2.60	8.2	524	42	14
22.8	Thatuna Park	9/16	1455								700															
22.6	WSU Boiler	9/16	1450	0.2	25.2	8.5	380							20	0.08	0.012	0.48			0.56		0.27	8.7	423	7	12
22.5	3	9/16	1445	6.0	16.7	8.4	470	10.85	110.7		1800			28	0.05	0.004	5.60			5.65		2.40	8.6	505	38	14
		9/17	1030	4.7	12.7	8.0	510				250			28	0.15	0.003	6.30			6.45		2.60	8.1	544	42	16
22.4	Storm Drain	9/16	1425	0.1	15.2	8.3	440	8.85	87.5		260			28	0.04	0.002	0.99			1.03		0.23	8.5	484	12	17
			1015	0.1	15.5	8.2	460				400			4	0.03	0.001	0.96			0.99		0.26	8.4	504	15	9
22.3	Std.Lumb.dr.	9/17	1115		14.2	7.4	325				<1			<4	0.09	0.001	0.02			0.11		0.08	7.8	349	5	2
22.2	4	9/16	1400	6.0	15.6		500	10.35	103.2		530			32	0.06	0.001	5.90			5.96		2.80	8.6	520	33	18
		9/17	1010	4.7	12.3	7.9	515				510			24	0.23	0.004	6.80			7.03		2.60	8.1	553	40	12
22.1	Missouri	9/16	1415	0.3	13.5	7.8	410	7.40	70.6		2600			32	0.10	0.002	2.50			2.60		0.32	7.9	457	13	38
	Flat Creek	9/17	1000	0.3	11.8	7.6	440				1500			20	0.20	0.002	2.50			2.70		0.26	7.8	477	11	23
21.4	5	9/16	1245	4.9	14.9	8.2	490	10.65	104.7	0.0	3500	1300		32	0.13	0.005		6.00	0.14	6.27	2.50	2.70	8.4	554	35	13
		9/17	0645		11.6			8.00	73.2																	
		9/17	0945	4.9	12.2	7.9	545	9.60	89.1		1800		<4	24	0.23	0.004		7.20	0.26	7.69		2.70	8.1	599	46	16
21.3	Pullman WWTP	9/16	1130	5.3	21.5	7.0	575				160	2100		53	1.70	0.007		23.0	1.30	26.00	5.6	6.5	7.2	632	44	20
		9/16	1535	5.0	22.0	7.0	600				200	2200		36	2.50	0.011		23.0	2.00	27.50	5.8	6.2	7.2	630	42	20
		9/17	0840	4.9	21.3		580				160			32	0.51	0.002		26.0	0.42	26.93	6.0	8.1	7.1	642	41	12
		**					600						17	44	2.00			24.0	1.30	27.30	5.8	7.0	7.3	652	41	7
21.2	6	9/16	1230	10.4	18.1	7.5	530	8.45	88.8	<0.1	3000	1700		20	1.20	0.013		14.00	0.80	16.00	4.50	4.60	7.6	595	39	22
		9/17	0620		13.7			7.35	70.4																	
		9/17	0930	9.6	17.0	7.3	575	7.60	78.0		180		6	24	0.27	0.002		18.00	0.34	18.61	4.80		7.4	583	42	15
20.9	7	9/16	1215		17.7	7.5	530	8.20	85.4		3900	1300		36	0.52	0.005		14.00	0.46	14.98	4.40	4.50	7.6	581	39	29
		9/17	0630					6.55	63.0																	
		9/17	0915		16.5	7.3	575	6.85	69.5		260		7	32	0.35	0.002		18.00	0.43	18.78	4.80	5.20	7.4	625	44	19
20.6	8	9/16	1150		17.5	7.5	530	8.40	87.1		370			36	0.17	0.002		15.00	0.21	15.38	4.50	4.60	7.6	582	40	26
		9/17	0640		14.0			6.10	58.8																	
		9/17	0900	12.4	13.9	7.5	580	7.30	70.3		250			28	0.36	0.003		13.00	0.45	13.81	4.00	4.10	7.6	625	52	23
19.5	9	9/16	1120		15.2	7.8	510	9.30	92.0		260			32	0.19	0.003		9.90	0.28	10.37	3.20	3.10	7.9	577	48	17
		9/17	0610		14.5			5.00	48.7																	
		9/17	0840	15.3	14.2	7.6	460				240			24	0.42	0.004		13.00	0.64	14.06	4.00	3.90	7.9	654	38	11
18.7	10	9/16	1050		15.3	7.8	460	8.30	82.3		240			32	0.32	0.006	11.00			11.32		3.10	7.9	525	33	14
		9/17	0605		14.4			5.15	50.1																	
		9/17	0845	15.2	14.1	7.5	525				240			20	0.70	0.006	14.00			14.70		4.30	7.7	586	38	8

* Un-ionized ammonia calculated from pH and temperature tables in Thurston, Russo, & Emerson, 1979.

**24-hour comp. Inhibited BOD results:

Day	BOD(mg/L)
5	4.1
10	8.1
14	9.8
20	14.0

Table 6. Pullman WWTP flow measurements, South Fork of the Palouse River, September 1986 (Heffner, 1987).

Month	Day	Time	Instantaneous Flow (MGD)	Totalizer Reading	Flow for Time Increment (MGD)
9	16	1150	--	29929	
				*	2.15
9	16	1510	2.80+	2408	
					2.71
9	17	0820	5.78	21770	
					4.82
9	17	1050	3.90	26786	
			Average flow during inspection =		2.85

*Totalizer reset to zero at approximately 1200 hours each day. Meter was reset from approximately 30500 on 9/16.

+Ecology instantaneous measurement 2.9 MGD (assumes standard 18-inch Parshall flume)

Table 7. South Fork of the Palouse River and Missouri Flat Creek discharge statistics, SFPR, 9/86.

Water Body	Station Number	Period of Record	MONTHLY & ANNUAL MEAN DISCHARGES (CFS) Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Low Flow 7Q10*
South Fork+ Palouse River	11348000	1934-1979	4.0	9.1	37.3	88.7	110.8	120.8	58.6	23.0	9.7	3.5	2.8	3.0	39.8	0.6
Missouri Flat+ Creek	13348400	1934-1979	0.4	1.2	7.5	22.4	27.2	28.6	8.9	2.4	1.0	0.4	0.4	0.3	8.5	0.1
South Fork** Palouse R. at r.m. 22.0			4.4	10.3	44.8	111.1	138.0	149.4	67.5	25.4	10.7	3.9	3.2	3.3	48.3	0.7

* = 7Q10 = Seven-day, 10-year flow event
** = Approximate flow values assuming a simple additive relationship
\+ = Provided by USGS (1985)

Table 8. Summary of water quality data collected by Ecology during S.F. Palouse River intensive survey, September 13-14, 1978, SFPR, 1986.*

Station	Description	Flow CFS	Flow MGD	Temp (°C)	S. Cond. (umhos/cm)	pH	Turb. (NTU)	D.O. (mg/l)	D.O. Sat. (%)	T. Chlorine (mg/l)	Total Coli. (Col/100 ml)	Fecal Coli. (Col/100 ml)	Fecal Strep (Col/100 ml)
1A	SF Palouse above Paradise Cr.	0.59	0.38	10.1	289	7.9	5	9.3	90	- -	700	100	40
1B	SF Palouse below Paradise Cr.	- -	- -	11.4	529	7.8	4	9.8	98	- -	9,000	180	70
PC	Paradise Creek at Mouth	3.20	2.05	11.2	592	7.8	5	9.0	89	- -	7,500	170	100
2	SF Palouse at Tatuna Park	- -	- -	11.3	485	7.9	3	10.1	101	- -	13,000	220	30
3	SF Palouse at Reany Park	- -	- -	12.5	517	7.8	5	12.3	126	- -	8,000	420	60
4	SF Palouse at USGS gaging station	5.73	3.67	11.6	507	7.8	4	9.3	93	- -	32,000	8200	60
MFC	Missouri Flat Creek @ Mouth	0.36	0.23	12.1	406	7.8	3	8.4	85	- -	6,800	940	570
PA	Palouse Produce Scrubber Effluent	- -	- -	- -	- -	9.0	--	- -	- -	- -	- -	- -	- -
PB	Palouse Producer cooling water effluent	- -	- -	50.0[1/]	- -	11.2	--	- -	- -	- -	- -	- -	- -
5	SF Palouse below Palouse Producers	- -	- -	15.1	567	9.3	6	9.9	107	- -	41,000	5200	790
6	SF Palouse above Pullman STP	5.32	3.41	13.4	586	9.2	7	10.3	108	- -	>100,000	6400	1100
PS	Pullman STP effluent	4.16	2.66	19.0	593	7.2	4	6.2	73	1.5	5,700	80	150
7	SF Palouse 200 feet below STP	7.75	4.96	18.5	605	7.4	6	7.2	84	- -	<100	<20	<10
8	SF Palouse 800 feet below STP	- -	- -	17.7	612	8.4	7	8.5	97	0.4	<100	<20	<10
9	SF Palouse 8/10 mile below STP	- -	- -	16.9	566	8.3	5	8.4	95	0.3	<100	<20	<10
10	SF Palouse 4/10 mile below STP	- -	- -	16.6	533	8.2	4	7.4	83	0.2	<100	<20	<10
11	SF Palouse 1-7/10 miles below STP	- -	- -	15.5	476	7.4	4	7.8	85	<0.1	2,000	70	20
12	SF Palouse 2-5/10 miles below STP	- -	- -	14.9	490	7.4	4	8.4	91	<0.1	- -	- -	- -

[1/] Read from gauge on scrubber

*From Bernhardt & Yake (1979)

Table 8. Summary of water quality data collected by Ecology during S.F. Palouse River intensive survey, September 13-14, 1978, SFPR, 1986.* (continued)

Station	Description	FC:FS Ratio	Ammonia-N (mg/l)	Un-ionized Ammonia (mg/l)	Nitrite-N (mg/l)	Nitrate-N (mg/l)	Total Kjeldahl-N (mg/l)	Total Ortho Phosphate-P (mg/l)	Total Phosphate-P (mg/l)
1A	SF Palouse above Paradise Cr.	2.5:1	.02	<.001	.01	.03	.45	.12	.14
1B	SF Palouse below Paradise Cr.	2.6:1	.02	<.001	.01	7.10	- -	3.70	3.30
PC	Paradise Creek at Mouth	1.7:1	.04	.001	.10	9.00	2.09	5.10	5.10
2	SF Palouse at Tatuna Park	7.3:1	.07	.001	.01	6.20	1.60	3.00	3.00
3	SF Palouse at Reany Park	7.0:1	.02	<.001	.02	7.10	- -	3.20	3.60
4	SF Palouse at USGS gaging station	136.7:1	.06	.001	.03	7.00	18.00	3.10	3.00
MFC	Missouri Flat Creek at Mouth	1.7:1	.07	.001	.20	1.50	.90	0.20	.90
PA	Palouse Producer Scrubber Effluent	- -	550.00	500+	- -	- -	- -	- -	- -
PB	Palouse Producer cooling water effluent	- -	150.00	- -	- -	- -	- -	- -	- -
5	SF Palouse below Palouse Producers	6.6:1	21.00	9.220	<.01	8.00	- -	2.80	2.80
6	SF Palouse above Pullman STP	5.8:1	20.00	7.020	.20	6.80	21.00	2.50	2.50
PS	Pullman STP effluent	1.0:1	13.10	.107	<.02	<.02	- -	3.00	3.30
7	SF Palouse 200 feet below STP	2.0:1	16.00	.184	<.01	3.40	- -	2.50	2.50
8	SF Palouse 800 feet below STP	2.0:1	16.00	1.620	.20	4.00	>10.00	2.60	2.70
9	SF Palouse 8/10 mile below STP	2.0:1	9.80	.801	.60	4.10	7.40	2.50	2.60
10	SF Palouse 4/10 mile below STP	2.0:1	5.50	.361	.60	4.40	9.20	2.90	9.20
11	SF Palouse 1-7/10 miles below STP	3.5:1	2.90	.027	.50	3.80	4.20	3.80	4.20
12	SF Palouse 2-5/10 miles below STP	- -	4.70	.042	.30	2.80	5.40	5.30	5.40

*From Bernhardt & Yake (1979)

- SFPR above Paradise Creek (Station 1) - Fecal coliform exceeded Class A criteria both days. Total suspended solids were high relative to other samples. Agricultural land uses predominate upstream of the site, although the branch flows through the south end of Moscow, Idaho.

