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SOUTH FORK PALOUSE RIVER TOTAL MAXIMUM DAILY LOAD OF AMMONIA

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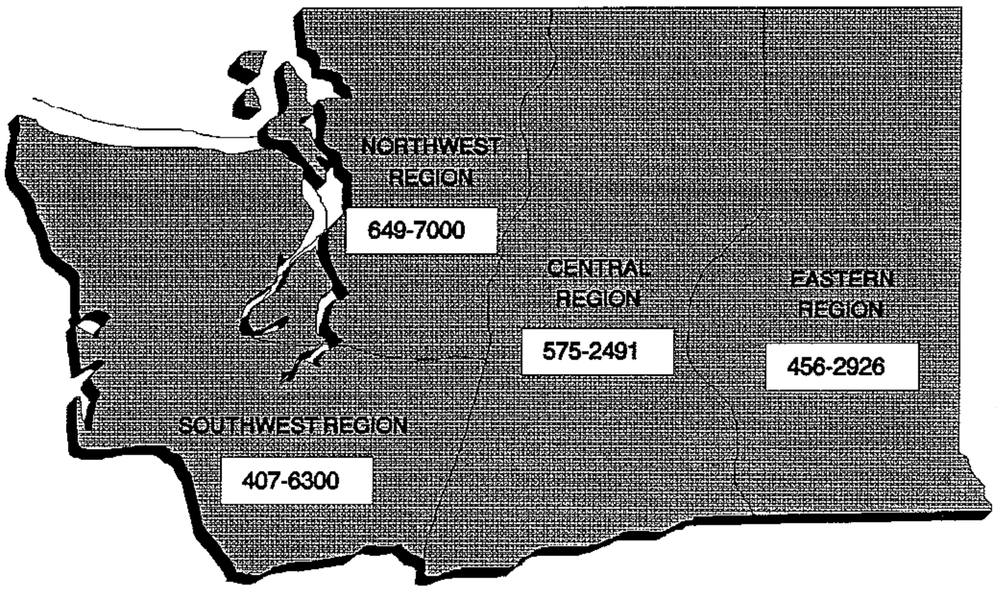

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The field work for this project was designed and conducted by Joe Joy, with the assistance of Rob Plotnikoff, Norm Glenn, and Paul Pickett. Many valuable comments were received after thorough review by Will Kendra, Bill Yake, Don Nichols, and Steve Butkus. Final report preparation was done by Barbara Tovrea.

ABSTRACT

Un-ionized ammonia concentrations in the South Fork Palouse River (SFPR) at Pullman often exceed state water quality standards. Effluent from publicly-owned treatment works (POTWs) from the cities of Moscow and Pullman comprises most of the river flow during July-November of a typical year and during any month of the year for design low flows. The Albion POTW makes up a relatively small fraction of the total river flow. Ecology ambient monitoring station 34B110 was recommended for developing design conditions for temperature and pH in combination with data collected by Pullman POTW upstream and downstream from the POTW outfall, and by Ecology during water year 1992 in Paradise Creek at the state line. Semi-annual total ammonia criteria for Paradise Creek at the state line were proposed based on design conditions for temperature and pH, and regressions with Ecology station 34B110.

Total maximum daily loads (TMDLs) for ammonia were established for critical points in the SFPR. Waste load allocations (WLAs) for POTWs, load allocations (LAs) for nonpoint sources, and a margin of safety were factored into the analysis. Semi-annual and monthly periods for permitting were evaluated. Exemptions from mixing zone size limits were also considered. Four alternatives were considered for evaluating TMDLs: monthly and semi-annual limits, each with and without mixing zone size restrictions. Semi-annual limits were recommended instead of monthly limits for administrative simplicity. An engineering analysis of the treatment process is recommended to determine feasibility of operational changes or improvements required to meet the proposed ammonia limits. Comparison of proposed limits with 1991 data from Pullman POTW suggests that the proposed limits could be achieved. Permit limits for effluent ammonia for the Albion POTW may be unnecessary during February and March, but may be required during April and May.

1.0 INTRODUCTION

The South Fork of the Palouse River (SFPR) at Pullman drains approximately 130 square miles around Pullman, Washington and Moscow, Idaho (Figure 1). The area is dominated by grain fields and pastures. The major land use is farming with the principal crops of wheat, peas, and lentils. Residential, commercial, and industrial developments are clustered around the two towns. Populations in both towns vary seasonally due to the presence of University of Idaho and Washington State University campuses. The town of Albion is located approximately seven river miles (RM) downstream from Pullman.

The SFPR has often been rated as having the worst water quality in the state, based on Ecology ambient monitoring data collected in Pullman (Singleton, 1980; Moore, 1984; Thielen, 1986). Past investigations by Ecology have identified several point and nonpoint source problems in the SFPR basin (Bernhardt and Yake, 1978; Yake, 1981; Joy, 1987). The SFPR is designated Class A under Chapter 173-201A WAC, and is regulated to meet or exceed requirements for: water supply (domestic, industrial, agricultural); stock watering; salmonid and other fish migration, rearing, spawning, and harvesting; wildlife habitat; and primary contact recreation, sport fishing, boating, and aesthetic enjoyment. The SFPR is currently listed as not attaining swimmable/fishable goals (section 304(l)(1)(A)(ii) of the federal Clean Water Act) and consistently exceeds state standards for fecal coliform. Joy (1987) noted verdant and widespread growths of attached algae, weeds, mosses, and periphyton attributed to abundant nutrients. Summer temperatures frequently exceed, and diel dissolved oxygen concentrations frequently are less than, Class A standards.

Three publicly-owned treatment works (POTWs) discharge wastewater to the SFPR: Albion POTW at RM 14.1; Pullman POTW at RM 21.3; and Moscow POTW to creek mile (CM) 6.9 of Paradise Creek. The Moscow POTW discharge is located in Idaho approximately 0.5 miles from the state line. During periods of low flow, the Moscow POTW comprises nearly the entire flow of Paradise Creek and the SFPR until confluence with the Pullman POTW discharge. POTW flows have the potential to account for most of the total river flow during any month of the year.

The Moscow POTW provides secondary treatment with trickling filters. The Pullman POTW provides secondary treatment with seasonal nitrification. Maximum monthly design flows for Moscow and Pullman POTWs are 3.5 and 4.3 million gallons per day (mgd), respectively. The Albion POTW discharges from a facultative lagoon to the SFPR only during the months of February through May with a design flow of 0.12 mgd.

Effluent flows reported by Moscow POTW prior to 1992 did not account for diversion of approximately 72 million gallons of effluent for irrigation and 0.22 mgd recycled to the primary clarifier. The current NPDES permit for Moscow POTW requires reporting of actual flows to Paradise Creek.

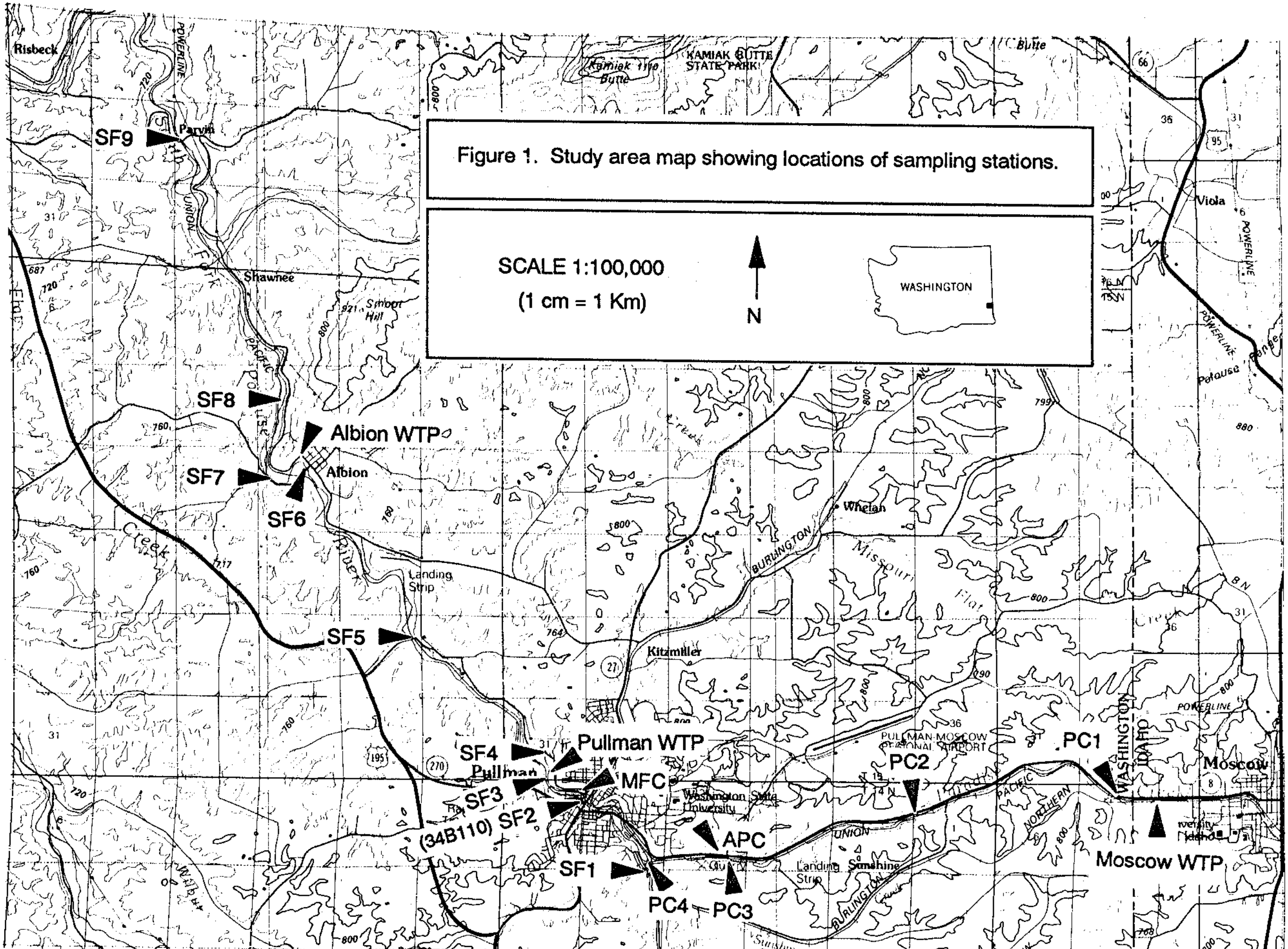

Figure 1. Study area map showing locations of sampling stations.

The city of Pullman is considering diversion of a portion of effluent flows during April through October. Seasonal diversion of Pullman POTW effluent of approximately 126 million gallons has been proposed (Don Nichols, Ecology ERO, personal communication).

The objectives of the present study are to:

- determine the loading capacity of the SFPR to discharges of ammonia for protection of aquatic life criteria for un-ionized ammonia (WAC 173-201; EPA, 1986);
- examine the sensitivity of dissolved oxygen concentrations to ammonia and biochemical oxygen demand (BOD) loads from POTWs;
- recommend total maximum daily loads (TMDLs), waste load allocations (WLAs), and load allocations (LAs) consistent with Ecology's guidance on TMDLs (Ecology, 1991).

The Pullman POTW discharge is the only National Pollutant Discharge Elimination System (NPDES) permit in the SFPR basin that contains limits on effluent ammonia. The Pullman POTW currently has the following effluent ammonia limits: no limitation from December through March; 5 mg/L as N during April and November; and 1 mg/L as N from May through October. The current permit limits are interim limits until adoption of a TMDL and WLA.

2.0 METHODS

2.1 Intensive Surveys During 1991

Ecology conducted intensive surveys in July and October 1991 of water quality and flow profiles between Paradise Creek near the state line (CM 6.4) and SFPR RM 8.9 below the Albion POTW. The intensive surveys coincided with Class II inspections of the Pullman POTW and Albion POTW (Glenn, 1992). Surface water grab samples were collected at stations shown in Figure 1. Intensive survey station SF2 is at the same location as Ecology ambient station 34B110.

Field analyses included: temperature by probe and mercury thermometer; dissolved oxygen by modified Winkler titration; and pH and specific conductance by probe (APHA *et al.*, 1989). Stream discharge was measured at selected sites using either a magnetic or propeller flow meter.

Grab samples collected for laboratory analyses were stored in the dark on ice and received via air freight or hand delivery by the Ecology/USEPA Manchester Environmental Laboratory within 24 hours of collection. All analyses were performed using approved procedures (EPA, 1983; APHA *et al.*, 1989). All field and lab measurements are presented in Appendix A.

2.2 Historical Data Analysis

Ecology has collected monthly water quality data in the SFPR at Pullman (Ecology station 34B110 at RM 22.2) since 1970 (Appendix B). Ecology also collected monthly data during water year 1992 from Paradise Creek at the state line and other stations in the SFPR basin (Appendix C; Hallock, 1993). Ecology data were examined to describe seasonal and annual trends in water quality. The USGS has recorded daily discharge in the SFPR at Pullman (RM 22.2) and in Missouri Flat Creek between 1933 and 1981. Ecology water quality data and USGS flow data were used to compute design conditions for TMDL modeling. Historical water quality data and USGS flow data were analyzed using the statistical software package WQHYDRO (Aroner, 1991) and SYSTAT® (SYSTAT, 1990).

The Pullman POTW has also collected water quality data (temperature, pH, dissolved oxygen, and ammonia) from the SFPR immediately upstream and downstream from the POTW outfall (RM 21.3) at approximately weekly intervals since May 1990 as part of its NPDES requirements (Appendix D). These data were used to evaluate mixing zone criteria for ammonia.

3.0 RESULTS AND DISCUSSION

3.1 Seasonal and Annual Water Quality Trends at SFPR RM 22.2

3.1.1 Ammonia Concentrations

Ammonia concentrations vary seasonally (Figure 2). Lowest values occur during warmer summer months. The seasonal pattern may be influenced by seasonal changes in loading and instream nitrification as temperatures change. Annual concentrations are relatively constant from year to year. Monthly and annual median ammonia concentrations typically range between 0.1 and 0.5 mg/L as N, but individual observations frequently exceed 1 mg/L as N.

3.1.2 Ammonia Criteria Excursions

Ammonia concentrations at SFPR RM 22.2 (Ecology ambient station 34B110) have shown repeated excursions above chronic criteria between 1970 and the present (Figure 3). Most excursions occur during summer months, but some were observed in all months except January, February, and March (Figure 4). The Pullman POTW monitoring data showed ammonia criteria excursions during seven months of the year upstream from the POTW outfall and six months of the year downstream between 1990 and 1992.

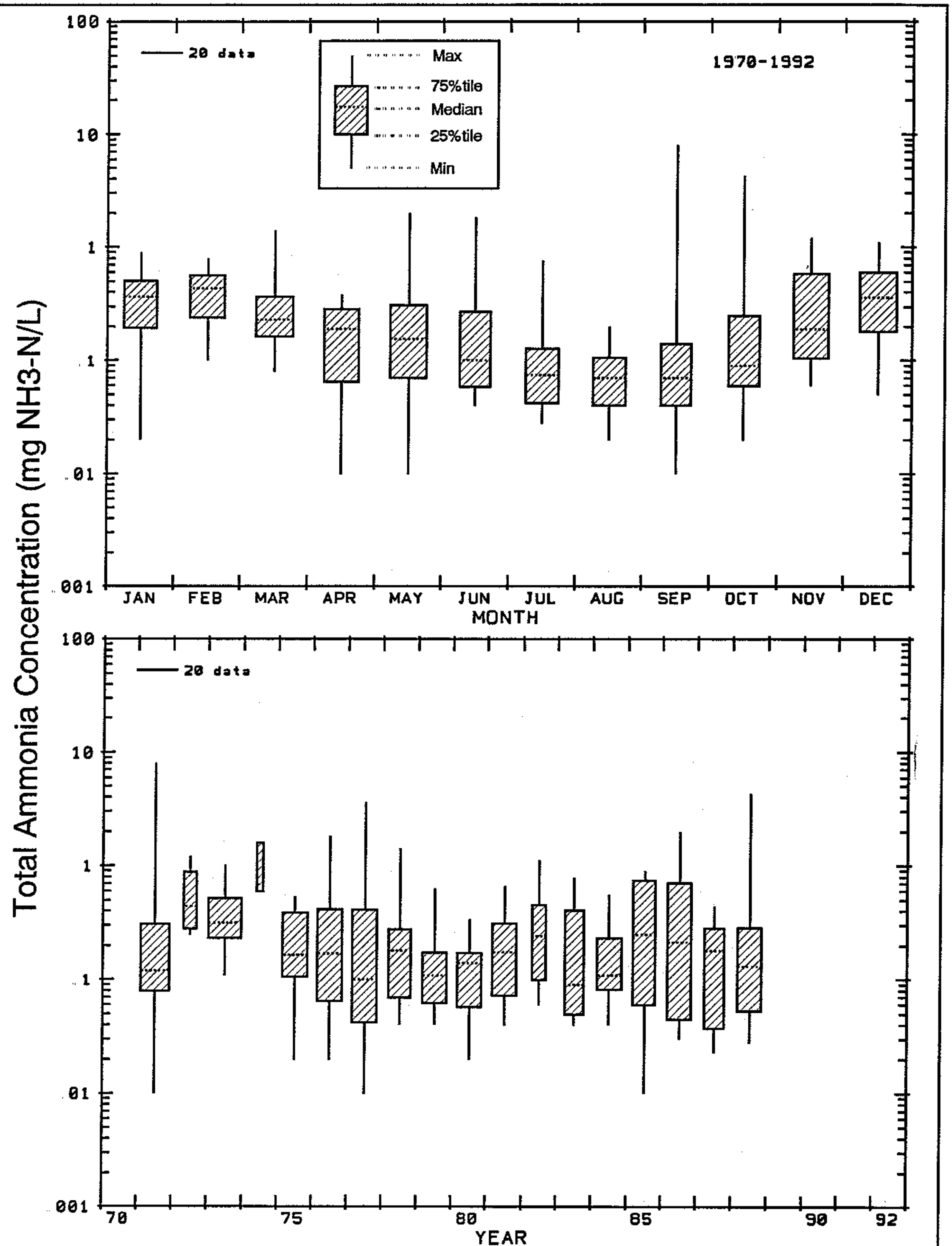

Figure 2. Monthly and annual variation in ammonia at Ecology Station 34B110, 1970-92.

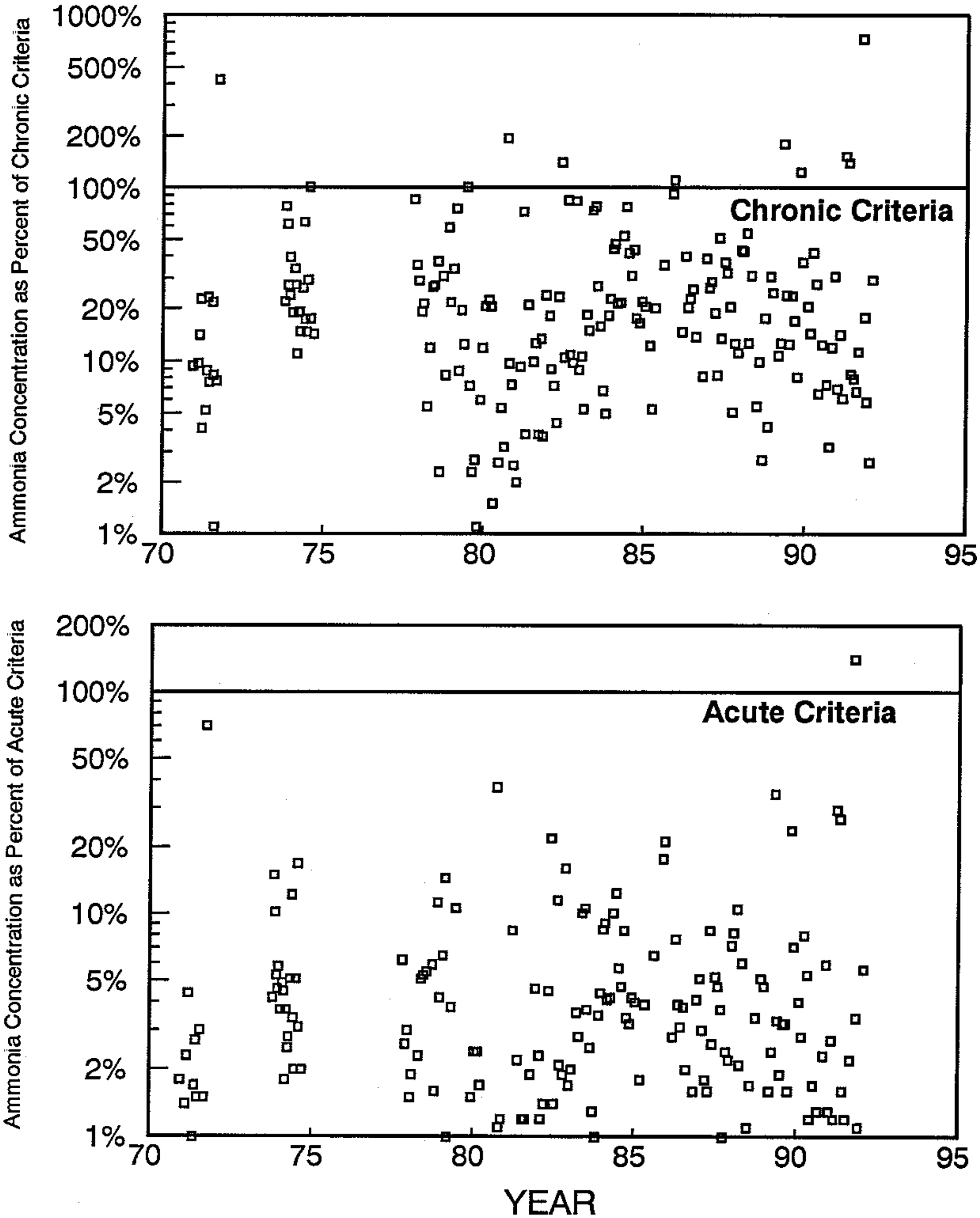

Figure 3. Ammonia concentrations in the South Fork Palouse River (34B110) as percent of the chronic and acute toxicity criteria. Values greater than 100 percent exceed criteria.

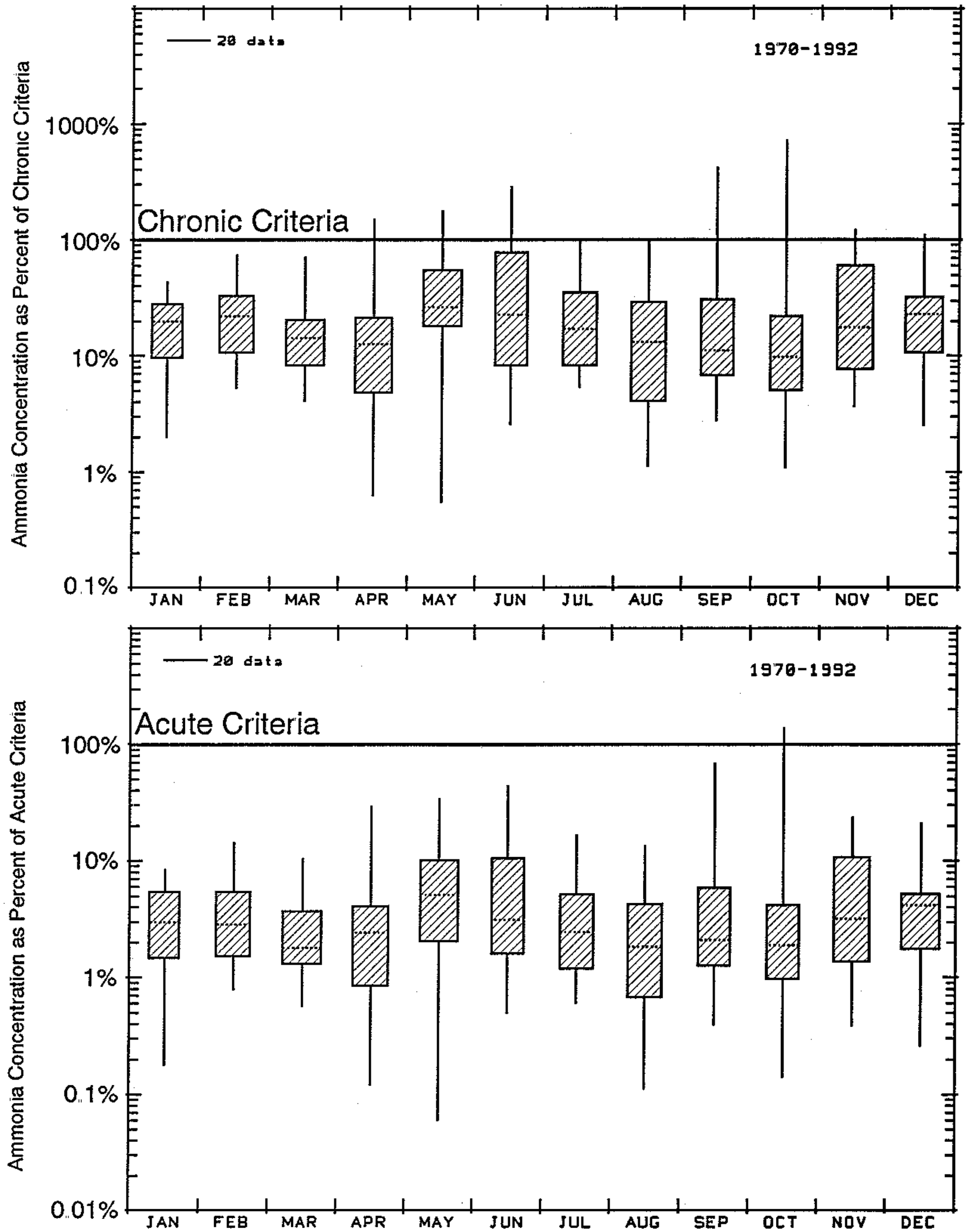

Figure 4. Monthly variation in exceedance of ammonia criteria at Ecology station 34B110, 1970-92. Values greater than 100 percent exceed criteria.

3.1.3 Temperature and pH

Total ammonia in water contains two components: ionized (NH_4^+) and un-ionized (NH_3). Ammonia toxicity is caused by the un-ionized fraction present in water, which is a function of temperature and pH. Seasonal patterns in temperature and pH result in seasonally changing criteria for total ammonia. The un-ionized fraction of ammonia increases as temperature and pH increase.

Figure 5 presents seasonal trends in temperature and pH. Temperatures peak in July in excess of the Class A criterion of 18°C. Summer pH also exceeds the Class A criterion. Seasonal increases in pH are probably caused by photosynthesis of algae and macrophytes in the river.

3.1.4 Dissolved Oxygen and Nutrients

Although the major focus of this analysis is ammonia, other parameters are related to ammonia. Dissolved oxygen is related to ammonia because of the demand for oxygen by nitrification. Nutrient concentrations are also relevant because algal productivity influences dissolved oxygen levels. Monthly ambient monitoring data at SFPR RM 22.2 shows nutrient concentrations typically 10 to 100 times greater than levels which might limit algal growth (Figures 6 and 7; assuming algal growth limitation by nutrients does not occur above 0.10 mg/L of nitrate, nitrite, plus ammonia N and 0.025 mg/L of soluble reactive P).

Dissolved oxygen measurements at SFPR RM 22.2 show occasional excursions below the Class A standard of 8 mg/L during May through September (Figure 8). However, the ambient monitoring data probably do not represent potential minimum concentrations which would occur before sunrise or at critical locations below POTWs. The intensive surveys during July and October 1991 (Appendix A) probably are more representative of minimum concentrations at critical locations and times of day. Diel minimum dissolved oxygen of less than 8 mg/L was consistently found at most stations. Lowest dissolved oxygen concentrations were found in Paradise Creek at the state line. Monthly sampling at the state line during water year 1992 shows a median daytime dissolved oxygen of less than 4 mg/L (Appendix C; Hallock, 1993).

3.2 Ammonia TMDL

The following sections present the procedures and design conditions used for evaluating ammonia TMDLs. The order of presentation is: 1) design river and POTW flows; 2) mixing zone temperature and pH; and 3) models for accounting for in-stream nitrification and background/nonpoint sources. Then, the TMDL, WLAs and LAs for total ammonia are developed.

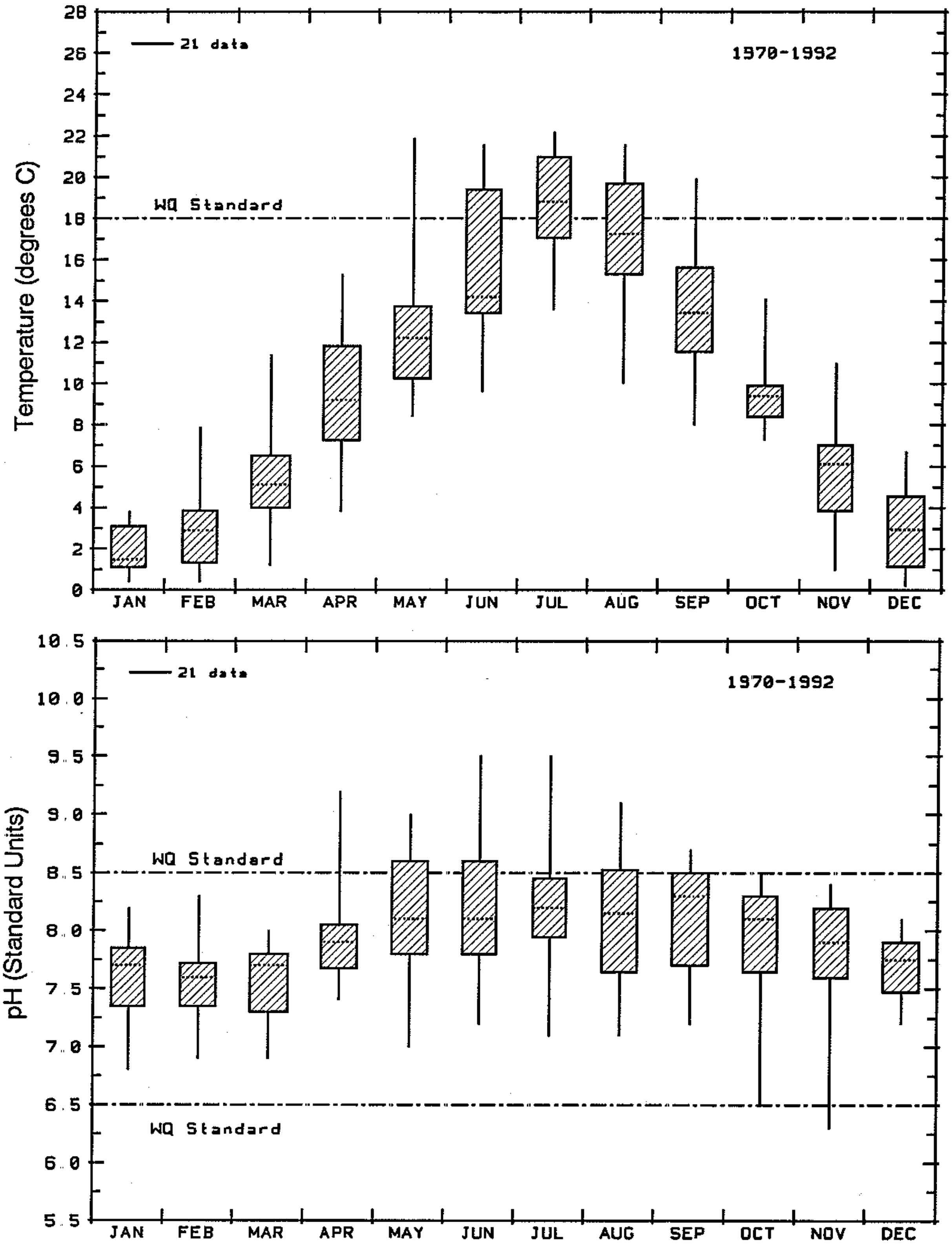

Figure 5. Monthly temperature and pH at Station 34B110, 1970-92.

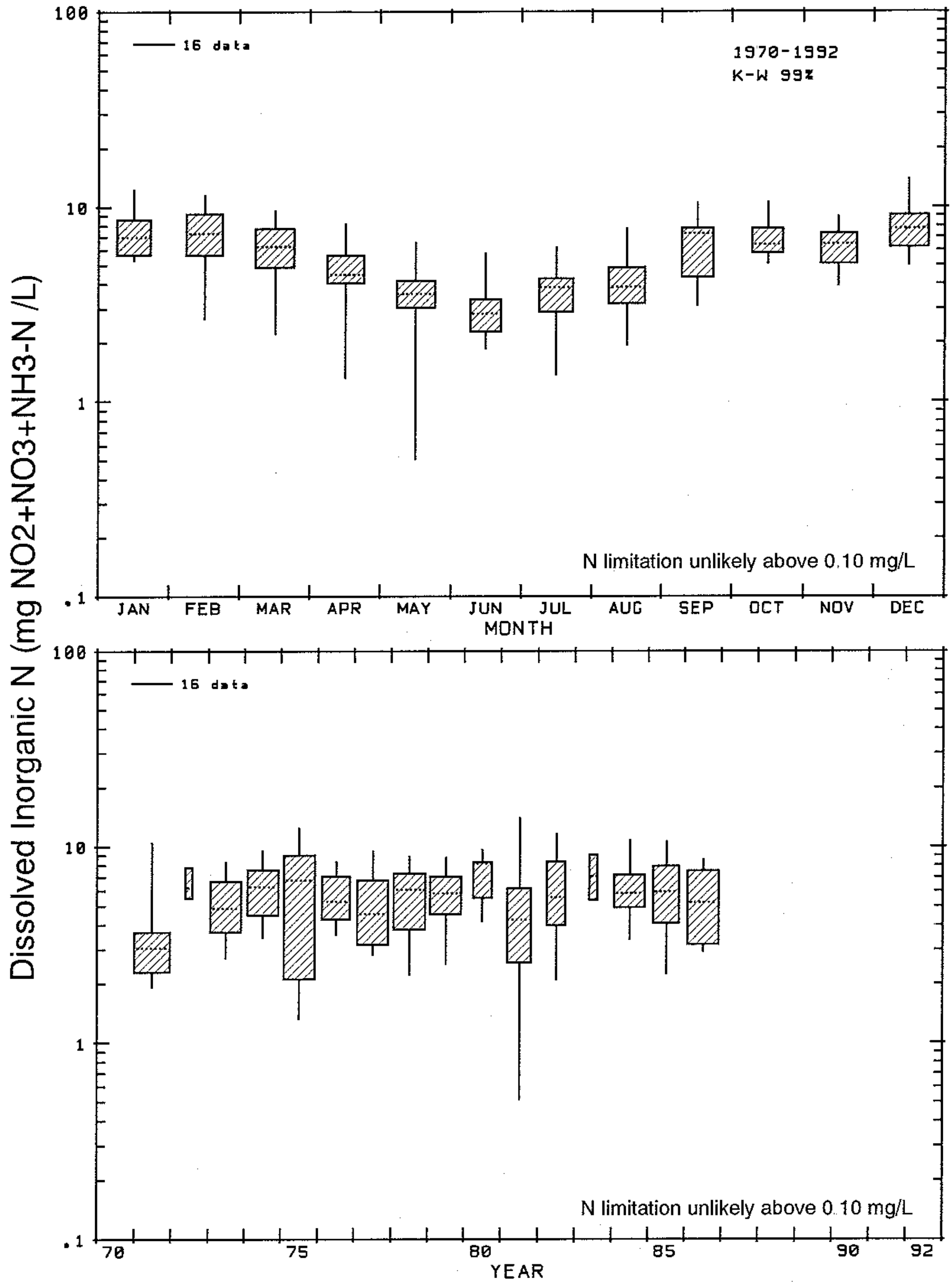

Figure 6 Monthly and annual variation in dissolved inorganic N (nitrite, nitrate, and ammonia as N) at Ecology Station 34B110, 1970-92.