- Paradise Creek - Elevated phosphorus and inorganic nitrogen contributed 94 percent and 91 percent of the respective loads to the SFPR below the Paradise Creek confluence. Ammonia toxicity was not apparent (Table 9). Samples had low coliform but high chloride and conductivity levels compared to Station 1 levels. Paradise Creek is the receiving water for the Moscow WWTP, 6.5 miles upstream.

- Thatuna Park Drain Tile - The sample from a non-discharging pool below a drain tile had an elevated coliform level. The source of the drain tile was not known, but it appeared to be part of the play field drainage system.

- WSU Boiler Cooling Water - The elevated temperature of the cooling water did not result in Class A violations. The pH and ammonia concentrations did not significantly affect the SFPR downstream.

- Grand Avenue Storm Drain - Fecal coliform levels were greater than Class A criteria, but about the same as Station 1. Other parameters were also similar to Station 1 values.

- Small Drain at Standard Lumber - The data did not indicate any problems.

- Missouri Flat Creek at Mouth - Fecal coliform concentrations exceeded Class A criteria. Total phosphorus was similar to Station 1 while total inorganic nitrogen was somewhat higher. A break in a sewage collection system line was detected approximately 25 feet up from the confluence with the SFPR. It was a likely source of the fecal contamination. The line was repaired shortly after our survey (Peterson, 1987).

Stations 2, 3, 4, and 5 in the main channel of the SFPR through Pullman showed many similarities to one another (Table 5):

- All fecal coliform samples exceeded Class A criteria.

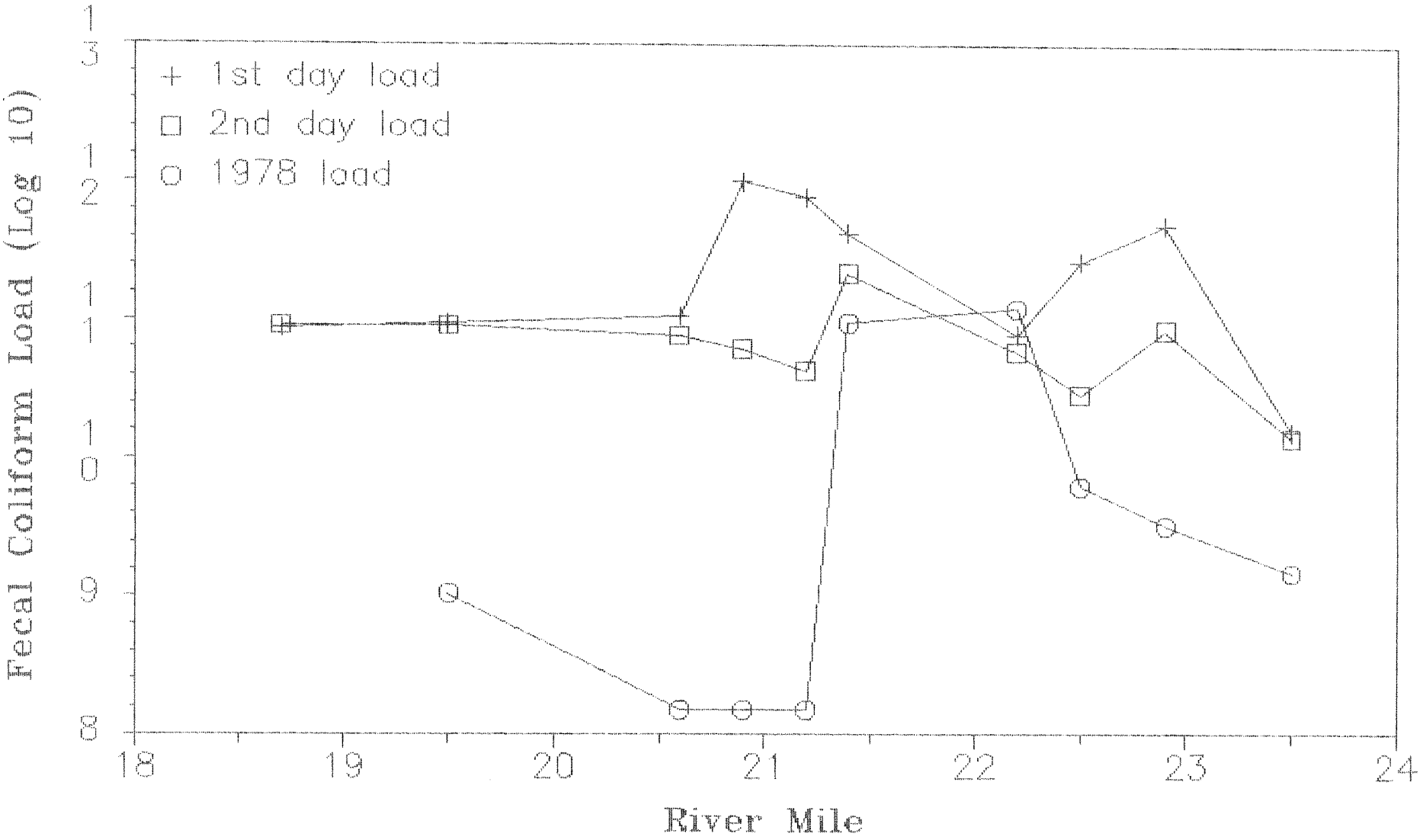
- All dissolved oxygen (D.O.) concentrations were above saturation.

- All pH levels were higher than Station 1 levels.

- Phosphorus and total inorganic nitrogen concentrations remained at nuisance levels throughout the reach.

Fecal coliform levels within the main channel were not always closely associated with the identified point sources. For example, Stations 2 and 5 had high coliform loads both days (Figure 6). Station 5, below

Figure 6. Fecal Coliform Loads- SFPR
September 1986 and September 1978



Pullman WWTP discharges at r.m. 21.3

Missouri Creek, probably received fecal contamination from both Missouri Creek and horses and donkeys that had access to the site from left bank pastures. In contrast, the source of contamination at Station 2 remains unknown. Station 2 was above the Thatuna Park drain tile (high fecal counts) and below Paradise Creek and Station 1 (relatively low fecal counts). The surrounding area of small warehouses, a business park, apartments, and a mobile home park is served by the Pullman sewage collection system (T. Dokken, personal conversation, April 1987). Obvious sources of fecal contamination were absent and the fecal load does not correlate with nutrients, TSS, chlorides, or conductivity.

Bernhardt and Yake (1979) found high fecal coliform levels above the WWTP to Paradise Creek, but the peak loads were at different sites than 1986 (Figure 6). They suspected human contamination along the entire reach, and a concentrated source just above Station 4; e.g., the Grand Avenue storm drain or other unknown discharge. The present survey results indicate the source above Station 4 is either intermittent or removed.

The pH and D.O. fluctuations are probably related to the heavy growth of filamentous algae, periphyton, and aquatic macrophytes present along the entire reach. The rich supply of nutrients and lack of riparian cover encourage benthic growth. The biota tend to elevate daytime D.O. and pH as a result of photosynthesis. At night the D.O. and pH often fall due to respiration processes (see Pullman WWTP and Receiving Water section).

As discussed earlier, there haven't been significant changes in water quality above Station 4. Bernhardt and Yake (1979) observed similar water quality characteristics, and ambient monitoring data haven't indicated any improvements. However, the benthic macroinvertebrate samples collected during the 1986 survey show some changes from 1978. These will be discussed in the Benthic Macroinvertebrate section.

Below Station 4 the removal of the Palouse Producers discharge of ammonia has improved water quality at Station 5, above the WWTP (Tables 5 and 8). However, fecal coliform concentrations exceed Class A criteria. Enterococci, a sub-family of the fecal streptococci, were also very high and exceeded the proposed Class A criterion of 61 organisms/100 mL. Total phosphorus and nitrite/nitrate loads and heavy benthic growths were as excessive as in 1978 (Bernhardt and Yake, 1979).

Water Quality below the Pullman WWTP

The Pullman WWTP significantly impacted the water quality of the SFPR because the volume of effluent equaled or exceeded the upstream discharge of the SFPR. Water quality sample results from Station 6, located approximately 600 feet below the outfall, indicated incomplete mixing based on mass balance calculations from effluent and Station 5 (upstream) sample results (Table 5). This is supported by formula from Fischer, et al., (1980) that indicate complete mixing of the effluent and receiving water would take approximately 850 feet.

The Ecology dilution zone guidelines suggest a maximum longitudinal mixing length of 300 feet (Ecology, 1985). Under current discharge operations, these guidelines are not feasible. The ERO is aware of this limitation.

Heffner (1987) stated in his Class II report:

"1) the WWTP achieved good removal of BOD and TSS,

2) all effluent parameters met NPDES permit limits except that the ammonia (NH_3-N) concentrations were greater than allowed monthly levels,

3) NH_3-N and total residual chlorine (TRC) were much lower in 1986 than in 1978."

These conditions were reflected in the receiving water data where TRC and NH_3-N toxicity were not detected (Tables 5 and 9), and mid-day (September 16) D.O. concentrations met the Class A criterion of 8 mg/L.

The WWTP effluent created violations of both pH and temperature Class A criteria (Table 2). The effluent lowered instream pH for at least 0.7 mile (Station 8) below the outfall (Table 5). The pH reduction may be a function of dechlorination processes and was probably beneficial in one aspect: the ammonia toxicity potential was also reduced. The instream temperatures remained elevated for 0.4 mile (Station 7). The temperature at Station 7 was an average of $3^{o}C$ higher than Station 5 despite Station 7's better riparian cover (Table 5).

Ammonia toxicity to aquatic organisms increases with increased temperature and/or pH. The WWTP effluent increased temperatures, but decreased pH in the SFPR and prevented toxic conditions. The pH measurements were taken earlier in the day than those upstream of the WWTP so that they may not represent daily maxima. However, the rate of pH increase also appeared to be suppressed at downstream stations compared to most upstream stations (Figure 7). Degradation processes may have contributed to pH suppression at Stations 6, 7, and 8.

The Pullman WWTP increased the instream ammonia load 11 times (50 pounds/day). Degradation processes generally decreased instream ammonia concentrations and loads to Station 8 - r.m. 20.6 (Figure 8). Loads increased at Stations 9 and 10 - r.m. 19.5 and 18.7, respectively. Possible explanations for these NH_3-N increases could be:

- Nonpoint source contamination, especially from livestock access to the SFPR
- WWTP effluent concentration and load variation
- Biological reduction of organic materials into inorganic forms