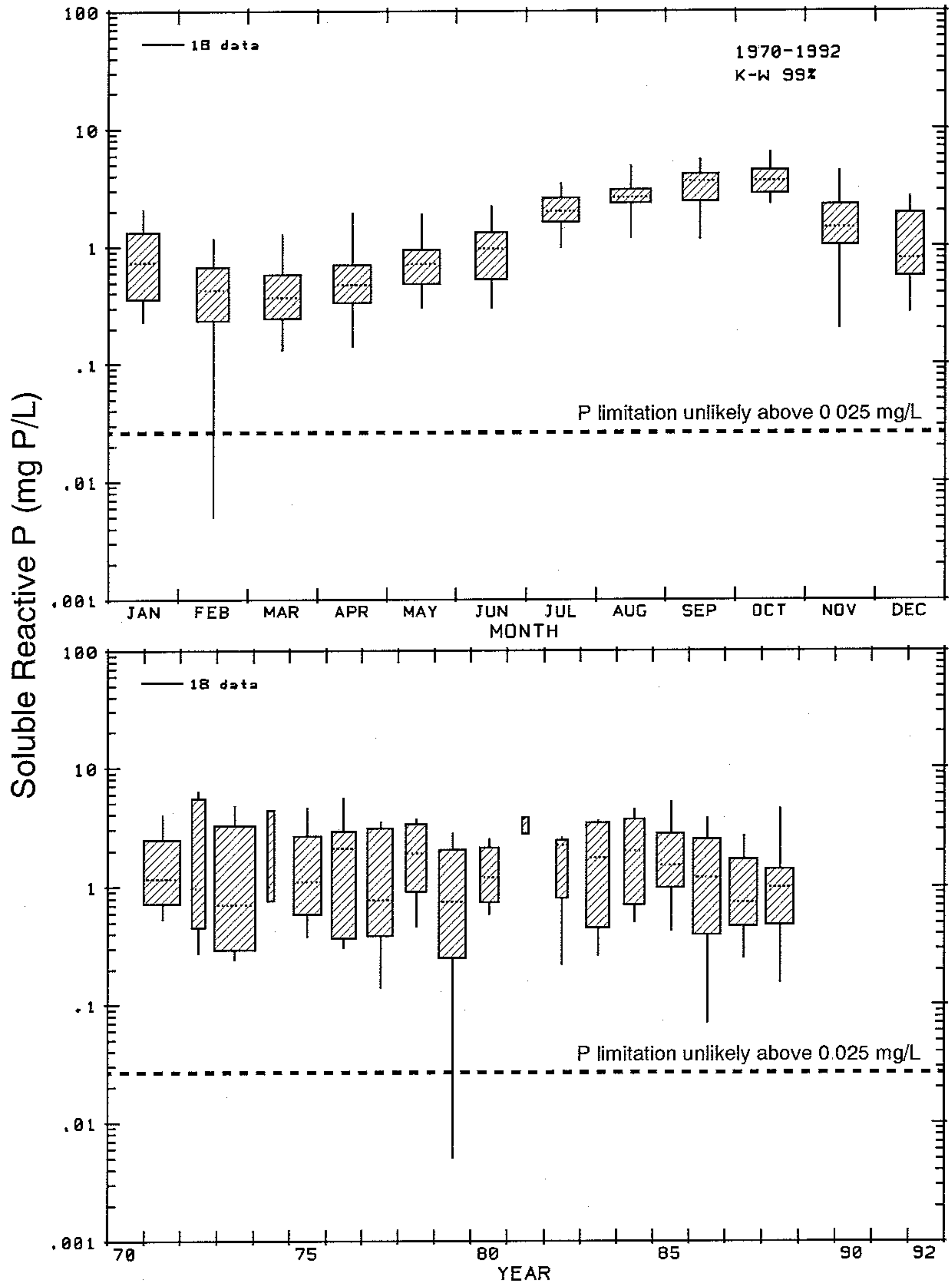

Figure 7. Monthly and annual variation in soluble reactive P at Ecology station 34B110, 1970-92.

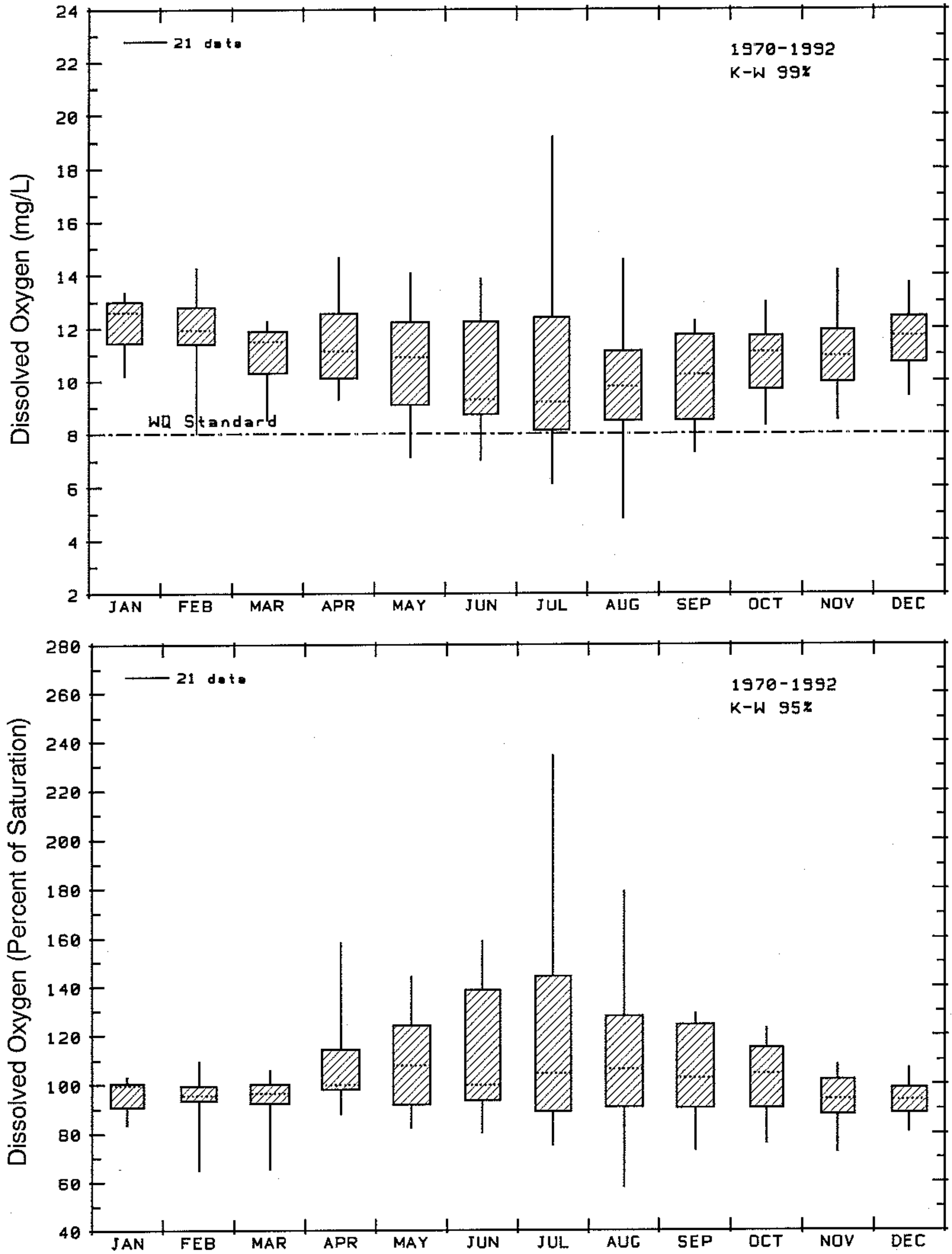

Figure 8. Monthly dissolved oxygen concentration and saturation at Ecology Station 34B110, 1970-92.

3.2.1 Duration and Frequency of Design Flows

Permit limits and WLAs have been traditionally based on a single critical period when the assimilative capacity of a waterbody is lowest. The 7-day-10-year low flow (7Q10) is stipulated by Ecology for such annual limits for most pollutants (Ecology, 1985; Chapter 173-201A WAC). However, Ecology guidance recommends the 30-day-10-year low flow (30Q10) for annual ammonia limits for facilities designed to remove ammonia (Ecology, 1987). Permit limits derived using the annual 7Q10 or 30Q10 are intended to apply during all months of the year even though those flows may only occur during summer months (EPA, 1988).

Ecology policy encourages use of seasonal permit limits for ammonia (Ecology, 1987). TMDLs and WLAs were evaluated for monthly and semi-annual periods. Annual design conditions were not evaluated because they would require overly restrictive permit limits. Seasonal WLAs and permit limits allow greater use of the loading capacity of a receiving water. However, design conditions for seasonal permit limits must be chosen to ensure that the allowable frequency of exceeding aquatic life criteria is not exceeded. For example, if the same return period (e.g., 10 year return period for 30Q10) is used for design conditions for annual, semi-annual, and monthly limits, then the semi-annual limits would be twice as likely to exceed criteria, and monthly limits would be about seven times more risky compared with annual limits (EPA, 1984). Table 1 presents annual and seasonal return periods for design conditions that have equivalent probability of annually exceeding criteria. Semi-annual and monthly design flows would require 20 and 114 year return periods, respectively, to maintain the same annual risk of exceeding criteria as the traditional 7Q10 or 30Q10 annual design flow.

In consideration of EPA guidance and criteria (EPA, 1986; EPA, 1984) and Ecology policy (Ecology, 1987), seasonal design conditions were selected to maintain the same annual risk as an annual 30Q10. Therefore, the seasonal design flows selected for evaluation of ammonia TMDLs for the SFPR are:

- 30-day-20-year low flows (30Q20) for semi-annual periods;
- 30-day-114-year low flows (30Q114) for monthly periods.

The periods chosen for semi-annual limits are April-October and November-March. These periods were chosen in consideration of seasonal changes in POTW flows, river flows, and aquatic life criteria for ammonia. The selected semi-annual periods maintain the same annual risk as annual permits and also maximize allowable POTW loading to most efficiently utilize loading capacity of the river. The method used to select semi-annual periods is presented in a later section since it requires evaluation of monthly WLAs.

Table 1. Return periods for equivalent annual probability of meeting water quality standards for various permit intervals.

Permit Interval	Number of Seasons N	Y = Return Period (1) (Years) P = Annual Failure Probability P = 10% = 1/10 years
Monthly	12	114.4
Seasonal	4	38.5
Semiannual	2	19.5
Annual	1	10.0

1) Y = { 1 - (1 - P)^(1/N) } ^ (-1)

$$Y = \left\{ 1 - (1 - P)^{1/N} \right\}^{-1}$$

3.2.2 River and POTW Flows

The distribution of monthly mean flows in the SFPR at RM 22.2 is presented in Figure 9. Monthly mean flows range from greater than 100 cubic feet per second (cfs) during February-March to less than 10 cfs during July-November. Low flows in the SFPR show an increasing trend during the period of 1960-80 (Figure 10), possibly because of increasing Moscow POTW flows during this period. The last 10 years of the period of record (1971-81) were selected for computing design flow statistics because of the observed increase in low flows.

The intensive surveys of July and October 1991 were used to check the surface water flow balance for the SFPR basin from Paradise Creek at the state line to SFPR RM 8.9 (Figure 11). In general, the sum of measured surface flow sources (Paradise CM 6.4, Airport CM 0.0, SFPR RM 23.6, Missouri Flat CM 0.0, Pullman POTW, and Albion POTW) adequately account for the observed profiles of flows throughout the river segment.

Pullman POTW effluent flows for 1989-91 are shown in Figure 12 and Appendix E with temperature, ammonia concentrations, and ammonia variability. Effluent flows vary seasonally with minimum flows in June-July and maximum flows during January-March. The maximum monthly average POTW flows are approaching 85% of the design flow of 4.3 mgd. Summer average design flows are often exceeded during dry-weather months of September and October.

The distribution of monthly flows during 1989-91 was used to estimate critical seasonal flows for the Moscow and Pullman POTWs by scaling the design flows (3.5 mgd for Moscow and 4.3 mgd for Pullman POTW) proportional to the 1989-91 monthly average flows. This was accomplished by the following procedure:

- Step 1: 1989-91 averages were calculated for each month for each POTW.
- Step 2: the maximum monthly average POTW flow for the 1989-91 period was found for each POTW.
- Step 3: the ratio of each monthly average to the maximum monthly average during 1989-91 was calculated for each POTW.
- Step 4: the monthly ratios from step 3 were multiplied by the design flows (3.5 mgd for Moscow and 4.3 mgd for Pullman POTW) to estimate the distribution of monthly average flows when the highest monthly average POTW flow reaches the design flow.

The fraction of POTW effluent expected in the SFPR at critical POTW flows is shown in Figure 13. The combination of critical flows from the Moscow POTW and Pullman POTW are estimated to comprise the majority of the river flow during July-November of a typical year and during any month of the year for low river flows. Albion POTW makes up a relatively small portion of the low river flows. Critical river and POTW flows are summarized in Table 2. Critical conditions for TMDL modeling were assumed to be represented by a combination of low

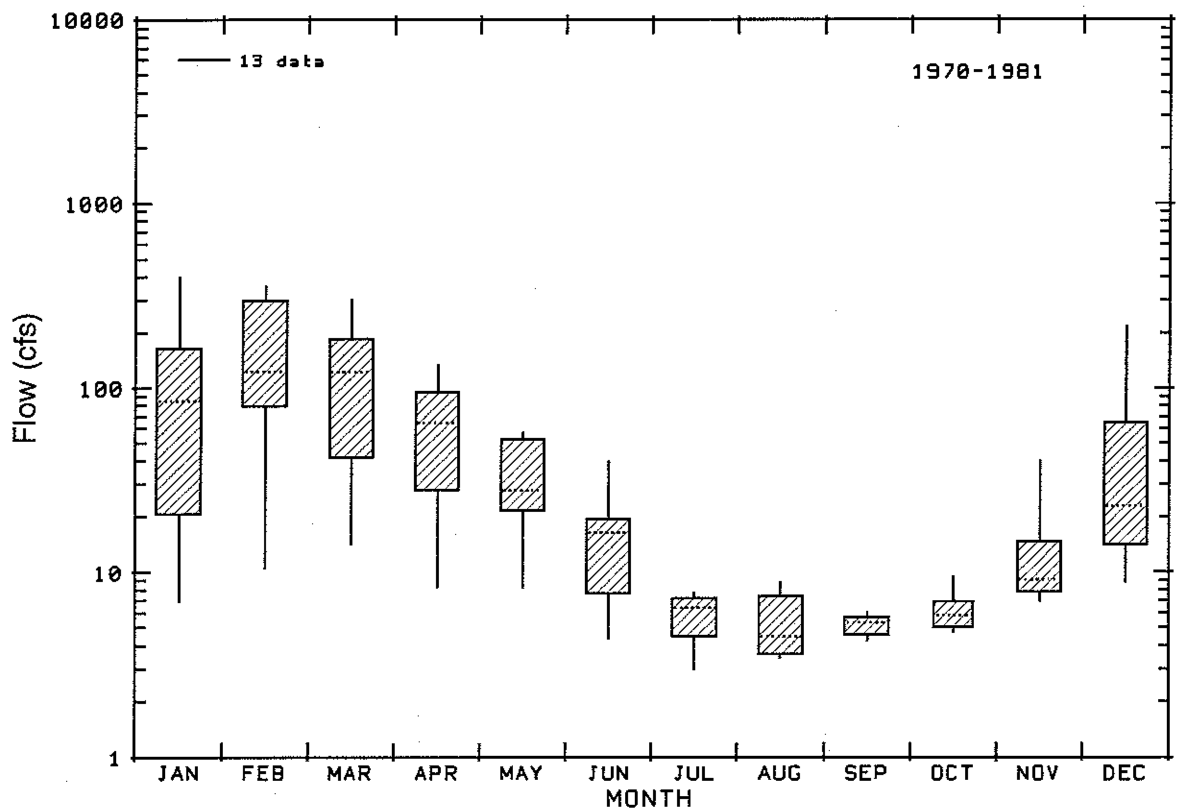

Figure 9 Distribution of monthly mean flows in the South Fork Palouse River at USGS station 133480 (RM 22.2) from 1970-81

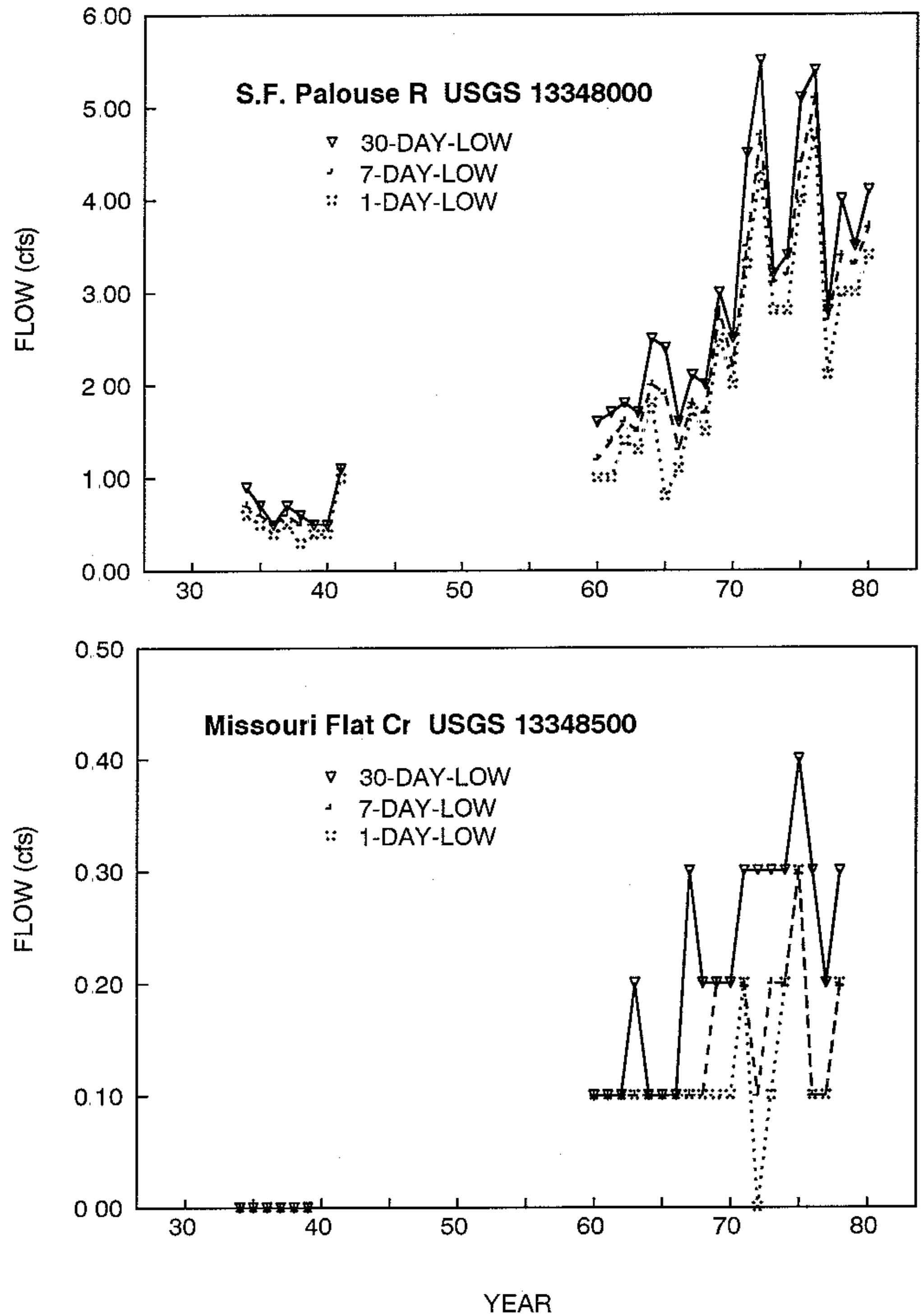

Figure 10. Trends in annual low flows of South Fork Palouse River and Missouri Flat Creek

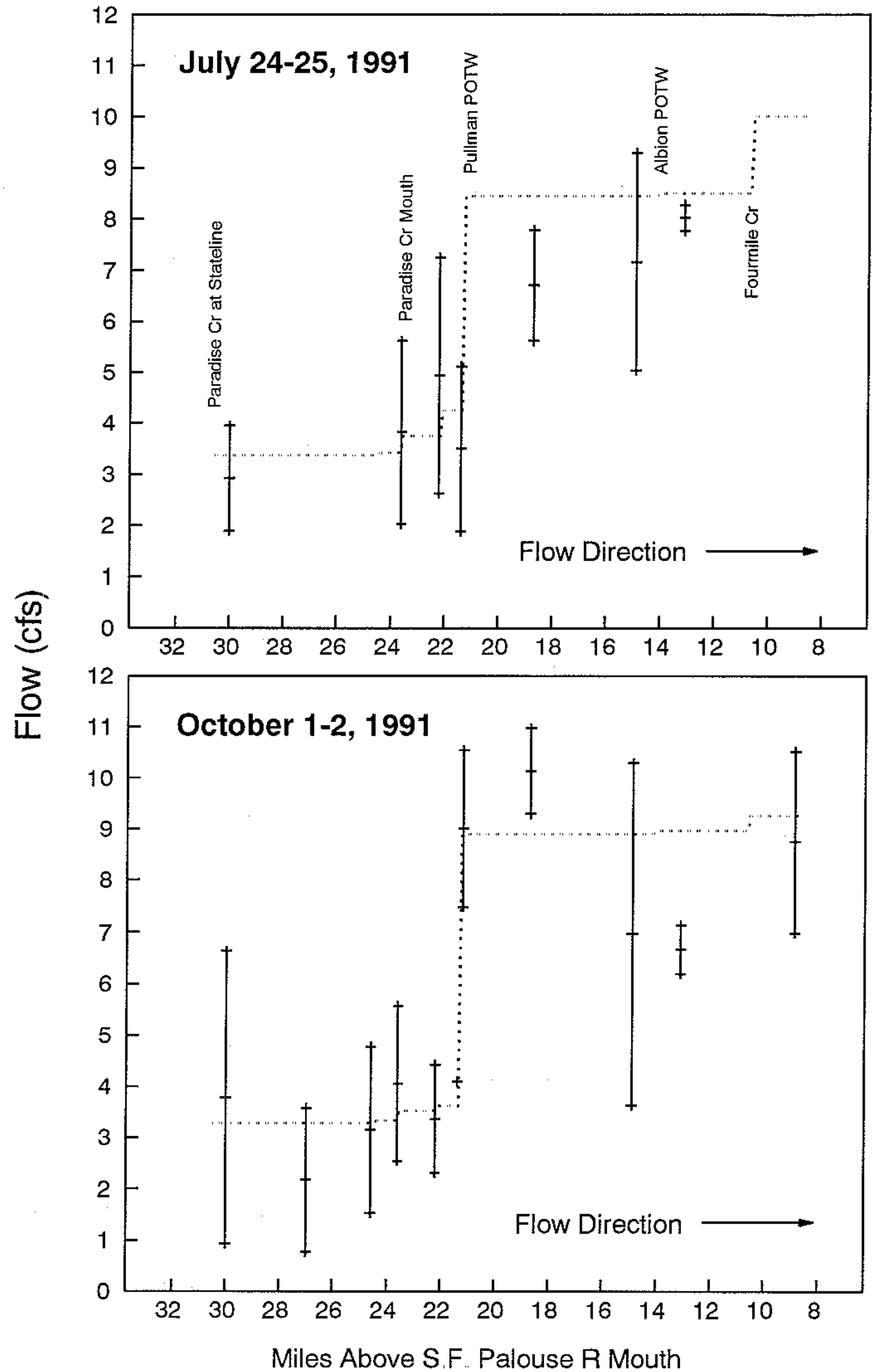

Figure 11 Flow balance from Paradise Cr at Stateline to S.F. Palouse RM 8.6 below Fourmile Cr. Dashed line is surface water flow balance. Vertical ranges are mean +/- standard deviation of observed flows.

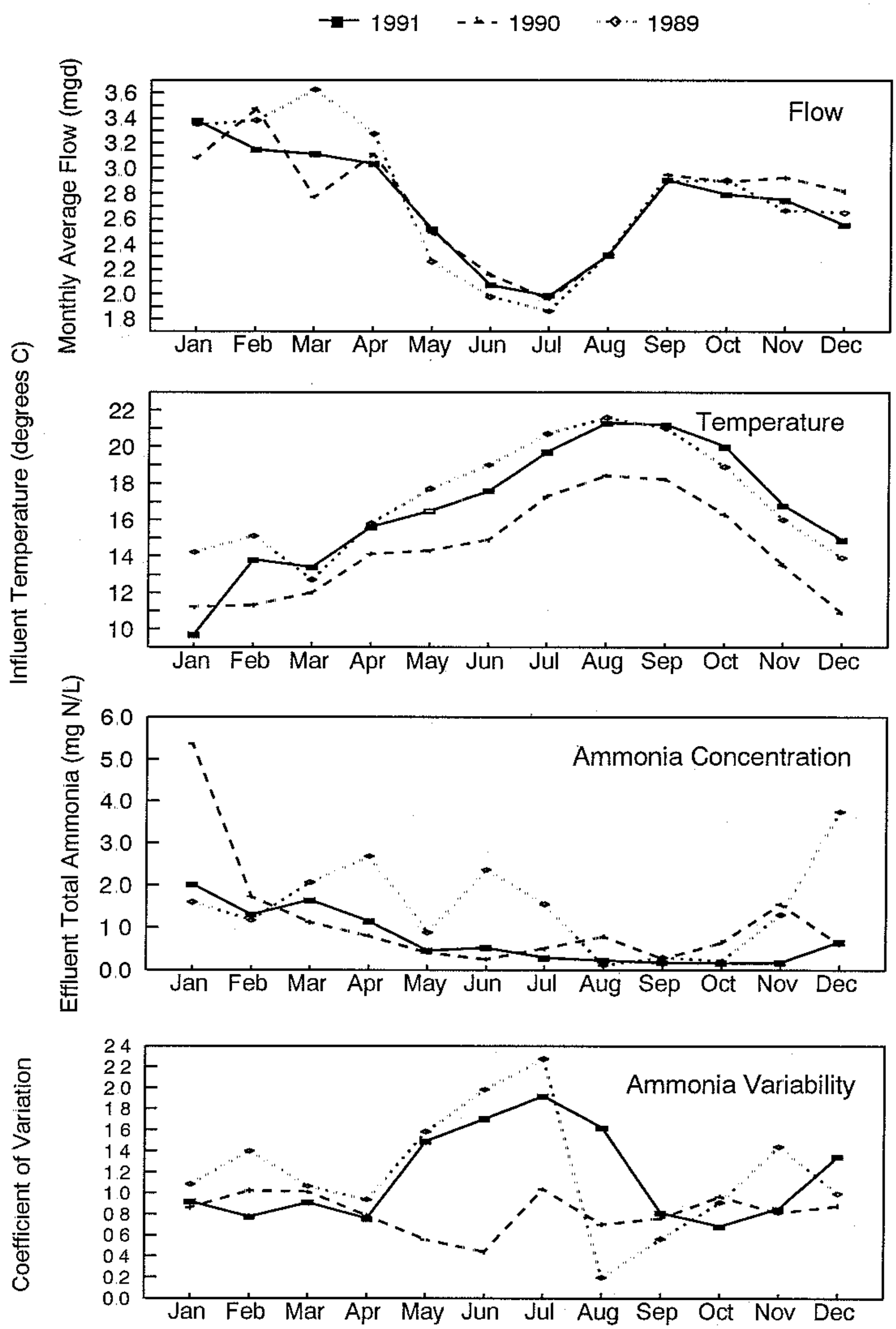

Figure 12. Summary of Pullman POTW effluent flow and quality for 1989, 1990, and 1991.

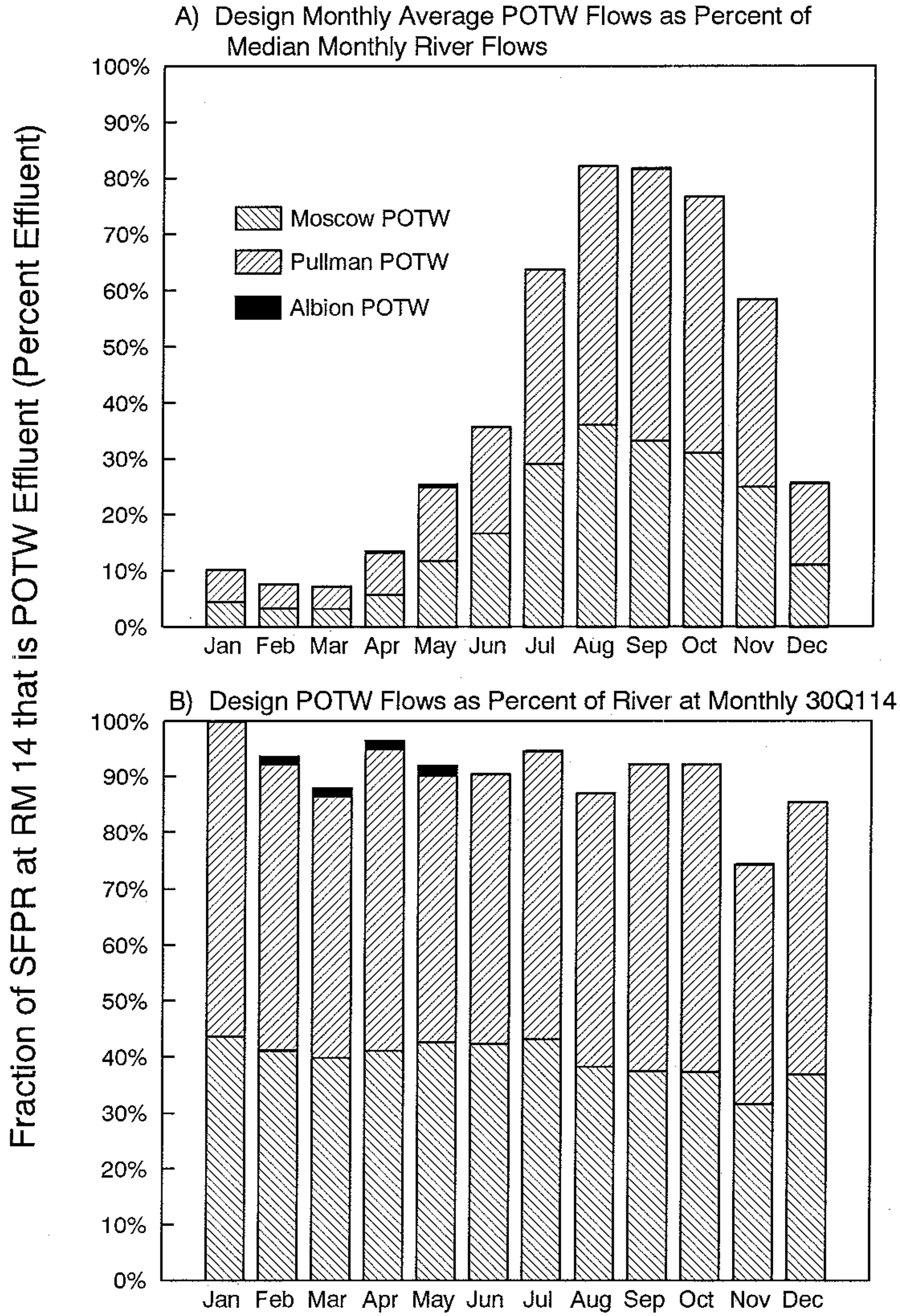

Figure 13. Estimated monthly fraction of POTW effluent in S.F. Palouse River Mile 14 for existing median and design river flows

Table 2. Summary of critical flows for the ammonia TMDL.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
	Monthly Limits												Semi-annual Limits	
BACKGROUND/NONPOINT SOURCES														
Paradise Cr at Stateline (1)	5.03	5.36	5.42	4.74	4.24	2.60	2.16	2.56	3.67	3.86	5.15	4.99	3.79	6.43
S.F. Palouse R above Paradise Cr (2)	0.00	0.62	1.24	0.31	0.62	0.62	0.31	0.93	0.62	0.62	1.87	0.62	0.65	1.09
Missouri Flat Cr (2)	0.00	0.20	0.40	0.10	0.20	0.20	0.10	0.30	0.20	0.20	0.60	0.20	0.21	0.35
POINT SOURCES														
Moscow POTW (3)	5.03	5.36	5.42	4.74	4.24	2.60	2.16	2.56	2.95	3.79	4.02	3.95	3.79	4.02
Pullman POTW (3)	6.52	6.65	6.32	6.26	4.83	4.12	3.86	4.62	5.82	5.71	5.55	5.33	5.82	5.55
Albion POTW (4)		0.19	0.19	0.19	0.19								0.19	0.19

1) Paradise Cr at Stateline estimated by sum of natural flow above Moscow POTW with design flow from Moscow POTW. Monthly flows from Moscow POTW were estimated as design flow scaled by distribution of monthly flows during 1989-91. Critical semi-annual POTW flows were estimated as maximum monthly average for each season. Natural Paradise Creek flows above Moscow POTW were estimated as difference between USGS station 13348000 and sum of flows from SF Palouse above Paradise Creek, and existing (1989-91) Moscow POTW flows. Flows from Moscow POTW to Paradise Creek during 1989-91 were estimated from NPDES DMR data after subracting 0.22 mgd for recycle to the primary clarifier, and 72 million gallons for irrigation during June-September each year.
2) Missouri Flat Cr estimated by Log-Pearson Type 3 analysis of USGS 13348500. South Fork Palouse above Paradise Cr and Fourmile Cr were estimated by scaling USGS 13348500 statistics proportional to drainage areas (drainage areas of S.F. Palouse above Paradise Cr, Missouri Flat Cr, and Fourmile Cr are 84, 27, and 72 square miles, respectively).
3) Pullman POTW flows estimated based on design flow of 4.3 mgd scaled monthly proportional to 1989-91 monthly average flows (see text). Critical semi-annual flows were assumed equal to maximum monthly average during critical portions of each period.
4) Discharge permitted during February 1 through May 31 only. Design flow = 0.12 mgd (0.19 cfs).

flows from natural sources and high POTW flows calculated as described above. This combination provides a reasonably conservative estimate of conditions when effluent dilution will be lowest.

3.2.3 Mixing Zone Considerations

Ecology uses WAC 173-201A-100 to define mixing zones for NPDES discharges. This regulation recognizes separate chronic and acute points of compliance.

In no case shall the zone of chronic criteria violation in rivers be greater than the most restrictive combination of the following:

- shall not utilize more than 25% of the river design 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 violation in rivers be greater than the most restrictive of the following:

- shall not utilize more than 2.5% of the river design flow;
- shall extend no more than 10% 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% of the width of the waterbody.

Exemptions from the maximum size limits of mixing zones are allowed under some circumstances under WAC 173-201A-100(12). The volume of water in the effluent may provide a greater benefit to the existing or characteristic uses of the river due to flow augmentation than the benefit of removing POTW discharges, if such removal is the remaining feasible option for complying with mixing zone size limits. Since POTW discharges comprise the majority of low flow in the SFPR, removal of POTW flows would substantially reduce instream flows, especially during summer months (Figure 13). Therefore, to the extent that it is desirable to maintain existing low flows, the POTW discharges should be considered for possible exemption of mixing zone size limits under WAC 173-201A-100(12).

3.2.4 Critical Conditions for Temperature and pH

Ecology station 34B110 at SFPR RM 22.2 provides the only long-term record of pH and temperature in the river basin (Figure 5). Data from 1971 to the present time were used to determine design conditions for TMDL modeling. The monthly 90th percentiles of temperature and pH were selected for design conditions for monthly permits (Table 3).

Design conditions for semi-annual periods were selected from critical portions of the permitting periods. Critical periods were selected based on occurrence of lowest monthly average flows during the 1971-81 period. For the April-October permit period, critical low flows occurred only during the months of July-October. For the November-March permit period, critical low flows only occurred in November. The 90th percentiles of temperature and pH during critical portions of semi-annual permit periods were selected as design conditions for semi-annual permits (Table 3).

The Pullman POTW has been collecting SFPR pH and temperature data upstream and downstream from the POTW outfall at approximately weekly intervals since May 1990 (Appendix D). These data show consistently higher temperature and lower pH in the downstream station relative to upstream. The same trend was observed during July and October 1991 intensive surveys. Ammonia criteria are expected to be less restrictive immediately downstream from major POTW inputs due to the influence of POTW effluent on ambient temperature and pH (Figure 14). The Pullman POTW monitoring of pH and temperature upstream and downstream from the effluent discharge was used to calculate regression equations (significant at the 95% confidence level) to predict downstream conditions as a function of upstream conditions. The Pullman mixing zone regression equations were used to adjust the 90th percentiles from Ecology station 34B110 to estimate design conditions for the mixing zone of the Pullman and Albion POTWs in the SFPR (Table 3).

Ecology ambient monitoring data during water year 1992 included monthly sampling of Paradise Creek at the state line and station 34B110 (SFPR at Pullman). Temperature and pH were found to be significantly higher and lower, respectively, in Paradise Creek at the state line compared with station 34B110. Regression equations (significant at the 95% confidence level) were developed relating Paradise Creek conditions at the state line with station 34B110. The design conditions from the longer record at station 34B110 were adjusted by the regression equations to predict design conditions in Paradise Creek at the state line (Table 3). This method was considered to provide the most representative estimate of critical conditions because of the relatively short record of monitoring in Paradise Creek.

3.2.5 Instream Nitrification and Background/Nonpoint Sources

Ammonia criteria become progressively more restrictive in the river proceeding downstream from the Moscow POTW until the Pullman POTW is reached, at which point criteria become less restrictive again due to reduced pH caused by the POTW effluent (Figure 14). At the same time, ammonia concentrations in the water column decrease dramatically proceeding downstream

Table 3. Design conditions of temperature and pH.

	<-- Ecology Ambient -> Station 34B110 (1)		<-- Pullman WTP Mixing Zone --> (2)		<-- Paradise Creek --> at State Line (3)	
	Temperature (deg C)	pH (S.U)	Temperature (deg C)	pH (S.U)	Temperature (deg C)	pH (S.U)
Jan	3.64	8.12	6.29	7.69	9.86	7.44
Feb	6.86	8.03	9.28	7.64	12.23	7.41
Mar	9.10	7.90	11.36	7.56	13.89	7.38
Apr	14.00	8.80	15.92	8.12	17.50	7.61
May	18.60	8.90	20.20	8.18	20.90	7.64
Jun	20.70	9.14	22.15	8.34	22.45	7.70
Jul	21.57	8.69	22.96	8.05	23.09	7.59
Aug	21.40	8.70	22.80	8.06	22.97	7.59
Sep	16.30	8.60	18.06	8.00	19.20	7.56
Oct	13.70	8.50	15.64	7.93	17.28	7.54
Nov	8.76	8.24	11.05	7.77	13.64	7.47
Dec	5.80	8.01	8.30	7.63	11.45	7.41
Apr-Oct	20.46	8.60	21.93	8.00	22.27	7.56
Nov-Mar	8.76	8.24	11.05	7.77	13.64	7.47

1) 90%tiles of ambient monitoring data. For semi-annual periods, 90%tiles of critical portions of each season were used, where critical portions were defined by occurrence of low flows.

2) Based on regression of downstream versus upstream temperature and pH from Pullman WTP data (1990-92) applied to Ecology station 34B110 values:
   Mixing Zone Temperature (deg C) = 2.904 + 0.9297 * [34B110 Temperature (deg C)]
   (P<0.05; Std Err of Estimate = 2.04 deg C)
   Mixing Zone pH (S.U.) = 2.592 + 0.6284 * [34B110 pH (S.U.)]
   (P<0.05; Std Err of Estimate = 0.21 S.U.)

3) Regression of Paradise Creek at Stateline (PCSL) versus Ecology Station 34B110 for water year 1992 monthly monitoring data
   PCSL Temperature (deg C) = 7.171 + 0.7381 * [34B110 Temperature (deg C)]
   (P<0.05; Std Err of Estimate = 1.87 deg C)
   PCSL pH (S.U.) = 5.305 + 0.2624 * [34B110 pH (S.U.)]
   (P<0.05; Std Err of Estimate = 0.14 S.U.)

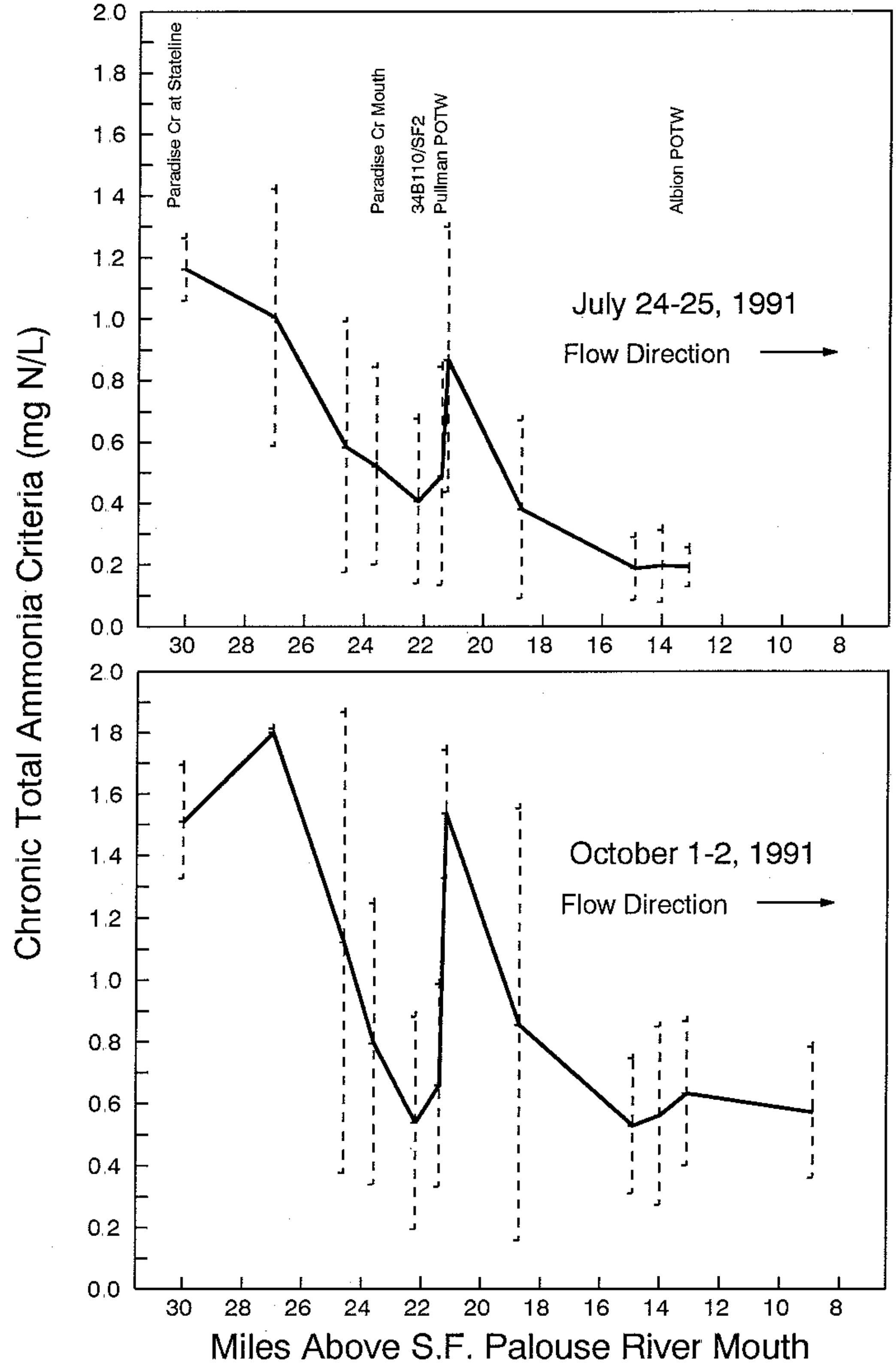

Figure 14. Chronic total ammonia criteria in Paradise Creek and SFPR. Vertical ranges are means +/- standard deviations.

from the Moscow POTW (Figure 15). Ammonia concentrations decrease much faster than criteria due to rapid instream nitrification. Therefore, the loading capacity of the river may be safely characterized by criteria at three critical points: Paradise Creek at the state line; SFPR in the Pullman POTW mixing zone; and SFPR in the Albion POTW mixing zone. However, instream nitrification must be accounted for between these points to realistically estimate the ammonia concentrations immediately upstream from Pullman and Albion POTWs for alternative loadings from point and nonpoint sources. WLAs for Pullman and Albion POTWs depend on three major factors: aquatic life criteria in the mixing zone, concentrations immediately upstream, and allowable dilution flows based on WAC 173-201A.

Dissolved oxygen concentrations are affected by instream nitrification as well as oxidation of carbonaceous biochemical oxygen demand (CBOD), photosynthesis, and respiration. The relationship between dissolved oxygen and other parameters is discussed in a later section.

The decrease in ammonia concentration in the water column occurs through the process of nitrification, which is the oxidation of ammonia to nitrite and nitrate by *Nitrosomonas* and *Nitrobacter* bacteria, respectively (EPA, 1985). This reaction is commonly described as a first-order process:

$$C = C_0 e^{-Kt}$$

where C is the ammonia concentration at any given point (mg/L as N), C_0 is the starting ammonia concentration (mg/L as N), K is the first-order rate constant (day^{-1}) at ambient temperature, t is the travel time (days) from the starting point to the downstream point of interest, and e is the base of natural logarithms. Travel time is estimated as the distance travelled by a parcel of water divided by river velocity.

The first-order nitrification rate constant is usually considered to be dependant on temperature. The relationship between the rate constant and temperature is described by:

$$K = K_{20} * 1.08^{(T-20)}$$

where K_{20} is the rate constant at 20 degrees C (days^{-1}), and T is ambient temperature (degrees C).

The first-order rate constant for nitrification was determined by linear regression (significant at the 95% confidence level) of the natural logarithm of ammonia concentrations versus travel time downstream in Paradise Creek from the state line to CM 0 (Figure 15). In addition to the July and October 1991 sampling, monthly monitoring data during water year 1992 were also used to estimate nitrification rate constants. The data from 1991 and water year 1992 were pooled to estimate an overall nitrification rate constant (K_{20}) of 8.2 ± 5.8 day^{-1} at 20 degrees C (mean ± standard deviation). The lowest 10th percentile was used for a design condition. Assuming a log-normal distribution, the lowest 10th percentile nitrification rate constant (K_{20}) was found to be 3.0 day^{-1} at 20 degrees C.

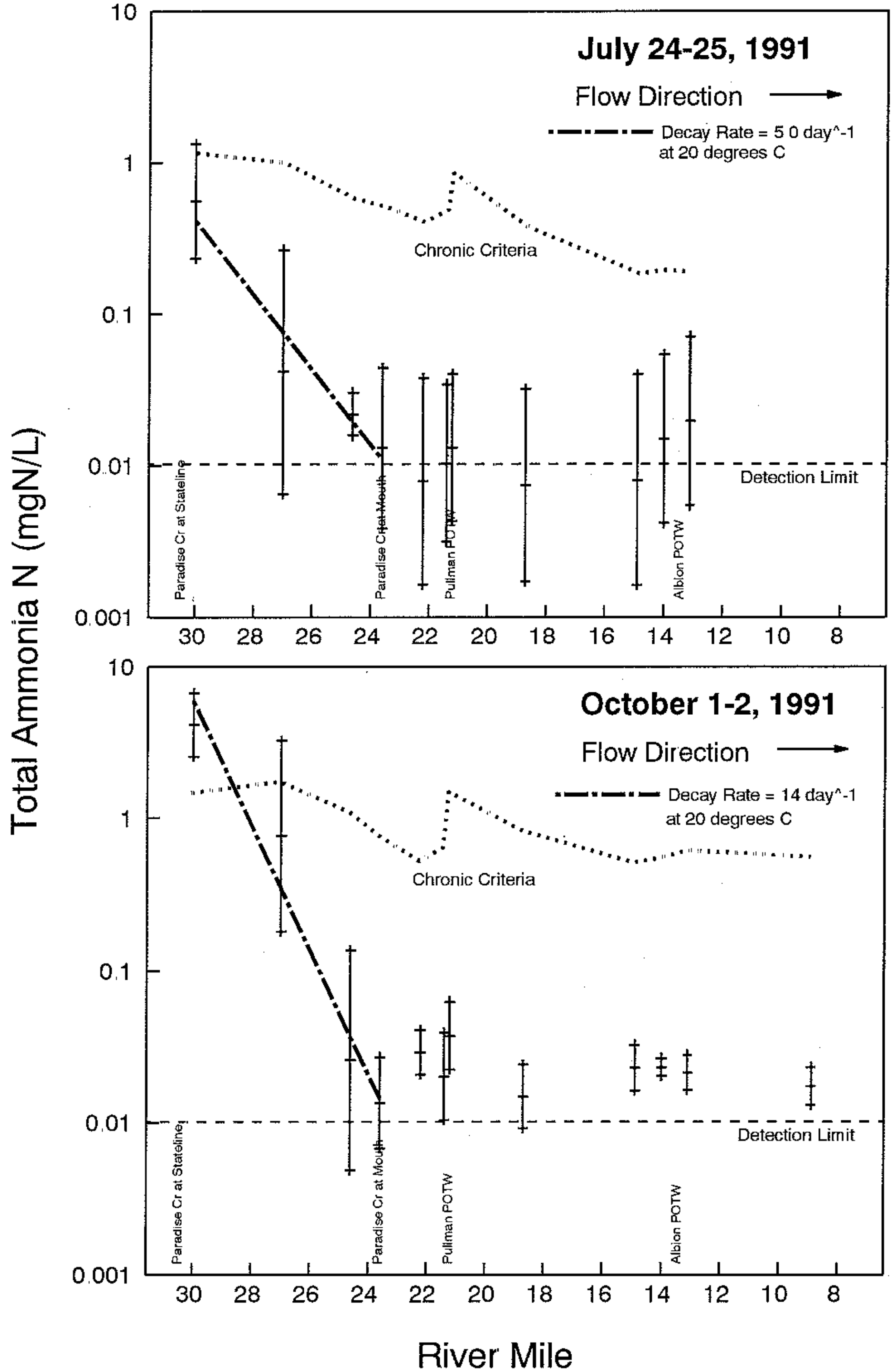

Figure 15. Profiles of total ammonia in Paradise Creek and SFPR during Ecology 1991 surveys Vertical ranges are means +/- std deviation.

The rapid rate of instream nitrification mitigates cumulative impacts of the POTW discharges. Ammonia concentrations were found to decrease to near background levels between Moscow and Pullman POTWs even though concentrations started at or above aquatic life criteria at the Moscow POTW (Figure 15). The WLA for the Pullman POTW is not greatly affected by loading from Moscow POTW if ammonia criteria are met in Paradise Creek at the state line. The WLA for Pullman POTW is based on the assumption that Paradise Creek meets criteria at the state line based on temperature and pH in Table 3. The Moscow POTW does not currently contain effluent limits on ammonia even though ammonia standards are currently exceeded in Paradise Creek in Washington. USEPA Region 10 and the state of Idaho are responsible for bringing conditions in Paradise Creek into compliance with WAC 173-201A at the state line.

USEPA Region X is presently evaluating WLAs for Idaho discharges. The temperature and pH values listed in Table 3 (either monthly or semi-annual) are recommended to establish criteria for total ammonia in Paradise Creek at the state line for the Idaho WLAs as well as immediately downstream from Pullman and Albion POTWs. Critical conditions of temperature and pH for Paradise Creek at the state line, as well as the corresponding criteria for total ammonia are as follows:

Period	Temperature (°C)	pH (s.u.)	Chronic Criterion 4-day average Total Ammonia (mg/L as N)	Acute Criterion 1-hour average Total Ammonia (mg/L as N)
April-October	22.3	7.56	1.1	9.4
November-March	13.6	7.47	1.8	13.

Nonpoint sources of ammonia from various tributaries were found to be relatively dilute compared with POTW effluent (Table 4). For the purpose of TMDL modeling, nonpoint sources were included by assuming that instream nitrification could reduce water column ammonia to no less than 0.05 mg/L as N, which is the flow-weighted average concentration at SFPR RM 23.6, Airport Creek, and Missouri Flat Creek (Table 4). Joy (1987) reported a similar nonpoint source ammonia concentration during September 16-17, 1986.

3.2.6 TMDL, WLAs, and LAs for Total Ammonia

Monthly and semi-annual periods for permitting were evaluated. Exemption from mixing zone width or flow limits was also considered. Alternative allocation schemes were based on changing mixing zone requirements. Four alternatives were considered for evaluating TMDLs as follows:

- Application of the mixing zone rule limiting available dilution flows to 25% of upstream flows for chronic and 2.5% for acute:

Table 4. Summary of flows and ammonia concentrations for headwaters, nonpoint sources, and point sources during 1991 Ecology surveys.

	<-- July 24-25, 1991 -->			<-- October 1-2, 1991 -->		
	Flow (cfs)	Total Ammonia (mg/L as N)	Total Ammonia (lbs/d as N)	Flow (cfs)	Total Ammonia (mg/L as N)	Total Ammonia (lbs/d as N)
HEADWATERS						
Paradise CM 6.4	3.37	0.614	11.2	3.29	4.257	75.5
SFPR RM 23.6	0.32	0.015	0.026	0.18	0.012	0.012
NONPOINT SOURCES						
Airport Creek	0.05	0.048	0.013	0.05	0.013	0.004
Missouri Flat Creek	0.5	0.020	0.054	0.1	0.022	0.012
POINT SOURCES						
Pullman WTP	4.21	0.020	0.454	5.28	0.087	2.478
Albion WTP	0.06	1.170	0.379	0.06	1.170	0.379

- Alternative 1A: Monthly design conditions with maximum mixing zone size of 25% and 2.5% of river design flow for chronic and acute, respectively;

- Alternative 1B: Semi-annual design conditions with maximum mixing zone size of 25% and 2.5% of river design flow for chronic and acute criteria, respectively;

- Exemption from mixing zone rules for maximum width or percentage of river flow available for dilution:

  - Alternative 2A: Monthly design conditions with maximum mixing zone size of 100% of river design flow for chronic and acute.

  - Alternative 2B: Semi-annual design conditions with maximum mixing zone size of 100% of river design flow for chronic and acute;

The method used to determine WLAs for Pullman and Albion POTWs was as follows for each alternative:

- Step 1: Select design condition temperature and pH at Ecology station 34B110 (Table 3). 90th percentiles of either monthly or semi-annual periods were used. For semi-annual periods, the critical period during each season was restricted to the period of occurrence of low natural flows for estimating 90th percentiles. For the April-October season, the critical period only occurred during July-October. For the November-March season, lowest flows occurred in November. [Example: for the April-October season, the 90th percentile temperature and pH (from July-October) were 20.46 degrees C and 8.60 standard units].

- Step 2: Calculate POTW mixing zone temperature, pH, and ammonia criteria from regression of Pullman POTW downstream versus upstream values applied to temperature and pH from Step 1 (Table 3). Also use regression of Paradise Creek at state line versus Ecology station 34B110 to estimate temperature and pH for Paradise Creek at state line from values in Step 1. [Example: for the Pullman POTW mixing zone during the April-October season, critical temperature = (20.46)(.9297)+2.904 = 21.93 degrees C, and critical pH = (8.60)(.6284)+2.592 = 8.00 standard units].

- Step 3: Estimate monthly and semi-annual POTW design flows for Pullman and Albion POTWs (Table 2). Monthly design flows at Pullman were estimated based on design maximum monthly flow (4.3 mgd) scaled monthly proportional to 1989-91 monthly averages. Semi-annual flows for Pullman POTW were estimated as the maximum monthly estimate during critical periods of each semi-annual season. Albion POTW design flow for February-May was assumed to be 0.12 mgd. [Example: for the Pullman POTW during the April-October season, the maximum monthly POTW flow during July-October is predicted to be 5.82 cfs].

- Step 4: Estimate the monthly and semi-annual river flow balance. Flows from background/nonpoint sources and from POTWs were assumed to represent all flows in the system and be at design flows in Table 2. SFPR flow upstream from the Pullman POTW was estimated as the sum of flows from Paradise Creek at the state line, SFPR above Paradise Creek, and Missouri Flat Creek. SFPR flow above Albion POTW was estimated as sum of SFPR flow upstream from Pullman POTW plus Pullman POTW flow. [Example: for the Pullman POTW during the April-October season, the critical flow upstream from the POTW is estimated as the sum of Paradise Creek at the state line (3.79 cfs), SFPR above Paradise Creek (0.65 cfs), and Missouri Flat Creek (0.21 cfs), which equals 4.65 cfs].

- Step 5: Estimate the instream nitrification rate. A first-order nitrification rate constant (K_{20}; day^{-1}) of 3.0 day^{-1} was assumed at 20°C based on the 10th percentile of 1991-92 data. Monthly and semi-annual nitrification rates (K; day^{-1}) were adjusted to design ambient temperature from Table 3. [Example: for the April-October season, the nitrification rate between Paradise Creek at the state line and the SFPR at the Pullman POTW is $(3.0)(1.08^{[20.46-20]}) = 3.1$ day^{-1} at ambient temperature of 20.46 degrees C].

- Step 6: Calculate design ammonia concentrations immediately upstream from Pullman and Albion POTWs (C_{up}). For Pullman POTW, assume that Paradise Creek at the state line begins at the chronic criterion value from temperature and pH in Step 2 (Table 3), then use the first-order decay equation to estimate the concentration above Pullman assuming instream concentrations cannot decrease to less than 0.05 mg/L as N. For Albion POTW, assume that Pullman discharges at the WLA (calculated in following step), then use first-order decay equation to calculate concentration above Albion POTW. Exponential equations relating velocities in stream reaches to flow at SFPR RM 22.2 were calibrated from July and October 1991 measurements and exponents from McCutcheon (1989). Velocities equations are as follows: between Paradise Creek at the state line and Pullman POTW, velocity (ft/sec) = 0.325 [Flow at SFPR RM 22.2 (cfs)]$^{0.4}$; between Pullman and Albion POTW, velocity (ft/sec) = 0.330 [Flow at SFPR RM 22.2 (cfs)]$^{0.4}$. [Example: for the Pullman POTW during the April-October season, the ammonia concentration upstream = $(1.1)(e^{-[(3.1)(.901)]}) = 0.067$ mg/L as N for an initial concentration of 1.1 mg/L as N at the state line, nitrification rate of 3.1 day^{-1}, and travel time of 0.901 days at ambient velocity of 0.59 ft/sec].

- Step 7: Calculate TMDL of ammonia for the SFPR at Pullman and Albion from the mass balance equation:

$$TMDL = ALC * (Q_{up} + Q_{potw})$$

where ALC is the aquatic life criteria for total ammonia (mg/L as N), Q_{up} is the upstream river flow from Step 4, and Q_{potw} is the critical POTW flow. [Example: for the Pullman POTW during the April-October season, the chronic ALC is 0.67 mg/L as N, Q_{up} is 4.65

cfs, and Q_{potw} is 5.82 cfs. Therefore the TMDL is (0.67)(4.65 + 5.82) multiplied by a conversion factor of 5.3936, which equals 37.8 lbs/day as N].

Step 8: Calculate the load allocation (LA) for upstream background/nonpoint sources from the mass balance:

$$LA = Q_{up} * C_{up}$$

[Example: for the Pullman POTW during the April-October season, the LA for upstream sources is (4.65 cfs)(0.067 mg/L as N)(5.3936) = 1.7 lbs/day as N].

- Step 9: Calculate WLAs for Pullman and Albion POTWs from a simple mass balance equation:

$$WLA = ALC * [(f*Q_{up} + Q_{potw})/ Q_{potw}] - [C_{up} * (f*Q_{up} / Q_{potw})]$$

where f is the fraction of upstream flow allowed for the mixing zone (25% and 2.5% for chronic and acute for Alternatives 1A and 1B; 100% for Alternatives 2A and 2B). [Example: for the Pullman POTW during the April-October season and Alternative 2B: ALC = 0.67 mg/L as N, f = 0.25, Q_{up} = 4.65 cfs, Q_{potw} = 5.82 cfs, and C_{up} = 0.067 mg/L as N. Therefore, the WLA = (0.67)[(0.25*4.65+5.82)/5.82]-[0.067*(0.25*4.65/5.82)] = 0.79 mg/L as N. The mass loading for the WLA is calculated by multiplying the WLA concentration (0.79 mg/L as N) by the critical POTW flow (5.82 cfs) and the conversion factor of 5.3936 to obtain (0.79)(5.82)(5.3936) = 24.8 lbs/day as N].

- Step 10: Calculate water quality-based permit limits from the WLAs incorporating effluent variability using the method of EPA (1991a). The effluent coefficient of variation (CV) for ammonia was assumed to be 0.6; 20 samples per month were assumed for Pullman POTW and 4 per month for Albion; Z-statistic for long-term average and daily maximum permit limits was 2.326 (99%tile); and Z-statistic for monthly average permit limits was 1.645 (95%tile). [Example: for the Pullman POTW during the April-October season, following calculation procedures of EPA 1991a (detailed in Appendix F-2), the permit limits for total ammonia were found to be a daily maximum of 1.9 mg/L as N and monthly average of 0.76 mg/L as N. These concentration limits correspond to mass load limits of a daily maximum of 60 lbs/day as N and a monthly average of 24 lbs/day as N for the critical POTW flow of 5.82 cfs].

The detailed intermediate calculations for the four alternatives are presented in Appendix F. A summary of the ammonia TMDLs, background LAs, POTW WLAs, and proposed permit limits for alternative permit scenarios is presented in Appendix F-4. A margin of safety, which is required for assigning WLAs and LAs in a TMDL (EPA, 1991b), was incorporated through conservative assumptions.

Semi-annual permit limits for the Pullman and Albion POTW, assuming mixing zone width and flow restrictions are enforced, are as follows [Alternative 1B effluent ammonia limits in terms of total ammonia as N; permitted loads were calculated using design flows for Pullman (5.82 cfs for April-October and 5.55 cfs for November-March) and Albion (0.12 mgd) POTWs]:

	Apr-Oct		Nov-Mar	
	mg/L	lbs/day	mg/L	lbs/day
Pullman POTW Total Ammonia-N				
Daily Max	1.9	60.	4.8	144.
Monthly Avg	0.76	24.	1.9	57.
Albion POTW Total Ammonia-N				
Daily Max	12.	12.	23.	23.
Monthly Avg	5.9	5.9	11.	11.

Semi-annual permit limits for the Pullman and Albion POTWs, assuming exemption from mixing zone width and flow restrictions, are as follows (Alternative 2B effluent ammonia limits in terms of total ammonia as N):

	Apr-Oct		Nov-Mar	
	mg/L	lbs/day	mg/L	lbs/day
Pullman POTW Total Ammonia-N				
Daily Max	2.8	88.	7.2	215.
Monthly Avg	1.1	35.	2.9	85.
Albion POTW Total Ammonia-N				
Daily Max	84.	84.	155.	155.
Monthly Avg	42.	42.	77.	78.

The method used to select the optimal semi-annual periods depends on results of monthly WLAs as described in EPA, 1984 (Table 5). The method begins by determining monthly WLAs using appropriate monthly design conditions. The 12 months of the year are divided into two contiguous groups so that the sum of the minimum monthly WLA times the number of days in each group is maximized. The optimal semi-annual periods are found by systematic trials of selected groups of months. To start the process, the year is divided into two groups: the month with the lowest WLA (period 1); and the other 11 months (period 2). Next, the minimum WLA from periods 1 and 2 are multiplied by the number of days in each period and these products

Table 5 Selection of semi-annual permit periods for load optimization.

Month	Pullman Design Flow mgd	Alt 1A Pullman Ammonia Monthly Avg Limit mgN/L	Alt 1A Pullman Ammonia Monthly Load #N/day
Jan	4 22	2 1	74.0
Feb	4 30	2 1	75.4
Mar	4.09	2.2	75.1
Apr	4.05	0 88	29 7
May	3 12	0 60	15 6
Jun	2 67	0.37	8.2
Jul	2.50	0 64	13.4
Aug	2.98	0.65	16.2
Sep	3 76	1 0	31.4
Oct	3 69	1 3	40.0
Nov	3 58	2 0	59 8
Dec	3 45	2 2	63 3

	Dry/Wet Season Periods	Min Monthly Avg During Season mg/L	Days in Season days	Time-wtd Effluent Ammonia Limit mg/L	Min Monthly Avg During Season #/day	Days in Season days	Time-wtd Effluent Ammonia Load #/day
	Jul	0 28	31		13.35	31	
	Aug-Jun	0 37	334		8 24	334	
				0 36 mg/L			8 7 #/day
	Jun-Jul	0.28	61		13.35	61	
	Aug-May	0 6	304		15 62	304	
				0 55 mg/L			15 2 #/day
	Jun-Aug	0.28	92		13 35	92	
	Sep-May	0 6	273		15.62	273	
				0 52 mg/L			15 0 #/day
	May-Aug	0 28	123		13 35	123	
	Sep-Apr	0.88	242		29.74	242	
				0 68 mg/L			24 2 #/day
	Apr-Aug	0 28	153		13.35	153	
	Sep-Mar	1	212		31 38	212	
				0 70 mg/L			23 8 #/day
	Apr-Sep	0 28	183		13 35	183	
	Oct-Mar	1.3	182		40 03	182	
				0.79 mg/L			26.7 #/day
OPTIMAL PERIOD:	Apr-Oct	0.28	214		13.35	214	
	Nov-Mar	2	151		59.75	151	
				0.99 mg/L			32.5 #/day
	Apr-Nov	0.28	244		13 35	244	
	Dec-Mar	2 1	121		63 34	121	
				0 88 mg/L			29 9 #/day
	Apr-Dec	0.28	275		13.35	274	
	Jan-Mar	2.1	90		73.95	91	
				0 73 mg/L			28 5 #/day

are added together to estimate the time-weighted annual average POTW load. For the next iteration the contiguous month with the next highest WLA is added to period 1 and deleted from period 2 and the time-weighted annual load is recalculated. This step is repeated until the periods which provide the maximum annual load are found. The optimal semi-annual periods were found to be April-October and November-March using this procedure. Semi-annual permit periods are recommended over monthly periods for administrative simplicity and because both schemes require similar levels of treatment throughout the year.

Alternatives 2A and 2B are provided to show the maximum loading which could be allowed if the POTWs are exempted from mixing zone size restrictions. In general, this exemption allows for some increased loading. The Water Quality Program will need to decide if the exemption for mixing zone size is appropriate for these facilities. If no exemption is allowed, then results for either Alternative 1A or 1B can be used depending on whether semi-annual or monthly average limits are required.

Pullman POTW WLAs and permit limits for all alternatives were found to be more restrictive than the existing permit. Permit limits will be required during all months to meet the proposed WLAs. Proposed semi-annual permit limits for monthly average and daily maximum ammonia were compared with Pullman POTW data from 1991 (Figure 16). Proposed permit limits under Alternative 2B would have been met during 1991, with the exception of monthly average during April 1991 and daily maximum during May and June 1991. The more restrictive limits of Alternative 1B were also met for 10 of 12 months and 5 of 12 months, respectively, for monthly average and daily maximum limits. An engineering analysis of the treatment process would need to be conducted to determine feasibility of operational changes or improvements required to meet the proposed limits. However, the comparison with 1991 data suggests that the proposed limits could be achieved.

WLAs for Albion POTW are generally much less restrictive than for Pullman POTW because of greater dilution. Glenn (1992) reported effluent total ammonia of 1.2 mg/L as N in July 1991. This observation suggests that values as high as 16 mg/L as N could be expected if effluent ammonia has a CV of 0.6 (EPA, 1991). Therefore, ammonia limits may be required if the Albion POTW is not exempted from mixing zone width and flow limits.

The WLAs for Pullman and Albion would probably not be reduced significantly if nonpoint sources are reduced (e.g., through use of best management practices or changes in land use). Nonpoint sources make up a relatively minor portion of the TMDL. Reductions of nonpoint loading sources would protect water quality more, but such reductions would probably mainly be achieved during seasons that are not critical for consideration of WLAs. Application of mixing zone size limits provides a reserve for water quality protection since the sum of WLAs and LAs is less than the loading capacity.