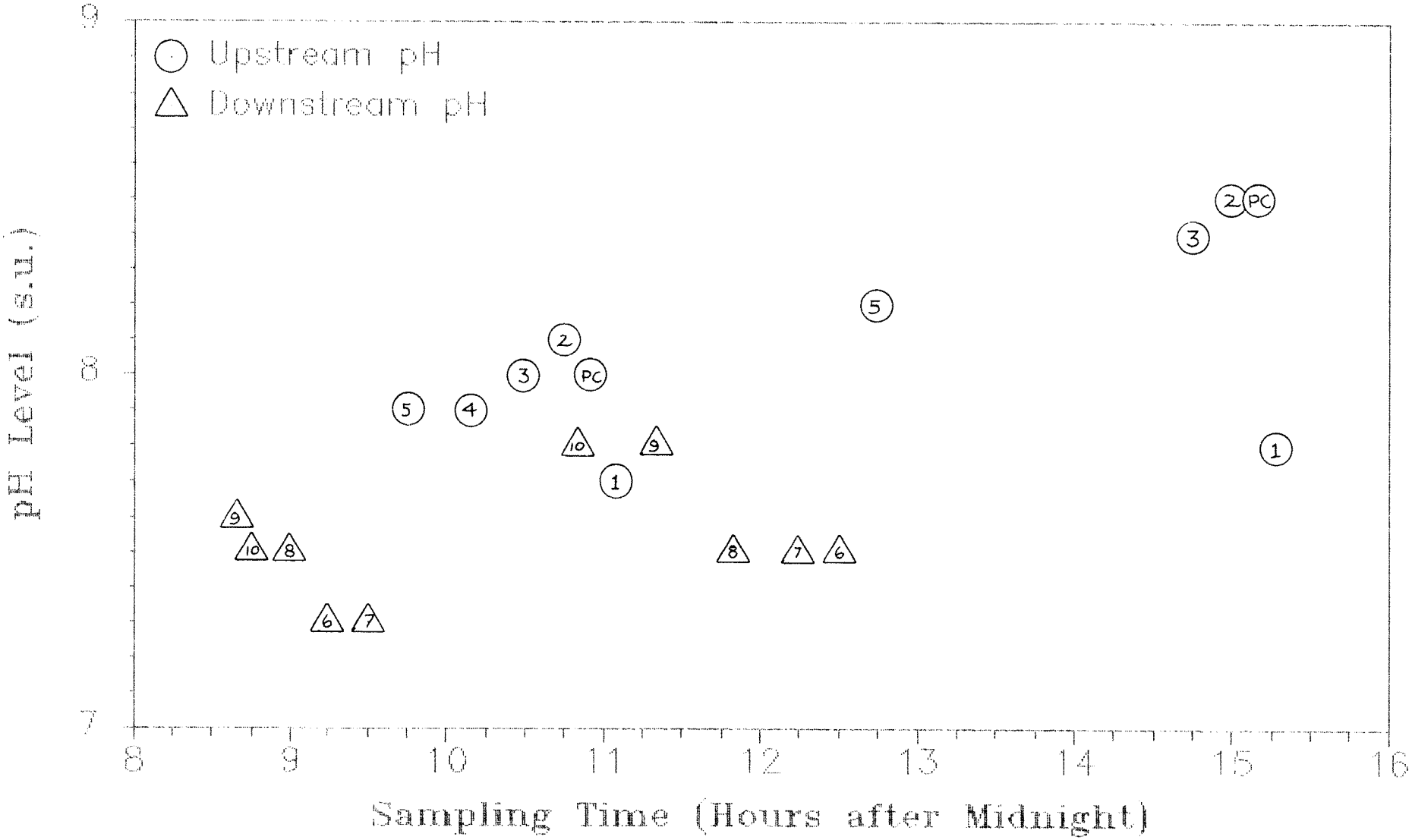
The data collected during the survey are not sufficient to fully assess any of these possibilities, especially when flow and loading variability are considered.

Table 9. Calculated ammonia criteria and un-ionized ammonia concentrations, SFPR, September 1986. All NH_3-N values are mg/L. Table courtesy of M. Heffner, WQIS.

Station Number	Instream Values pH (S.U.)	Temp. (°C)	NH_3-N	Un-ionized NH_3-N	Criteria Calculations One-Hour FT*	FPH*	Criteria Un-ionized NH_3-N	Five-Day Ratio*	FT*	Criteria Un-ionized NH_3-N
1	7.8	15.3	0.06	0.001	1.384	1.118	0.138	16.000	1.384	0.027
	7.7	12.3	0.02	0.001	1.702	1.201	0.105	16.000	1.702	0.020
Paradise Cr.	8.5	15.2	0.03	0.002	1.393	1.000	0.153	16.000	1.393	0.030
	8.0	12.7	0.09	0.002	1.656	1.001	0.129	16.000	1.656	0.025
2	8.5	15.6	0.04	0.003	1.355	1.000	0.158	16.000	1.355	0.030
	8.1	13.3	0.11	0.003	1.589	1.000	0.135	16.000	1.589	0.026
WSU Boiler	8.5	25.2	0.08	0.012	0.698	1.000	0.306	16.000	1.000	0.041
3	8.4	16.7	0.05	0.004	1.256	1.000	0.170	16.000	1.256	0.033
	8.0	12.7	0.15	0.003	1.656	1.001	0.129	16.000	1.656	0.025
Storm drain	8.3	15.2	0.04	0.002	1.393	1.000	0.153	16.000	1.393	0.030
	8.2	15.5	0.03	0.001	1.365	1.000	0.157	16.000	1.365	0.030
Std.Lumb.dr.	7.4	14.2	0.09	0.001	1.493	1.600	0.089	23.943	1.493	0.011
4		15.6	0.06	0.001	1.355	*****	0.000	47.886	1.355	0.000
	7.9	12.3	0.23	0.004	1.702	1.053	0.119	16.000	1.702	0.023
Missouri	7.8	13.5	0.10	0.002	1.567	1.118	0.122	16.000	1.567	0.023
Flat Creek	7.6	11.8	0.20	0.002	1.762	1.305	0.093	18.525	1.762	0.015
5	8.2	14.9	0.13	0.005	1.422	1.000	0.150	16.000	1.422	0.029
	7.9	12.2	0.23	0.004	1.714	1.053	0.118	16.000	1.714	0.023
Pullman WWTP	7.0	21.5	1.70	0.007	0.902	2.810	0.084	34.251	1.000	0.007
	7.0	22.0	2.50	0.011	0.871	2.810	0.087	34.251	1.000	0.007
	7.0	21.3	0.51	0.002	0.914	2.810	0.083	34.251	1.000	0.007
	7.0	21.5	2.00	0.009	0.902	2.810	0.084	34.251	1.000	0.007
6	7.5	18.1	1.20	0.013	1.140	1.435	0.131	21.199	1.140	0.019
	7.3	17.0	0.27	0.002	1.230	1.807	0.096	26.688	1.230	0.011
7	7.5	17.7	0.52	0.005	1.172	1.435	0.127	21.199	1.172	0.018
	7.3	16.5	0.35	0.002	1.274	1.807	0.093	26.688	1.274	0.011
8	7.5	17.5	0.17	0.002	1.189	1.435	0.125	21.199	1.189	0.018
	7.5	13.9	0.36	0.003	1.524	1.435	0.098	21.199	1.524	0.014
9	7.8	15.2	0.19	0.003	1.393	1.118	0.137	16.000	1.393	0.026
	7.6	14.2	0.42	0.004	1.493	1.305	0.110	18.525	1.493	0.018
10	7.8	15.3	0.32	0.006	1.384	1.118	0.138	16.000	1.384	0.027
	7.5	14.1	0.70	0.006	1.503	1.435	0.099	21.199	1.503	0.014

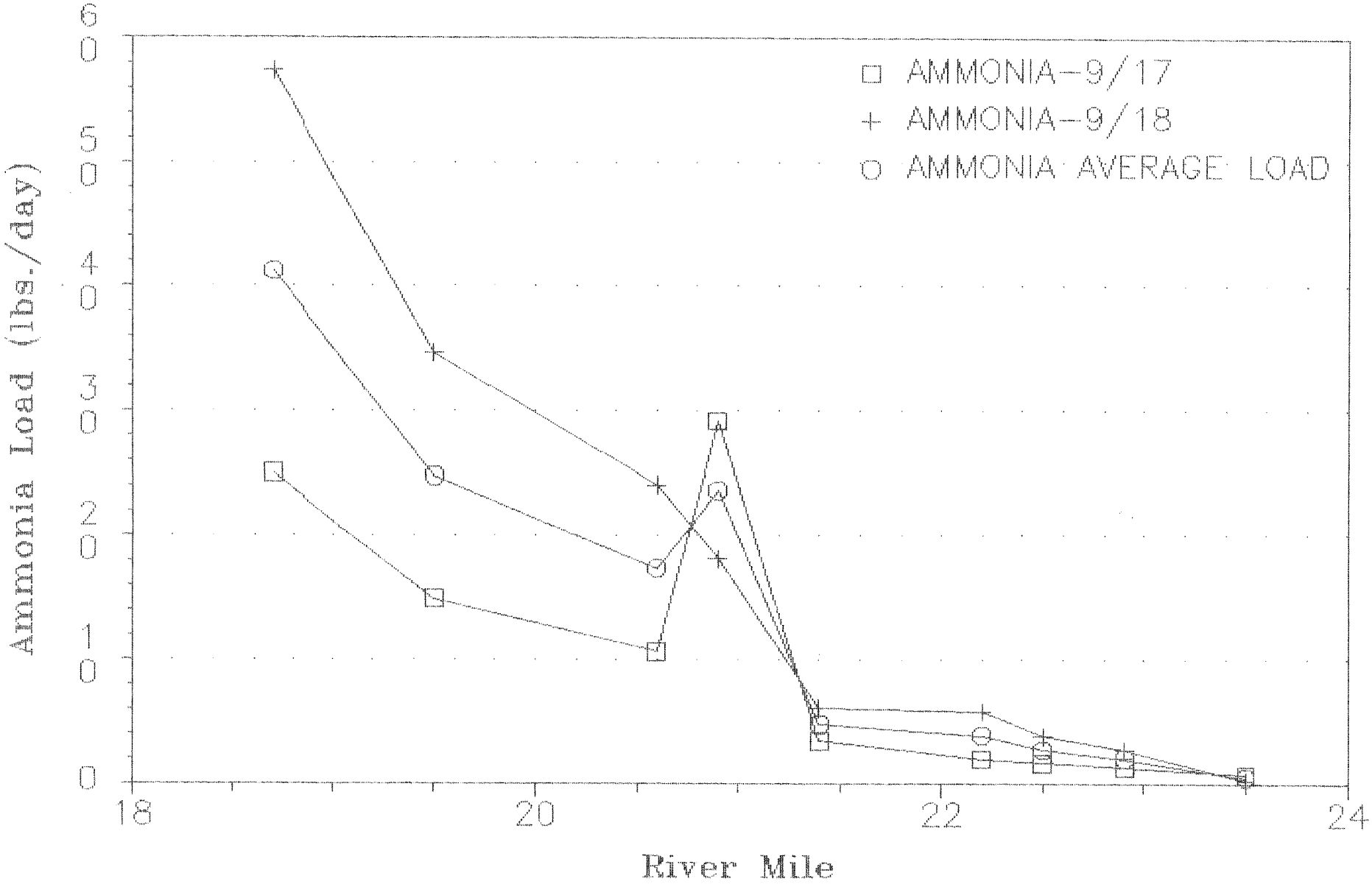
* = FT, FPH, and ratio are coefficents used in calculating the USEPA criteria.
See reference - USEPA, 1986
- Heffner, 1987

Figure 7. SFPR pH vs. Sampling Time, September 1986



Numbers within shapes denote sampling station

Figure 8. Ammonia Loads- SFPR, 1986



Pullman WWTP discharges at r.m. 21.3

The impact of the WWTP effluent on average instream loads of total inorganic nitrogen (TIN) and total phosphorus (TP) are shown in Figure 9. The WWTP was responsible for a five-fold (700 lbs/day) increase of TIN and a four-fold (200 lbs/day) increase of TP in the river. Average TIN and TP loads stayed fairly constant with progress downstream within the study area.