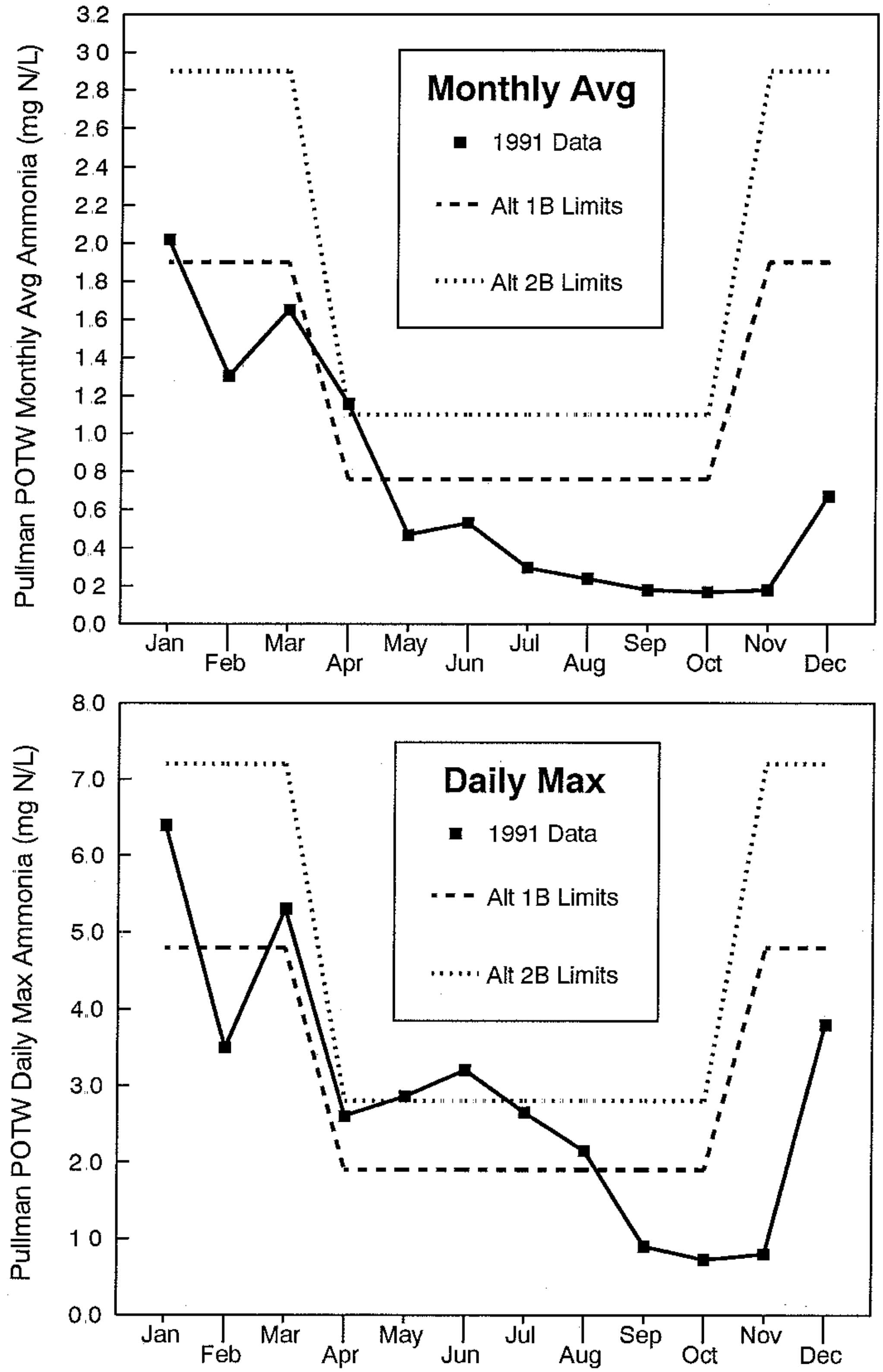

Figure 16. Comparison of Pullman POTW effluent ammonia during 1991 with proposed semi-annual permit limits for monthly average and daily maximum

3.2.7 Monte Carlo Simulation of Ammonia

Monte Carlo simulation was used to combine the water quality model and permit limit calculations with statistically described inputs. The purpose of Monte Carlo simulation of Pullman and Albion POTW permit limits was to examine whether design conditions assumed in the preceding analysis were too conservative compared with frequency requirements of the water quality criteria. The major advantages of Monte Carlo simulation for derivation of permit limits are (EPA, 1992):

- It can directly estimate the permit limits that correspond to the allowable frequency and duration requirements of the water quality criteria.
- It can be used with the same steady state water quality model that is used for the point-estimate method (section 3.2.6).
- It can incorporate the cross-correlation and interaction of model variables such as river flow and temperature.

Using this technique, probability density functions are assigned to each term in the water quality model reflecting the variability in that characteristic. Then, with synthetic sampling, values are randomly chosen from the distributions of each term. These values are inserted into the model, and a prediction is calculated. After this is repeated a large number of times, a distribution of predicted values results, which reflects the combined uncertainties of all model variables. A detailed description of the steps used in Monte Carlo simulation for estimating ammonia limits for Pullman and Albion POTWs is presented in Appendix G.

Results of Monte Carlo simulation yielded similar permit limits compared with the point-estimate method. Permit limits based on Monte Carlo simulation are as follows:

	Apr-Oct	Nov-Mar
Pullman POTW Total Ammonia-N (mg/L as N)		
Daily Max	2.1	4.7
Monthly Avg	0.83	1.9
Albion POTW Total Ammonia-N (mg/L as N)		
Daily Max	12.	28.
Monthly Avg	6.2	14.

This result suggests that the design conditions assumed in section 3.2.6 are reasonable and not overly conservative for protection of water quality criteria. Results using the point-estimate method of section 3.2.6 are recommended for establishing permit limits.

3.2.8 Analysis of Dissolved Oxygen Sag

A Streeter-Phelps model was used to estimate the dissolved oxygen concentration at critical points below the Moscow, Pullman, and Albion POTWs. This approach accounts for the demand for oxygen from carbonaceous BOD (CBOD), nitrogenous BOD (NBOD) from nitrification of ammonia, the deficit from photosynthesis and respiration by algae and plants, and reaeration. NBOD from organic forms of nitrogen were considered to be negligible because of the relatively slow rates of hydrolysis of organic N compared with more rapid CBOD decay and nitrification rates. The dissolved oxygen model used in this report is more complex than the DOSAG spreadsheet used by Ecology permit writers (Ecology, 1992) because it accounts for diel changes, photosynthesis, and respiration.

The diel average and minimum dissolved oxygen concentrations below a POTW are described by the following equations in relationship with the saturation concentration (calculated by APHA et al., 1989 equation and EPA 1985 equation for elevation adjustment), daily average deficit below saturation at the point of critical sag, and diel range of dissolved oxygen:

$$c_{avg} = c_s - D_c$$

$$c_{min} = c_s - D_c - \Delta_c/2$$

$$c_s = \exp[-139.34411 + (1.575701 * 10^5/T_k) - (6.642308 * 10^7/T_k^2) + (1.2438 * 10^{10}/T_k^3) - (8.621949 * 10^{11}/T_k^4)] * [1 - 0.0000355\,E]$$

where:

c_{avg} = diel average dissolved oxygen (mg/L)
c_{min} = diel minimum dissolved oxygen (mg/L)
c_s = saturation concentration at ambient temperature (mg/L)
D_c = diel average dissolved oxygen deficit (mg/L)
Δ_c = diel range of dissolved oxygen (mg/L)
T_k = temperature (degrees Kelvin)
E = elevation (2300 feet above sea level).

The equations for the dissolved oxygen deficit (D_c), which is the diel average suppression below the saturation concentration, is as follows (Thomann and Mueller, 1987):

$$D_c = D_0 \exp[-K_a t_c] \qquad \text{(initial deficit)}$$

$$+ [K_d/(K_a-K_d)][\exp(-K_r t_c)-\exp(-K_a t_c)]\, L_0 \qquad \text{(ultimate CBOD)}$$

$$+ [K_n/(K_a-K_n)][\exp(-K_n t_c)-\exp(-K_a t_c)]\, L_0^N \qquad \text{(NBOD)}$$

$$- [1 - \exp(-K_a t_c)]\, (p_a/K_a) \qquad \text{(photosynthesis)}$$

$$+ [1 - \exp(-K_a t_c)] (R/K_a) \qquad \text{(respiration)}$$

$$K_d = [10.3\ Q^{-0.49}] * 1.047^{(I-20)} \qquad \text{(CBOD decay rate)}$$

$$K_a = 7776 * U * S * 0.8882 * 1.024^{(I-20)} \qquad \text{(reaeration rate)}$$

$$K_n = 3.0 * 1.08^{(I-20)} \qquad \text{(nitrification rate)}$$

where:

D_0 = initial deficit (mg/L)
L_0 = initial ultimate CBOD concentration (mg/L)
L_0^N = initial NBOD concentration (mg/L; 4.57 times ammonia-N)
K_a = reaeration rate (day^{-1} base e; Tsivoglou-Wallace equation, EPA, 1985)
K_d = CBOD decay rate (day^{-1} base e; Wright-McDonnell equation, EPA, 1985)
K_n = nitrification rate (day^{-1} base e; measured)
p_a = gross photosynthesis (mg/L-day; measured)
R = gross respiration (mg/L-day; measured)
t_c = travel time to critical sag (days)
Q = flow (cfs)
T = temperature (degrees C)
U = stream velocity (ft/sec)
S = channel slope (ft/ft).

The travel time to the critical location of minimal dissolved oxygen (t_c) below each POTW was estimated using the following equation (Thomann and Mueller, 1987):

$$t_c = [1/(K_a-K_d)] \text{ Ln } \{(K_a/K_d)[1 - D_0(K_a-K_d)/(K_d L_0)]\}.$$

The gross photosynthesis and respiration rates were estimated from measurements of the diel range of dissolved oxygen concentrations (Δ_c; mg/L) during July and October 1991 surveys as follows (Thomann and Mueller, 1987):

$$p_a = 3.2\ \Delta_c$$

$$R = 0.25\ p_a.$$

The model parameters and results for alternative concentrations of CBOD and NBOD in POTW effluent are presented in Appendix H. The accuracy of the model was tested by comparison of predictions with observations during July and October 1991 surveys. The model was found to predict daily average and minimum dissolved oxygen at the point of critical sag with an approximate standard deviation of 0.7 mg/L (root mean squared error of observed versus predicted values). The location of the lowest dissolved oxygen was predicted with an accuracy of about one mile below Moscow and Pullman POTWs.

The sensitivity of dissolved oxygen in the river was examined for effluent 5-day CBOD ($CBOD_5$) in the range of 0 to 45 mg/L and ammonia decreasing from proposed limits in section 3.2.6 (ultimate CBOD was estimated from CBOD5 by assuming a constant ratio of 1.47; EPA, 1985). This analysis showed that further reductions in ammonia below the recommended limits in section 3.2.6 will provide only minor increases in dissolved oxygen. Assuming that ammonia is reduced to the proposed limits, dissolved oxygen would be most sensitive to reductions in CBOD concentrations. Figure 17 shows the sensitivity of dissolved oxygen to various concentrations of effluent CBOD at critical points below Moscow, Pullman, and Albion POTW for critical conditions during the April through October season.

The Class A standard for dissolved oxygen of 8 mg/L is probably not attainable during critical conditions in the SFPR and Paradise Creek. High temperatures in summer result in diel average saturation concentrations that are approximately 8 mg/L at critical conditions. Therefore, a relatively small amount of diel range and deficit could drive concentrations below the standard. Since normal diel ranges of 1 mg/L or greater should be expected in any natural stream (EPA, 1980), the Class A standard would probably be violated even if all POTW loads are eliminated. Reductions in nutrient loads would reduce but not eliminate diel fluctuations in dissolved oxygen. If stream temperatures can be reduced during summer (e.g., through riparian management to increase shading), then dissolved oxygen concentrations may also increase. For example, if the Class A temperature criterion of 18 degrees is attained during summer, the saturation concentration of dissolved oxygen would be 8.7 mg/L (after accounting for Pullman elevation of 2300 feet above sea level). Therefore, the daily average deficit and half the diel range combined must be less than 0.7 mg/L, which is unlikely, to attain the Class A standard for dissolved oxygen at 18 degrees C.

Achievable targets for dissolved oxygen during the April-October and November-March periods were estimated from the Streeter-Phelps model assuming that POTW effluent from Moscow and Pullman is limited to 10 mg/L of $CBOD_5$ year-round. Even if effluent $CBOD_5$ is limited to 10 mg/L and ammonia is limited to meet aquatic life criteria, the Class A standard of 8 mg/L as an instantaneous minimum would not be attainable under critical conditions for most of the year. The targets for attainable dissolved oxygen are as follows for Paradise Creek and the SFPR if POTWs are allowed to discharge with reduced BOD and ammonia limits:

	Lowest 24-hour Average	Instantaneous Minimum
April-October	5 mg/L	4 mg/L
November-March	8 mg/L	6 mg/L

The target for lowest 24-hour average represents the lowest daily average that is likely at the critical conditions for each season. Seasonal average concentrations would be higher than the lowest 24-hour average because the critical conditions would probably only occur for a short period of time at most.

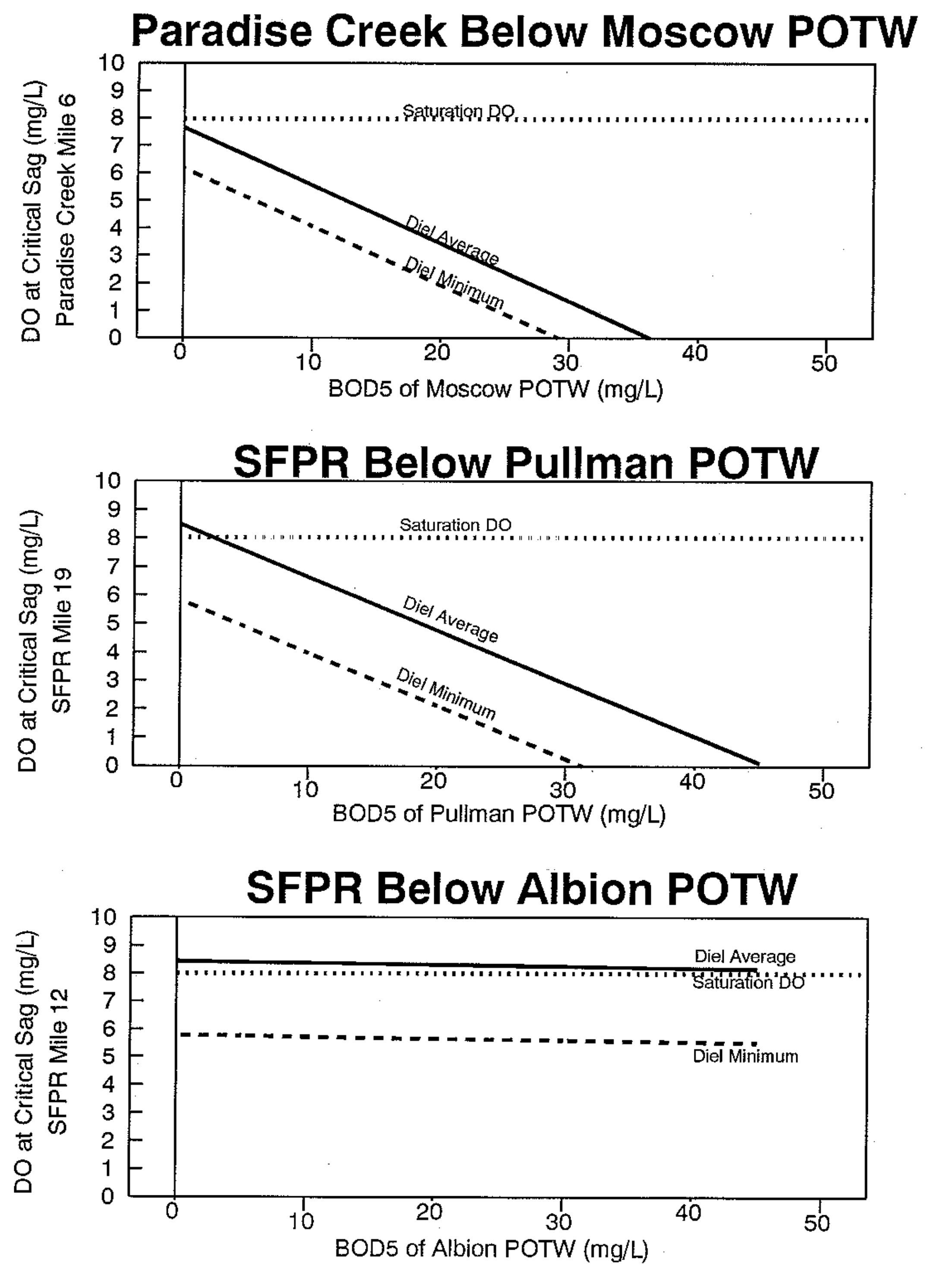

Figure 17. Critical DO concentrations below Moscow, Pullman, and Albion POTWs for various effluent BOD5 concentrations, April-October critical conditions. Effluent ammonia was assumed at proposed limits to meet un-ionized criteria.

Effluent from the Pullman POTW currently discharges 5-day BOD at less than 10 mg/L during the summer even though the NPDES permit allows up to 45 mg/L. Moscow POTW had effluent 5-day BOD of about 20 mg/L during 1991 surveys. If a nitrification unit process is added to the Moscow POTW, it is possible that lower effluent CBOD could also be expected. Existing BOD limits in the Albion POTW permit are adequate to meet the proposed targets for dissolved oxygen (Figure 17). EPA (1980) suggests that $CBOD_5$ limits for POTWs as low as 10 mg/L can be justified by the type of modeling analysis presented in this section.

3.2.9 Effect of Proposed Diversion of Pullman POTW Effluent

The city of Pullman has proposed to irrigate a city park and a new golf course with wastewater from the Pullman POTW. Approximately 128 million gallons of wastewater would be diverted for irrigation during the April through October period (Don Nichols, Ecology Eastern Regional Office, personal communication). A peak daily rate of diversion is estimated to be 1.5 mgd. For the purpose of estimating the effect of the proposed diversion of wastewater on permit limits, WLAs for ammonia were recalculated assuming Pullman POTW flows would be reduced by 1.5 mgd through the April through October period. This analysis represents a first approximation of the maximum benefit of the proposed diversion on ammonia limits. A more refined analysis could be conducted if monthly diversion rates could be accurately estimated.

A comparison of critical POTW flows and monthly ammonia WLAs for the discharge to the SFPR during the April through October period is as follows (ammonia WLAs with effluent diversion were calculated using the method presented in section 3.2.6; monthly POTW flows without diversion are from Table 2 after converting from cfs to mgd; WLAs without diversion are from Appendix F-4 for Alternative 1A):

	Without Diversion			Diversion of 1.5 mgd		
	Flow mgd	WLA mg/L	WLA lbs/d	Flow mgd	WLA mg/L	WLA lbs/d
Apr	4.05	0.88	30.	2.55	0.93	20.
May	3.12	0.60	16.	1.62	0.70	9.5
Jun	2.66	0.37	8.2	1.16	0.45	4.4
Jul	2.49	0.64	13.	0.99	0.76	6.3
Aug	2.99	0.65	16.	1.49	0.76	9.4
Sep	3.76	1.0	31.	2.26	1.1	21.
Oct	3.69	1.3	40.	2.19	1.5	27.

This analysis shows that the proposed diversion will probably have a minimal effect on permit limits for ammonia concentration. A similar analysis for dissolved oxygen showed that the proposed diversion would also have a minimal effect on permit limits for BOD concentration. WLA concentrations at rates of diversion exceeding 1.5 mgd were calculated and found to be insensitive to the amount of diversion until nearly complete diversion. Effluent loading of ammonia and BOD to the SFPR would be substantially less depending on the amount of diversion.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- Un-ionized ammonia concentrations at Ecology station 34B110 often exceed chronic aquatic life criteria. Most excursions occur during summer months, but January through March were the only months without excursions .

- Ammonia concentrations in excess of chronic criteria were observed in Paradise Creek near the state line during October 1991. The cause of excessive ammonia concentrations during Ecology surveys appears to be the Moscow POTW.

- Dissolved oxygen measurements at Ecology station 34B110 show occasional excursions below the Class A standard of 8 mg/L during May through September. However, the ambient monitoring data probably do not represent potential minimum concentrations which would occur before sunrise or at critical locations below POTWs. The intensive surveys during July and October 1991 probably are more representative of minimum concentrations at critical locations and times of day. Diel minimum dissolved oxygen of less than 8 mg/L was consistently found at most stations. Lowest dissolved oxygen concentrations were found in Paradise Creek at the state line. Monthly sampling of Paradise Creek at the state line during water year 1992 shows sub-standard dissolved oxygen throughout the year.

- River flows recommended for semi-annual and monthly steady-state modeling were 30-day-20-year and 30-day-114-year low flows, respectively. These design flows are equivalent to annual critical conditions required under WAC 173-201A.

- Effluent from Moscow and Pullman POTWs comprises most of the river flow during July-November of a typical year and during any month of the year for design low flows. The Albion POTW only discharges during February through May and makes up a relatively small fraction of the total river flow.

- Temperature and pH at Ecology station 34B110 are recommended for developing design conditions in combination with monitoring data collected by Pullman POTW upstream and downstream from the POTW outfall and by Ecology during water year 1992 in Paradise Creek at the state line. Weekly monitoring of upstream and downstream temperature and pH by Pullman POTW shows consistently higher temperature and lower pH downstream from the outfall. Paradise Creek at the state line shows a similar pattern compared with Ecology station 34B110. The design conditions of temperature and pH in the two POTW mixing zones and in Paradise Creek at the state line were estimated by applying regression equations to 90th percentiles of data at station 34B110. For semi-annual permit periods, 90th percentiles were developed from critical portions of each season, which were defined as months shown to exhibit critical low flows.

- Critical conditions of temperature and pH for Paradise Creek at the state line, as well as ammonia criteria, are proposed as follows (criteria in terms of total ammonia as N):

Period	Temperature (deg C)	pH (s.u.)	Chronic Criterion 4-day average Total Ammonia (mg/L as N)	Acute Criterion 1-hour average Total Ammonia (mg/L as N)
April-October	22.3	7.56	1.1	9.4
November-March	13.6	7.47	1.8	13.

- USEPA Region X, in consultation with Idaho Division of Environmental Quality, should establish WLAs and LAs in Idaho to meet the ammonia and dissolved oxygen criteria for Paradise Creek at the state line.

- Rapid instream nitrification was observed during 1991 intensive surveys and in ambient monitoring data collected during water year 1992. The nitrification rate was estimated assuming first-order kinetics. A 10th percentile nitrification rate constant of 3.0 day^{-1} at 20°C was used for steady-state modeling to develop WLAs. Ammonia concentrations were found to decrease to near background levels between POTW discharges.

- Nonpoint sources of ammonia were found to be relatively dilute compared with point sources. Nonpoint and background sources were included by assuming instream concentrations cannot decrease to less than 0.05 mg/L as N based on intensive survey data from 1991 and 1986.

- A margin of safety, which is required for any TMDL, was incorporated by the use of conservative design assumptions.

- Semi-annual and monthly periods for permitting were evaluated. Exemptions from mixing zone flow limits were also considered. Four alternatives were considered for evaluating TMDLs: monthly and semi-annual limits each with and without mixing zone flow restrictions. Semi-annual limits are recommended instead of monthly limits for administrative simplicity.

- Semi-annual permit limits for the Pullman and Albion POTWs, assuming mixing zone size restrictions are enforced and Washington State standards are met in Paradise Creek at the state line, are as follows (Alternative 1B effluent ammonia limits in terms of total ammonia as N):

	Apr-Oct		Nov-Mar	
	mg/L	lbs/day	mg/L	lbs/day
Pullman POTW Total Ammonia-N				
Daily Max	1.9	60.	4.8	144.
Monthly Avg	0.76	24.	1.9	57.
Albion POTW Total Ammonia-N				
Daily Max	12.	12.	23.	23.
Monthly Avg	5.9	5.9	11.	11.

- Semi-annual permit limits for the Pullman and Albion POTWs, assuming standards are met at the state line and POTWs are exempted from mixing zone flow restrictions, are as follows (Alternative 2B effluent ammonia limits in terms of total ammonia as N):

	Apr-Oct		Nov-Mar	
	mg/L	lbs/day	mg/L	lbs/day
Pullman POTW Total Ammonia-N				
Daily Max	2.8	88.	7.2	215.
Monthly Avg	1.1	35.	2.9	85.
Albion POTW Total Ammonia-N				
Daily Max	84.	84.	155.	155.
Monthly Avg	42.	42.	77.	78.

- Pullman POTW WLAs and permit limits for all alternatives were found to be more restrictive than the existing permit. Permit limits will be required during all months for the Pullman POTW to meet WLAs for ammonia. An engineering analysis of the treatment process is recommended to determine feasibility of operational changes or improvements required to meet the proposed ammonia limits. Comparison of proposed limits with 1991 data suggests that the proposed limits could be achieved.

- Monthly permit limits may be specified for Pullman POTW if preferred (Alternatives 1A or 2A). Use of monthly limits may allow greater utilization of available loading capacity. However, monthly limits are more restrictive than semi-annual limits during some months. Monthly permits are generally more difficult to track and do not necessarily provide more protection of water quality criteria than semi-annual limits.

- Permit limits for ammonia for the Albion POTW may be required. An effluent monitoring program is recommended to define effluent concentrations of ammonia and determine whether there is a reasonable potential to exceed WLAs presented in this report.

- The Class A standard for dissolved oxygen of 8 mg/L is probably not attainable during critical conditions in the SFPR and Paradise Creek. High temperatures in summer result in dissolved oxygen saturation of only 8 mg/L at critical conditions. Therefore, a relatively small amount of BOD load or diel fluctuation could drive concentrations below the standard. If stream temperatures can be reduced during summer (e.g., through riparian management to increase shading), then dissolved oxygen concentrations may also increase.

- Achievable targets for dissolved oxygen during the April-October and November-March periods were estimated from a steady-state model assuming that POTW effluent from Moscow and Pullman is limited to 10 mg/L of CBOD5 year-round. Even if effluent $CBOD_5$ is limited to 10 mg/L and ammonia is limited to meet aquatic life criteria, the Class A standard of 8 mg/L as an instantaneous minimum would not be attainable under critical conditions for most of the year. A special condition for dissolved oxygen may need to be adopted in WAC 173-201A for Paradise Creek and the SFPR if POTWs are allowed to continue discharging effluent. The targets for attainable dissolved oxygen are as follows for Paradise Creek and the SFPR if POTWs are allowed to discharge with reduced BOD and ammonia limits:

	Lowest 24-hour Average	Instantaneous Minimum
April-October	5 mg/L	4 mg/L
November-March	8 mg/L	6 mg/L

- Effluent limits for $CBOD_5$ of 10 mg/L are proposed for the Moscow and Pullman POTWs to meet realistic targets for dissolved oxygen in Paradise Creek and the SFPR. Existing limits for Albion POTW are adequate to meet the dissolved oxygen targets.

- The proposed diversion of effluent from the Pullman POTW for irrigation of a city park and a new golf course was found to have a minimal effect on permit limits for ammonia. A sensitivity analysis of ammonia WLAs for various amounts of diversion showed that permit limits would not be greatly affected until nearly total diversion during the April through October season.

5.0 REFERENCES

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APPENDIX A

Results of field and lab measurements during 1991 intensive surveys

Water Body	Station ID	River Mile	Time	Date	Flow	Velocity	X-Section Area	Top Width	Mean Depth	Temperature	pH	Conductivity	Diss. Oxygen	Total N	Ammonia N	Nitrite+ Nitrate N	Total P	Fecal Coliform	Chloride	Alkalinity	Soluble Reactive P	Total Organic Carbon	Turbidity	Total Suspended Solids	Nitrite N
		miles			cfs	fps	ft^2	ft	ft	deg.C	s.u.	umhos/cr	mg/L	mgN/L	mgN/L	mgN/L	mgP/L	cfu/100m	mg/L	mgCaCO3/l	mgP/L	mg/L	NTU	mg/L	mgN/L
Airport Cr	APC	0.0	08:04 AM	24-Jul-91	0.05	999999	999999	999999	999999	13.9	7.81	630	7.80	1.420	0.025	1.140	0.490	220	21.5	301	999999	999999	999999	999999	999999
Airport Cr	APC	0.0	01:32 PM	24-Jul-91	999999	999999	999999	999999	999999	16.1	7.85	670	6.70	1.610	0.041	0.993	0.523	260	20.9	294	999999	999999	999999	999999	999999
Airport Cr	APC	0.0	01:23 PM	25-Jul-91	999999	999999	999999	999999	999999	16.4	7.55	550	999999	1.350	0.079	1.110	0.445	1000	14.8	233	999999	999999	999999	999999	999999
Missouri Flat Cr	MFC3	0.0	09:24 AM	24-Jul-91	<1	999999	999999	999999	999999	18.4	7.84	480	6.35	1.760	0.037	1.480	0.255	1500	14.3	209	999999	999999	999999	999999	999999
Missouri Flat Cr	MFC3	0.0	03:10 PM	24-Jul-91	<1	999999	999999	999999	999999	22.5	8.12	550	9.85	1.640	0.019	1.230	0.208	770	38	212	999999	999999	999999	999999	999999
Missouri Flat Cr	MFC3	0.0	11:36 AM	25-Jul-91	<1	999999	999999	999999	999999	18.6	7.48	425	999999	1.600	0.005	0.970	0.186	6200	14.5	177	999999	999999	999999	999999	999999
Paradise Cr	PC1	6.4	07:06 AM	24-Jul-91	2.04	1.05	1.95	4	0.49	19.6	6.85	670	2.70	10.800	0.933	8.210	2.780	66	66.9	178	999999	999999	999999	999999	999999
Paradise Cr	PC1	6.4	12:45 PM	24-Jul-91	2.66	1.15	2.32	3.9	0.59	22.1	7.32	620	5.10	7.110	0.396	5.750	1.980	420	54.4	169	999999	999999	999999	999999	999999
Paradise Cr	PC1	6.4	12:58 PM	25-Jul-91	4.06	1.35	3.02	4.4	0.69	20.6	7.08	525	4.60	10.700	0.514	8.400	2.340	190	47.7	131	999999	999999	999999	999999	999999
Paradise Cr	PC2	3.4	07:40 AM	24-Jul-91	999999	999999	999999	999999	999999	19.3	7.48	690	4.50	11.700	0.148	10.300	2.850	560	81.1	159	999999	999999	999999	999999	999999
Paradise Cr	PC2	3.4	01:10 PM	24-Jul-91	999999	999999	999999	999999	999999	22.5	8.09	670	9.70	11.200	0.039	10.400	2.710	400	70.3	156	999999	999999	999999	999999	999999
Paradise Cr	PC2	3.4	12:48 PM	25-Jul-91	999999	999999	999999	999999	999999	20.5	7.54	525	999999	5.300	0.005	4.350	1.350	6900	48	149	999999	999999	999999	999999	999999
Paradise Cr	PC3	1.0	07:54 AM	24-Jul-91	999999	999999	999999	999999	999999	19.8	8.04	650	7.70	9.050	0.018	8.360	2.480	780	56.9	175	999999	999999	999999	999999	999999
Paradise Cr	PC3	1.0	01:22 PM	24-Jul-91	999999	999999	999999	999999	999999	23.9	8.89	730	13.70	9.550	0.025	8.630	2.450	480	93.2	164	999999	999999	999999	999999	999999
Paradise Cr	PC3	1.0	06:22 AM	25-Jul-91	999999	999999	999999	999999	999999	20.6	7.77	999999	5.25	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
Paradise Cr	PC3	1.0	12:38 PM	25-Jul-91	999999	999999	999999	999999	999999	20.8	8.21	665	999999	12.200	0.023	11.200	2.590	2600	72.4	155	999999	999999	999999	999999	999999
Paradise Cr	PC4	0.0	08:16 AM	24-Jul-91	3.05	0.84	3.63	7.5	0.48	19.4	8.08	630	8.00	6.760	0.016	6.080	2.080	800	58.5	181	999999	999999	999999	999999	999999
Paradise Cr	PC4	0.0	02:02 PM	24-Jul-91	2.54	0.71	3.56	7.8	0.46	24.3	8.93	670	10.20	8.630	0.026	7.750	2.320	500	75.2	169	999999	999999	999999	999999	999999
Paradise Cr	PC4	0.0	06:08 AM	25-Jul-91	999999	999999	999999	999999	999999	20.0	7.94	999999	6.75	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
Paradise Cr	PC4	0.0	12:26 PM	25-Jul-91	5.87	1.1	5.35	7.4	0.72	20.6	8.19	645	999999	5.270	0.005	7.210	2.200	2200	69.5	168	999999	999999	999999	999999	999999
S.F. Palouse R	SF1	23.6	08:23 AM	24-Jul-91	0.11	0.11	0.99	4.6	0.22	21.7	7.61	315	6.00	0.471	0.017	0.197	0.127	370	9.85	129	999999	999999	999999	999999	999999
S.F. Palouse R	SF1	23.6	02:09 PM	24-Jul-91	0.15	0.13	1.13	3	0.38	24.9	7.85	305	7.00	0.465	0.022	0.074	0.146	340	9.15	130	999999	999999	999999	999999	999999
S.F. Palouse R	SF1	23.6	06:13 AM	25-Jul-91	999999	999999	999999	999999	999999	22.1	7.63	999999	5.60	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF1	23.6	12:28 PM	25-Jul-91	0.7	0.53	1.32	5	0.26	21.6	7.72	305	999999	0.534	0.005	0.083	0.151	1600	6.93	132	999999	999999	999999	999999	999999
S.F. Palouse R	SF2	22.2	09:10 AM	24-Jul-91	4.32	1.77	2.44	6.2	0.39	20.3	8.06	630	7.80	5.840	0.022	6.110	1.580	1300	95.4	171	999999	999999	999999	999999	999999
S.F. Palouse R	SF2	22.2	03:02 PM	24-Jul-91	2.99	1.54	1.94	6	0.32	25.6	8.73	575	12.25	4.440	0.005	3.760	1.350	640	53.6	174	999999	999999	999999	999999	999999
S.F. Palouse R	SF2	22.2	11:52 AM	25-Jul-91	7.5	2.58	2.9	6	0.48	20.3	8.23	600	999999	6.890	0.005	6.170	2.190	3900	59.2	172	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	10:00 AM	24-Jul-91	2.41	0.49	4.95	14.4	0.34	21.5	8.30	650	10.00	5.270	0.021	4.550	1.500	1300	65	176	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	03:36 PM	24-Jul-91	2.73	0.5	5.42	14.5	0.37	26.9	8.81	545	13.10	4.560	0.011	3.930	1.310	500	46.6	174	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	05:56 AM	25-Jul-91	999999	999999	999999	999999	999999	20.4	7.86	999999	4.80	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	11:20 AM	25-Jul-91	5.36	0.72	7.47	15.3	0.49	19.9	8.14	600	9.30	7.110	0.005	6.270	1.920	5100	59.3	168	999999	999999	999999	999999	999999
S.F. Palouse R	SF4	21.2	10:21 AM	24-Jul-91	999999	999999	999999	999999	999999	22.1	7.88	610	9.65	7.240	0.023	6.600	1.990	720	50.2	171	999999	999999	999999	999999	999999
S.F. Palouse R	SF4	21.2	04:02 PM	24-Jul-91	999999	999999	999999	999999	999999	26.1	8.27	550	11.05	7.890	0.005	7.100	1.860	380	44.4	167	999999	999999	999999	999999	999999
S.F. Palouse R	SF4	21.2	05:47 AM	25-Jul-91	999999	999999	999999	999999	999999	20.7	7.70	999999	4.50	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF4	21.2	10:38 AM	25-Jul-91	999999	999999	999999	999999	999999	20.3	7.43	540	8.60	8.130	0.018	6.570	2.050	5600	51.7	169	999999	999999	999999	999999	999999
S.F. Palouse R	SF5	18.7	10:58 AM	24-Jul-91	6.62	0.43	15.26	19.1	0.8	23.1	8.45	550	11.85	6.130	0.019	5.780	1.870	150	40.5	172	999999	999999	999999	999999	999999
S.F. Palouse R	SF5	18.7	04:31 PM	24-Jul-91	7.84	0.47	16.5	19.2	0.86	26.7	8.94	500	14.30	4.320	0.005	3.820	1.410	50	34.8	173	999999	999999	999999	999999	999999
S.F. Palouse R	SF5	18.7	05:35 AM	25-Jul-91	999999	999999	999999	999999	999999	22.4	7.91	999999	4.35	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF5	18.7	10:14 AM	25-Jul-91	5.66	0.52	16.12	19.3	0.84	21.8	8.18	560	8.35	6.840	0.005	6.230	1.870	180	45.6	175	999999	999999	999999	999999	999999
S.F. Palouse R	SF6	14.9	11:21 AM	24-Jul-91	999999	999999	999999	999999	999999	23.9	8.72	530	9.50	4.940	0.023	4.560	1.620	190	35.1	172	999999	999999	999999	999999	999999
S.F. Palouse R	SF6	14.9	04:56 PM	24-Jul-91	8.67	0.41	21.08	32	0.66	27.7	8.93	500	11.30	4.450	0.005	3.940	1.540	220	34.5	174	999999	999999	999999	999999	999999
S.F. Palouse R	SF6	14.9	05:23 AM	25-Jul-91	999999	999999	999999	999999	999999	23.0	8.32	999999	5.30	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF6	14.9	09:47 AM	25-Jul-91	5.66	0.28	20.37	31.4	0.65	22.4	8.50	500	7.10	4.300	0.005	3.750	1.600	260	37	176	999999	999999	999999	999999	999999
S.F. Palouse R	SF7	14.0	11:33 AM	24-Jul-91	999999	999999	999999	999999	999999	23.9	8.56	570	8.50	6.740	0.031	6.240	1.810	240	39.8	170	999999	999999	999999	999999	999999
S.F. Palouse R	SF7	14.0	05:16 PM	24-Jul-91	999999	999999	999999	999999	999999	27.3	8.89	495	11.00	4.200	0.005	3.720	1.480	240	33.9	173	999999	999999	999999	999999	999999
S.F. Palouse R	SF7	14.0	09:21 AM	25-Jul-91	999999	999999	999999	999999	999999	22.6	8.32	530	6.00	4.730	0.019	7.810	1.740	510	40.7	179	999999	999999	999999	999999	999999
S.F. Palouse R	SF8	13.1	12:00 PM	24-Jul-91	7.8	0.86	9.06	13.4	0.68	24.4	8.60	590	8.20	6.810	0.029	6.370	1.680	220	44.4	169	999999	999999	999999	999999	999999
S.F. Palouse R	SF8	13.1	05:45 PM	24-Jul-91	7.97	0.9	8.82	16.5	0.53	27.0	8.70	545	10.05	7.070	0.005	6.390	1.700	110	42.3	171	999999	999999	999999	999999	999999
S.F. Palouse R	SF8	13.1	05:09 AM	25-Jul-91	999999	999999	999999	999999	999999	23.6	8.46	999999	5.00	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF8	13.1	09:00 AM	25-Jul-91	8.3	1.29	6.4	17.1	0.37	22.3	8.43	530	5.20	4.940	0.038	4.380	1.700	210	40.1	177	999999	999999	999999	999999	999999

999999 denotes mising data

Water Bodv	Station ID	River Mile	Time	Date	Flow	Velocity	X-Section Area	Top Width	Mean Depth	Temp-erature	pH	Conduc-tivity	Diss. Oxygen	Total N	Ammonia N	Nitrite+ Nitrate N	Total P	Fecal Coliform	Chloride	Alka-linity	Soluble Reactive P	Total Organic Carbon	Turb-idity	Total Suspended Solids	Nitrite N
		miles			cfs	fps	ft^2	ft	ft	deg.C	s.u.	umhos/cr	mg/L	mgN/L	mgN/L	mgN/L	mgP/L	cfu/100m	mg/L	mgCaCO3/l	mgP/L	mg/L	NTU	mg/L	mgN/L
Airport Cr	APC	0.0	08:35 AM	01-Oct-91	999999	999999	999999	999999	999999	7.1	8.12	740	999999	1.090	0.012	0.715	0.139	9	24.7	328	999999	999999	999999	2	999999
Airport Cr	APC	0.0	02:54 PM	01-Oct-91	999999	999999	999999	999999	999999	10.3	8.01	755	8.95	1.230	0.017	0.728	999999	999999	24.7	999999	999999	999999	999999	999999	999999
Airport Cr	APC	0.0	01:19 PM	02-Oct-91	999999	999999	999999	999999	999999	8.4	8.03	680	999999	1.030	0.010	0.697	0.274	4	34.9	999999	999999	999999	999999	3	999999
Missouri Flat Cr	MFC3	0.0	09:45 AM	01-Oct-91	0.1	0.04	2.17	5	0.43	11.6	7.86	620	6.50	0.851	0.029	0.539	0.780	250	42.8	233	999999	999999	999999	2	999999
Missouri Flat Cr	MFC3	0.0	03:50 PM	01-Oct-91	0.09	0.04	2.49	6	0.42	13.4	8.00	750	8.40	1.160	0.027	0.803	0.461	999999	96	999999	999999	3.23	999999	999999	999999
Missouri Flat Cr	MFC3	0.0	12:07 PM	02-Oct-91	0.1	999999	999999	999999	999999	11.6	7.97	530	7.50	0.653	0.010	0.376	0.269	590	18.9	999999	999999	8.32	3.1	3	999999
Paradise Cr	PC1	6.4	07:30 AM	01-Oct-91	0.65	0.08	8.54	11.7	0.73	15.4	7.24	780	1.30	13.200	5.190	6.410	3.700	120	134	193	3.4	999999	3	1	0.629
Paradise Cr	PC1	6.4	02:13 PM	01-Oct-91	6.2	0.38	16.26	12.4	1.31	18.3	7.12	840	1.70	15.900	4.450	9.010	3.450	999999	107	999999	999999	10.2	999999	999999	999999
Paradise Cr	PC1	6.4	01:03 PM	02-Oct-91	4.5	0.38	11.69	12.5	0.94	18.0	7.23	730	1.50	17.500	3.130	12.100	3.920	460	77	150	999999	10.5	4.2	2	0.902
Paradise Cr	PC2	3.4	08:00 AM	01-Oct-91	3.65	0.49	7.39	9.5	0.78	12.9	7.36	830	2.70	11.400	1.940	8.830	3.760	130	103	160	999999	999999	999999	2	0.435
Paradise Cr	PC2	3.4	02:35 PM	01-Oct-91	0.87	0.05	18.52	15.2	1.22	14.5	7.42	670	4.30	12.100	0.520	10.200	999999	999999	93.8	999999	999999	7.45	999999	999999	999999
Paradise Cr	PC2	3.4	05:45 AM	02-Oct-91	999999	999999	999999	999999	999999	11.8	7.15	999999	2.90	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
Paradise Cr	PC2	3.4	12:52 PM	02-Oct-91	2	0.1	21.13	15.7	1.35	13.2	7.44	810	4.00	13.200	0.519	11.500	2.960	130	112	999999	999999	6.2	999999	2	0.447
Paradise Cr	PC3	1.0	08:24 AM	01-Oct-91	999999	999999	999999	999999	999999	11.6	7.78	680	7.80	10.300	0.013	9.740	3.690	160	67.1	161	999999	999999	999999	2	0.015
Paradise Cr	PC3	1.0	02:46 PM	01-Oct-91	2	0.35	5.73	10	0.57	14.6	8.71	680	12.50	9.470	0.018	8.930	999999	999999	61.7	999999	999999	6.09	999999	999999	999999
Paradise Cr	PC3	1.0	05:57 AM	02-Oct-91	999999	999999	999999	999999	999999	10.4	7.62	999999	7.10	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
Paradise Cr	PC3	1.0	12:42 PM	02-Oct-91	4.3	0.64	6.75	9.5	0.71	13.2	8.15	830	10.90	12.000	0.079	11.200	3.490	280	99.6	999999	999999	999999	999999	2	0.237
Paradise Cr	PC4	0.0	08:55 AM	01-Oct-91	4	0.83	4.82	6.6	0.73	11.1	8.06	580	9.50	10.800	0.020	10.300	3.640	150	77.3	156	3.45	999999	999999	2	0.010
Paradise Cr	PC4	0.0	03:06 PM	01-Oct-91	3	0.74	4.08	6.4	0.64	14.4	8.61	680	10.40	9.160	0.013	8.170	3.520	63	63.5	999999	999999	5.54	999999	2	999999
Paradise Cr	PC4	0.0	03:06 PM	01-Oct-91	3	0.74	4.08	6.4	0.64	999999	999999	999999	999999	999999	999999	999999	999999	999999	63.2	999999	999999	5.36	999999	999999	999999
Paradise Cr	PC4	0.0	06:05 AM	02-Oct-91	999999	999999	999999	999999	999999	9.3	7.81	999999	9.25	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
Paradise Cr	PC4	0.0	12:30 PM	02-Oct-91	6.2	1.05	5.42	7	0.77	12.4	8.29	800	10.60	10.800	0.010	9.900	3.580	200	98.1	165	999999	6.02	999999	3	0.102
S.F. Palouse R	SF1	23.6	09:08 AM	01-Oct-91	0.15	0.08	1.98	5.1	0.39	10.4	7.99	450	9.40	0.553	0.014	0.010	0.139	49	25.7	181	0.092	999999	7.6	17	999999
S.F. Palouse R	SF1	23.6	03:12 PM	01-Oct-91	0.18	0.1	1.84	5.5	0.33	16.2	8.07	470	8.70	0.630	0.012	0.010	0.162	69	25.9	999999	999999	6.01	999999	999999	999999
S.F. Palouse R	SF1	23.6	06:07 AM	02-Oct-91	999999	999999	999999	999999	999999	9.2	7.94	999999	9.15	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF1	23.6	12:24 PM	02-Oct-91	0.2	0.11	1.76	4.7	0.37	14.5	8.01	340	8.80	0.622	0.010	0.021	0.200	270	26.5	186	999999	6.54	35	40	999999
S.F. Palouse R	SF2	22.2	09:31 AM	01-Oct-91	3.2	1.72	1.88	6	0.31	11.7	8.09	545	9.05	9.620	0.029	8.250	3.020	500	59.8	163	999999	999999	999999	4	999999
S.F. Palouse R	SF2	22.2	03:32 PM	01-Oct-91	2.4	1.41	1.68	6	0.28	15.4	8.71	650	12.85	8.580	0.035	7.580	999999	330	61.8	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF2	22.2	12:13 PM	02-Oct-91	4.5	2.02	2.25	6	0.38	12.2	8.38	740	11.50	9.040	0.025	8.240	3.090	530	81.5	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	10:30 AM	01-Oct-91	4.1	0.83	4.99	13.9	0.36	12.6	8.16	510	10.20	7.440	0.026	6.960	2.600	320	53	176	2.22	999999	4.9	8	0.020
S.F. Palouse R	SF3	21.4	03:59 PM	01-Oct-91	999999	999999	999999	999999	999999	15.4	8.54	550	12.75	8.590	0.025	7.740	2.740	999999	59.1	999999	999999	4.95	999999	4	999999
S.F. Palouse R	SF3	21.4	06:20 AM	02-Oct-91	999999	999999	999999	999999	999999	11.4	8.02	999999	7.70	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF3	21.4	11:52 AM	02-Oct-91	999999	999999	999999	999999	999999	12.4	8.38	740	12.20	7.810	0.013	7.110	2.880	670	91.4	174	999999	4.8	3.3	4	0.017
S.F. Palouse R	SF4	21.2	10:55 AM	01-Oct-91	11	0.62	17.71	18.3	0.97	17.9	7.42	670	8.20	16.500	0.040	13.900	3.820	180	48.3	147	3.29	999999	2.8	5	0.024
S.F. Palouse R	SF4	21.2	04:17 PM	01-Oct-91	7.25	0.44	16.64	18.5	0.9	18.1	7.61	655	9.60	16.900	0.048	14.400	3.560	999999	50.1	999999	999999	5.46	999999	4	999999
S.F. Palouse R	SF4	21.2	06:34 AM	02-Oct-91	999999	999999	999999	999999	999999	13.2	7.64	999999	6.70	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF4	21.2	11:25 AM	02-Oct-91	8.9	0.46	19.39	19.9	0.97	999999	999999	999999	999999	999999	999999	999999	999999	260	62	152	999999	5.05	999999	999999	999999
S.F. Palouse R	SF4	21.2	11:25 AM	02-Oct-91	8.9	0.46	19.39	19.9	0.97	16.7	7.61	645	9.90	14.300	0.028	12.600	3.570	220	61.8	153	999999	5.08	3.1	3	0.025
S.F. Palouse R	SF5	18.7	11:30 AM	01-Oct-91	9.6	0.64	14.9	18.7	0.8	15.7	8.20	700	12.65	14.600	0.018	14.400	3.300	110	59.8	148	3.33	999999	999999	4	0.053
S.F. Palouse R	SF5	18.7	04:33 PM	01-Oct-91	9.7	0.71	13.66	18.5	0.74	17.2	8.94	595	15.10	12.500	0.017	11.300	3.120	999999	54.2	999999	999999	5.36	999999	999999	999999
S.F. Palouse R	SF5	18.7	06:45 AM	02-Oct-91	999999	999999	999999	999999	999999	13.6	7.63	999999	5.20	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF5	18.7	11:00 AM	02-Oct-91	11.1	0.46	24.45	25.2	0.97	14.4	8.13	650	11.60	15.600	0.011	14.000	3.550	140	50.9	999999	999999	999999	999999	999999	0.047
S.F. Palouse R	SF6	14.9	12:00 PM	01-Oct-91	4.7	0.28	16.7	29.7	0.56	14.6	8.36	690	9.90	13.900	0.027	12.900	3.320	73	61.8	155	3.04	999999	1.4	2	0.030
S.F. Palouse R	SF6	14.9	04:49 PM	01-Oct-91	10.8	0.5	21.41	30	0.71	16.0	8.63	650	10.50	12.100	0.024	11.600	3.170	999999	61.5	999999	999999	4.91	999999	4	999999
S.F. Palouse R	SF6	14.9	06:58 AM	02-Oct-91	999999	999999	999999	999999	999999	12.3	8.16	999999	7.40	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF6	14.9	10:33 AM	02-Oct-91	5.4	0.33	16.48	29.6	0.56	12.5	8.27	675	8.90	14.800	0.019	12.100	3.410	39	58	155	999999	4.95	999999	999999	0.032
S.F. Palouse R	SF6	14.9	06:20 AM	04-Oct-91	999999	999999	999999	999999	999999	9.3	999999	999999	8.70	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF7	14.0	12:10 PM	01-Oct-91	999999	999999	999999	999999	999999	14.3	8.27	695	9.50	14.900	0.025	13.700	3.320	67	61.1	999999	999999	999999	2.2	2	999999
S.F. Palouse R	SF7	14.0	05:01 PM	01-Oct-91	999999	999999	999999	999999	999999	15.9	8.64	645	11.10	12.800	0.023	11.800	3.120	999999	61.5	999999	999999	4.79	999999	999999	999999
S.F. Palouse R	SF7	14.0	10:18 AM	02-Oct-91	999999	999999	999999	999999	999999	12.2	8.13	680	8.10	15.600	0.022	12.600	3.560	68	61.9	999999	999999	999999	999999	999999	0.031
S.F. Palouse R	SF8	13.1	12:38 PM	01-Oct-91	6.5	0.79	8.21	12.7	0.65	14.5	8.27	700	8.95	13.700	0.025	12.700	3.210	55	60	159	2.88	999999	999999	6	0.029
S.F. Palouse R	SF8	13.1	05:15 PM	01-Oct-91	6.3	0.64	9.94	17.5	0.57	15.8	8.54	670	11.80	14.200	0.020	13.200	3.210	999999	60.7	999999	999999	4.56	999999	5	999999
S.F. Palouse R	SF8	13.1	07:07 AM	02-Oct-91	999999	999999	999999	999999	999999	12.4	8.15	999999	6.90	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF8	13.1	10:04 AM	02-Oct-91	7.2	1.16	6.14	14.9	0.41	12.4	8.13	660	7.70	14.500	0.020	12.000	3.320	59	61.8	164	999999	999999	999999	999999	0.032
S.F. Palouse R	SF8	13.1	06:09 AM	04-Oct-91	999999	999999	999999	999999	999999	9.6	999999	999999	8.30	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF9	8.9	12:55 PM	01-Oct-91	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	150	58	158	2.96	999999	999999	6	999999
S.F. Palouse R	SF9	8.9	12:55 PM	01-Oct-91	999999	999999	999999	999999	999999	15.2	8.43	660	10.10	13.000	0.018	12.300	3.090	100	58	158	2.82	999999	999999	6	0.024
S.F. Palouse R	SF9	8.9	05:32 PM	01-Oct-91	7.5	0.77	9.8	21.5	0.46	15.7	8.47	670	9.90	12.800	0.020	11.800	3.040	999999	60.7	999999	999999	4.57	999999	4	999999
S.F. Palouse R	SF9	8.9	07:20 AM	02-Oct-91	999999	999999	999999	999999	999999	12.5	8.21	999999	8.20	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999
S.F. Palouse R	SF9	8.9	09:30 AM	02-Oct-91	10	0.9	11.12	22.8	0.49	12.7	8.14	680	8.95	14.700	0.015	12.000	3.360	120	63.8	162	999999	4.73	999999	999999	999999
S.F. Palouse R	SF9	8.9	05:52 AM	04-Oct-91	999999	999999	999999	999999	999999	9.7	999999	999999	9.25	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999

999999 denotes mising data

APPENDIX B

Ambient monitoring data from Ecology station 34B110

Appendix B: Water quality data from Ecology station 34B110. Missing data are reported as "999999"
For results at the detection limit, the values reported are half the detection limit

Temperature (deg C)	Conductivity (um/cm @25C)	Diss. Oxygen (mg/L)	pH (s.u.)	Total Susp Solids (mg/L)	Total Ammonia as N (mgN/L)	Total P (mgP/L)	Soluble Reactive P (mgP/L)	Hardness (mg/L CaCO3)	Turbidity (NTU)	Fecal Coliform (CFU /100mL)	Nitrate +Nitrite as N (mgN/L)	Nitrite as N (mgN/L)	Flow (cfs)	Date
2	999999	12.1	7.7	999999	0.19	1.14	0.36	999999	160	1200	11.27	999999	999999	701209
3.6	241	10.2	7.2	999999	999999	3.55	999999	999999	370	1200	999999	999999	999999	710126
0.4	327	12.4	7.5	999999	0.2	1.23	1.19	999999	25	999999	3.31	999999	999999	710209
3.3	295	11.6	7.6	999999	0.28	0.38	0.54	999999	65	999999	2.37	999999	999999	710223
2.5	356	12.3	7.8	999999	0.39	0.93	0.58	999999	65	999999	2.5	999999	999999	710309
4	211	11.7	7.6	999999	0.08	1.1	1.03	999999	170	999999	2.13	999999	999999	710323
9.6	255	9.9	7.7	999999	999999	2.23	1.95	999999	35	999999	2.64	999999	999999	710406
8.8	284	10.2	7.8	999999	0.01	0.88	0.7	999999	25	999999	3.94	999999	999999	710420
14.2	269	8.5	7.8	999999	0.08	0.81	0.89	999999	25	999999	3.13	999999	999999	710504
8.4	300	10.8	7.9	999999	0.12	0.91	0.81	999999	25	999999	2.215	999999	999999	710518
9.6	243	8.4	7.3	999999	0.43	2.41	2.2	999999	680	999999	4.33	999999	999999	710602
13	305	8.9	7.9	999999	0.1	0.93	0.53	999999	210	999999	2.24	999999	999999	710615
13.6	395	8.3	8	999999	999999	1.86	1.59	999999	15	999999	2.86	999999	9	710706
21.5	674	6.1	8.1	999999	0.12	2.83	2.69	999999	15	999999	1.98	999999	6	710720
20.4	680	4.8	7.5	999999	0.1	2.96	2.56	999999	45	999999	1.83	999999	6	710803
15	700	7.7	7.1	999999	0.02	2.98	2.81	999999	10	999999	3.42	999999	4	710817
11.7	597	7.3	7.7	999999	0.14	1.95	1.14	999999	10	999999	3.45	999999	6	710907
8	640	8.2	7.6	999999	8	4.1	3.99	999999	8	999999	2.54	999999	5	710921
8.6	500	8.7	8	999999	0.25	5.5	5.2	140	7	999999	999999	999999	5	731017
9.4	670	11.7	8.5	999999	0.29	6.5	6.4	120	5	999999	999999	999999	5	731029
5	330	8.5	7.6	999999	1.2	4.7	0.52	92	360	999999	999999	999999	52	731113
1.8	480	11.1	7.9	999999	0.4	1.5	1.4	120	22	999999	999999	999999	25	731127
2.5	300	11.7	7.7	999999	0.48	0.76	0.54	90	45	999999	999999	999999	93	731211
5.3	200	9.4	7.5	999999	0.77	0.68	0.27	65	200	900	999999	999999	293	731218
999999	380	10.5	7.5	999999	0.31	0.65	0.6	110	15	999999	999999	999999	66	740108
1	230	11.9	7.7	999999	0.39	0.55	0.48	76	40	490	999999	999999	215	740122
0.9	180	12.8	7.5	999999	0.7	0.6	0.26	64	75	400	999999	999999	373	740205
1.2	150	13	7.6	999999	0.56	0.55	0.3	66	100	1200	999999	999999	200	740220
2.6	200	11.9	7.6	999999	0.22	0.78	0.24	71	130	820	999999	999999	262	740305
4.3	220	11.7	7.8	999999	0.32	0.48	0.28	68	39	900	999999	999999	165	740319
3.8	210	12	7.4	999999	0.38	1.2	0.25	42	200	840	999999	999999	289	740402
7.5	240	10.8	7.7	999999	0.28	0.56	0.4	72	20	560	999999	999999	93	740416
13.6	300	8.9	8	999999	0.29	0.66	0.53	83	16	450	999999	999999	44	740507
10.4	400	9.1	7.8	999999	1	1.8	0.9	98	40	999999	999999	999999	48	740521
13.1	360	8.6	7.8	999999	0.27	1.1	0.82	100	12	1100	999999	999999	22	740604
20.2	430	7	8	999999	0.11	1.5	1.4	999999	11	1600	999999	999999	15	740619
16.5	480	8	7.9	999999	0.34	2	2	130	17	520	999999	999999	10	740709
17.1	660	6.9	8.1	999999	0.76	3.3	3.3	140	4	1100	999999	999999	5	740723
16.2	770	6.4	8.1	999999	0.14	3.3	3.3	160	6	320	999999	999999	5	740806
13.5	790	7.9	8.2	999999	999999	3.3	3.2	160	6	150	999999	999999	5	740820
14.6	710	7.5	8.2	999999	999999	5	4.2	150	10	300	999999	999999	5	740904
19.9	740	8.1	7.9	999999	0.13	5	4.8	150	11	130	999999	999999	6	740917
8.3	999999	999999	6.5	999999	1.6	5.2	4.4	999999	84	3520	4.6	999999	9	771026
7	230	999999	6.3	999999	0.68	1.5	1	999999	240	3400	4.8	999999	19	771129
0.2	250	999999	7.2	999999	0.6	1.03	0.77	999999	210	360	7.25	999999	21	771220
1.5	255	13	6.8	999999	0.39	0.71	0.56	999999	120	120	7.9	999999	46	780124
2.2	210	12.9	7	999999	0.43	0.56	0.39	999999	185	450	3.8	999999	68	780214
11.4	250	10.2	7.2	999999	0.1	0.58	0.38	999999	78	260	4.9	999999	40	780328
14	275	9.5	8	999999	0.13	0.87	0.82	999999	43	423	4.5	999999	30	780425
11.6	275	10.5	8.2	999999	0.19	0.72	0.68	999999	70	6300	3	999999	22	780523
14.2	400	9.1	8	999999	0.3	1.2	1.1	999999	70	10	2.4	999999	6	780620
18.8	550	9	8.4	999999	0.13	3.6	3.5	999999	40	2100	3.8	999999	4	780725
14.4	450	10.1	8.1	14	0.02	2.4	2.2	999999	85	5400	3.6	999999	7	780822
13.1	520	10.1	8.4	5	0.14	4.7	4.6	999999	6	1900	7.8	999999	5	780926
9.7	600	11	8.2	1000	0.06	3.9	2.6	999999	8	1100	6.3	999999	7	781024
7.7	560	10.3	8.1	85	0.54	2.8	1.1	999999	70	675	5.6	999999	10	781129
1	530	12.3	7.8	1600	0.38	3.2	2.7	999999	15	525	6.4	999999	8	781220
0.4	540	999999	7.8	71	0.6	2.7	2.1	999999	999999	220	6.2	999999	8	790125
1.8	295	12	8.3	82	0.47	0.52	0.44	999999	120	420	9	999999	76	790222
5.7	250	12.3	7.3	1580	0.17	0.44	0.35	999999	25	540	4.3	999999	81	790320
11.6	400	9.9	7.9	122	0.26	0.58	0.37	999999	39	2300	3.2	999999	79	790425
18.6	480	7.1	7	48	0.17	0.97	0.3	999999	39	4200	4.4	999999	24	790522
14.2	505	9.3	7.2	18	1.8	999999	0.68	999999	80	3200	4	999999	13	790619
17	999999	9.2	7.1	7	0.11	0.12	2.1	999999	60	3200	3.7	999999	5	790724
15.4	840	9.8	7.3	24	0.04	0.44	4.9	999999	5	3150	4.7	999999	5	790828
12.2	700	9.7	7.7	24	0.05	5.7	5.5	999999	15	900	7.2	999999	6	790925
9.5	600	11.2	7.4	9	0.02	3.3	2.9	999999	10	650	7.8	999999	8	791023

Appendix B: Water quality data from Ecology station 34B110. Missing data are reported as "999999"
For results at the detection limit, the values reported are half the detection limit.

Temperature (deg C)	Conductivity (um/cm @25C)	Diss Oxygen (mg/L)	pH (s.u.)	Total Susp Solids (mg/L)	Total Ammonia as N (mgN/L)	Total P (mgP/L)	Soluble Reactive P (mgP/L)	Hardness (mg/L CaCO3)	Turbidity (NTU)	Fecal Coliform (CFU /100mL)	Nitrate +Nitrite as N (mgN/L)	Nitrite as N (mgN/L)	Flow (cfs)	Date
2.4	543	12.8	7.2	120	0.12	1.5	2.2	999999	40	720	6.6	999999	8	791127
5.2	485	11.8	7.4	20	0.23	2.2	999999	999999	25	275	9	999999	16	791218
1.8	400	12.9	7.3	18	0.42	0.97	0.87	999999	60	180	12	999999	31	800122
6.6	190	11.6	7.2	180	0.43	0.65	0.41	999999	205	156	8.6	999999	76	800227
5.1	310	11	6.9	27	0.4	0.68	0.5	999999	160	675	6.9	999999	41	800325
12.4	330	10.2	7.9	13	0.02	0.15	0.14	999999	85	1080	1.3	999999	22	800422
12	270	9.1	7.3	120	0.01	0.82	0.39	999999	175	790	3	999999	44	800529
13.7	290	9.2	7.8	130	0.04	1.1	0.77	999999	80	6700	1.8	999999	12	800624
21.5	570	8	7.6	12	0.06	3.2	3.1	999999	10	950	1.3	999999	6	800722
10	600	9.8	7.7	22	0.06	3.6	3.2	999999	65	450	7.76	999999	5	800826
10	600	10.4	7.7	15	3.6	3.6	1.4	999999	35	475	0.53	999999	6	800923
9.8	636	9.9	7.3	19	0.18	3.5	3.5	999999	35	320	9.18	999999	5	801021
6.1	470	10.9	7.6	30	0.14	1.5	0.2	999999	35	850	8.805	999999	8	801118
3.4	500	10.6	7.2	17	0.05	2	999999	999999	60	450	6.14	999999	8	801216
3.4	440	11	7	12	0.04	1.6	1.3	999999	75	710	5.23	999999	10	810120
5.4	240	10.3	6.9	49	0.18	0.17	999999	999999	36	875	6.45	999999	90	810223
5.9	360	10.1	7.3	15	1.4	1.3	1.3	999999	28	1050	7.025	999999	20	810324
9.4	310	9.3	7.6	12	0.07	0.59	0.53	999999	40	780	4.225	999999	34	810421
12.8	300	9.6	7.2	44	0.38	0.46	0.46	999999	70	675	3.17	999999	28	810526
17.2	490	8.9	7.5	14	0.15	1.9	1.9	999999	150	1100	4.025	999999	5	810721
16.6	500	8.8	7.2	100	0.2	999999	2.45	999999	60	750	4.225	999999	3	810818
8.7	550	10	7.2	11	0.07	3.9	3.7	999999	35	870	7.57	999999	5	810922
8.8	575	9.6	7.5	311	0.25	999999	3.5	999999	30	230	6.3	999999	5	811020
6.4	610	9.9	7.2	10	0.07	3.5	3.2	999999	8	480	7	999999	7	811111
5.7	370	10.8	8	30	0.28	0.4	999999	999999	130	1500	4.7	999999	18	811208
1.5	230	11.9	7.4	600	0.37	999999	0.26	999999	260	720	9.125	999999	744	820126
3.2	160	8	7.4	2900	0.18	0.03	0.005	999999	980	4600	7.15	999999	750	820215
5	204	10.2	7.7	170	0.14	0.27	0.25	999999	180	220	5.025	999999	260	820315
9	235	12	7.9	28	0.06	999999	0.23	999999	33	390	4.25	999999	90	820419
9.8	321	12.6	8.6	9	0.07	0.52	0.42	999999	8	110	4.05	999999	400	820510
18	318	13.9	9.5	8	0.16	0.5	0.5	999999	7	370	3.05	999999	260	820606
20.5	560	13.2	8.2	4	0.05	1.8	1.7	999999	5	680	2.75	999999	6	820711
21.6	580	14.6	9.1	8	0.08	2.3	2.2	999999	6	160	3.125	999999	4	820817
13	505	11.9	8.5	41	0.04	2	1.9	999999	11	250	3.05	999999	9	820914
7.3	520	13	8.1	8	0.09	2.8	2.8	999999	6	3500	4.95	999999	7	821019
5	525	12	8.2	4	0.63	2.6	2.1	999999	6	3700	4.2	999999	10	821116
2.4	420	13.5	7.9	14	0.13	1.2	1	999999	23	100	7.6	999999	20	821228
3.6	310	12.6	7.8	120	0.18	0.15	999999	999999	410	1200	6.8	999999	42	830125
7.9	241	10.5	7.6	79	0.1	0.06	999999	999999	100	300	7.35	999999	180	830222
9.1	252	10.3	8	16	0.21	0.33	999999	999999	31	999999	6.05	999999	68	830322
15.3	330	14.7	9.2	11	0.02	0.5	0.58	999999	12	150	5.05	999999	33	830419
21.9	350	11.7	8.6	7	0.14	0.75	0.75	999999	8	370	3.25	999999	18	830524
21.6	390	11.9	8.6	8	0.15	1.3	1.3	999999	7	1400	2.05	999999	8	830628
22.2	455	13.1	8.6	4	0.05	1.8	1.6	999999	2	630	3.225	999999	4	830719
17.9	490	8.7	8	10	0.14	2.6	2.5	999999	16	2900	5.05	999999	6	830823
15.2	580	12	8.6	29	0.02	2.7	999999	999999	62	17000	5.9	999999	5	830927
9.6	485	12	7.8	4	0.08	2.8	2.3	999999	7	600	6.25	999999	7	831025
3.5	435	13.1	8.2	9	0.14	1.1	1.1	999999	21	440	7.85	999999	16	831129
0.4	415	13.7	7.9	32	0.34	0.76	0.74	999999	28	180	8.625	999999	29	831220
0.4	288	13.4	7.9	14	0.66	0.64	999999	999999	22	910	8.15	999999	28	840117
3.2	330	12.3	8	61	0.57	0.23	999999	999999	89	580	6.625	999999	35	840207
5.2	270	11.8	7.9	98	0.3	0.12	999999	999999	110	190	6.35	999999	62	840306
6.8	210	11.3	7.9	140	0.3	0.1	999999	999999	180	290	5.525	999999	140	840410
12.6	317	12.3	9	90	0.07	0.24	999999	999999	67	460	4.5	999999	32	840508
17.7	321	13.7	9.1	14	0.09	0.5	999999	999999	13	250	2.425	999999	21	840612
21.4	435	19.2	9.5	28	0.04	0.47	999999	999999	11	220	3.825	999999	6	840710
18.4	535	13	8.7	10	0.06	2.9	2.8	999999	8	950	4.45	999999	4	840814
13.6	535	11.9	8.5	8	0.16	4.2	3.8	999999	9	9900	7.65	999999	5	840911
14.1	600	11	8.4	13	0.08	4	3.7	999999	11	1200	6.125	999999	6	841009
8.2	392	9.9	8	21	0.19	1.35	999999	999999	37	3100	5.55	999999	15	841113
2	275	12	7.9	130	0.32	0.16	999999	999999	350	980	5.425	999999	44	841211
1.2	440	13	7.8	5	0.36	1.4	1.4	999999	11	220	8.025	999999	15	850115
4.1	232	12.1	7.5	100	0.24	999999	0.22	999999	200	260	9.425	999999	108	850312
7.4	190	11	7.6	370	0.1	0.02	999999	999999	260	150	8.125	999999	270	850402
11.4	270	12	8.6	11	0.06	0.38	999999	999999	9	200	4.1	999999	26	850507
18.8	372	8.6	8.2	16	999999	999999	999999	999999	18	1200	999999	999999	15	850611
15.8	540	11.1	8.6	16	0.1	3	2.6	999999	999999	610	5.41	999999	4	850813

Appendix B: Water quality data from Ecology station 34B110. Missing data are reported as "999999".
For results at the detection limit, the values reported are half the detection limit.