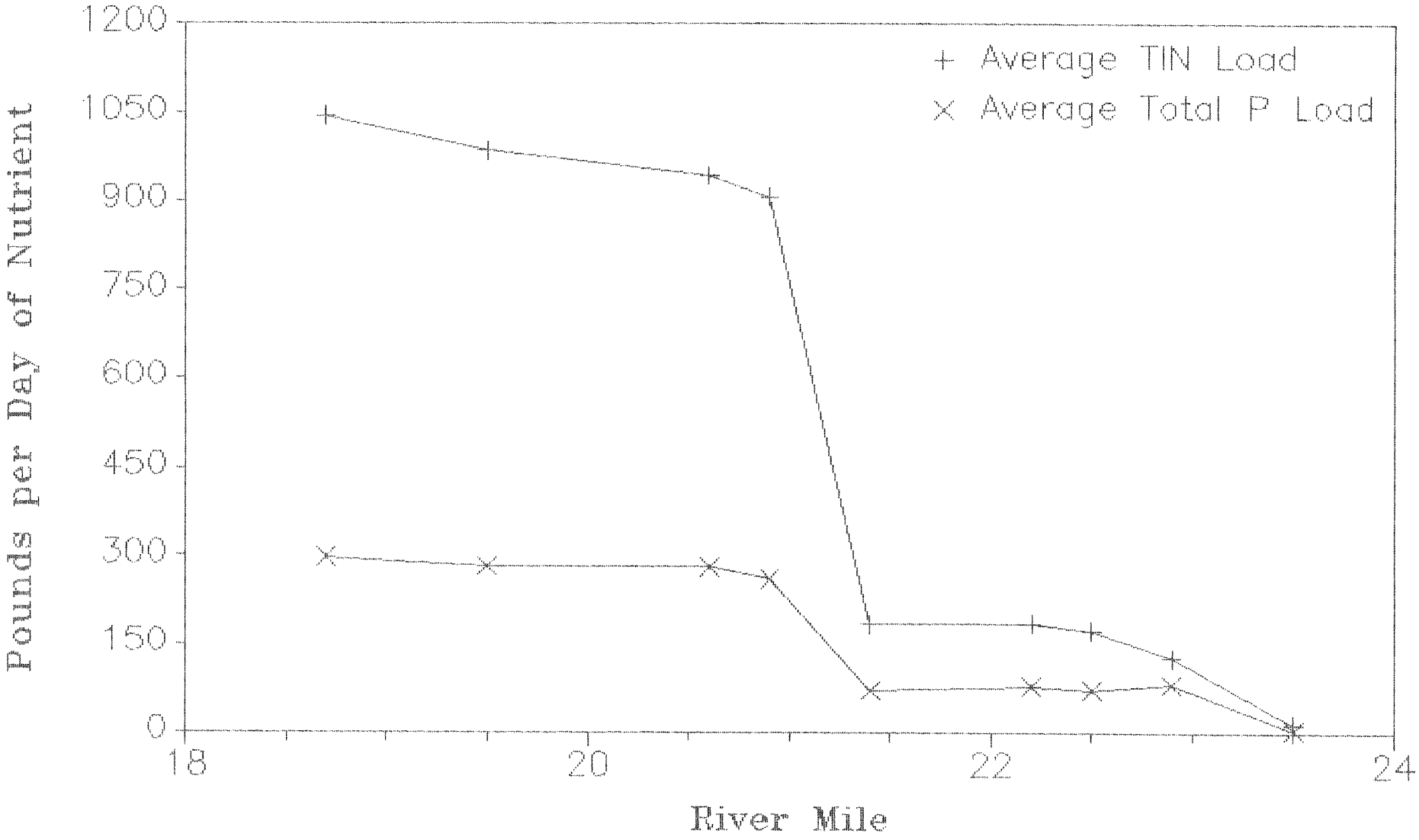
The nutrient loads created verdant growths of attached algae, weeds, mosses, and periphyton. The impact of this aquatic growth on dissolved oxygen (D.O.) below the WWTP was very apparent in samples taken at dawn (0600 to 0645 hours) on September 17 (Table 5, Figure 10). D.O. concentrations were all below the Class A criterion of 8 mg/L, and ranged from 5 to 7.35 mg/L. The D.O. at the control station (Station 5) for these samples was 8.0 mg/L. Three hours later, D.O. concentrations below the outfall continued to be depressed and in violation of the 8 mg/L criterion.

The expected daytime D.O. profile based on generalized effluent and receiving water parameters was simulated using a simple D.O. model (Joy, 1983). Model parameters and constants are presented in Table 10. The simulated D.O. profile matches the September 16 field data profile fairly well (Figure 11). The model assumes rather rapid nitrification and BOD decay rates that are characteristic of small, quick streams with cobble substrates (USEPA, 1983b). Respiration and D.O. generation through photosynthesis were not modelled. Therefore, the September 17 field data are not well represented by the simulation. The simulation suggests that under the September 1986 SFPR and WWTP effluent flow and quality conditions, the SFPR D.O. losses would not be extreme due to direct effluent degradation processes. Class A D.O. violations would be limited to the 0.5 mile section below the outfall.

Fecal coliform and enterococcus counts below the WWTP were not significantly different from upstream counts (Table 5). Fecal coliforms exceeded Class A criteria, although disinfection of the WWTP effluent was effective and effluent probably did not contribute to the fecal "load." Coliform "loads" remained stable below Station 8 (Figure 6). Livestock access to the river and other nonpoint sources may have been responsible for this. Enterococci counts at Stations 6 and 7 were the same order of magnitude as upstream counts, but far exceeded the proposed 61 organism/100 mL Class A criterion. More sampling will be necessary to assess the effectiveness of chlorine disinfection on WWTP effluent enterococcus loads since downstream loads appeared to increase (Note: Coliform loads also increased the first day, but did not on the second.) Some researchers have reported that disinfection is less effective for enterococci than for coliform organisms (Miescier and Cabelli, 1982).

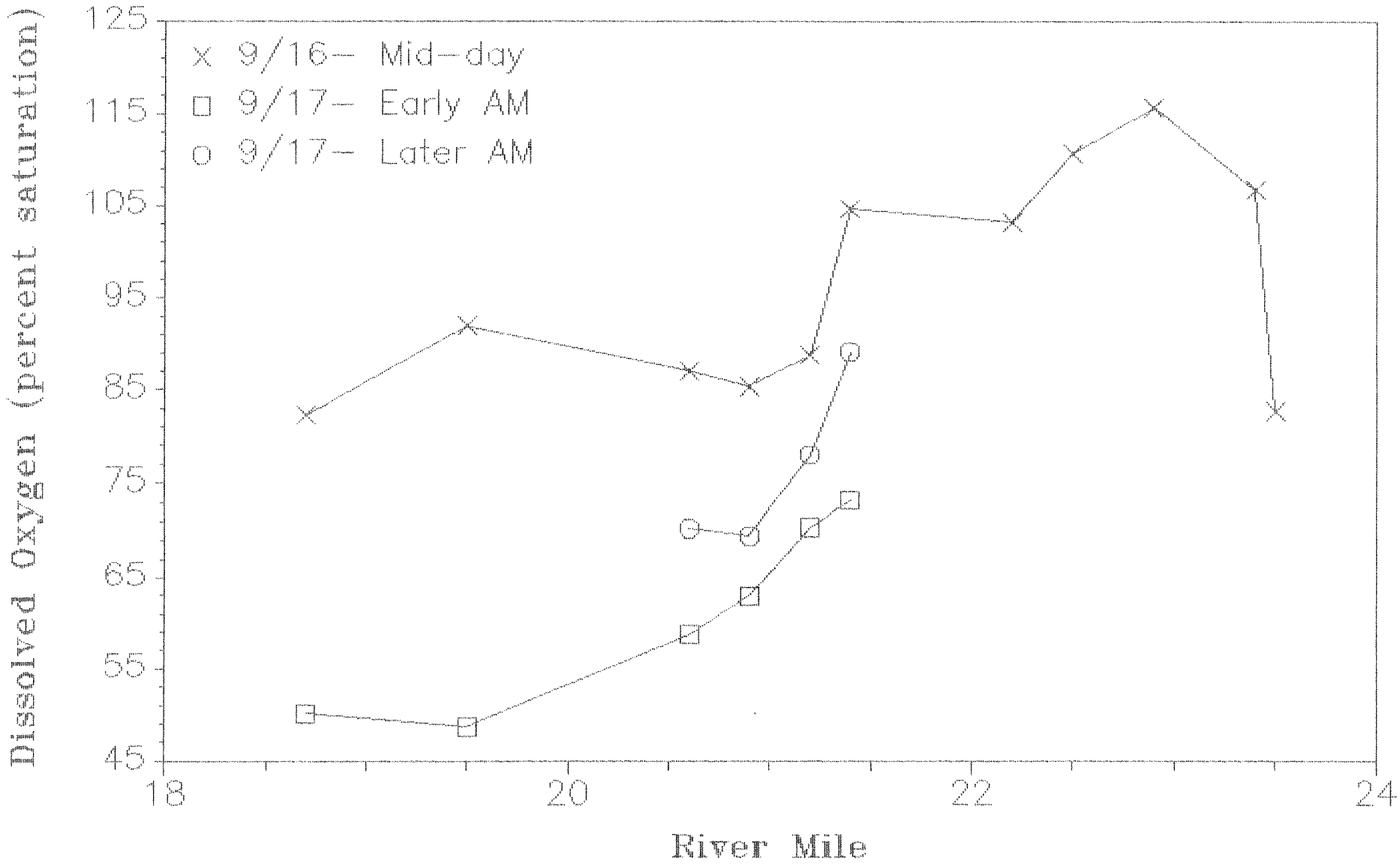
The major changes in the Pullman WWTP receiving water since Bernhardt and Yake's (1979) survey have been the removal of chlorine toxicity and the decreased potential for ammonia toxicity. Effluent and receiving water pH levels were lower in 1986 than 1978. Receiving water nutrient and BOD loads were not significantly different, although the inorganic nitrogen is now primarily nitrate rather than ammonia. However, the quality of the SFPR above the WWTP discharge has improved

Figure 9. Average Total Inorganic Nitrogen & Total Phosphorus Loads during the Survey- SFPR, 1986.



Pullman WWTP discharges at r.m.21.3

Figure 10. Dissolved Oxygen Profiles- SFPR, 1986.

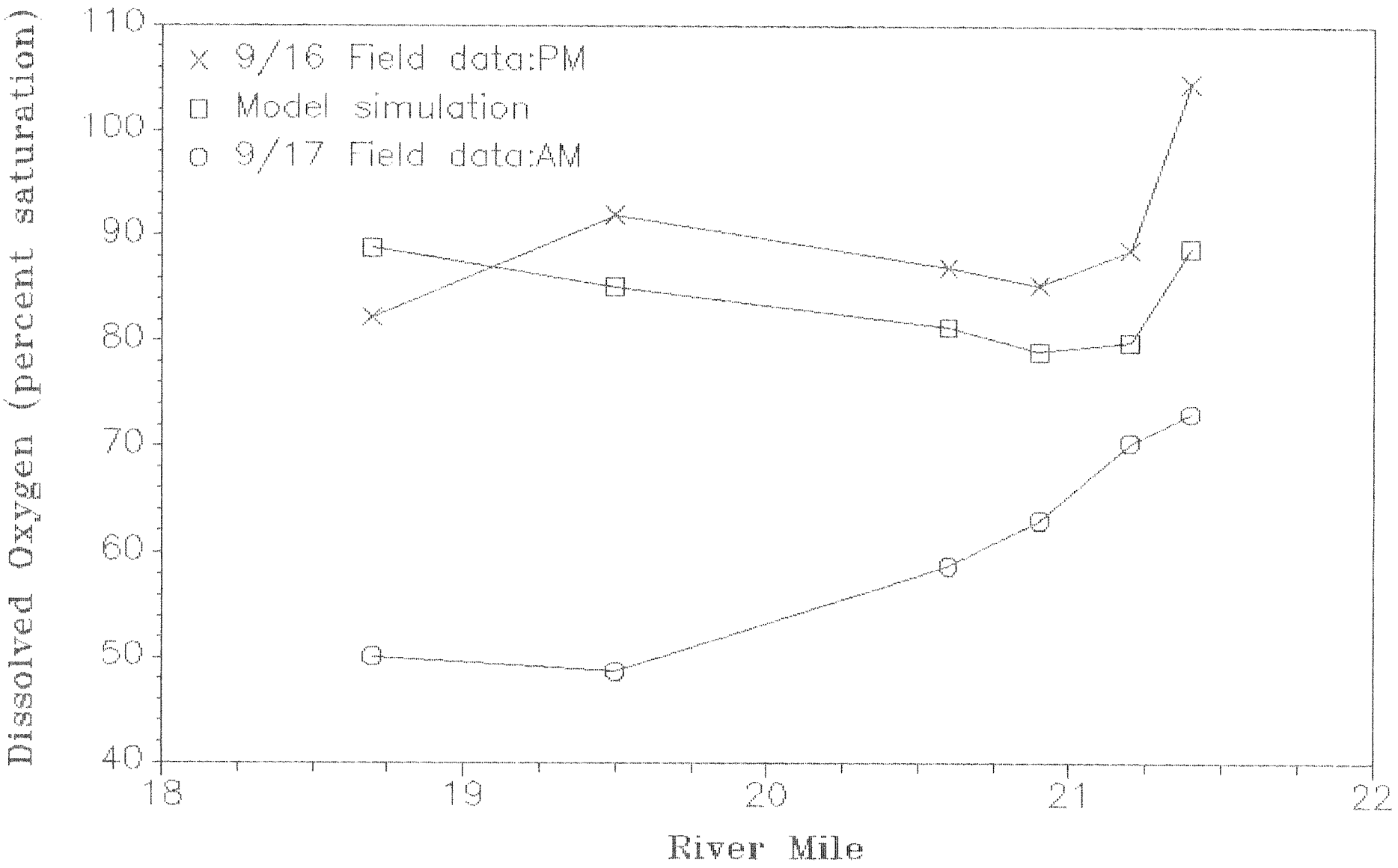


Pullman WWTP discharges at r.m. 21.3

Table 10. Dissolved oxygen model variables and coefficient, SFPR, September 1987.

Model Variable or Coefficient	SIMULATION 9/16/1986	9/86 Load	Max. NPDES	Max. @ 20°C
Number of Reaches	3	3	3	3
Reach 1: r.m. 21.3 - 20.9				
Flow: (upstream), (source) cfs	4.9; 5.5	0.7; 5.5	0.7; 6.65	0.7; 6.65
Temp. (upstream), (source) °C	14.9; 21.5	12.2; 21.3	12.2; 21.3	20; 21.3
D.O. (upstream), (source) mg/L	10.7; 6	9.6; 6	9.6; 6	9.2; 6
NH_3-N (upstream), (source) mg/L	0.13; 2	0.23; 2	0.23; 1	0.23; 1
Ultimate CBOD, up, source	4; 20	4; 20	4; 30	4; 30
CBOD decay rate (log e)	2	2	2	2
NOD conversion rate (log e)	1.9	1.9	1.9	1.9
Reaeration rate	18.6	23.3	21.5	21.7
Reach 2: r.m. 20.9 - 20.0				
Flow	12	7.5	7.5	7.5
Temp.	17.5	16	16	20
NH_3-N	0.88	1.4	0.73	0.73
CBOD decay rate	2	2	2	2
NOD conversion rate	1.9	1.9	1.9	1.9
Reaeration rate	19.6	20.3	20.3	21.6
Reach 3: r.m. 20.0 - 18.0				
Flow	12	7.5	7.5	7.5
Temp.	15.3	14.2	14.2	20
NH_3-N	0.5	0.74	0.39	0.39
CBOD decay rate	2	2	2	2
NOD conversion rate	1.9	1.9	1.9	1.9
Reaeration rate	26.2	36.7	36.7	40.2

Figure 11. Dissolved Oxygen Field Data and Model Simulation Results- SFPR, 1986



Pullman WWTP discharges at r.m. 21.3

slightly, but still remains poor. Therefore, many of the eutrophication problems and Class A criteria violations downstream of the WWTP are not just effluent problems. The quantity of the SFPR remains a major problem for proper dilution of the effluent.

Benthic Macroinvertebrates

Benthic macroinvertebrate assessments are used to reflect longer term water quality conditions and verify assessments made from intensive chemical water quality results. Also, macroinvertebrate population diversities and abundances are often better measures of progress toward "fishable-swimmable" criteria than chemical parameters. Many fish forage on macroinvertebrates and are often sensitive to water quality conditions affecting macroinvertebrates.

The seven macroinvertebrate sites sampled in 1986 roughly correspond to seven of the ten sites sampled by Bernhardt and Yake (1979). The macroinvertebrate data from the 1986 and 1978 collections are summarized in Table 11. Shannon-Wiener diversity indices for the samples were calculated and are also presented (Hellawell, 1978).

The Shannon-Wiener index scores and a calculation of percent similarity between sites indicated three somewhat distinct macroinvertebrate communities within the 1986 survey area (Figure 12). The communities illustrated in the dendogram are:

1. Stations 2 and 4 -- characterized by a relatively high percentage of Trichoptera and Gastropoda, but relatively few Diptera and Oligiochaeta; Shannon indices both about 2.6.

2. Stations 6, 8, and 5 -- characterized by a relatively high percentage of Oligiochaetes and Diptera; Shannon indices among lowest calculated: 1.4 to 2.4.

3. Stations 9 and 10 -- characterized by having a wide variety of organisms while still being somewhat dominated by Diptera; Shannon indices 2.6, 2.8.

The 1986 macroinvertebrate results poignantly illustrate some of the findings of the chemical water quality results discussed earlier:

- Water quality conditions upstream of Station 4 are fairly uniform.

- Deterioration of water quality just upstream of the Pullman WWTP (Station 5) from the broken sewage line and the livestock access becomes more severe below the WWTP outfall.

- Some recovery in water quality conditions are evident by Stations 9 and 10, 1.8 to 2.6 miles below the WWTP outfall.

The 1986 macroinvertebrate populations were much more diverse below the Pullman WWTP and Palouse Producers (Station 5) than in 1978 (Table 11). Diversity may have improved because severe ammonia and chlorine toxicity from these sources has been eliminated. The Shannon-Wiener

Table 11. Benthic macroinvertebrate and diversity index data - SFPR, 1986.

Organisms	Station 2	Station 4	Station 5	Station 6	Station 8	Station 9	Station 10
TURBELLARIA :		1	3				
OLIGIOCHAETA :		1	124	393	356	55	11
HIRUNDINEA							
Hellobdella :					1	8	
Dina :					2	2	
ARACHNOIDEA :							
Hydracarina :			6	5	2	2	2
INSECTA :							
Collembolla :	1						
Ephemeroptera :							
Baetidae :			3	2			6
Odonata :							
Coenagrionidae :	2	2	1	5	5	4	4
Trichoptera :							
Hydropsychidae :	13	69	2	5	1	4	61
Hydroptilidae :							11
Lepidoptera :							
Pyralidae :		1				2	1
Coeloptera :							
Elmidae :	3	2	4	1	3	2	
Diptera :							
Chironomidae :		23	17	73	58	68	110
Simuliidae :	1		5	51	1	35	14
Empididae :	1	1	1	1	12	1	3
GASTROPODA :							
Physidae :	14	19	33	4	8	17	22
Lymnaeidae :	6	19	3	4		1	
Planorbidae :		31	6	1	32	21	37
Ancylidae :	5	80	28	5		1	
PELECYPODA :							
Sphaeridae :		1					
Total 'Families'	9	13	14	13	12	15	12
Total Organisms	46	250	236	550	481	223	282
Percent EPT*	28.3	27.6	2.1	1.3	0.2	1.8	27.7
Percent Diptera	4.3	9.6	9.7	22.7	14.8	46.6	45.0
Shannon Diversity Index	2.58	2.57	2.38	1.48	1.42	2.77	2.61
1978 Shannon Index**	1.50	0.92	0.09	0.00	0.13	0.02	0.01

* EPT = Ephemeroptera, Plecoptera, & Tricoptera
** from Bernhardt and Yake (1979)

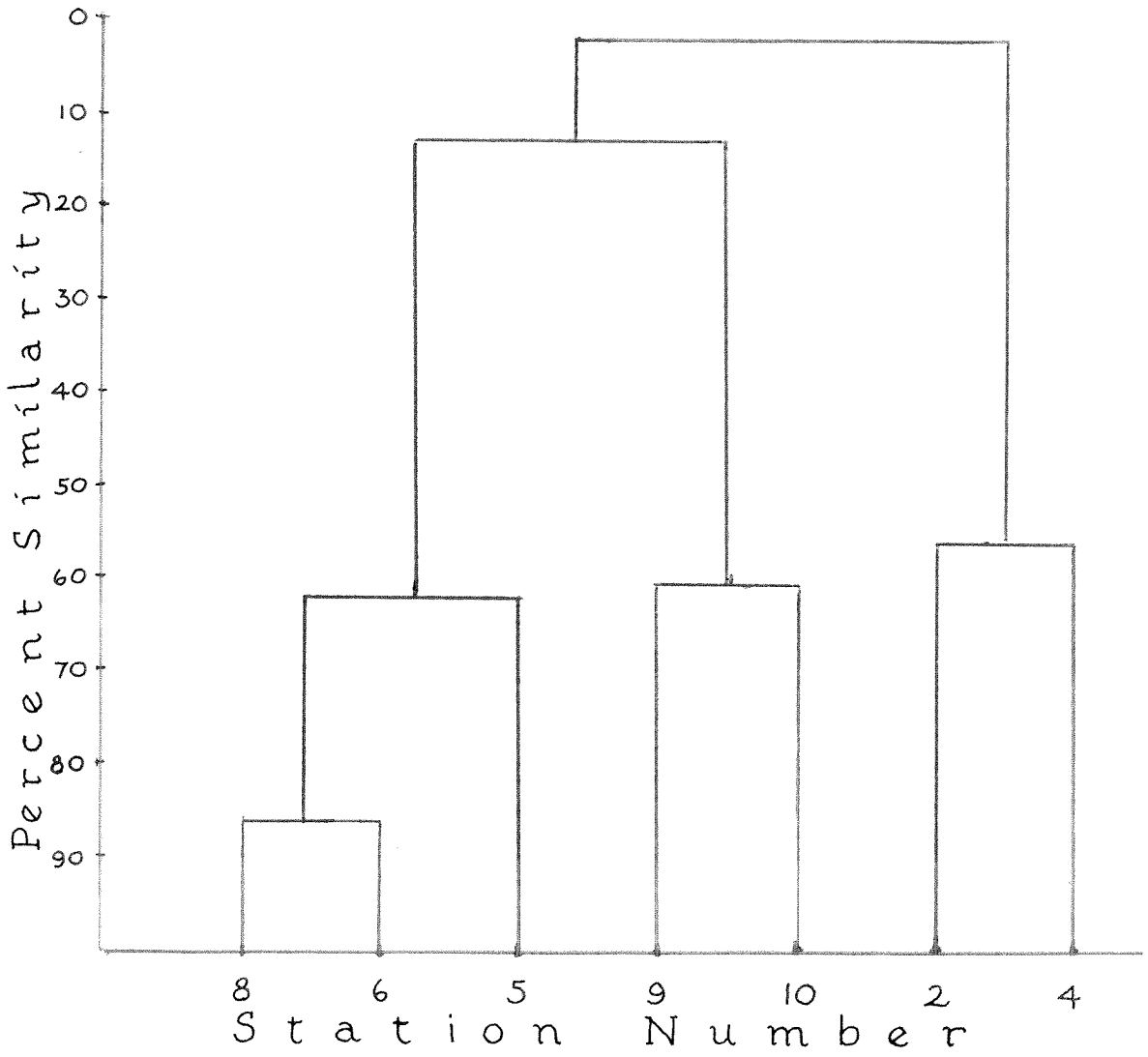


Figure 12. Similarity* of benthic macroinvertebrate assemblages - SFPR, 1986.

*Dendogram illustrating a possible association between benthic macroinvertebrate assemblages taken from seven sites in the S.F. Palouse R. near Pullman, September 1986. Percent similarity (or Raabes coefficient) coefficient defined as Σ (min xij, yij).

scores for Stations 2 and 4 also improved greatly. This is in contrast to the ambient monitoring station and 1986 survey data that indicated no apparent improvements in water quality in this upstream section of the study area (see discussion in Background and Water Quality Above the Pullman WWTP).

Comparisons made on only two or three sets of macroinvertebrate data are not highly reliable because of natural variation in macroinvertebrate populations and the influence of annual variations in temperature, discharge, and factors other than water quality on these populations. However, the data from Stations 2 and 4 are interesting, and future surveys should include macroinvertebrate samples from this area.

Total Maximum Daily Load Evaluation

As discussed throughout this report, the SFPR above the Pullman WWTP continues to have very poor water quality. Its WQI score is the worst in the state. Ambient monitoring network data and intensive survey data in 1978 and the present have shown few apparent water quality improvements: excessive fecal coliform, nutrients, TSS, and high pH levels. The SFPR receives Moscow WWTP effluent and nonpoint runoff. Flows are inadequate to handle these through much of the year. The river has nutrient, bacterial, and solids loads in excess of its capacity upstream of the Pullman WWTP discharge.

Many of the water quality problems experienced in the SFPR above the Pullman WWTP occur during the low-flow period of July through October. The critical flow used in a total maximum daily load (TMDL) evaluation is usually the 7-day, 10-year low-flow (7Q10). The 7Q10 above the Pullman WWTP outfall is approximately 0.7 cfs which is approximately one-tenth the 6.7 cfs permitted monthly WWTP discharge. This constitutes an extreme critical condition. Also, under most flow conditions, the WWTP effluent is not adequately diluted according to Ecology guidelines (Ecology, 1985):

- The WWTP 6.7 cfs discharge exceeds the mean monthly SFPR flow for the months of July through October.
- The older 20:1 receiving-water-to-effluent dilution ratio guideline (in this case, 134:6.7) is met only with SFPR mean monthly flows in January through March.
- The current 100:1 dilution ratio guideline (670:6.7 in this case) is not met by any SFPR mean monthly flow.