Temperature (deg C)	Conductivity (um/cm @25C)	Diss Oxygen (mg/L)	pH (s.u.)	Total Susp. Solids (mg/L)	Total Ammonia as N (mgN/L)	Total P (mgP/L)	Soluble Reactive P (mgP/L)	Hardness (mg/L CaCO3)	Turbidity (NTU)	Fecal Coliform (CFU /100mL)	Nitrate +Nitrite as N (mgN/L)	Nitrite as N (mgN/L)	Flow (cfs)	Date
11.1	320	8.6	7.8	999999	999999	999999	999999	999999	999999	5600	999999	999999	14	850917
8	320	8.3	7.9	42	999999	999999	999999	999999	999999	2600	999999	999999	15	851022
1	510	14.2	8.4	8	0.46	2.3	2.3	999999	999999	210	7.705	999999	8	851119
0.7	525	13.7	8.1	10	1.1	2.5	2.2	999999	999999	2600	5.905	999999	10	851210
1.3	295	12	999999	35	0.53	0.39	0.39	999999	999999	22000	4.805	999999	36	860114
1.6	323	12.8	7.7	999999	999999	999999	999999	999999	999999	560	999999	999999	37	860211
8.1	230	11.4	7.9	48	0.2	0.26	0.26	999999	999999	330	5.32	999999	110	860311
8.7	320	10.9	8.2	14	0.29	0.9	0.47	999999	12	360	3.75	999999	33	860415
12.5	350	13.7	8.8	999999	0.04	1.1	1.1	999999	7	540	0.47	999999	19	860513
20	395	12.7	8.7	999999	0.04	1.7	1.4	999999	5	200	2.88	999999	8	860610
18.8	540	10.2	8.4	9	0.09	2.2	2.1	999999	4	999999	4.16	999999	5	860708
19.1	600	9	8.1	999999	0.09	1	2.4	999999	999999	4500	2.14	999999	4	860812
16	580	9.3	8	999999	999999	999999	3.4	999999	15	1400	999999	999999	5	860909
8.3	498	11.2	8.1	20	999999	999999	3.6	999999	17	900	999999	999999	10	861021
7	585	11.5	8.2	4	0.06	999999	3.5	999999	4	590	6.74	999999	6	861104
1.2	487	12.6	7.2	15	0.79	999999	999999	999999	16	260	13.15	999999	15	861209
1.2	490	13.2	8.1	7	0.26	1.3	999999	999999	6	2500	8.19	999999	10	870113
4.3	303	11.4	7.2	80	0.56	0.47	0.5	999999	30	520	11.09	999999	46	870210
6.5	265	10.5	7.1	60	0.36	0.55	0.56	999999	999999	3300	4.52	999999	48	870317
11.2	372	12.7	7.9	9	0.11	0.86	0.85	999999	11	700	5.43	999999	16	870414
17.3	440	11	8.6	25	0.13	1.4	1.9	999999	22	999999	1.97	999999	11	870505
13.8	400	12.6	8.6	15	0.04	1.1	999999	999999	9	1700	999999	999999	9	870602
19.5	490	11.8	8.5	9	0.1	0.72	2	999999	4	4500	6.16	999999	6	870707
19	540	10	8.4	16	0.11	2.9	2.7	999999	5	5000	3.9	999999	5	870804
16	620	11.6	8.5	8	0.07	3.4	3.6	999999	999999	1500	999999	999999	6	870908
11.2	562	8.7	7.8	7	0.08	4.6	3.7	999999	3	3300	999999	999999	11	871006
11	560	10.8	8.2	3	0.09	4.6	4.5	999999	4	1100	999999	999999	7	871103
4.1	443	11.2	7.9	17	0.16	999999	999999	999999	14	490	999999	999999	12	871208
0.9	500	13.1	7.6	11	0.89	1.4	1.2	999999	10	740	999999	999999	11	880112
1.1	445	14.3	7.8	21	0.75	1.3	1.05	999999	16	180	999999	999999	14	880202
5.8	383	11.5	7.9	47	0.76	0.86	0.88	999999	37	890	999999	999999	18	880308
4.4	281	12.7	7.6	94	0.25	0.52	0.42	999999	32	490	999999	999999	59	880405
9.4	352	12.2	8	21	0.35	1.1	0.96	999999	13	3500	999999	999999	18	880503
13.3	395	10.3	8.1	31	999999	999999	1.2	999999	12	700	999999	999999	16	880607
14.8	390	8.4	8	16	0.06	1	1.8	999999	11	2600	999999	999999	8	880705
16.6	720	12.5	8.4	9	0.04	3.2	2.98	999999	6	1300	999999	999999	5	880802
13.2	600	12.3	8.5	3	0.01	3.5	3.6	999999	2	870	999999	999999	7	880913
13.6	530	11.7	8.3	1	0.1	3.5	5.2	999999	3	330	5.3	0.11	7	881004
6	370	11.7	7.8	6	0.07	2.5	2.1	999999	4	410	7	0.07	10	881107
4.3	415	10.4	7.6	5	0.6	2.4	2.2	999999	7	2000	8.5	0.16	12	881206
1.9	510	12.4	8.1	57	0.24	1.9	1.9	999999	24	3700	5.7	0.04	12	890103
999999	433	11.9	7.4	9	0.8	0.94	0.07	999999	9	30000	10	0.01	9	890207
1.2	182	8.5	7.5	680	0.22	0.005	0.13	999999	110	999999	8.4	0.03	300	890307
5.4	213	11.6	7.8	40	0.21	0.44	0.32	999999	22	300	7.2	0.06	82	890404
12	330	11.1	8	4	2	0.77	0.66	999999	5	180	4.6	0.18	32	890502
20.6	403	9.2	8.5	6	0.06	1.32	1.22	999999	4.2	8200	3.29	0.06	9	890606
18.2	560	13	8.6	12	0.03	2.47	2.33	999999	5.9	1800	5.69	0.05	5	890705
20.4	645	11.3	8.5	4	0.06	2.56	2.64	999999	2.7	3700	3.5	0.06	2	890808
15.5	510	11.7	8.7	13	0.04	2.43	2.55	999999	5.4	1900	4.81	0.06	9	890905
10	560	12.9	8.5	8	0.03	3.69	3.71	999999	2.7	350	5.57	0.01	12	891003
6.9	340	10.2	8.1	22	1.14	1.23	1.18	999999	19	650	4.03	0.08	19	891107
6.7	270	9.8	8	210	0.43	999999	0.61	999999	70	1400	5.44	0.09	56	891205
3.8	233	10.7	7.4	999999	999999	0.33	0.25	999999	300	360	11	0.04	130	900109
1.5	462	12.7	7.7	25	0.42	0.8	0.64	999999	21	140	8.36	0.12	7	900206
4.8	326	11.9	7.8	32	0.24	0.52	0.44	999999	24	170	7.45	0.07	11	900306
12.7	340	12.7	8.4	9	0.19	0.63	0.68	999999	12	200	5.13	0.18	5	900403
9.1	319	10.8	8.2	31	0.2	0.58	0.56	999999	17	710	3.38	0.09	21	900508
13.5	228	9.3	7.8	102	0.1	0.13	0.3	999999	48	620	2.14	0.04	37	900605
19.9	525	10.1	8.4	12	0.04	0.98	1.35	999999	5.1	4700	4.23	0.03	6	900710
19.4	600	10.7	8.6	999999	999999	1.89	1.82	999999	6.7	1700	2.88	999999	3	900807
16.3	648	10.7	8.4	9	0.03	2.8	2.6	999999	3.8	1500	7.24	0.04	7	900904
8.6	650	11.3	8.2	7	0.023	3.6	2.7	999999	3.2	5600	10.6	0.026	4	901009
4.2	402	11	7.9	33	0.17	1.17	1.01	999999	45.5	970	4.61	0.1	21	901106
3.5	465	11.1	7.9	15	0.44	0.89	0.8	999999	19	680	6.07	0.09	24	901204
1.6	497	12.8	7.7	8	0.14	1.41	1	999999	6	6700	6.22	0.04	16	910108
3.4	188	11.4	7.7	1050	0.282	1.36	0.155	999999	330	830	5.84	0.039	135	910205
3.6	212	11.6	7.7	560	0.12	0.23	0.17	999999	195	300	7.59	0.02	210	910305

Appendix B: Water quality data from Ecology station 34B110. Missing data are reported as "999999"
For results at the detection limit, the values reported are half the detection limit.

Temp-erature (deg C)	Cond-uctivity (um/cm @25C)	Diss. Oxygen (mg/L)	pH (s.u.)	Total Susp Solids (mg/L)	Total Ammonia as N (mgN/L)	Total P (mgP/L)	Soluble Reactive P (mgP/L)	Hard-ness (mg/L CaCO3)	Turb-idity (NTU)	Fecal Coliform (CFU /100mL)	Nitrate +Nitrite as N (mgN/L)	Nitrite as N (mgN/L)	Flow (cfs)	Date
10.4	340	12.5	8.8	25	0.299	0.626	0.473	999999	13	500	3.986	0.124	26	910402
12.4	380	14.1	8.9	9	0.224	0.822	0.959	999999	5.5	999999	3.42	0.174	17	910507
14.1	340	10.3	8.2	44	0.059	0.425	0.493	999999	24	380	2.84	0.049	18	910604
18.5	458	10	8.4	12	0.028	1.082	0.967	999999	8.1	570	2.901	0.034	6	910709
21.4	501	9.1	8.2	14	0.03	1.32	1.18	999999	7.2	4100	2.98	0.024	3	910806
14.8	720	11.2	8.4	4	0.051	2.37	2.38	999999	2.5	1900	7.58	0.018	5	910903
8.5	645	10.5	8.3	9	4.24	5.25	4.55	999999	6.2	650	3.06	0.076	999999	911008
6.2	388	9.2	7.8	27	0.292	1.55	1.49	999999	20	2900	3.58	0.087	999999	911105
3.8	435	11.5	7.7	12	0.115	1.32	1.14	999999	10	1500	8.42	0.059	999999	911203
2.8	455	12.9	8.2	6	0.02	1.31	0.232	999999	7	180	5.43	0.005	999999	920107
2.9	394	11.9	7.8	20	0.499	0.861	0.772	999999	25	999999	6.82	0.154	999999	920204
7.4	372	10.3	7.8	999999	999999	999999	999999	999999	999999	999999	999999	999999	999999	920303

APPENDIX C

Ambient monitoring data from Ecology supplemental stations during water year 1992

Appendix C: Water quality data from Ecology's monthly ambient monitoring during water year 1992 at four stations in the SFPR basin.

River Mile	Temp-erature (deg C)	Cond-uctivity (um/cm @25C)	Dissolved Oxygen (mg/L)	Diss. Oxygen Saturation (% sat)	Chemical Oxygen Demand (mg/L)	pH (s.u.)	Total Suspended Solids (mg/L)	Total Ammonia as N (mgN/L)	Total P (mgP/L)	Soluble Reactive (mgP/L)	Hardness (mg/L CaCO3)	Turbidity (NTU)	Fecal Coliform (CFU /100mL)	Nitrate +Nitrite as N (mgN/L)	Nitrite as N (mgN/L)	Flow (cfs)	Date	Time
Station 34B110, SF Palouse at Pullman (above Pullman POTW and Missouri Flat Creek):																		
22.2	8.5	645	10.5	96.3	999999	8.3	9	4.24	5.25	4.55	999999	6.2	650	3.06	0.076	999999	911008	1135
22.2	6.2	388	9.2	80	999999	7.8	27	0.292	1.55	1.49	999999	20	2900	3.58	0.087	999999	911105	1045
22.2	3.8	435	11.5	93.8	999999	7.7	12	0.115	1.32	1.14	999999	10	1500	8.42	0.059	999999	911203	1030
22.2	2.8	456	12.9	102.7	999999	8.2	6	0.02	1.31	0.232	999999	7	180	5.43	0.005	999999	920107	1100
22.2	2.9	394	11.9	96	999999	7.8	20	0.499	0.861	0.772	999999	25	999999	6.82	0.154	999999	920204	1040
22.2	7.4	372	10.3	93.2	999999	7.8	18	0.343	0.56	0.488	999999	18	360	5.94	0.179	999999	920303	1030
22.2	6.2	425	15.8	137.2	999999	8.5	8	0.023	1.46	1.39	999999	4.6	140	5.65	0.025	999999	920407	1100
22.2	14.6	418	10.3	109.1	999999	8.3	5	0.059	1.45	1.38	999999	3.6	240	3.82	0.031	999999	920505	1020
22.2	17.9	493	11.7	133	999999	8.6	6	0.027	1.8	1.78	999999	2.6	1000	4.82	0.041	999999	920602	1055
22.2	16.2	484	9.3	101.8	999999	8.2	8	0.043	1.54	1.62	999999	5.5	1100	2.67	0.014	999999	920707	1100
22.2	18.1	570	12.3	140.5	999999	8.6	3	0.027	1.79	0.806	999999	2.3	430	3.94	0.014	999999	920804	1145
22.2	13.2	560	11.5	117.3	999999	8.3	3	0.037	3.14	0.844	999999	2.7	220	5.16	0.03	999999	920909	1045
Station 34C100, Paradise Creek near border (at culvert at upstream end of Wilber-Ellis fertilizer company):																		
5.8	16.8	795	0.5	5.5	999999	7.2	4	5.33	4.54	4.36	999999	6.8	440	9.49	0.874	999999	911008	1245
5.8	8	309	5.5	50.2	999999	7.6	63	1.61	1.5	1.07	999999	31.5	580	2.99	0.141	999999	911105	1150
5.8	10.3	590	3.7	35.5	999999	7.2	14	3	2.96	2.67	999999	11	8	12.2	0.326	999999	911203	1140
5.8	8.8	540	3.2	29.8	999999	7.5	9	1.75	3.18	2.94	999999	10	2	9.4	0.372	999999	920107	1205
5.8	10.2	590	4.6	44.8	999999	7.2	23	3.7	2.32	2.07	999999	15	999999	8.39	0.295	999999	920204	1155
5.8	11.3	500	6.1	60.7	999999	7.4	23	2.42	1.67	1.42	999999	18	52	8.38	0.212	999999	920303	1135
5.8	12.2	650	5.2	52.4	999999	7.5	10	2.87	3	2.77	999999	5.3	9	9.78	0.372	999999	920407	1225
5.8	18	610	3.4	38.9	999999	7.5	10	4.41	3.38	3.1	999999	5.2	57	9.49	0.496	999999	920505	1120
5.8	19.4	548	4.0	45.3	999999	7.6	15	2.33	3.28	2.45	999999	8.1	4100	7.92	0.589	999999	920602	1205
5.8	18.4	552	2.8	32.3	999999	7.6	30	1.91	3.14	2.79	999999	15	1300	7.97	0.743	999999	920707	1220
5.8	20.4	580	4.9	59	999999	7.6	21	0.829	2.07	0.845	999999	6.3	470	5.55	0.839	999999	920804	1250
5.8	19.2	730	2.0	23.3	999999	7.5	5	3.49	4.1	0.846	999999	4.7	140	9.85	1.03	999999	920909	1150
Station 34B140, SF Palouse near Busby (just past intersection of Johnson (Busby) Road and Sand Road):																		
25.8	8	371	11.3	102.5	999999	8.3	3	7.67	9.94	7.12	999999	4.1	120	0.838	0.093	999999	911008	1220
25.8	2.9	311	10.7	85.5	999999	7.9	24	0.123	1.4	1.16	999999	14.5	1300	1.6	0.015	999999	911105	1120
25.8	1.9	265	12.3	95.1	999999	7.8	8	0.045	0.48	0.37	999999	14	11	5.72	0.022	999999	911203	1115
25.8	1.5	280	12.8	98.5	999999	8.1	8	0.026	0.359	2.06	999999	12	29	2.83	0.005	999999	920107	1130
25.8	1.7	223	12.3	96.3	999999	7.9	30	0.058	0.201	0.136	999999	26	999999	4.42	0.014	999999	920204	1130
25.8	6.6	303	10.4	92.2	999999	7.7	34	0.03	0.225	0.123	999999	27	69	4.71	0.015	999999	920303	1105
25.8	5	268	12.8	108	999999	8.2	35	0.029	0.186	0.099	999999	29	110	1.97	0.005	999999	920407	1145
25.8	15.2	267	10.2	109.7	999999	8.5	7	0.029	0.228	0.178	999999	4.4	210	0.298	0.005	999999	920505	1055
25.8	19.5	330	9.2	108.2	999999	8.5	16	0.054	0.356	0.27	999999	7	2500	0.063	0.013	999999	920602	1140
25.8	16.7	400	9.2	101.9	999999	8.6	6	0.036	0.442	0.417	999999	3.6	120	0.012	0.005	999999	920707	1150
25.8	19.9	276	14.2	168.4	999999	9.4	4	0.026	0.622	0.562	999999	3.7	1900	0.005	0.005	999999	920804	1220
25.8	13.6	341	13	134	999999	9	2	0.021	0.196	0.208	999999	1.7	8	0.005	0.005	999999	920909	1120
Station 34C060, Paradise Creek at Mouth (where creek crosses under Johnson (Busby) Road, below Best Western):																		
0.1	8.4	700	10.2	93.4	999999	8.3	6	4.67	3.99	4.07	999999	4.7	5100	3.18	0.098	999999	911008	1150
0.1	6.8	655	9.1	80.5	999999	7.8	34	1.05	2.68	2.58	999999	23.5	25000	6.79	0.196	999999	911105	1105
0.1	4.9	610	10.9	91.3	999999	7.6	4	1.26	2.1	2.01	999999	5	14	10	0.188	999999	911203	1050
0.1	4	580	12.5	102.9	999999	8.2	2	0.015	2.21	1.25	999999	5	15	8.18	0.01	999999	920107	1115
0.1	4.6	585	11.1	93.8	999999	7.8	80	0.979	1.68	1.64	999999	6.6	999999	9.75	0.398	999999	920204	1110
0.1	8.7	465	9.6	89.6	999999	7.9	5	1.07	1.28	1.21	999999	6	23	8.11	0.377	999999	920303	1050
0.1	6.6	605	13.6	119.5	999999	8.4	3	0.231	2.3	1.99	999999	2	8	7.69	0.123	999999	920407	1130
0.1	15.3	570	10.5	113.1	999999	8.4	2	0.094	2.44	2.44	999999	1.7	110	5.55	0.163	999999	920505	1040
0.1	17.8	515	9.4	106.7	999999	8.5	3	0.029	2.68	2.22	999999	1.9	360	5.42	0.072	999999	920602	1110
0.1	16	590	8.6	93.8	999999	8.2	4	0.029	2.07	2.15	999999	2.3	220	5.18	0.005	999999	920707	1130
0.1	17.6	999999	9.1	102.8	999999	8.4	3	0.028	2.07	0.817	999999	2.6	270	4.36	0.005	999999	920804	1205
0.1	13	620	9.7	98.6	999999	8.2	2	0.037	3.11	0.751	999999	2.9	40	7.58	0.053	999999	920909	1105

APPENDIX D

Pullman POTW monitoring data of the S.F. Palouse River

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

Yr	Mo	Day	Time	UPSTREAM STATION: Temperature (deg C)	UPSTREAM STATION: Dissolved Oxygen (mg/L)	UPSTREAM STATION: pH (S.U.)	UPSTREAM STATION: Total NH3-N (mgN/L)	DOWNSTREAM STATION: Temperature (deg C)	DOWNSTREAM STATION: Dissolved Oxygen (mg/L)	DOWNSTREAM STATION: pH (S.U.)	DOWNSTREAM STATION: Total NH3-N (mgN/L)
90	5	21	930	12.5		7.0	0.25	14.5		6.9	0.43
90	5	21	1500	18.5		7.7	0.23	19.0		7.4	0.32
90	5	29	900	14.2		6.9	0.28	14.5		6.8	0.28
90	5	29	1500	15.1		7.3	0.82	15.2		7.1	0.73
90	6	6	915	16.0		6.7	0.25	15.5		6.8	0.25
90	6	6	1530	16.3		7.0	0.25	18.5		6.9	0.32
90	6	14	1000	14.5		7.1	0.17	15.5		7.2	0.15
90	6	14	1500	18.0		7.1	0.17	18.0		7.1	0.13
90	6	18	1000	17.2		7.0	0.21	18.0		6.9	0.19
90	6	18	1500	22.8		7.3	0.13	22.0		7.2	0.11
90	6	26	1045	21.5		7.5	0.13	21.7		7.4	0.17
90	6	26	1500	14.8		7.9	0.11	24.5		7.7	0.23
90	7	6	1030	18.0		7.6	0.28	18.8		7.3	0.85
90	7	5	1500	21.1		8.1	0.15	21.9		7.8	0.75
90	7	12	1000	18.0	7.2	7.3	0.46	18.3	8.8	7.2	0.25
90	7	16	1100	16.8	9.0	7.3	0.46	18.9	10.1	7.3	1.05
90	7	16	1430	20.9	9.4	7.6	0.25	20.8	10.1	7.3	0.25
90	7	20	1000	15.6	8.8	8.2	0.23	17.6	10.6	8.0	0.34
90	7	20	1500	20.8	11.6	7.6	0.51	22.0	13.6	7.5	0.30
90	7	24	1245	18.7	7.7	7.4	1.53	20.0	10.0	7.4	0.28
90	7	24	1500	20.0	10.2	7.8	0.30	21.1	10.5	7.5	0.48
90	7	28	950	18.1	8.3	7.6	0.13	20.3	9.1	7.4	0.17
90	7	28	1440	23.5	11.6	7.9	0.28	24.0	11.7	7.6	0.15
90	8	1	1100	20.0	7.1	7.4	0.32	22.0	10.3	7.3	0.28
90	8	1	1515	24.0	10.6	8.2	0.32	24.1	11.0	7.6	0.28
90	8	5	1000	18.8	8.0	7.8	0.08	21.0	8.9	7.5	0.08
90	8	5	1430	24.0	13.0	8.4	0.15	25.0	13.1	8.1	0.13
90	8	9	1045	20.9	8.7	7.7	0.21	22.0	9.7	7.3	0.30
90	8	9	1515	23.0	11.4	8.1	0.06	22.6	9.2	7.4	0.11
90	8	13	1100	20.3	9.2	7.7	0.19	22.2	10.8	7.5	0.23
90	8	13	1430	24.0	10.5	8.3	0.17	24.5	12.8	7.8	0.25
90	8	17	1030	17.2	10.2	7.6	0.09	20.5	10.0	7.2	0.30
90	8	17	1430	18.5	12.2	7.9	0.09	21.5	11.2	7.3	0.61
90	8	21	1015	16.2	8.9	7.4	0.32	18.3	8.8	7.1	0.39
90	8	21	1430	19.0	11.0	7.8	0.17	20.0	10.9	7.1	0.82
90	8	25	1030	16.0	7.9	7.9	0.21	19.0	7.4	7.4	0.32
90	8	25	1430	19.0	12.7	8.4	0.30	20.7	11.0	7.8	0.61
90	8	29	1100	17.2	13.0	8.4	0.21	21.0	11.2	7.7	0.59
90	8	29	1500	20.8	16.6	9.0	0.21	22.1	12.5	8.4	0.43
90	9	2	1100	16.1	12.3	8.4	0.36	20.3	11.8	7.8	0.43
90	9	2	1430	19.9	8.6	8.4	0.06	22.0	13.8	8.4	0.21
90	9	6	1015	17.8	11.0	8.2	0.21	21.2	10.4	7.8	0.28
90	9	6	1445	22.5	14.2	8.7	0.17	23.5	12.0	8.2	0.21
90	9	10	1100	19.0	8.0	8.2	0.32	21.1	10.8	7.8	0.32
90	9	10	1500	21.9	14.6	8.8	0.11	23.8	12.0	8.0	0.15
90	9	14	1000	12.8	8.3	8.8	0.05	15.9	8.0	8.4	0.05
90	9	14	1445	17.0	13.2	8.6	0.05	21.2	10.6	8.3	0.05
90	9	18	1030	14.7	7.0	8.4	0.05	19.0	9.5	7.6	0.05
90	9	18	1443	17.3	13.9	8.6	0.05	20.9	10.9	7.6	0.05
90	9	22	1030	13.8	9.4	8.0	0.05	19.8	9.0	7.6	0.05
90	9	22	1440	16.8	13.6	8.6	0.05	21.2	10.9	7.6	0.05
90	9	26	1030	15.1	8.7	8.0	0.05	19.9	8.6	7.6	0.05
90	9	26	1430	17.0	12.4	8.5	0.11	20.5	10.2	7.7	0.10

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

Yr	Mo	Day	Time	UPSTREAM STATION: Temperature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)	DOWNSTREAM STATION: Temperature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)
90	9	30	1040	12.4	9.2	8.0	0.05	18.7	9.5	7.4	0.05
90	9	30	1500	15.9	15.0	8.8	0.05	20.7	10.8	7.6	0.05
90	10	4	1100	17.9	10.4	8.1	0.05	17.4	8.8	7.8	0.05
90	10	4	1500	15.1	13.2	8.4	0.15	19.0	10.3	7.5	0.05
90	10	8	1045	6.5	12.3	8.2	0.05	13.9	10.1	7.6	0.32
90	10	8	1500	9.7	14.8	8.6	0.05	15.5	11.4	7.8	0.33
90	10	12	1030	9.8	9.0	7.7	0.05	14.8	8.4	7.6	0.13
90	10	12	1445	11.2	12.6	8.2	0.05	15.4	9.6	7.4	0.40
90	10	16	1015	9.7	9.5	7.6	0.35	13.8	8.4	7.2	0.22
90	10	16	1430	11.0	11.9	7.8	0.33	15.0	9.2	7.2	0.54
90	10	20	1000	6.1	10.1	8.3	0.05	11.5	9.2	7.6	0.05
90	10	20	1400	8.3	12.5	8.4	0.11	13.2	10.2	7.6	0.12
90	10	24	1020	7.5	9.7	7.6	0.16	12.8	8.6	7.4	0.20
90	10	24	1445	10.0	9.9	7.7	0.20	14.0	9.2	7.3	0.56
90	10	28	1045	13.2	8.8	7.6	0.05	18.3	8.0	7.4	0.05
90	10	28	1405	13.7	10.6	7.9	0.05	19.8	9.4	7.4	0.05
90	11	1	1030	8.0	9.6	7.6	0.34	11.5	8.3	7.0	0.38
90	11	1	1445	8.2	9.0	7.7	0.05	11.5	8.2	7.2	0.93
90	11	5	1030	6.4	10.8	8.2	0.25	9.5	9.1	7.7	0.65
90	11	5	1430	6.8	10.2	7.8	0.24	9.2	9.5	7.4	1.20
90	11	9	1015	8.9	9.6	7.6	0.05	12.5	8.2	7.3	0.18
90	11	9	1430	9.0	9.4	8.2	0.11	12.3	8.1	7.5	1.70
90	11	13	1030	8.5	9.2	7.9	0.05	13.1	7.7	7.3	0.44
90	11	13	1430	9.0	9.0	8.2	0.14	12.6	8.0	7.5	2.40
90	11	17	1125	5.8	11.5	7.8	0.55	11.6	8.9	7.3	0.30
90	11	17	1455	6.5	11.3	7.8	0.74	11.2	8.8	7.2	1.40
90	11	21	1000	4.0	10.2	7.6	0.59	7.8	9.8	7.4	0.44
90	11	21	1440	5.0	10.8	7.6	0.31	6.8	9.7	7.2	0.28
90	11	25	1045	8.7	10.0	7.3	0.25	9.0	9.2	7.2	0.19
90	11	25	1400	7.8	9.7	7.2	0.26	8.3	9.5	7.0	0.26
90	11	29	1030	4.0	11.0	7.6	0.40	7.5	9.4	7.3	0.23
90	11	29	1430	4.8	10.5	7.8	0.26	7.4	9.1	7.4	1.30
90	12	3	1030	2.9	12.2	7.7	0.37	6.5	10.6	7.6	0.26
90	12	3	1445	3.8	11.2	7.7	0.42	6.9	10.2	7.6	1.22
90	12	7	1030	2.0	11.6	7.8	0.48	6.0	10.0	7.5	0.24
90	12	7	1430	3.1	11.0	7.7	0.65	6.0	9.6	7.3	1.54
90	12	11	1045	4.2	10.7	7.6	0.39	5.5	10.3	7.4	0.29
90	12	11	1445	4.5	10.8	7.7	0.31	5.1	10.7	7.4	0.54
90	12	15	1030	1.4	11.9	7.8	0.95	5.9	9.5	7.5	0.59
90	12	15	1345	1.8	12.6	7.8	0.63	5.2	9.4	7.6	0.53
90	12	19	1215	0.5	13.0	7.8	1.02	3.8	11.0	7.5	0.73
90	12	19	1500	0.4	12.1	8.1	1.01	3.1	10.8	7.8	1.10
90	12	23	1040	FROZEN				4.7	10.5	7.3	0.84
90	12	23	1420	FROZEN				3.9	11.1	7.5	0.79
90	12	27	1000	0.7	11.2	7.5	0.29	4.0	10.2	7.4	0.24
90	12	27	1425	0.5	11.6	7.4	0.40	3.5	10.1	7.2	0.23
90	12	31	1010	FROZEN				3.1	11.2	7.4	0.20
90	12	31	1430	FROZEN				3.3	11.1	7.6	0.42
91	1	4	1020	1.0	12.3	7.6	0.18	3.2	11.0	7.6	0.14
91	1	4	1500	0.9	11.9	8.0	0.32	3.1	11.0	7.6	0.68
91	1	8	1015	1.8	12.4	7.6	0.31	4.0	11.1	7.4	0.43
91	1	8	1500	2.2	12.3	8.0	0.30	4.0	11.0	7.8	0.65
91	1	12	1040	1.2	12.2	7.6	0.86	1.8	11.8	7.5	0.80

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

Yr	Mo	Day	Time	UPSTREAM STATION: Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)	DOWNSTREAM STATION: Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)
91	1	12	1515	0.3	12.2	7.3	0.50	0.6	12.0	7.2	0.59
91	1	16	1020	0.8	13.4	7.4	0.24	0.9	13.0	7.6	0.36
91	1	16	1445	1.5	12.7	7.4	0.19	1.9	12.6	7.2	0.36
91	1	20	1015	0.1	13.4	7.5	0.31	1.2	12.6	7.4	0.28
91	1	20	1245	0.9	13.2	7.3	0.27	1.9	12.6	7.4	0.24
91	1	24	1000	1.0	12.6	7.7	0.80	2.8	12.0	7.3	0.61
91	1	24	1500	1.5	12.9	7.7	0.68	3.0	12.2	7.6	0.66
91	1	28	1030	1.0	12.7	7.7	1.10	3.3	11.5	7.4	0.93
91	1	28	1430	1.2	11.5	7.7	0.90	3.1	11.2	7.5	1.75
91	2	1	1020	2.5	12.3	7.7	1.10	5.0	11.0	7.5	0.76
91	2	1	1500	3.0	11.0	7.8	1.28	5.2	10.4	7.8	2.20
91	2	5	1020	3.1	12.6	7.2	0.28	3.7	12.0	7.1	0.26
91	2	5	1315	4.7	11.6	7.1	0.24	4.5	11.5	7.3	0.26
91	2	9	1110	3.9	12.8	7.3	0.41	5.1	11.8	7.5	0.44
91	2	9	1315	5.1	12.4	7.0	0.27	5.9	11.8	7.3	0.34
91	2	13	1015	5.0	12.0	7.6	0.35	6.0	11.1	7.5	0.28
91	2	13	1500	4.9	10.8	7.5	0.41	6.4	10.7	7.5	0.73
91	2	17	1045	3.8	12.3	7.5	0.32	5.3	11.7	7.6	0.27
91	2	17	1410	5.8	12.3	7.4	0.30	6.2	11.6	7.2	0.32
91	2	21	1030	6.0	11.8	7.6	0.23	6.5	11.2	7.6	0.22
91	2	21	1500	7.3	10.6	7.4	0.27	8.0	10.4	7.6	0.27
91	2	25	1100	5.3	12.5	7.2	0.51	6.0	11.8	7.2	0.49
91	2	25	1450	7.0	11.6	7.5	0.48	8.0	11.1	7.4	0.79
91	3	1	1030	5.1	11.6	7.5	0.58	6.0	10.8	7.2	0.50
91	3	1	1515	6.0	10.6	7.9	0.85	6.3	10.8	7.9	1.30
91	3	5	1045	3.0	12.8	7.2	0.27	3.1	12.2	7.2	0.28
91	3	5	1300	4.1	12.2	7.5	0.23	4.1	11.8	7.4	0.40
91	3	9	1045	5.2	12.0	7.8	0.28	5.8	11.5	7.5	0.24
91	3	9	1415	6.3	11.6	7.5	0.19	6.3	11.2	7.4	0.18
91	3	13	1000	4.1	11.8	7.4	0.31	4.9	11.4	7.4	0.26
91	3	13	1445	5.8	11.4	7.3	0.20	6.0	11.3	7.2	0.37
91	3	17	1045	6.1	11.6	7.6	0.18	6.5	11.5	7.8	0.15
91	3	17	1450	8.8	10.8	7.7	0.05	8.9	10.7	7.8	0.05
91	3	21	1030	9.0	10.8	7.6	0.15	6.3	11.0	7.6	0.05
91	3	21	1500	8.0	10.9	7.7	0.12	8.1	10.6	7.6	0.22
91	3	25	1030	4.5	12.2	7.7	0.21	5.5	11.4	7.6	0.59
91	3	25	1300	5.8	11.8	7.8	0.05	6.1	11.6	7.6	1.22
91	3	29	1030	5.5	13.0	8.0	0.34	6.8	12.0	7.8	0.32
91	3	29	1500	8.6	12.1	8.1	0.18	9.0	11.8	8.0	0.72
91	4	2	1020	10.5	12.6	8.0	0.33	11.8	11.9	7.4	0.31
91	4	2	1500	11.1	13.2	8.6	0.19	12.0	12.8	8.3	0.85
91	4	6	1115	7.9	12.4	7.7	0.14	9.0	11.8	7.4	0.18
91	4	6	1450	10.8	12.1	8.0	0.12	11.2	11.8	7.7	0.23
91	4	10	1030	4.2	11.8	7.5	0.35	5.6	11.2	7.2	0.30
91	4	10	1515	6.0	11.1	7.6	0.28	7.0	11.2	7.4	0.58
91	4	14	1130	10.3	13.3	8.4	0.13	11.1	12.8	8.0	0.12
91	4	14	1440	12.9	13.6	8.8	0.05	13.7	12.8	8.5	0.05
91	4	18	1230	11.4	14.2	8.4	0.41	12.9	14.2	8.0	0.30
91	4	18	1520	14.5	13.4	8.8	0.39	14.8	13.4	8.6	0.23
91	4	22	1015	12.9	12.0	8.4	0.38	14.0	11.7	7.9	0.41
91	4	22	1315	17.2	13.1	8.8	0.14	17.6	13.0	8.6	0.72
91	4	26	1040	9.5	13.2	8.1	0.19	11.1	12.6	7.8	0.16
91	4	26	1440	11.5	12.9	8.3	0.05	12.8	13.0	8.2	0.81