The dilution ratio guidelines have been set at levels considered reasonable for adequately diluting conventional and priority pollutants in most secondary municipal effluents (Ecology, 1985). On this basis, the Pullman WWTP effluent should be diverted from the SFPR from at least April through December, based on the dilution ratio guidelines rationale. However, it is not within the scope of this report to

assess the cost/benefit and water right issues of seasonal diversion or alternative treatment.

Improvements in the plant have helped to alleviate some of the most serious water quality problems below the WWTP outfall; i.e., ammonia and chlorine toxicity. Heffner (1987) has discussed in detail the possible violations of the current USEPA ammonia criteria based on upstream monitoring data and Pullman WWTP records. Heffner's analysis indicated that the four-day criterion for un-ionized ammonia downstream of the WWTP could have been violated several times over the past year while the WWTP was meeting its NPDES ammonia limits. However, Heffner also recognized the role the effluent plays in dampening instream pH and thereby decreasing the probability of ammonia toxicity. His recommendation was to monitor pH and temperature above and below the WWTP outfall to see if ammonia violations occur.

The findings of this survey concur with Heffner's assessment. Furthermore, I would suggest that the downstream monitoring site should be below the Old City Dump Bridge where full mixing has occurred. In addition, the rapid and variable rates of ammonia conversion into nitrite, nitrate, and organic compounds makes it prudent to measure ammonia concentrations as well as pH and temperature at these sites.

Dissolved oxygen concentrations below the WWTP were within the Class A criterion during the midday sampling survey. Early morning D.O. concentrations were far below the 8 mg/L criterion. Secondary effects from nutrient stimulation including periphyton and algal growth and the subsequent respiration and oxygen production affected instream D.O. for 2.5 miles downstream.

The model simulation of the daytime survey conditions indicated the effluent was directly responsible for Class A violations for 0.5 mile below the outfall. Two additional simulations were performed to estimate the WWTP effluent's direct impact on instream D.O. concentrations during a 7Q10 event in the SFPR. The first simulation used the Pullman WWTP effluent loads observed during the September 1986 survey. The second simulation used the maximum allowable monthly loads under the NPDES discharge permit. The data used in the simulations are presented in Table 10; results are displayed in Figure 13.

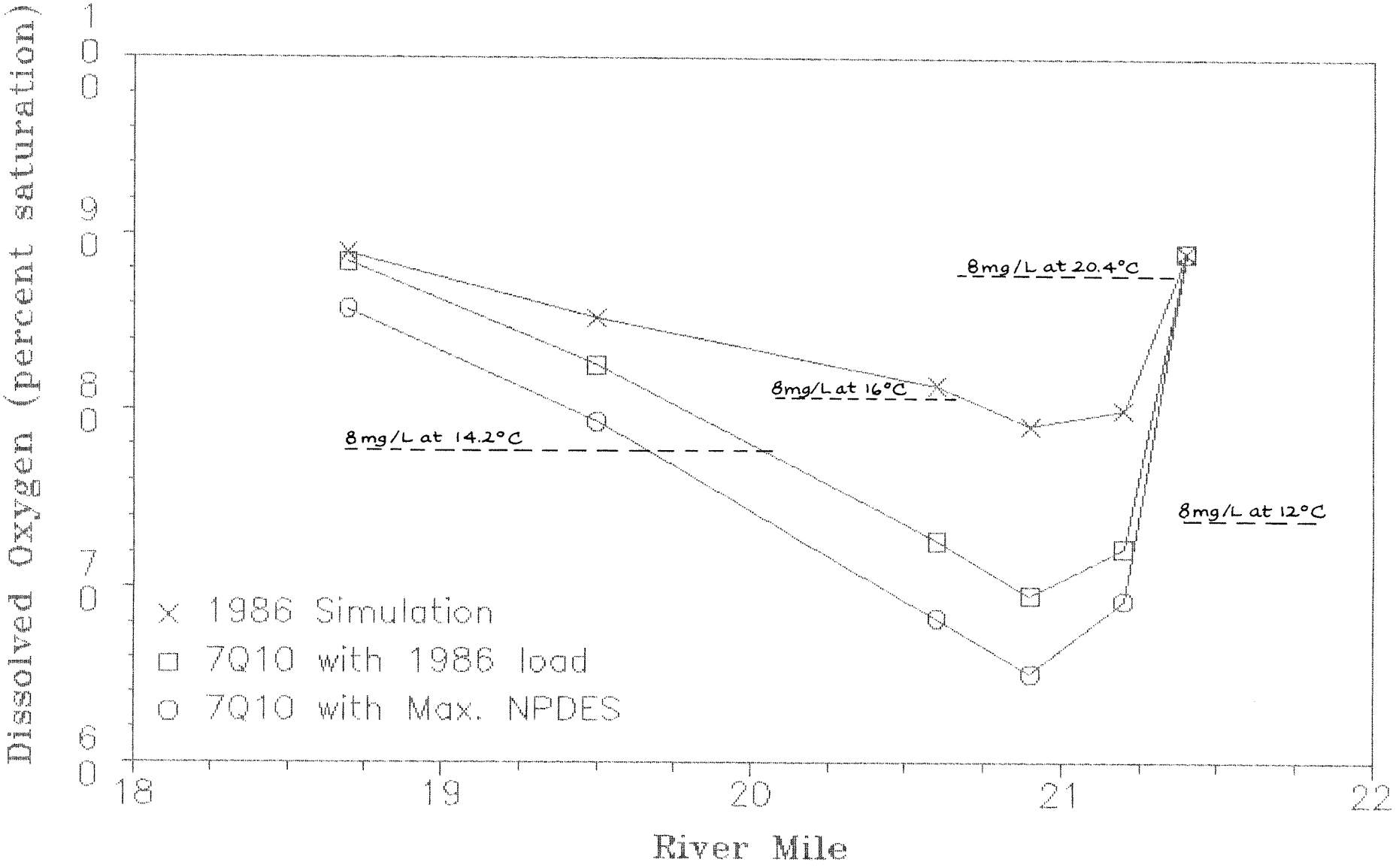
Generally, the model simulations indicate an immediate loss of 3 to 3.5 mg/L D.O. below the outfall. Instream D.O. concentrations would tend to return to Class A (8 mg/L) about 1.5 miles downstream if:

1. the instream temperatures below the outfall gradually returned to near-upstream temperatures (approximately 14^{o}C), and

2. the respiration and oxygen production effects of the benthic biota are not considered.

If instream temperatures remained at 20^{o}C, D.O. concentrations could remain below 8.0 mg/L for more than 2.5 miles below the plant. Benthic flora would tend to rapidly elevate D.O. concentrations during the daylight hours and depress them considerably (over night).

Figure 13. Dissolved Oxygen Simulations SFPR, 1986.



Pullman WWTP discharges at r.m. 21.3

The simulation exercises and the field data from the 1978 and 1986 surveys reinforce the need for adequate effluent dilution for both extreme effluent loading conditions and periods of relatively good effluent quality as observed in September 1986. Direct D.O. effects may be minor, but during the growing season (generally May through October), excessive nutrients from upstream sources and the WWTP create severe D.O. loss at night and reduce acceptable habitat for fish and other aquatic life.

CONCLUSIONS AND RECOMMENDATIONS

The 1986 water quality assessment and the receiving water survey of the South Fork of the Palouse River at Pullman found:

Water quality within the five-mile study area was generally poor. Class A fecal coliform criteria were violated along the entire length. Excessive nutrients from the Moscow and Pullman WWTPs created nuisance growths of attached algae and periphyton. These in turn created pH and nighttime D.O. violations. D.O. problems were especially evident below the Pullman WWTP in the early morning. Ambient monitoring data at r.m. 22.2 have shown no improvement in upstream water quality during the past 13 years, although benthic invertebrate communities above r.m. 22.2 have showed some.

- Some water quality improvements below r.m. 22.2 have been made since 1978. The removal of the Palouse Producers ammonia discharge helped reduce toxic conditions from r.m. 22.2 to r.m. 18.7. Benthic invertebrate communities below r.m. 22.2 showed greatly improved diversity--an indication of better water quality.

- The Pullman WWTP was meeting most of its NPDES permit limits. Ammonia and chlorine toxicity problems were not detected below the outfall. WWTP effluent created temperature and pH violations for 0.4 mi. and 0.7 mi. below the outfall, respectively. The inadequate volume and poor water quality of the SFPR above the outfall prevents proper mixing and dilution of the effluent, especially nutrients and oxidizable materials. As a result, morning D.O. concentrations below the outfall violated the Class A criterion. The recommended 20:1 dilution ratio cannot be met for the Pullman WWTP maximum monthly discharge (6.7 cfs) by SFPR mean monthly discharges in April through December. The 7Q10 for the SFPR is one-tenth the 6.7 cfs.

- Several point sources were investigated above r.m. 21.4. Of these, Paradise Creek and Missouri Flat Creek were the most significant. Paradise Creek was the main source of nutrients to the upstream reach--the Moscow WWTP and nonpoint sources probably were the major contributors to Paradise Creek. Missouri Flat Creek contained high fecal coliform levels, a result of a broken Pullman wastewater collection line just above the SFPR confluence.

- The WSU boiler cooling water outfall and the Grand Avenue storm drain were having minor water quality impacts during the survey.

The source of heavy fecal coliform loading between Paradise Creek and Thatuna Park was not identified.

- The TMDL evaluation of the Pullman WWTP discharge restated the problems associated with the poor water quality and inadequate volume of the SFPR. Heffner's (1987) ammonia load analysis showed the possibility of continued toxicity below the WWTP outfall at NPDES effluent ammonia limits. D.O. simulation of 7Q10 low-flow events with September 1986 and maximum permitted loading suggested some daytime D.O. violations of Class A criteria for 1.5 miles below the outfall. The area of violation would extend to 2.5 miles at higher temperatures ($20^{o}C$) and limited attached algae and periphyton oxygen production. Heavy losses of D.O. overnight were predicted based on September 1986 field observations.

The following recommendations are made based on the findings of 1978 and 1986 surveys and review of the ambient monitoring network data collected over the past 13 years.

- Monitor pH, temperature, and ammonia concentrations in the SFPR above and below the Pullman WWTP to ensure non-toxic conditions. Monitoring stations should be positioned to obtain a fully mixed sample.

- Investigate seasonal removal of the Pullman WWTP effluent from the SFPR during the months of June through October. During these months, mean monthly SFPR discharge does not meet 1:1 dilution, and attached algae and periphyton activity is high.

- Encourage the Moscow WWTP to reduce or remove its nutrient load from Paradise Creek.

- Identify the intermittent source of heavy fecal coliform contamination between Paradise Creek and Thatuna Park. Also identify nonpoint fecal contamination along the entire study area.

- Verify the fecal contamination in the Thatuna Park drain tile and investigate its source.

- Collect benthic macroinvertebrates from sites above r.m. 22.2 (USGS gage station) during any future survey to confirm general water quality conditions.

- Target the watershed for nonpoint action, e.g. livestock access controls, riparian habitat enhancement, and streambank erosion mitigation.

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APPENDIX I.