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

				UPSTREAM STATION:				DOWNSTREAM STATION:			
Yr	Mo	Day	Time	Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)	Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)
91	4	30	1100	9.9	13.7	8.1	0.42	11.8	12.1	7.7	0.25
91	4	30	1430	13.8	13.4	8.6	0.11	14.8	14.0	8.4	0.93
91	5	4	1115	13.6	14.7	8.4	0.41	13.9	13.1	8.2	0.05
91	5	4	1320	15.1	15.6	8.9	0.39	15.6	15.2	8.6	0.13
91	5	8	1015	11.0	8.9	7.8	0.64	11.5	8.7	7.4	0.45
91	5	8	1500	13.0	8.6	7.3	0.58	11.7	8.5	7.2	0.54
91	5	12	1120	14.4	11.8	8.0	0.33	13.7	11.6	7.8	0.15
91	5	12	1455	13.3	11.2	8.2	0.26	14.8	10.6	8.0	0.05
91	5	16	1030	14.7	10.2	7.7	0.05	14.9	10.4	7.8	0.05
91	5	16	1445	17.1	12.8	8.6	0.05	17.3	13.4	8.4	0.05
91	5	20	1030	11.1	10.4	7.5	0.13	11.6	9.7	7.6	0.12
91	5	20	1500	15.0	10.0	7.5	0.11	14.8	8.5	7.5	0.05
91	5	24	900	13.8	9.5	7.6	0.05	14.0	9.4	7.6	0.05
91	5	24	1330	16.2	8.9	8.0	0.12	16.7	9.2	7.9	0.49
91	5	28	1100	12.5	9.0	7.0	0.11	13.3	8.5	7.2	0.05
91	5	28	1430	16.2	8.6	7.4	0.12	16.2	8.5	7.4	0.16
91	6	1	1120	14.3	10.2	7.9	0.11	15.9	10.0	7.8	0.18
91	6	1	1415	19.0	9.6	8.2	0.05	18.6	9.6	7.9	0.05
91	6	5	1100	13.1	8.8	7.5	0.13	14.0	8.7	7.5	0.05
91	6	5	1510	13.1	9.1	8.0	0.05	13.8	8.5	7.6	0.76
91	6	9	1045	14.5	8.9	7.9	0.05	15.4	9.0	7.7	0.05
91	6	9	1415	18.8	8.8	7.9	0.05	17.8	8.9	7.5	0.05
91	6	13	1100	13.9	9.2	7.6	0.05	14.0	9.0	7.4	0.05
91	6	13	1510	14.0	9.1	7.9	0.05	14.9	9.0	7.7	0.05
91	6	17	1050	14.1	9.8	7.9	0.05	15.4	9.6	7.8	0.05
91	6	17	1500	18.0	9.4	8.1	0.10	19.0	9.6	7.8	0.27
91	6	21	1100	13.6	8.9	7.6	0.30	14.2	8.5	7.4	0.11
91	6	21	1500	16.0	8.3	7.7	0.25	16.2	8.3	7.6	0.24
91	6	25	1045	16.9	8.7	7.8	0.11	17.5	8.5	7.6	0.11
91	6	25	1500	20.0	8.4	8.0	0.16	20.0	8.5	7.7	0.80
91	6	29	1115	17.5	7.6	7.8	0.12	18.3	8.3	7.7	0.05
91	6	29	1410	16.9	7.4	7.7	0.05	17.1	8.1	7.7	0.05
91	7	3	1130	21.4	9.5	7.8	0.05	12.9	9.4	7.4	0.05
91	7	3	1525	21.6	8.6	7.8	0.05	16.9	9.4	7.4	1.55
91	7	7	1145	19.3	11.0	7.9	0.05	20.6	13.5	7.8	0.05
91	7	7	1500	23.4	11.6	8.0	0.05	19.5	14.4	7.8	0.05
91	7	11	1110	19.1	11.1	8.2	0.11	20.5	12.4	7.8	0.14
91	7	11	1430	23.3	12.4	8.2	0.05	23.8	13.0	8.0	0.15
91	7	15	1045	18.9	10.3	7.8	0.05	20.3	11.0	7.7	0.05
91	7	15	1445	21.8	12.4	8.1	0.15	21.9	11.8	7.6	0.05
91	7	19	1040	17.1	10.0	7.6	0.05	19.1	10.9	7.4	0.05
91	7	19	1450	22.5	12.2	7.9	0.05	23.0	13.4	7.7	0.05
91	7	23	1045	20.3	9.7	8.0	0.05	22.0	11.1	8.0	0.05
91	7	23	1500	25.9	11.4	7.9	0.05	25.2	12.2	7.7	0.05
91	7	27	1115	18.3	10.4	7.9	0.05	21.0	11.0	7.8	0.05
91	7	27	1315	21.6	10.7	8.0	0.05	23.0	11.8	7.7	0.05
91	7	31	1045	19.5	9.5	7.8	0.05	21.5	10.2	7.6	0.05
91	7	31	1515	24.1	12.2	8.0	0.05	24.8	11.7	7.6	0.05
91	8	4	1100	20.0	9.7	7.9	0.14	21.8	10.0	7.7	0.05
91	8	4	1500	24.5	11.4	8.1	0.05	25.1	11.2	7.6	0.19
91	8	8	1000	19.5	8.0	7.5	0.05	21.5	8.5	7.1	0.05
91	8	8	1500	24.2	10.4	8.0	0.05	25.0	10.8	7.7	0.05
91	8	12	1110	16.4	9.6	7.9	0.05	19.9	9.9	7.4	0.05

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

Yr	Mo	Day	Time	UPSTREAM STATION: Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)	DOWNSTREAM STATION: Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)
91	8	12	1500	19.3	11.2	8.2	0.05	22.0	11.2	7.6	0.05
91	8	16	1000	18.1	7.6	7.6	0.15	18.0	7.8	7.2	0.05
91	8	16	1330	20.9	11.8	8.1	0.05	21.1	10.7	7.2	0.05
91	8	20	1050	19.1	8.7	8.0	0.13	21.8	9.7	7.6	0.11
91	8	20	1515	23.5	10.4	8.3	0.05	24.1	10.6	7.8	0.05
91	8	24	1100	16.9	9.7	8.0	0.11	18.4	9.1	7.2	0.11
91	8	24	1350	19.4	10.7	8.0	0.26	21.7	10.6	7.6	0.20
91	8	28	1100	16.8	8.8	7.8	0.13	20.0	9.2	7.2	0.11
91	8	28	1500	18.5	10.7	8.2	0.05	21.0	10.1	7.7	0.11
91	9	1	1140	16.0	9.3	7.8	0.27	19.2	8.7	7.5	0.05
91	9	1	1515	13.9	11.5	8.0	0.20	20.3	10.6	7.2	0.25
91	9	5	1045	13.5	5.5	8.0	0.05	20.0	8.7	7.5	0.17
91	9	5	1515	19.5	11.4	8.1	0.05	22.2	9.6	7.7	1.22
91	9	9	1045	13.0	10.0	8.0	0.12	17.9	9.1	7.6	0.13
91	9	9	1500	15.8	11.1	8.3	0.05	19.0	9.9	7.7	0.05
91	9	13	1045	13.9	8.7	7.9	0.11	18.1	7.4	7.6	0.26
91	9	13	1445	15.9	11.3	8.1	0.05	19.1	9.6	7.3	0.13
91	9	17	1100	13.0	10.3	8.0	0.05	18.0	9.3	7.3	0.11
91	9	17	1430	16.1	11.6	8.1	0.05	20.0	11.0	7.3	0.05
91	9	21	915	11.0	8.9	8.0	0.05	15.5	8.4	7.4	0.05
91	9	21	1330	14.1	8.3	8.1	0.05	18.0	10.1	7.5	0.05
91	9	25	1100	11.8	10.2	7.6	0.05	17.5	8.9	7.5	0.05
91	9	25	1430	14.8	12.0	8.3	0.05	19.5	10.4	7.6	0.05
91	9	29	1115	12.5	10.2	8.0	0.11	17.7	8.9	7.5	0.05
91	9	29	1430	14.3	11.0	8.4	0.05	19.0	9.4	7.6	0.05
91	10	3	1100	9.9	9.2	8.0	0.11	16.0	8.3	7.5	0.05
91	10	3	1500	12.1	12.4	8.2	0.05	17.0	10.4	7.5	0.05
91	10	7	1000	7.6	9.5	7.7	2.31	14.9	7.8	6.9	1.00
91	10	7	1300	9.3	10.2	7.6	2.59	16.1	8.6	7.1	0.98
91	10	11	915	8.5	8.7	7.8	1.59	15.9	7.3	7.3	0.66
91	10	11	1500	11.2	12.4	7.9	1.52	16.1	9.8	7.1	0.76
91	10	15	1045	8.7	9.0	7.8	0.29	15.5	8.3	7.3	0.15
91	10	15	1430	11.5	12.6	7.9	0.21	16.7	10.2	6.9	0.13
91	10	19	1130	8.0	10.3	7.9	0.31	14.6	8.7	7.5	0.11
91	10	19	1315	12.1	12.6	7.8	0.19	16.8	9.9	7.5	0.05
91	10	23	900	6.1	8.6	7.7	0.16	14.0	6.8	7.4	0.12
91	10	23	1500	7.7	10.6	8.0	0.05	12.5	8.8	7.6	0.05
91	10	27	1130	6.0	9.7	7.4	0.63	10.6	8.2	6.8	0.39
91	10	27	1500	6.1	8.8	7.5	0.84	10.0	7.9	6.9	0.60
91	10	31	900	3.5	9.2	7.8	1.13	9.9	7.8	7.5	0.50
91	10	31	1445	5.1	8.7	7.9	0.57	9.1	7.9	7.6	0.60
91	11	4	1045	4.0	9.4	7.8	0.54	10.0	8.2	7.3	0.24
91	11	4	1500	5.4	9.4	7.8	0.28	8.9	8.8	7.6	0.30
91	11	8	910	7.5	8.9	7.6	0.28	11.8	7.5	7.2	0.14
91	11	8	1440	8.1	9.7	7.6	0.46	12.2	8.3	7.1	0.20
91	11	12	1015	8.9	8.4	7.7	0.27	12.3	7.2	7.3	0.14
91	11	12	1430	9.8	8.8	8.0	0.19	13.0	8.0	7.8	0.19
91	11	16	1016	3.5	10.0	7.9	0.15	10.0	8.3	7.0	0.05
91	11	16	1400	4.0	9.6	8.0	0.14	10.0	8.1	7.7	0.13
91	11	20	1030	5.7	12.1	7.6	0.46	8.1	10.2	7.2	0.25
91	11	20	1500	6.5	10.9	7.6	1.30	8.0	8.8	7.5	0.54
91	11	24	1030	4.0	11.0	7.5	0.60	6.8	10.0	7.0	0.25
91	11	24	1245	4.0	8.2	7.2	0.34	7.0	8.0	7.4	0.33

Appendix D: Pullman WTP monitoring data from the S.F. Palouse River.

				UPSTREAM STATION:				DOWNSTREAM STATION:			
Yr	Mo	Day	Time	Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)	Temp-erature (deg C)	Dissolved Oxygen (mg/L)	pH (S.U.)	Total NH3-N (mgN/L)
91	11	28	1015	2.7	12.3	7.8	0.16	3.3	11.2	7.4	0.15
91	11	28	1230	2.9	13.1	7.4	0.35	3.9	11.4	7.6	0.21
91	12	2	1100	3.1	13.4	7.8	0.12	6.1	11.4	7.6	0.33
91	12	2	1510	4.0	8.7	7.8	0.15	6.1	6.9	7.5	0.47
91	12	6	1045	6.0	11.2	7.7	0.96	7.1	9.0	7.4	0.56
91	12	6	1445	6.1	7.3	7.6	0.90	7.4	7.9	7.2	0.90
91	12	10	1030	2.6	10.8	7.7	0.60	5.2	12.0	7.4	0.46
91	12	10	1500	2.9	9.6	7.6	0.17	5.0	9.5	7.2	0.25
91	12	14	1000	1.0	9.9	7.4	0.23	5.0	8.5	6.9	0.45
91	12	14	1315	0.0	7.8	7.5	0.36	5.5	7.7	6.9	0.90
91	12	18	1030	2.0	9.5	7.5	0.60	5.0	8.6	7.2	0.59
91	12	18	1500	2.3	12.4	7.9	0.38	6.0	9.8	7.6	0.52
91	12	22	1015	1.5	10.2	8.0	0.58	5.0	9.2	7.2	0.34
91	12	22	1400	3.0	8.7	7.6	0.41	5.0	8.1	7.1	0.29
91	12	26	1045	1.0	12.7	7.5	0.11	4.9	9.5	7.1	0.11
91	12	26	1500	2.0	9.1	7.6	0.15	3.9	8.8	7.2	0.15
91	12	30	1050	2.0	13.6	7.3	0.05	4.5	11.7	7.5	0.05
91	12	30	1445	3.0	10.6	8.0	0.05	5.0	10.6	7.8	0.05
92	1	3	1000	0.9	11.6	7.9	0.05	3.0	10.5	7.6	0.05
92	1	3	1445	1.5	10.0	7.4	0.05	3.1	9.2	7.4	0.44
92	1	7	1015	1.8	11.2	8.0	0.05	4.0	10.3	7.5	0.05
92	1	7	1500	2.0	9.5	8.1	0.05	3.8	8.9	7.8	0.70
92	1	11	1015	1.0	9.1	7.4	0.05	4.0	8.9	7.1	0.23
92	1	11	1445	1.8	8.9	7.6	0.05	3.0	7.2	7.2	0.21
92	1	15	1010	2.0	9.6	7.6	0.43	6.1	8.0	7.1	0.29
92	1	15	1445	3.0	12.2	8.0	0.30	6.1	9.8	7.8	0.41
92	1	19	1010	0.0	8.9	7.2	0.13	4.0	7.4	7.1	0.10
92	1	19	1430	1.0	8.0	7.9	0.13	4.5	7.3	7.5	0.05
92	1	23	1040	1.1	10.4	7.4	0.27	3.0	8.7	7.2	0.22
92	1	23	1500	1.8	9.7	7.5	0.39	3.0	8.6	7.4	0.36
92	1	27	1015	2.0	12.6	7.5	0.33	4.0	8.6	7.2	0.18
92	1	27	1500	3.1	13.8	7.6	0.23	4.0	10.5	7.6	0.59
92	1	31	1045	3.9	10.4	7.5	0.16	5.2	8.6	7.4	0.20
92	1	31	1500	4.0	9.7	7.2	0.15	5.1	9.0	7.1	0.64
92	2	4	1045	1.5	10.8	7.6	0.67	4.1	9.4	7.3	0.56
92	2	4	1450	3.0	9.7	7.5	0.34	5.0	8.7	7.6	1.35
92	2	8	1020	2.0	10.6	7.2	0.56	4.9	9.3	7.1	0.31
92	2	8	1445	3.0	8.6	7.1	0.50	5.1	8.8	7.0	0.35
92	2	12	1000	3.5	10.4	7.3	0.78	6.2	8.7	6.9	0.54
92	2	12	1505	6.0	13.2	8.0	0.66	8.0	9.4	7.7	0.58
92	2	16	1005	3.0	9.6	7.2	0.31	5.5	9.2	7.0	0.39
92	2	16	1330	4.8	9.5	7.4	0.05	6.9	9.2	7.0	0.05
92	2	20	1040	4.0	11.0	7.2	0.25	4.5	9.8	7.3	0.20
92	2	20	1445	4.9	10.6	7.1	0.90	4.5	9.4	7.2	0.16
92	2	24	1010	4.8	9.0	7.4	0.14	5.1	8.3	7.2	0.14
92	2	24	1500	5.0	8.1	7.8	0.10	5.8	8.1	7.6	0.14
92	2	28	1040	6.0	10.0	7.6	0.28	7.0	8.9	7.4	0.25
92	2	28	1430	6.9	9.2	7.4	0.25	7.2	8.7	7.0	0.52

APPENDIX E

Summary of Pullman POTW effluent quality during 1989-1991

Appendix E: Pullman WTP effluent ammonia concentrations during 1989-91.

Month	Monthly Average Flow (mgd)	Monthly Average Influent Temp (deg C)	Number of Effluent Ammonia Samples	Monthly Average Effluent Ammonia (mgN/L)	Monthly Std Dev Effluent Ammonia (mgN/L)	Monthly CV Effluent Ammonia
JAN-91	3.38	9.7	31	2.02	1.86	0.920
FEB	3.15	13.8	28	1.30	1.01	0.776
MAR	3.11	13.4	31	1.65	1.50	0.910
APR	3.04	15.6	30	1.16	0.88	0.758
MAY	2.52	16.5	31	0.47	0.70	1.491
JUN	2.07	17.6	30	0.53	0.91	1.705
JUL	1.99	19.7	31	0.30	0.57	1.920
AUG	2.31	21.3	31	0.24	0.39	1.621
SEP	2.91	21.2	30	0.18	0.14	0.812
OCT	2.79	20.0	31	0.17	0.12	0.685
NOV	2.75	16.8	30	0.18	0.15	0.849
DEC	2.55	14.9	31	0.67	0.90	1.343
JAN-90	3.08	11.2	31	5.36	4.61	0.861
FEB	3.48	11.3	28	1.73	1.77	1.022
MAR	2.77	12.0	31	1.12	1.13	1.010
APR	3.11	14.1	30	0.80	0.63	0.786
MAY	2.49	14.3	31	0.41	0.23	0.556
JUN	2.15	14.9	30	0.26	0.11	0.443
JUL	1.96	17.3	31	0.51	0.53	1.039
AUG	2.31	18.4	31	0.79	0.55	0.700
SEP	2.95	18.2	30	0.27	0.21	0.756
OCT	2.89	16.3	31	0.65	0.63	0.967
NOV	2.93	13.5	30	1.55	1.26	0.811
DEC	2.82	10.9	31	0.60	0.53	0.877
JAN-89	3.35	14.2	7	1.60	1.74	1.084
FEB	3.38	15.1	7	1.17	1.64	1.399
MAR	3.63	12.7	8	2.06	2.20	1.064
APR	3.27	15.8	26	2.67	2.50	0.937
MAY	2.26	17.7	31	0.89	1.41	1.581
JUN	1.98	19.0	30	2.36	4.67	1.980
JUL	1.86	20.7	31	1.55	3.52	2.274
AUG	2.32	21.6	31	0.12	0.02	0.197
SEP	2.90	21.0	30	0.29	0.17	0.564
OCT	2.91	18.9	31	0.22	0.20	0.910
NOV	2.66	16.0	29	1.30	1.87	1.437
DEC	2.65	13.9	31	3.74	3.72	0.994

APPENDIX F

Detailed calculations of WLAs and permit limits for Pullman and Albion POTWs

Appendix F.1: Criteria used for monthly and semi-annual permit limit analysis for ammonia. NH3CRI5.WK1\CRITSMRY

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
INPUT FOR ECOLOGY STATION 34B110 DATA														
1. Sample Ambient Temperature (seasonal 90%tile)	3.64	6.86	9.10	14.00	18.60	20.70	21.57	21.40	16.30	13.70	8.76	5.80	20.46	8.76
2. Sample Ambient pH (seasonal 90%tile)	8.12	8.03	7.90	8.80	8.90	9.14	8.69	8.70	8.60	8.50	8.24	8.01	8.60	8.24
INPUT FOR ADJUSTMENT OF ECOLOGY STATION 34B110 DATA TO PREDICT PULLMAN WTP MIXING ZONE CRITERIA														
1. Regression estimate of Mixing Zone Temperature (deg C)	6.29	9.28	11.36	15.92	20.20	22.15	22.96	22.80	18.06	15.64	11.05	8.30	21.93	11.05
2. Mixing Zone pH by Regression (S.U.)	7.69	7.64	7.56	8.12	8.16	8.34	8.05	8.06	8.00	7.93	7.77	7.63	8.00	7.77
3. Acute TCAP (Salmonids present- 20; absent- 25)	20	20	20	20	20	20	20	20	20	20	20	20	20	20
4. Chronic TCAP (Salmonids present- 15; absent- 20)	15	15	15	15	15	15	15	15	15	15	15	15	15	15
OUTPUT FOR CRITERIA AT PULLMAN WTP MIXING ZONE														
1. Intermediate Calculations:														
Acute FT	2.58	2.10	1.82	1.33	1.00	1.00	1.00	1.00	1.14	1.35	1.86	2.24	1.00	1.86
Chronic FT	2.58	2.10	1.82	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.86	2.24	1.41	1.86
FPH	1.21	1.26	1.36	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.14	1.28	1.00	1.14
RATIO	16	18	20	16	16	16	16	16	16	16	16	18	16	16
pKa	9.86	9.75	9.68	9.53	9.39	9.33	9.31	9.31	9.46	9.54	9.69	9.79	9.34	9.69
Fraction Of Total Ammonia Present As Un-ionized	0.68%	0.76%	0.74%	3.74%	5.81%	9.14%	5.26%	5.28%	3.30%	2.41%	1.18%	0.68%	4.33%	1.18%
2. Un-ionized Ammonia Criteria:														
Acute (1-hour) Un-ionized Ammonia Criterion (ug N/L)	68.7	80.7	86.7	161.2	213.7	213.7	213.7	213.7	186.4	152.9	100.9	74.6	213.1	100.9
Chronic (4-day) Un-ionized Ammonia Criterion (ug N/L)	13.1	14.2	13.6	29.1	29.1	29.1	29.1	29.1	29.0	28.1	19.4	12.9	29.0	19.4
3. Total Ammonia Criteria:														
Acute Total Ammonia Criterion (ug N/L)	10,076	10,631	11,701	4,310	3,680	2,339	4,060	4,048	5,647	6,355	8,575	10,926	4,919	8,575
Chronic Total Ammonia Criterion (ug N/L)	1,923	1,865	1,829	778	501	318	553	551	879	1,169	1,649	1,882	670	1,649
INPUT FOR ADJUSTMENT OF ECOLOGY STATION 34B110 DATA TO PREDICT PARADISE CR AT STATE LINE														
1. Paradise Cr Stateline Temperature by Regression (deg C)	9.86	12.23	13.89	17.50	20.90	22.45	23.09	22.97	19.20	17.28	13.64	11.45	22.27	13.64
2. Paradise Cr Stateline pH by Regression (S.U.)	7.44	7.41	7.38	7.61	7.64	7.70	7.59	7.59	7.56	7.54	7.47	7.41	7.56	7.47
3. Acute TCAP (Salmonids present- 20; absent- 25)	20	20	20	20	20	20	20	20	20	20	20	20	20	20
4. Chronic TCAP (Salmonids present- 15; absent- 20)	15	15	15	15	15	15	15	15	15	15	15	15	15	15
OUTPUT FOR CRITERIA AT PARADISE CR AT STATE LINE														
1. Intermediate Calculations:														
Acute FT	2.01	1.71	1.53	1.19	1.00	1.00	1.00	1.00	1.06	1.21	1.55	1.80	1.00	1.55
Chronic FT	2.01	1.71	1.53	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.55	1.80	1.41	1.55
FPH	1.54	1.58	1.64	1.29	1.26	1.20	1.32	1.32	1.35	1.39	1.49	1.59	1.35	1.49
RATIO	23	24	25	18	17	16	19	19	20	20	22	24	20	22
pKa	9.73	9.65	9.60	9.48	9.37	9.32	9.30	9.31	9.43	9.49	9.61	9.68	9.33	9.61
Fraction Of Total Ammonia Present As Un-ionized	0.50%	0.57%	0.60%	1.34%	1.82%	2.34%	1.88%	1.87%	1.35%	1.10%	0.72%	0.53%	1.68%	0.72%
2. Un-ionized Ammonia Criteria:														
Acute (1-hour) Un-ionized Ammonia Criterion (ug N/L)	69.0	79.2	85.3	139.6	169.6	178.4	161.6	162.0	149.7	127.8	92.7	74.6	158.1	92.7
Chronic (4-day) Un-ionized Ammonia Criterion (ug N/L)	9.2	10.3	10.7	19.9	21.1	24.3	18.6	18.7	17.6	16.6	12.9	9.7	17.6	12.9
3. Total Ammonia Criteria:														
Acute Total Ammonia Criterion (ug N/L)	13,804	13,913	14,290	10,411	9,323	7,624	8,616	8,662	11,111	11,591	12,900	14,084	9,422	12,900
Chronic Total Ammonia Criterion (ug N/L)	1,850	1,813	1,791	1,484	1,162	1,038	992	1,001	1,309	1,505	1,796	1,824	1,050	1,796

Appendix F.2: Alternatives 1A (monthly) and 1B (semi-annual) WLAs and permit limits for ammonia discharge from Pullman WTP and Albion WTP. Mixing zones were based on 25% and 2.5% of flow for chronic and acute criteria.

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
MONTHLY TMDL/WLA GENERAL INPUT ASSUMPTIONS														
1. Monthly Design Flows (cfs):														
Paradise Creek at Stateline	5.03	5.36	5.42	4.74	4.24	2.60	2.16	2.56	3.67	3.86	5.15	4.99	3.79	6.43
SF Palouse R above Paradise Creek	0.00	0.62	1.24	0.31	0.62	0.62	0.31	0.93	0.62	0.62	1.87	0.62	0.65	1.09
Missouri Flat Cr	0.00	0.20	0.40	0.10	0.20	0.20	0.10	0.30	0.20	0.20	0.60	0.20	0.21	0.35
S.F. Palouse immediately above Pullman WTP	5.03	6.18	7.06	5.15	5.07	3.42	2.57	3.80	4.50	4.68	7.62	5.81	4.65	7.87
2. Pullman WTP Semi-annual Design Flows (cfs)	6.52	6.65	6.32	6.26	4.83	4.12	3.86	4.62	5.82	5.71	5.55	5.33	5.82	5.55
3. Albion WTP Design Flows (cfs)		0.19	0.19	0.19	0.19								0.19	0.19
5. In-stream nitrification rates:														
Nitrification rate at 20 deg C (day^-1)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Temperature for Correction of Rate (deg C)	3.6	6.9	9.1	14.0	18.6	20.7	21.6	21.4	16.3	13.7	8.8	5.8	20.5	8.8
Nitrification rate at ambient temperature (day^-1)	0.8	1.1	1.3	1.9	2.6	3.1	3.3	3.3	2.2	1.8	1.2	1.0	3.1	1.2
6. In-stream Percent Reduction in Total Ammonia														
Estimated Flow at SFPR RM 22.2 (cfs)	5.0	6.0	6.7	5.0	4.9	3.2	2.5	3.5	4.3	4.5	7.0	5.6	4.4	7.5
Velocity, Paradise Cr state line to Pullman POTW (fps)	0.620	0.665	0.694	0.621	0.612	0.519	0.467	0.536	0.582	0.592	0.709	0.648	0.590	0.728
Velocity from Pullman to Albion POTW (fps)	0.630	0.675	0.705	0.631	0.621	0.527	0.474	0.544	0.591	0.601	0.720	0.658	0.599	0.740
Travel time Paradise Cr state line to Pullman POTW (days)	0.857	0.800	0.766	0.856	0.869	1.024	1.139	0.992	0.913	0.898	0.750	0.821	0.901	0.730
Travel time from Pullman to Albion POTW (days)	0.699	0.652	0.625	0.698	0.708	0.835	0.928	0.808	0.744	0.732	0.611	0.669	0.734	0.595
Ammonia Reduction Between Stateline and Pullman WTP	51%	58%	62%	80%	90%	96%	98%	96%	87%	80%	61%	56%	94%	60%
Ammonia Reduction Between Pullman WTP and Albion WTP	44%	50%	55%	73%	85%	93%	95%	93%	81%	74%	53%	48%	89%	52%

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
INPUT ASSUMPTIONS FOR PULLMAN WTP WLAs/PERMIT LIMITS														
i. Aquatic Life Criteria at Pullman WTP (Total Ammonia mg/L as N)														
Acute (one-hour) Criteria	10.08	10.63	11.70	4.31	3.68	2.34	4.06	4.05	5.65	6.35	8.57	10.93	4.92	8.57
Chronic (n-day) Criteria	1.92	1.86	1.83	0.78	0.50	0.32	0.55	0.55	0.88	1.17	1.65	1.88	0.67	1.65
2. Receiving Water Concentration Upstream from Pullman WTP														
Upstream Concentration for Acute Condition	0.90	0.77	0.67	0.30	0.12	0.05	0.05	0.05	0.17	0.29	0.71	0.81	0.07	0.73
Upstream Concentration for Chronic Condition	0.90	0.77	0.67	0.30	0.12	0.05	0.05	0.05	0.17	0.29	0.71	0.81	0.07	0.73
3. Dilution Factors (1/{Effluent Volume Fraction})														
Fraction of River Flow to Allow for Acute Dilution Factor	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Fraction of River Flow to Allow for Chronic Dilution Factor	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Acute Receiving Water Dilution Factor	1.02	1.02	1.03	1.02	1.03	1.02	1.02	1.02	1.02	1.02	1.03	1.03	1.02	1.04
Chronic Receiving Water Dilution Factor	1.19	1.23	1.28	1.21	1.26	1.21	1.17	1.21	1.19	1.21	1.34	1.27	1.20	1.35
4. Coefficient of Variation for Effluent Concentration	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
5. Number of days (n1) for chronic average	30	30	30	30	30	30	30	30	30	30	30	30	30	30
6. Number of samples (n2) per month to base permit on	20	20	20	20	20	20	20	20	20	20	20	20	20	20
WLAs and PERMIT LIMITS FOR PULLMAN WTP														
i. Z Statistics														
LTA Derivation (99%tile)	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
Daily Maximum Permit Limit (99%tile)	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
Monthly Average Permit Limit (95%tile)	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
2. Calculated Waste Load Allocations (WLA's)														
Acute (one-hour) WLA	10.25	10.86	12.01	4.39	3.77	2.39	4.13	4.13	5.75	6.48	8.84	11.20	5.02	8.85
Chronic (n1-day) WLA	2.12	2.12	2.15	0.88	0.60	0.37	0.64	0.65	1.02	1.35	1.97	2.17	0.79	1.98
3. Back-Calculation of Long Term Averages (LTA's)														
Sigma (same for acute and chronic)	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555
Mu for Acute WLA	1.038	1.095	1.196	0.190	0.038	-0.420	0.128	0.128	0.460	0.579	0.890	1.126	0.323	0.891
Mu-n1 for Chronic WLA	0.497	0.497	0.512	-0.387	-0.762	-1.237	-0.706	-0.679	-0.239	0.045	0.425	0.522	-0.490	0.427
Mu for Chronic WLA	0.350	0.349	0.365	-0.535	-0.910	-1.385	-0.854	-0.826	-0.386	-0.103	0.277	0.375	-0.637	0.280
LTA for Acute (one-hour) WLA	3.29	3.49	3.86	1.41	1.21	0.77	1.32	1.33	1.85	2.08	2.84	3.60	1.61	2.84
LTA for Chronic (n1-day) WLA	1.65	1.65	1.68	0.68	0.47	0.29	0.50	0.51	0.79	1.05	1.54	1.70	0.62	1.54
Most Limiting LTA (minimum of acute and chronic)	1.65	1.65	1.68	0.68	0.47	0.29	0.50	0.51	0.79	1.05	1.54	1.70	0.62	1.54
4. Derivation of Permit Limits From Limiting LTA														
Mu for daily maximum permit limit	0.350	0.349	0.365	-0.535	-0.910	-1.385	-0.854	-0.826	-0.386	-0.103	0.277	0.375	-0.637	0.280
Mu-n2 for monthly average permit limit	0.494	0.494	0.509	-0.390	-0.765	-1.240	-0.709	-0.681	-0.242	0.042	0.422	0.519	-0.493	0.424
Sigma^2-n for monthly avg permit limit	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Daily Maximum Permit Limit	5.15	5.15	5.23	2.13	1.46	0.91	1.55	1.59	2.47	3.28	4.79	5.28	1.92	4.80
Monthly Average Permit Limit	2.04	2.04	2.07	0.84	0.58	0.36	0.61	0.63	0.98	1.30	1.90	2.09	0.76	1.90

Appendix F.2 (continued):

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
INPUT ASSUMPTIONS FOR ALBION WTP WLAs/PERMIT LIMITS														
1. Water Quality Standards/Criteria (Concentration)														
Acute (one-hour) Criteria		10.63	11.70	4.31	3.68								4.92	8.57
Chronic (n-day) Criteria		1.86	1.83	0.78	0.50								0.67	1.65
2. Upstream Receiving Water Concentration														
Upstream Concentration for Acute Condition		0.73	0.62	0.17	0.05								0.05	0.59
Upstream Concentration for Chronic Condition		0.73	0.62	0.17	0.05								0.05	0.59
3. Dilution Factors (1/(Effluent Volume Fraction))														
Fraction of River Flow to Allow for Acute Dilution Factor		2.5%	2.5%	2.5%	2.5%								2.5%	2.5%
Fraction of River Flow to Allow for Chronic Dilution Factor		25%	25%	25%	25%								25%	25%
Acute Receiving Water Dilution Factor		2.728	2.802	2.537	2.332								2.410	2.807
Chronic Receiving Water Dilution Factor		18.28	19.02	16.37	14.32								15.10	19.07
4. Coefficient of Variation for Effluent Concentration		0.6	0.6	0.6	0.6								0.6	0.6
5. Number of days (n1) for chronic average		30	30	30	30								30	30
6. Number of samples (n2) per month to base permit on		4	4	4	4								4	4
WLAs and PERMIT LIMITS FOR ALBION WTP														
1. Z Statistics														
LTA Derivation (99%tile)		2.326	2.326	2.326	2.326								2.326	2.326
Daily Maximum Permit Limit (99%tile)		2.326	2.326	2.326	2.326								2.326	2.326
Monthly Average Permit Limit (95%tile)		1.645	1.645	1.645	1.645								1.645	1.645
2. Calculated Waste Load Allocations (WLA's)														
Acute (one-hour) WLA		27.74	31.67	10.67	8.51								11.78	22.99
Chronic (n1-day) WLA		21.48	23.65	10.14	6.45								9.40	20.71
3. Back-Calculation of Long Term Averages (LTA's)														
Sigma (same for acute and chronic)		0.555	0.555	0.555	0.555								0.555	0.555
Mu for Acute WLA		2.033	2.166	1.078	0.851								1.177	1.845
Mu-n1 for Chronic WLA		2.813	2.909	2.062	1.610								1.987	2.777
Mu for Chronic WLA		2.666	2.761	1.915	1.463								1.839	2.629
LTA for Acute (one-hour) WLA		8.91	10.17	3.43	2.73								3.78	7.38
LTA for Chronic (n1-day) WLA		16.76	18.45	7.91	5.04								7.34	16.16
Most Limiting LTA (minimum of acute and chronic)		8.91	10.17	3.43	2.73								3.78	7.38
4. Derivation of Permit Limits From Limiting LTA														
Mu for daily maximum permit limit		2.033	2.166	1.078	0.851								1.177	1.845
Mu-n2 for monthly average permit limit		2.144	2.276	1.189	0.962								1.287	1.956
Sigma^2-n for monthly avg permit limit		0.086	0.086	0.086	0.086								0.086	0.086
Daily Maximum Permit Limit		27.74	31.67	10.67	8.51								11.8	23.0
Monthly Average Permit Limit		13.83	15.79	5.32	4.24								5.9	11.5

Appendix F.3: Alternatives 2A (monthly) and 2B (semi-annual) WLAs and permit limits for ammonia discharge from Pullman WTP and Albion WTP. Mixing zones were based on 100% of flow for chronic and acute criteria.