Water Quality Monitoring Data
from
Ecology Station 34B110,
South Fork of the Palouse River at Pullman,
1971 - 1986

DEPARTMENT OF ECOLOGY

RETRIEVAL --- JANUARY 12

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER QUALITY INVESTIGATIONS SECTION

34B110 SF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 58.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: WHITMAN SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: RMP

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH FEET	00060 STREAM FLOW CFS-AVG	00010 WATER TEMP DEG C	00300 DISSOLVED OXYGEN mg/l	00301 DO PERCENT SATURATN	00400 pH STANDARD UNITS	00095 CONDUCTVY @ 25 C MICROMHOS	00530 SOLIDS SUSPENDED mg/l	31504 TOTAL COLIFORM /100ml MF	31616 FECAL COLIFORM /100ml MF	31672 FECAL STREP /100ml PC
70/12/09	0830			2.0	12.1	95.2J	7.7			80000L	1200L	
71/01/26	0815			3.6	10.2	83.7	7.2	241		20000	1200	
71/02/09	0810			0.4	12.4	93.4	7.5	327		25000		
71/02/23	0835			3.3	11.6	94.5	7.6	295		20000		
71/03/09	0900			2.5	12.3	98.1	7.8	356		20000		
71/03/23	0800			4.0	11.7	97.0	7.6	211		13000		
71/04/06	0850			9.6	9.9	94.3	7.7	255		20000		
71/04/20	0750			8.8	10.2	95.3	7.8	284		30000		
71/05/04	0745			14.2	8.5	89.7	7.8	269		20000		
71/05/18	0830			8.4	10.8	100.0	7.9	300		40000		
71/06/02	0830			9.8	8.4	80.0	7.3	243		30000L		
71/06/15	0800			13.0	8.9	91.5	7.9	305		40000		
71/07/06	0740		9.0	13.6	8.3	86.5	8.0	395		30000		
71/07/20	0800		6.0	21.5	6.1	74.6	8.1	674		40000		
71/08/03	0815		6.0	20.4	4.8	57.5	7.5	680		50000L		
71/08/17	0855		4.0	15.0	7.7	82.8	7.1	700		140000		
71/09/07	0755		6.0	11.7	7.3	73.0	7.7	597		70000		
71/09/21	0745		5.0	8.0	8.2	75.3	7.6	640		50000		
73/10/17	0815		4.5	9.6	9.7	91.0	8.0	500		4000		
73/10/29	1605		4.8	9.4	11.7	111.1	8.5	670		7400		
73/11/13	0645		52.0	5.0	9.5	72.4	7.6	330		94000		
73/11/27	0645		25.0	1.8	11.1	86.9	7.9	480		10000		
73/12/11	0700		93.0	3.5	11.7	92.3	7.7	300		26000		
73/12/18	0645		293.0	5.3	9.4	80.6	7.5	200		24000	900	1000
74/01/08	0715		66.0	0.0	10.5	78.3	7.5	380				
74/01/22	0700		215.0	1.0	11.9	91.1	7.7	230		22000	490	160
74/02/05	0715		373.0	0.9	12.8	97.7	7.5	180		7800	400L	590
74/02/20	0715		200.0	1.2	13.0	100.0	7.6	150		16000	1200	270
74/03/05	0715		262.0	2.6	11.9	95.1	7.6	200		16000	820	200
74/03/19	0745		165.0	4.3	11.7	97.8	7.8	220		3600	900E	180E
74/04/02	0750		289.0	3.8	12.0	99.0	7.4	210		13000	8400	510
74/04/16	0730		93.0	7.5	10.6	97.8	7.7	240		7000	540	80E
74/05/07	0745		44.0	13.6	8.9	92.7	8.0	300		10000	450	160
74/05/21	0735		48.0	10.4	9.1	88.2	7.8	400		40000L	0B	320
74/06/04	0735		22.0	13.1	8.6	88.6	7.8	360		22000	1100	490
74/06/18	0740		15.0	20.2	7.0	83.5	8.0	430		30000	1600	240
74/07/09	0830		10.0	16.5	8.0	88.6	7.9	480		320000	520	940
74/07/23	0750		4.5	17.1	6.9	77.5	8.1	660		10000	1100	1500
74/08/06	0815		4.8	16.2	6.4	70.6	8.1	770		150000	3200	490
74/08/20	0805		5.1	13.5	7.5	82.1	8.2	790		6000	150	210
74/09/04	0805		5.3	14.6	7.5	79.9	8.2	710		30000L	300	150
74/09/17	0800		5.5	19.9	8.1	96.1	7.9	740		5600	130	90
77/10/26	0830		9.2	8.3			6.5				3520	
77/11/29	1115		19.0	7.0			6.3	230			3400	
77/12/20	0800		21.0	0.2			7.2	250			360	
78/01/24	0730		42.0	1.5	13.0	101.0	6.6	253			1200	
78/02/14	0815		68.0	2.2	12.9	102.2	7.0	210			450	
78/03/28	0815		40.0	11.4	10.2	101.7	7.2	250			240	
78/04/25	0730		30.0	14.0	9.5	100.4	8.0	275			423	
78/05/23	0815		22.0	11.6	10.5	105.2	8.2	275			6200E	
78/06/20	0800		5.7	14.2	9.1	96.6	8.0	400			108	
78/07/25	0815		3.9	18.8	9.0	105.3	8.4	350			2100	
78/08/22	0820		6.7	14.4	10.1	107.7	8.1	450	14		5600L	
78/09/26	0845		4.7	13.1	10.1	104.7	8.4	520	5		1900	

DEPARTMENT OF ECOLOGY

RETRIEVAL --- JANUARY 12

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER QUALITY INVESTIGATIONS SECTION

34B110 EF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 58.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: WHITMAN SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: RMP

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH FEET	00060 STREAM FLOW CFS-AVG	00010 WATER TEMP DEG C	00300 DISSOLVED OXYGEN mg/l	00301 DO PERCENT SATURATN	00400 pH STANDARD UNITS	00095 CONDUCTVY @ 25 C MICROMHOS	00530 SOLIDS SUSPENDED mg/l	31504 TOTAL COLIFORM /100ml MF	31616 FECAL COLIFORM /100ml MF	31672 FECAL STREP /100ml PC
78/10/24	0745		6.9	9.7	11.0	105.4	8.2	600	1000		1100	
78/11/29	0930		9.6	7.7	10.3	94.1	8.1	560	43		675	
78/12/20	0845		9.2	1.0	12.3	94.3	7.8	530	1600		520	
79/01/25	0930		7.7	0.4			7.8	540	71		2200	
79/02/22	0950		76.0	1.8	12.0	94.3	8.3	295	82		420	
79/03/20	0905		61.0	5.7	12.3	106.4	7.3	250	1500		540	
79/04/25	0915		79.0	11.6	9.9	98.0	7.9	400	122		2300	
79/05/22	1000		24.0	18.6	7.1	80.6	7.0	460	48		4200	
79/06/19	0930		13.0	14.2	9.3	97.9	7.2	505	18		32008	
79/07/24	0915		4.7	17.0	9.2	102.8	7.1		7		3200	
79/08/28	0900		5.2	15.4	9.8	106.5	7.3	940	24		31500	
79/09/25	0915		5.5	12.2	9.7	97.9	7.7	700	24		900	
79/10/23	0945		7.9	9.5	11.2	107.8	7.4	600	9		650	
79/11/27	0930		7.5	2.4	12.8	101.6	7.2	543	120		720	
79/12/18	0900		16.0	5.2	11.8	102.4	7.4	485	20		275	
80/01/22	0900		31.0	1.8	12.9	100.8	7.3	400	10		150	
80/02/27	0910		76.0	6.6	11.6	104.3	7.2	190	180		156	
80/03/25	0920		41.0	5.1	11.0	95.3	6.9	310	27		6750	
80/04/22	0930		23.0	12.4	10.2	105.3	7.9	330	13		1080	
80/05/29	0750		44.0	12.0	9.1	92.8	7.3	270	120		7900	
80/06/24	0750		12.0	13.7	9.2	97.4	7.8	290	130		67000	
80/07/22	1020		5.7	21.5	8.0	99.4	7.6	570	12		9500	
80/08/26	0800		5.0	10.0	9.8	95.4	7.7	600	22		4500	
80/09/23	0800		5.8	10.0	10.4	101.4	7.7	600	15		425	
80/10/21	0940		5.2	9.8	9.9	95.8	7.3	635	19		3200	
80/11/18	0745		7.9	6.1	10.9	95.3	7.6	470	30		6500	
80/12/16	0745		8.2	3.4	10.6	88.8	7.2	500	17		4500	
81/01/20	0730		10.0	3.4	11.0	90.6	7.0	440	12		7100	
81/02/23	0630		90.0	5.4	10.3	90.2	6.9	240	49		9750	
81/03/24	0730		20.0	5.9	10.1	88.8	7.3	360	15		10500	
81/04/21	0730		34.0	9.4	9.3	89.1	7.6	310	12		7900	
81/05/26	0700		20.0	12.8	9.6	99.4	7.2	300	44		675	
81/07/21	0710		5.0	17.2	8.9	100.9	7.5	490	14		11000	
81/08/18	0640		2.0	16.6	8.8	99.4	7.2	500	100		7500	
81/09/22	0650		5.0	9.7	10.0	96.3	7.2	550	11		870	
81/10/20	0610		5.0	8.8	9.6	90.2	7.5	575	211		2300	
81/11/11	0800		3.0	6.4	9.9	88.4	7.2	610	10		480	
81/12/08	1600		16.0	5.7	10.9	94.5	8.0	370	30		1500	
82/01/26	1440		744.0	1.5	11.9	91.8	7.4	230	600		220	
82/02/15	1550		750.0	3.2	8.0	64.4	7.4	160	2900		4400	
82/03/15	1545		260.0	5.0	10.2	79.3	7.7	200	170		220	
82/04/19	1430		90.0	9.0	12.0	100.6	7.6	225	28		390	
82/05/10	1415		400.0	9.8	12.6	118.7	9.6	321	9		110	
82/06/08	1620		200.0	18.0	13.9	156.1	9.5	318	5		3700	
82/07/11	1130		5.5	20.5	13.2	155.1	8.2	580	4		6600	
82/08/17	1310		4.4	21.6	14.6	180.8	9.1	580	8		160	
82/09/14	1135		8.9	13.0	11.9	122.6	8.5	505	41		2500	
82/10/19	1115		7.7	7.3	13.0	114.0	8.1	520	8		45000	
82/11/16	1125		10.0	5.0	12.0	103.4	8.2	525	4		3700	
82/12/28	1055		30.0	2.4	13.5	104.1	7.9	420	14		1000	
83/01/25	1135		42.0	3.6	12.6	101.5	7.8	310	120		12000	
83/02/22	1150		180.0	7.9	10.5	96.6	7.6	241	79		300	
83/03/22	1800		60.0	9.1	10.3	99.2	8.0	252	16			
83/04/19	1235		33.0	15.3	14.7	169.7	9.2	320	11		150	
83/05/24	1325		18.0	21.9	11.7	145.0	8.6	350	7		3700	
83/06/28	1215		8.2	21.6	11.9	143.1	8.6	390	8		14000	

DEPARTMENT OF ECOLOGY

RETRIEVAL --- JANUARY 12

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER QUALITY INVESTIGATIONS SECTION

34B110 EF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 58.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: WHITMAN SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: RMP

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH FEET	00060 STREAM FLOW CFS-AVG	00010 WATER TEMP DEG C	00300 DISSOLVED OXYGEN mg/l	00301 DO PERCENT SATURATN	00400 pH STANDARD UNITS	00095 CONDUCTVY @ 25 C MICROMHOS	00530 SOLIDS SUSPENDED mg/l	31504 TOTAL COLIFORM /100ml MF	31616 FECAL COLIFORM /100ml MF	31672 FECAL STREP /100ml PC
83/07/19	1230		4.0	22.2	13.1	160.3	8.6	455	4		6300	
83/08/23	1240		5.7	17.9	8.7	100.3	8.0	490	10		29001	
83/09/27	1235		5.2	15.2	12.0	130.9	8.6	580	29		170000	
83/10/25	1210		7.0	9.6	12.0	114.4	7.8	480	4		6000	
83/11/29	1215		16.0	3.5	13.1	108.2	8.2	435	9		440	
83/12/30	1220		29.0	0.4	12.7	104.1	7.9	415	32		100	
84/01/17	1115		28.0	0.4	13.4	100.4	7.9	280	14		2100	
84/02/07	1045		35.0	3.2	12.3	99.7	8.0	330	61		580	
84/03/06	1120		62.0	5.2	11.9	101.5	7.9	270	96		190	
84/04/10	1110		140.0	6.8	11.2	99.7	7.9	210	140		290	
84/05/08	1105		32.0	12.6	12.3	126.7	9.0	317	90		460	
84/06/12	1130		21.0	17.7	12.7	157.7	9.1	329	14		250	
84/07/10	1210		6.0	21.4	12.2	236.8	9.5	435	28		320	
84/08/14	1125		4.0	18.4	12.0	191.5	8.7	535	10		9500	
84/09/11	1210		5.0	13.6	11.9	127.0	8.5	535	8		97000	
84/10/09	1120		6.0	14.1	11.0	101.7	8.4	600	12		1700	
84/11/13	1140		15.0	8.2	9.9	92.0	8.0	392	21		3100	
84/12/11	1300		44.0	2.0	12.0	93.5	7.9	270	130		260	
85/01/15	1130		15.0	1.2	13.0	99.2	7.8	440	5		220	
85/03/12	1205		100.0	4.1	12.1	100.0	7.5	270	100		320	
85/04/02	1120		270.0	7.4	11.0	96.8	7.6	190	370		150	
85/05/07	1145		26.0	11.4	12.0	121.0	8.6	310	11		200	
85/06/11	1130		15.0	18.8	8.6	96.2	8.2	372	16		12000	
85/08/13	1155		4.0	15.0	11.1	105.9	8.6	540	16		6100	
85/09/17	1155		14.0	11.1	8.6	75.5	7.8	320			5600	
85/10/22	1200		15.0	5.0	9.2	75.2	7.9	329	42		2600	
85/11/19	1205		8.0	1.0	14.2	107.0	8.4	510	5		210	
85/12/10	1200		10.0	0.7	13.7	75.7	8.1	525	10		24000	
86/01/14	1150		36.0	1.3	12.0	91.2	7.7	295	35		220000	
86/02/11	1155		37.0	1.6	12.8	101.0	7.7	323	40		540	
86/03/11	1150		110.0	8.1	11.4	93.2	7.9	230	68		330	
86/04/15	1155		33.0	8.7	10.9	105.1	8.2	320	14		300	
86/05/13	1150		17.0	13.5	13.9	163.6	8.9	350	13		540	
86/06/10	1205		8.0	20.0	12.7	147.4	8.7	395	6		200	
86/07/08	1210		5.0	18.8	10.2	119.9	8.4	540	9			
86/08/12	1145		4.0	19.1	9.0	105.0	8.1	600	12		45000	
86/09/09	1220		5.0	16.0	9.3	100.3	8.0	530	25		1400	
86/10/21	1145			8.2	11.2	101.4	8.1	495				
86/11/04	1150			7.0	11.5	101.1	8.2	535				
86/12/09	1145			1.2	12.4	94.6	7.2	487				
87/01/13	1110			1.2	13.2	100.7	8.1	499				
87/02/10	1115			4.3	11.4	94.9	7.2	403				
87/03/17	1140			6.5	10.5	91.5	7.1	285				
87/04/14	1125			11.2	12.7	122.0	7.9	322				

DEPARTMENT OF ECOLOGY

RETRIEVAL --- JANUARY 12

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER QUALITY INVESTIGATIONS SECTION

34B110 SF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 58.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: WHITMAN SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: RMC

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH FEET	00070 TURBIDITY TURBMETER NTU	00080 COLOR PT-CO UNITS	00630 NITROGEN NO2 + NO3 mg/l	00620 NITRATE T NO3-N mg/l	00615 NITRITE T NO2-N mg/l	00610 AMMONIA T NH3-N mg/l	00671 DIS-ORTHO PHOSPHRUS mg/l P	00665 TOTAL PHOSPHRUS mg/l P	00410 ALKALINE T CaCO3 mg/l	00440 BICARB HCO3 ION mg/l
70/12/09	0830		160.0			11.20	0.07	0.19	0.36	1.14		
71/01/26	0815		370.0			3.29	0.00			3.55		
71/02/09	0810		25.0	18		3.29	0.02	0.20	1.19	1.23		
71/02/23	0835		65.0	122		2.31	0.06	0.29	0.54	0.38		
71/03/09	0900		65.0	102		2.45	0.05	0.39	0.50	0.93		
71/03/23	0800		170.0	242		2.11	0.02	0.09	1.03	1.10		
71/04/06	0850		25.0	118		2.51	0.13	0.00	1.95	2.27		
71/04/20	0750		25.0	62		3.04	0.10	0.01	0.79	0.80		
71/05/04	0745		20.0	64		2.07	0.20	0.05	0.69	0.51		
71/05/18	0830		25.0	72		3.21	0.01X	0.12	0.81	0.91		
71/06/02	0830		600.0	168		4.21	0.02	0.43	2.00	2.43		
71/06/15	0800		210.0	209		2.15	0.09	0.10	0.53	0.93		
71/07/06	0740		15.0	28		2.03	0.02	0.00	1.59	1.61		
71/07/20	0800		15.0	44		1.93	0.05	0.12	2.69	2.83		
71/08/03	0815		45.0	95		1.77	0.04	0.10	2.56	2.96		
71/08/17	0855		10.0	54		3.31	0.08	0.02	2.81	2.98		
71/09/07	0750		10.0	58		3.43	0.02	0.34	1.14	1.89		
71/09/21	0745		8.0	55		2.51	0.03	8.00	3.99	4.19		
73/10/17	0815		7.0	57	5.50			0.25	5.20	5.50	109	242
73/10/29	1805		5.0	53	6.90			0.29	6.40	6.50	107	228
73/11/13	0645		360.0	364	9.80			1.20	0.52	4.70	59	72
73/11/27	0645		22.0	58	9.40			0.40	1.40	1.50	112	136
73/12/11	0700		45.0	136	8.90			0.48	0.54	0.76	66	80
73/12/18	0645		200.0	301	8.30			0.72	0.27	0.68	39	48
74/01/08	0715		15.0	58	8.60			0.31	0.20	0.65	92	112
74/01/22	0700		40.0	157	8.00			0.39	0.48	0.55	55	67
74/02/05	0715		75.0	194	6.50			0.70	0.26	0.60	44	54
74/02/20	0715		100.0	203	6.20			0.58	0.30	0.55	53	65
74/03/05	0715		120.0	249	5.60			0.22	0.24	0.28	55	67
74/03/19	0745		39.0	106	4.50			0.32	0.28	0.48	60	73
74/04/02	0750		200.0	242	3.20			0.38	0.25	1.20	51	62
74/04/16	0730		20.0	88	4.00			0.28	0.40	0.56	74	90
74/05/07	0745		16.0	48	3.70			0.29	0.53	0.66	87	106
74/05/21	0735		40.0	80	3.00			1.00	0.90	1.80	99	121
74/06/04	0735		12.0	85	2.60			0.27	0.83	1.10	107	131
74/06/19	0740		11.0	50	2.70			0.11	1.40	1.50		
74/07/09	0830		17.0	59	3.00			0.34	2.00	2.00	150	183
74/07/23	0750		4.0	52	4.50			0.76	3.30	3.30	180	220
74/08/06	0815		6.0		4.90			0.14	3.30	3.30	185	225
74/08/20	0805		6.0	44	4.20				3.20	3.30	182	222
74/09/04	0805		10.0	36	5.60				4.20	5.00	185	226
74/09/17	0800		11.0	58	5.50			0.13	4.80	5.00	187	228
77/10/26	0830		84.0		4.60			1.60	4.40	5.20		
77/11/29	1115		240.0		4.80			0.68	1.00	1.50		
77/12/20	0800		210.0		7.25			0.60	0.77	1.02		
78/01/24	0730		120.0	30	7.90			0.39	0.56	0.71		
78/02/14	0815		185.0	55	3.80			0.43	0.39	0.56		
78/03/29	0815		78.0	35	4.90			0.10	0.39	0.59		
78/04/25	0930		43.0	20	4.50			0.12	0.82	0.87		
78/05/23	0815		70.0		3.00			0.19	0.68	0.72		
78/06/20	0800		70.0	25	2.40			0.30	1.10	1.20		
78/07/25	0815		40.0	20	3.80			0.13	3.50	3.60		
78/08/22	0820		85.0	30	3.60			0.60	2.20	2.40		
78/09/26	0845		6.0	6	7.80			0.14	4.60	4.70		

DEPARTMENT OF ECOLOGY

RETRIEVAL --- JANUARY 12

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER QUALITY INVESTIGATIONS SECTION

34B110 SF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 58.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: WHITMAN SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: RMP

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH FEET	00070 TURBIDITY TURBMETER NTU	00080 COLOR PT-CO UNITS	00630 NITROGEN NO2 + NO3 ug/l	00620 NITRATE T NO3-N ug/l	00615 NITRITE T NO2-N ug/l	00610 AMMONIA T NH3-N ug/l	00671 DIS-ORTHO PHOSPHRUS ug/l P	00665 TOTAL PHOSPHRUS ug/l P	00410 ALKALINE T CaCO3 ug/l	00440 BICARB HCO3 ION ug/l
78/10/24	0745		8.0	20	6.30			0.04	2.60	3.70		
78/11/29	0930		70.0	20	5.60			0.54	1.10	2.80		
78/12/20	0845		15.0	5	6.40			0.35	2.70	3.20		
79/01/25	0930				6.20			0.60	2.10	2.70		
79/02/22	0550		120.0	32	9.00			0.42	0.44	0.52		
79/03/20	0905		25.0	4	4.30			0.17	0.35	0.44		
79/04/25	0915		39.0	4	3.20			0.26	0.37	0.56		
79/05/22	1000		39.0	6	4.40			0.17	0.30	0.97		
79/06/19	0930		80.0	15	4.00			1.80	0.65			
79/07/24	0915		60.0	20	3.70			0.11	2.10	0.12		
79/08/28	0900		5.0	8	4.20			0.04	4.00	0.44		
79/09/25	0915		15.0	6	7.20			0.05	5.50	5.70		
79/10/23	0945		10.0	20	7.80			0.02	2.95	3.20		
79/11/27	0930		40.0	10	6.60			0.12	2.20	1.50		
79/12/18	0900		25.0	3	9.00			0.22		2.20		
80/01/22	0930		60.0	11	12.00			0.42	0.37	0.97		
80/02/27	0910		205.0		2.60			0.43	0.41	0.45		
80/03/25	0920		160.0	8	6.90			0.40	0.50	0.66		
80/04/22	0930		85.0	15	1.30			0.02	0.14	0.15		
80/05/29	0750		175.0		3.00			0.01	0.39	0.82		
80/06/24	0750		80.0		1.80			0.04	0.77	1.10		
80/07/22	1020		10.0	6	1.30	1.30	0.01K	0.06	3.10	3.20		
80/08/26	0800		65.0	16	7.70	7.70	0.04	0.06	2.20	2.60		
80/09/23	0800		35.0	16	0.53	0.46	0.07	3.60	1.40	3.60		
80/10/21	0940		35.0	15		9.00	0.10	0.10	3.50	3.50		
80/11/18	0745		35.0	16		8.80	0.01K	0.16	0.20	1.50		
80/12/16	0745		60.0	15		6.10	0.04	0.05		2.00		
81/01/20	0730		75.0	40		5.20	0.02	0.04	1.30	1.60		
81/02/23	0620		30.0	15		6.40	0.05	0.11		0.17		
81/03/24	0730		28.0	5		7.00	0.05K	1.40	1.30	1.30		
81/04/21	0720		40.0	12		4.20	0.05K	0.07	0.53	0.59		
81/05/26	0700		70.0	10		3.10	0.07	0.32	0.48	0.48		
81/07/21	0710		150.0	21		4.00	0.05U	0.15	1.90	1.90		
81/08/18	0640		60.0	18		4.20	0.05K	0.20	2.45			
81/09/22	0650		35.0	20		7.50	0.07	0.07	3.70	3.90		
81/10/20	0610		30.0	16		6.20	0.10	0.20	3.50			
81/11/11	0800		8.0	50		6.90	0.10	0.07	2.20	1.50		
81/12/08	1600		130.0	130		4.60	0.10	0.20		0.40		
82/01/26	1440		260.0	220		5.10	0.05U	0.37	0.26			
82/02/15	1555		280.0	320		7.10	0.05	0.18	0.01K	0.02		
82/03/15	1545		100.0	120		5.00	0.05U	0.14	0.25	0.27		
82/04/19	1430		33.0	79		4.10	0.15	0.06	0.23			
82/05/10	1415		8.0	46		3.90	0.15	0.07	0.42	0.52		
82/06/08	1620		7.0	46		3.00	0.05	0.16	0.50	0.50		
82/07/11	1130		5.0	42		2.70	0.05	0.05	1.70	1.60		
82/08/17	1310		6.0	38		3.10	0.05K	0.08	2.20	2.30		
82/09/14	1135		11.0	32		3.00	0.05	0.04	1.90	2.00		
82/10/19	1115		6.0	38		4.90	0.05	0.09	2.80	2.80		
82/11/16	1125		6.0	29		4.10	0.10	0.63	2.10	2.60		
82/12/28	1055		23.0	67		7.50	0.10	0.13	1.00	1.20		
83/01/25	1125		410.0	140		6.60	0.20	0.15		0.15		
83/02/22	1150		100.0	120		7.30	0.05	0.10		0.09		
83/03/22	1000		31.0	71		6.00	0.05	0.21		0.33		