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Nov	Dec-Mar
MONTHLY TMDL/WLA GENERAL INPUT ASSUMPTIONS ·														
1. Monthly Design Flows (cfs):														
Paradise Creek at Stateline	5.03	5.36	5.42	4.74	4.24	2.60	2.16	2.56	3.67	3.86	5.15	4.99	3.79	6.43
SF Palouse R above Paradise Creek	0.00	0.62	1.24	0.31	0.62	0.62	0.31	0.93	0.62	0.62	1.87	0.62	0.65	1.09
Missouri Flat Cr	0.00	0.20	0.40	0.10	0.20	0.20	0.10	0.30	0.20	0.20	0.60	0.20	0.21	0.35
S.F. Palouse immediately above Pullman WTP	5.03	6.18	7.06	5.15	5.07	3.42	2.57	3.80	4.50	4.68	7.62	5.81	4.65	7.87
2. Pullman WTP Semi-annual Design Flows (cfs)	6.52	6.65	6.32	6.26	4.83	4.12	3.86	4.62	5.82	5.71	5.55	5.33	5.82	5.55
3. Albion WTP Design Flows (cfs)		0.19	0.19	0.19	0.19								0.19	0.19
5. In-stream nitrification rates:														
Nitrification rate at 20 deg C (day^-1)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Temperature for Correction of Rate (deg C)	3.6	6.9	9.1	14.0	18.6	20.7	21.6	21.4	16.3	13.7	8.8	5.8	20.5	8.8
Nitrification rate at ambient temperature (day^-1)	0.8	1.1	1.3	1.9	2.6	3.1	3.3	3.3	2.2	1.8	1.2	1.0	3.1	1.2
6. In-stream Percent Reduction in Total Ammonia														
Estimated Flow at SFPR RM 22.2 (cfs)	5.0	6.0	6.7	5.0	4.9	3.2	2.5	3.5	4.3	4.5	7.0	5.6	4.4	7.5
Velocity, Paradise Cr state line to Pullman POTW (fps)	0.620	0.665	0.694	0.621	0.612	0.519	0.467	0.536	0.582	0.592	0.709	0.648	0.590	0.728
Velocity from Pullman to Albion POTW (fps)	0.630	0.675	0.705	0.631	0.621	0.527	0.474	0.544	0.591	0.601	0.720	0.658	0.599	0.740
Travel time Paradise Cr state line to Pullman POTW (days)	0.857	0.800	0.766	0.856	0.869	1.024	1.139	0.992	0.913	0.898	0.750	0.821	0.901	0.730
Travel time from Pullman to Albion POTW (days)	0.699	0.652	0.625	0.698	0.708	0.835	0.928	0.808	0.744	0.732	0.611	0.669	0.734	0.595
Ammonia Reduction Between Stateline and Pullman WTP	51%	58%	62%	80%	90%	96%	98%	96%	87%	80%	61%	56%	94%	60%
Ammonia Reduction Between Pullman WTP and Albion WTP	44%	50%	55%	73%	85%	93%	95%	93%	81%	74%	53%	48%	89%	52%

	A: Monthly Permit Limits												B: Semi-Annual Limits	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
INPUT ASSUMPTIONS FOR PULLMAN WTP WLAs/PERMIT LIMITS														
i. Aquatic Life Criteria at Pullman WTP (Total Ammonia mg/L as N)														
Acute (one-hour) Criteria	10.08	10.63	11.70	4.31	3.68	2.34	4.06	4.05	5.65	6.35	8.57	10.93	4.92	8.57
Chronic (n-day) Criteria	1.92	1.86	1.83	0.78	0.50	0.32	0.55	0.55	0.88	1.17	1.65	1.88	0.67	1.65
2. Receiving Water Concentration Upstream from Pullman WTP														
Upstream Concentration for Acute Condition	0.80	0.77	0.67	0.30	0.12	0.05	0.05	0.05	0.17	0.29	0.71	0.81	0.07	0.73
Upstream Concentration for Chronic Condition	0.80	0.77	0.67	0.30	0.12	0.05	0.05	0.05	0.17	0.29	0.71	0.81	0.07	0.73
3. Dilution Factors (1/(Effluent Volume Fraction))														
Fraction of River Flow to Allow for Acute Dilution Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100.0%	100.0%
Fraction of River Flow to Allow for Chronic Dilution Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Acute Receiving Water Dilution Factor	1.77	1.93	2.12	1.82	2.05	1.83	1.67	1.82	1.77	1.82	2.37	2.09	1.80	2.42
Chronic Receiving Water Dilution Factor	1.77	1.93	2.12	1.82	2.05	1.83	1.67	1.82	1.77	1.82	2.37	2.09	1.80	2.42
4. Coefficient of Variation for Effluent Concentration	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
5. Number of days (n1) for chronic average	30	30	30	30	30	30	30	30	30	30	30	30	30	30
6. Number of samples (n2) per month to base permit on	20	20	20	20	20	20	20	20	20	20	20	20	20	20
WLAs and PERMIT LIMITS FOR PULLMAN WTP														
i. Z Statistics														
LTA Derivation (99%tile)	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
Daily Maximum Permit Limit (99%tile)	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326	2.326
Monthly Average Permit Limit (95%tile)	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645	1.645
2. Calculated Waste Load Allocations (WLA's)														
Acute (one-hour) WLA	17.15	19.80	24.01	7.60	7.42	4.24	6.73	7.34	9.88	11.32	19.39	21.95	8.80	19.72
Chronic (n1-day) WLA	2.71	2.88	3.12	1.17	0.90	0.54	0.89	0.96	1.43	1.89	2.94	3.05	1.15	2.96
3. Back-Calculation of Long Term Averages (LTA's)														
Sigma (same for acute and chronic)	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555	0.555
Mu for Acute WLA	1.552	1.696	1.889	0.739	0.714	0.154	0.617	0.703	1.000	1.137	1.675	1.799	0.885	1.692
Mu-n1 for Chronic WLA	0.743	0.805	0.883	-0.098	-0.354	-0.868	-0.374	-0.292	0.100	0.381	0.825	0.861	-0.113	0.831
Mu for Chronic WLA	0.595	0.657	0.736	-0.246	-0.502	-1.016	-0.521	-0.439	-0.048	0.233	0.678	0.713	-0.261	0.683
LTA for Acute (one-hour) WLA	5.51	6.36	7.71	2.44	2.38	1.36	2.16	2.36	3.17	3.64	6.22	7.05	2.82	6.33
LTA for Chronic (n1-day) WLA	2.12	2.25	2.43	0.91	0.71	0.42	0.69	0.75	1.11	1.47	2.30	2.38	0.90	2.31
Most Limiting LTA (minimum of acute and chronic)	2.12	2.25	2.43	0.91	0.71	0.42	0.69	0.75	1.11	1.47	2.30	2.38	0.90	2.31
4. Derivation of Permit Limits From Limiting LTA														
Mu for daily maximum permit limit	0.595	0.657	0.736	-0.246	-0.502	-1.016	-0.521	-0.439	-0.048	0.233	0.678	0.713	-0.261	0.683
Mu-n2 for monthly average permit limit	0.740	0.802	0.881	-0.101	-0.357	-0.871	-0.377	-0.294	0.097	0.378	0.822	0.858	-0.116	0.828
Sigma^2-n for monthly avg permit limit	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Daily Maximum Permit Limit	6.59	7.01	7.58	2.84	2.20	1.32	2.16	2.34	3.46	4.58	7.15	7.41	2.80	7.19
Monthly Average Permit Limit	2.61	2.78	3.00	1.13	0.87	0.52	0.85	0.93	1.37	1.82	2.84	2.94	1.11	2.85

Appendix F.3 (continued):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
	A: Monthly Permit Limits												B: Semi-Annual Limits	
INPUT ASSUMPTIONS FOR ALBION WTP WLAs/PERMIT LIMITS														
1. Water Quality Standards/Criteria (Concentration)														
Acute (one-hour) Criteria		10.63	11.70	4.31	3.68								4.92	8.57
Chronic (n-day) Criteria		1.86	1.83	0.78	0.50								0.67	1.65
2. Upstream Receiving Water Concentration														
Upstream Concentration for Acute Condition		0.93	0.83	0.21	0.08								0.07	0.79
Upstream Concentration for Chronic Condition		0.93	0.83	0.21	0.08								0.07	0.79
3. Dilution Factors (1/(Effluent Volume Fraction))														
Fraction of River Flow to Allow for Acute Dilution Factor		100%	100%	100%	100%								100.0%	100.0%
Fraction of River Flow to Allow for Chronic Dilution Factor		100%	100%	100%	100%								100%	100%
Acute Receiving Water Dilution Factor		70.133	73.091	62.476	54.286								57.383	73.261
Chronic Receiving Water Dilution Factor		70.13	73.09	62.48	54.29								57.38	73.26
4. Coefficient of Variation for Effluent Concentration		0.6	0.6	0.6	0.6								0.6	0.6
5. Number of days (n1) for chronic average		30	30	30	30								30	30
6. Number of samples (n2) per month to base permit on		4	4	4	4								4	4
WLAs and PERMIT LIMITS FOR ALBION WTP														
1. Z Statistics														
LTA Derivation (99%tile)		2.326	2.326	2.326	2.326								2.326	2.326
Daily Maximum Permit Limit (99%tile)		2.326	2.326	2.326	2.326								2.326	2.326
Monthly Average Permit Limit (95%tile)		1.645	1.645	1.645	1.645								1.645	1.645
2. Calculated Waste Load Allocations (WLA's)														
Acute (one-hour) WLA		681.56	795.74	256.17	195.66								278.27	571.27
Chronic (n1-day) WLA		66.74	74.24	35.52	23.10								34.43	63.89
3. Back-Calculation of Long Term Averages (LTA's)														
Sigma (same for acute and chronic)		0.555	0.555	0.555	0.555								0.555	0.555
Mu for Acute WLA		5.235	5.389	4.256	3.987								4.339	5.058
Mu-n1 for Chronic WLA		3.947	4.053	3.316	2.886								3.285	3.903
Mu for Chronic WLA		3.799	3.905	3.168	2.738								3.137	3.755
LTA for Acute (one-hour) WLA		218.84	255.50	82.25	62.82								89.35	183.43
LTA for Chronic (n1-day) WLA		52.08	57.93	27.72	18.03								26.86	49.85
Most Limiting LTA (minimum of acute and chronic)		52.08	57.93	27.72	18.03								26.86	49.85
4. Derivation of Permit Limits From Limiting LTA														
Mu for daily maximum permit limit		3.799	3.905	3.168	2.738								3.137	3.755
Mu-n2 for monthly average permit limit		3.910	4.016	3.279	2.849								3.248	3.866
Sigma^2-n for monthly avg permit limit		0.086	0.086	0.086	0.086								0.086	0.086
Daily Maximum Permit Limit		162.19	180.41	86.32	56.14								83.7	155.3
Monthly Average Permit Limit		80.85	89.93	43.03	27.99								41.7	77.4

Appendix F-4. Summary of ammonia TMDL, WTP WLAs, and permit limits for alternative permit scenarios.
Units are total ammonia in lbs/day as NH3-N or mg/L as NH3-N as noted. NH3CRI5.WK1\SMRY2

			A: Monthly Permit Limits												B: Semi-Annual Limits	
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
ALTERNATIVE 1A and 1B: MIXING ZONE MAX OF 25% and 2.5% of UPSTREAM FLOW FOR CHRONIC AND ACUTE.																
PULLMAN POTW	TMDL:	lbs/day NH3-N	119.8	129.1	132.1	47.9	26.7	13.0	19.2	25.0	48.9	65.6	117.1	113.1	37.8	119.3
	Nonpoint/Background LA:	"	24.5	25.6	25.7	8.4	3.2	0.9	0.7	1.0	4.2	7.4	29.1	25.4	1.7	30.8
	POTW WLA:	"	74.6	76.1	73.4	29.6	15.7	8.3	13.3	16.3	31.9	41.5	59.0	62.5	24.8	59.1
	Reserve Unallocated Load:	"	20.8	27.4	33.0	9.9	7.9	3.7	5.2	7.7	12.8	16.6	29.0	25.2	11.3	29.4
	POTW WLA:	mg/L NH3-N	2.1	2.1	2.2	0.68	0.60	0.37	0.64	0.65	1.0	1.3	2.0	2.2	0.79	2.0
	PERMIT LIMITS:															
	Daily Max:	mg/L NH3-N	5.2	5.2	5.2	2.1	1.5	0.91	1.5	1.6	2.5	3.3	4.8	5.3	1.9	4.8
	Monthly Avg:	"	2.0	2.0	2.1	0.84	0.58	0.36	0.61	0.63	0.98	1.3	1.9	2.1	0.76	1.9
	Daily Max:	lbs/day NH3-N	181	185	178	72	38	20	32	40	77	101	143	152	60	144
	Monthly Avg:	"	72	73	71	28	15	8	13	16	31	40	57	60	24	57
ALBION POTW	TMDL:	lbs/day NH3-N		131.0	133.9	48.7	27.2								38.5	121.0
	Nonpoint/Background LA:	"		50.5	44.7	10.4	2.9								2.8	43.0
	POTW WLA:	"		27.8	31.7	10.7	8.5								11.8	23.0
	Reserve Unallocated Load:	"		52.7	57.5	27.6	15.8								23.9	55.0
	POTW WLA:	mg/L NH3-N		28	32	11	8.5								12	23
	PERMIT LIMITS:															
	Daily Max:	mg/L NH3-N		28	32	11	8.5								12	23
	Monthly Avg:	"		14	16	5.3	4.2								5.9	11
	Daily Max:	lbs/day NH3-N		28	32	11	8.5								12	23
	Monthly Avg:	"		14	16	5.3	4.2								5.9	11
ALTERNATIVE 2A and 2B: MIXING ZONE MAX OF 100% of UPSTREAM FLOW FOR CHRONIC AND ACUTE.																
PULLMAN POTW	TMDL:	lbs/day NH3-N	119.8	129.1	132.1	47.9	26.7	13.0	19.2	25.0	48.9	65.6	117.1	113.1	37.8	119.3
	Nonpoint/Background LA:	"	24.5	25.6	25.7	8.4	3.2	0.9	0.7	1.0	4.2	7.4	29.1	25.4	1.7	30.8
	POTW WLA:	"	95.4	103.5	106.4	39.5	23.6	12.0	18.5	24.0	44.7	58.1	88.0	87.7	36.1	88.5
	Reserve Unallocated Load:	"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	POTW WLA:	mg/L NH3-N	2.7	2.9	3.1	1.2	0.90	0.54	0.89	1.0	1.4	1.9	2.9	3.0	1.2	3.0
	PERMIT LIMITS:															
	Daily Max:	mg/L NH3-N	6.6	7.0	7.6	2.8	2.2	1.3	2.2	2.3	3.5	4.6	7.2	7.4	2.8	7.2
	Monthly Avg:	"	2.6	2.8	3.0	1.1	0.87	0.52	0.85	0.93	1.4	1.8	2.8	2.9	1.1	2.9
	Daily Max:	lbs/day NH3-N	232	251	259	96	57	29	45	58	109	141	214	213	88	215
	Monthly Avg:	"	92	100	103	38	23	12	18	23	43	56	85	84	35	85
ALBION POTW	TMDL:	lbs/day NH3-N		131.0	133.9	48.7	27.2								38.5	121.0
	Nonpoint/Background LA:	"		64.1	59.6	13.1	4.1								4.0	57.0
	POTW WLA:	"		66.8	74.3	35.6	23.1								34.5	64.0
	Reserve Unallocated Load:	"		0.0	0.0	0.0	0.0								0.0	0.0
	POTW WLA:	mg/L NH3-N		67	74	36	23								34	64
	PERMIT LIMITS:															
	Daily Max:	mg/L NH3-N		162	180	86	56								84	155
	Monthly Avg:	"		81	90	43	28								42	77
	Daily Max:	lbs/day NH3-N		162	181	86	56								84	155
	Monthly Avg:	"		81	90	43	28								42	78

APPENDIX G

Derivation of Permit Limits by Monte Carlo Simulation

Monte Carlo simulation was used to combine the water quality model and permit limit calculations with statistically described inputs. The major advantages of Monte Carlo simulation for derivation of permit limits are (EPA, 1992):

- It can directly estimate the permit limits that correspond to the allowable frequency and duration requirements of the water quality criteria.
- It can be used with the same steady state water quality model that is used for the point estimate method.
- It can incorporate the cross-correlation and interaction of model variables such as river flow and temperature.

Using this technique, probability density functions are assigned to each term in the water quality model reflecting the variability in that characteristic. Then, with synthetic sampling, values are randomly chosen from the distributions of each term. These values are inserted into the model, and a prediction is calculated. After this is repeated a large number of times, a distribution of predicted values results, which reflects the combined uncertainties of all model variables.

The following steps describe the Monte Carlo procedure used to estimate water quality-based permit limits for total ammonia:

Step 1: Estimate 30-day seasonal low flow for USGS gaging stations for each Monte Carlo iteration. Weibull distributions of annual 30-day low flows for USGS stations 13348000 and 13348500 were estimated. The lowest 30-day low flows for each year of 1971-81 were calculated and the Weibull distribution was fit using WQHYDRO (Aroner, 1992). The Weibull distribution was found to closely represent low-flow frequencies in the SFPR and Missouri Flat Creek, and is the most widely used distribution for low-flow frequency analysis (Nathan and McMahon, 1990). The following parameters describe the low flow distributions using the notation of Haan (1977) for flows in cfs:

Weibull Parameter	Apr-Oct	Nov-Mar
USGS Station 13348000, 1971-81		
Alpha	2.8922	0.7435
Beta	4.4580	11.910
Epsilon	1.6170	6.7620
USGS Station 13348500, 1971-81		
Alpha	3.6000	0.9052
Beta	0.3190	1.9986
Epsilon	0.1268	0.2880

Step 2: Estimate river flows for each iteration immediately above Pullman POTW as sum of natural flows of Paradise Creek excluding Moscow POTW, design discharge from Moscow POTW, natural flow from SFPR above Paradise Creek, and Missouri Flat Creek. River flow immediately above Albion POTW was estimated by also adding design flow from Pullman POTW. POTW design flows were estimated as highest monthly averages for the season of interest when the POTW reaches the design capacity maximum monthly flow. The distribution of monthly average POTW flows for the 1989-91 period was scaled proportionally to the ratio of:

(maximum monthly design flow) / (maximum monthly 1989-91 flow)

to estimate seasonal design flows when the POTWs are at maximum monthly design flows. The resulting seasonal design flows for Moscow, Pullman, and Albion POTWs are as follows:

POTW	Apr-Oct	Nov-Mar
POTW Design Flows (cfs)		
Moscow	4.80	5.42
Pullman	6.26	6.65
Albion	0.19	0.19

Natural river flows from Paradise Creek (i.e. excluding Moscow POTW) were estimated as the SFPR flows at USGS 13348000 less SFPR flows from above Paradise Creek and current Moscow POTW flows. SFPR flows from above Paradise creek were estimated as Missouri Flat Creek flows at USGS 13348500 multiplied by the ratio of drainage areas of SFPR above Paradise Creek and Missouri Flat Creek. Flows at the USGS stations were randomly selected from the Weibull distributions for Monte Carlo simulation estimates of flows above the POTWs.

Step 3: Estimate temperature and pH distributions at Ecology station 34B110. Distributions of temperature and pH for permitting periods were estimated from critical periods within each permitting period. Critical periods were selected based on occurrence of lowest monthly average flows during the 1971-81 period. For the April-October permit period, critical low flows occurred only during the months of July-October. For the November-March permit period, critical low flows occurred during November. A log-normal distribution was assumed for temperature and normal for pH. Means and standard deviations of critical temperature and pH were found to be as follows:

Parameter	Apr-Oct	Nov-Mar
Temperature (degrees C)		
Mean	14.82	5.61
Std Dev	4.28	2.50
pH (standard units)		
Mean	8.10	7.81
Std Dev	0.50	0.52

Temperature and pH distributions were found to be independent of flow for the critical periods, with the exception of July-October temperature. A regression analysis of July-October temperature versus flow was used to estimate temperatures for the April-October permit period:

Jul-Oct Temperature at 34B110 (deg C) =
27.334 * [Jul-Oct Flow at 34B110 (cfs)] ^ (-0.3755)
Std Dev = 3.90 deg C

<u>Step 4</u>: Estimate mixing zone temperature and pH for each iteration by regression analysis of Pullman POTW upstream and downstream data. The regression equation was applied to temperature and pH at Ecology station 34B110 to estimate mixing zone temperature and pH. The regression equations for temperature and pH are:

Mixing Zone Temperature (deg C) =
2.904 + 0.9297 * [34B110 Temperature (deg C)]
Std Dev = 2.04 deg C
$r^2 = 0.91$

Mixing Zone pH (s.u.) =
2.592 + 0.6284 * [34B110 pH (s.u.)]
Std Dev = 0.21
$r^2 = 0.58$

<u>Step 5</u>: Estimate temperature and pH of Paradise Creek at the state line for each iteration by regression analysis of monthly monitoring data during water year 1992 (unpublished Ecology ambient monitoring data). The following regression equations were obtained:

Temperature of Paradise Cr at State Line (deg C) =
7.171 + 0.7381 * [34B110 Temperature (deg C)]
Std Dev = 1.87 deg C
$r^2 = 0.85$

pH of Paradise Cr at State Line (s.u.) =
5.305 + 0.2624 * [34B110 pH (s.u.)]
Std Dev = 0.14
$r^2 = 0.28$

<u>Step 6</u>: Acute and chronic aquatic life criteria for total ammonia were calculated for each iteration from randomly selected temperature and pH estimates from Steps 4 and 5. Results of Step 4 were used to estimate criteria for Pullman and Albion POTW mixing zones. Results of Step 5 were used to estimate criteria for Paradise Creek at the state line.

<u>Step 7</u>: Estimate instream nitrification rates for each iteration. The nitrification rates were randomly selected from a log-normal distribution with mean of 8.15 day^{-1} and standard deviation of 5.76 day^{-1} (base e) at 20 degrees C based on monitoring data during water year 1992. Nitrification rates (K) at ambient temperature (T) were estimated from rates at 20 degrees C (K_{20}) by the equation:

$$K = K_{20} * 1.08^{(T-20)}$$

<u>Step 8</u>: Estimate ammonia concentrations immediately upstream from Pullman POTW and Albion POTW for each iteration. For Pullman POTW, Paradise Creek at the state line was assumed to begin at the chronic criterion calculated in Step 6. Then nitrification rates from Step 7 were used in a first-order decay equation to estimate the concentration above Pullman POTW assuming a minimum concentration of 0.05 mg/L as N. For Albion POTW, Pullman POTW was assumed to discharge at the WLA (calculated in the following step), then the first-order decay equation was used to calculate concentration above Albion also assuming a minimum concentration of 0.05 mg/L as N. The first-order decay equation used to account for nitrification was:

$$C_{up} = C_0 * \exp(-Kt)$$

where C_{up} is the ammonia concentration immediately above Pullman or Albion POTW, C_0 is the chronic criterion for Pullman POTW or the mixed river concentration below Pullman (at Pullman's WLA) for the Albion POTW, K is the nitrification rate from Step 6, t is travel time from C_0 to C_{up} (0.89 days from Paradise Creek at state line to Pullman POTW; 0.69 days from Pullman POTW to Albion POTW).

<u>Step 9</u>: Estimate acute and chronic WLAs for Pullman POTW and Albion POTW for total ammonia for each iteration. A simple mass balance equation was used:

$$WLA = ALC*[(f*Q_{up}+Q_{potw})/Q_{potw}]-[C_{up}*(f*Q_{up}/Q_{potw})]$$

where ALC is the aquatic life criterion for total ammonia from Step 6, f is the fraction of upstream flow allowed for the mixing zone (25% for chronic and 2.5% for acute), and Q_{potw} is the POTW design flow from Step 2.

Step 10: Calculate water quality-based permit limits for each iteration from the WLAs incorporating effluent variability using the method of EPA (1991). The effluent coefficient of variation (CV) for ammonia was assumed to be 0.6; 20 samples per month were assumed for Pullman POTW and 4 per month for Albion; 30-day averaging period for chronic; Z-statistic for long-term average and daily maximum permit limits was 2.326 (99%tile); and Z-statistic for monthly average limits was 1.645 (95%tile).

Step 11: Run Monte Carlo simulation for 1000 iterations using @RISK (Palisade Corporation) and Lotus 1-2-3 (Lotus Development Corporation) to obtain distributions of seasonal WLAs and permit limits. The WLAs and permit limits corresponding to an annual excursion frequency of once every three years were selected to meet the frequency requirement of WAC 173-201A-040(3). For semi-annual permits, excursion frequencies of once every six years for each season were assumed to correspond to an annual excursion frequency of once every three years (EPA, 1984). The resulting daily maximum and monthly average permit limits were obtained:

	Apr-Oct	Nov-Mar
Pullman POTW Total Ammonia-N (mg/L as N)		
Daily Max	2.1	4.7
Monthly Avg	0.83	1.9
Albion POTW Total Ammonia-N (mg/L as N)		
Daily Max	12.	28.
Monthly Avg	6.2	14.

Appendix H

Dissolved Oxygen Analysis

Appendix H-1
PARADISE CREEK DO PREDICTIONS BELOW STATE LINE

Temperature = 22.27 degrees C

Stateline NH3-N = 1.1 BOD5 = 45, 30, 20, 10, 0

1 EFFLUENT CHARACTERISTICS (Moscow POTW)						
Discharge (cfs) (max monthly avg April-Oct)	3.79	3.79	3.79	3.79	3.79	3.79
CBOD5 (mg/L) (max weekly avg)	45	30	20	10	5	0
Ammonia (mg/L) (chronic criterion at state line assumed to est max weekly avg)	1.1	1.1	1.1	1.1	1.1	1.1
NBOD (mg/L)	5.027	5.027	5.027	5.027	5.027	5.027
Dissolved Oxygen (mg/L) (assume at sat'n w/ temp)	7.988	7.988	7.988	7.988	7.988	7.988
Temperature (deg C) (regression est for 90%tile at stateline)	22.27	22.27	22.27	22.27	22.27	22.27
2. RECEIVING WATER CHARACTERISTICS (Physical data for Paradise Creek to Critical Sag)						
Upstream Discharge (cfs) (assume)	0	0	0	0	0	0
Upstream CBOD5 (mg/L) (load=0)	2.0	2.0	2.0	2.0	2.0	2.0
Upstream NBOD (mg/L) (load=0)	0.2	0.2	0.2	0.2	0.2	0.2
Upstream Dissolved Oxygen (mg/L)	7.988	7.988	7.988	7.988	7.988	7.988
Upstream Temperature (deg C)	22.27	22.27	22.27	22.27	22.27	22.27
Elevation (ft NGVD)	2300	2300	2300	2300	2300	2300
Downstream Average Channel Slope (ft/ft)	0.00392	0.00392	0.00392	0.00392	0.00392	0.00392
Downstream Average Channel Depth (ft)	0.81	0.81	0.81	0.81	0.81	0.81
Downstream Average Channel Velocity (fps)	0.59	0.59	0.59	0.59	0.59	0.59
3. REAERATION RATE (Base e) AT 20 deg C (day^-1)	15.92	15.92	15.92	15.92	15.92	15.92
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Churchill	9.86	9.86	9.86	9.86	9.86	9.86
O'Connor and Dobbins	13.62	13.62	13.62	13.62	13.62	13.62
Owens	22.33	22.33	22.33	22.33	22.33	22.33
Tsivoglou-Wallace	15.92	15.92	15.92	15.92	15.92	15.92
4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1)	3.33	3.33	3.33	3.33	3.33	3.33
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Wright and McDonnell, 1979	3.33	3.33	3.33	3.33	3.33	3.33

OUTPUT **

1 INITIAL MIXED RIVER CONDITION						
CBOD5 (mg/L)	45.0	30.0	20.0	10.0	5.0	0.0
NBOD (mg/L)	5.0	5.0	5.0	5.0	5.0	5.0
Dissolved Oxygen (mg/L)	8.0	8.0	8.0	8.0	8.0	8.0
Temperature (deg C)	22.3	22.3	22.3	22.3	22.3	22.3
2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)						
Reaeration (day^-1)	16.80	16.80	16.80	16.80	16.80	16.80
BOD Decay (day^-1)	3.70	3.70	3.70	3.70	3.70	3.70
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU						
Initial Mixed CBODU (mg/L)	66.2	44.1	29.4	14.7	7.4	0.0
Initial Mixed Total BODU (CBODU + NBOD, mg/L)	71.2	49.1	34.4	19.7	12.4	5.0
4. INITIAL DISSOLVED OXYGEN DEFICIT						
Saturation Dissolved Oxygen (mg/L)	7.988	7.988	7.988	7.988	7.988	7.988
Initial Deficit (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days)	0.12	0.12	0.12	0.12	0.12	0.12
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles)	1.11	1.11	1.11	1.11	1.11	1.11
7 CRITICAL DO DEFICIT (mg/L)	10.22	7.06	4.94	2.83	1.78	0.72
8. CRITICAL DO CONCENTRATION (mg/L) [negative value indicates DO = 0]	-2.23	0.93	3.04	5.15	6.21	7.27

****

Full solution DO deficit (Chapter 6.4.4 of Thomann and Mueller, 1987 eqns a, b, c, e, and f):

1 Reaction Rates (same Ka and Kd as above, Kn may be different)						
Ka = reaeration (d^-1 base e at ambient temperature)	16.80	16.80	16.80	16.80	16.80	16.80
Kd = BOD decay (d^-1 base e at ambient temperature)	3.70	3.70	3.70	3.70	3.70	3.70
Kr = overall BOD loss rate (d^-1 base e at ambient temp)	3.70	3.70	3.70	3.70	3.70	3.70
Kn = nitrification (d^-1 base e at ambient temperature)	3.57	3.57	3.57	3.57	3.57	3.57
pa = daily averaged gross photosynthesis (mg/L/d)	9.70	9.70	9.70	9.70	9.70	9.70
R = daily averaged gross respiration (mg/L/d)	2.43	2.43	2.43	2.43	2.43	2.43
half of diurnal DO range (mg/L)	1.5	1.5	1.5	1.5	1.5	1.5
(a) = initial value of DO deficit (mg/L)	0.000	0.000	0.000	0.000	0.000	0.000
(b) = deficit due to CBOD (mg/L)	9.500	6.334	4.222	2.111	1.056	0.000
(c) = deficit due to NBOD (mg/L)	0.704	0.704	0.704	0.704	0.704	0.704
(e) = deficit due to gross photosynthesis (mg/L)	-0.495	-0.495	-0.495	-0.495	-0.495	-0.495
(f) = deficit due to gross respiration (mg/L)	0.124	0.124	0.124	0.124	0.124	0.124
D = a+b+c+e+f = total DO deficit at point of critical sag (mg/L)	9.833	6.666	4.555	2.444	1.388	0.333
DO = DOsat - D = daily avg DO at point of critical sag (mg/L)	-1.845	1.321	3.432	5.544	6.599	7.655
DOmin = DO - (half diurnal range) = diel min DO at point of critical sag (mg/L)	-3.345	-0.179	1.932	4.044	5.099	6.155
[negative values for DO or DOmin indicate DO = 0]						
Remaining CBOD5 and NBOD above Pullman WTP						
Travel time from Paradise Cr at state line to SFPR RM 21.3 (days)	0.904	0.904	0.904	0.904	0.904	0.904
CBOD5 remaining at SFPR RM 21.3 above Pullman WTP (mg/L)	1.590	1.060	0.707	0.353	0.177	0.000
NBOD remaining at SFPR RM 21.3 above Pullman WTP (mg/L)	0.199	0.199	0.199	0.199	0.199	0.199

****

Daily Averaged Gross Photosynthesis and Respiration (pa and R) estimated from
Diurnal min/max DO data for Paradise Creek
using eqn 6.44 and 6.46 of Thomann and Mueller, 1987:

Creek Mile	DATE	DOmax (mg/L)	DOmin (mg/L)	Temp (degC)	pa (mg/L/d)	R (mg/L/d)	Half Diurnal Range (mg/L)
6.4	910724	5.10	2.70	20.85	7.68	1.92	1.20
6.4	911001	1.70	1.30	16.85	1.28	0.32	0.20
3.4	910724	9.70	4.50	20.9	16.64	4.16	2.60
3.4	911001	4.30	2.70	13.7	5.12	1.28	0.80
3.4	911002	4.00	2.90	12.5	3.52	0.88	0.55
1.0	910724	13.70	5.25	22.25	27.04	6.76	4.23
1.0	911001	12.50	7.80	13.1	15.04	3.76	2.35
1.0	911002	10.90	7.10	11.8	12.16	3.04	1.90
0.0	910724	10.20	6.75	22.15	11.04	2.76	1.72
0.0	911001	10.40	9.50	12.75	2.88	0.72	0.45
0.0	911002	10.60	9.25	10.85	4.32	1.08	0.67
AVG:					9.70	2.43	1.52

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Appendix H-2
S FORK PALOUSE RIVER DO PREDICTIONS BELOW PULLMAN WTP
Temperature = 21.93 degrees C

Pullman NH3-N = 76, BOD5 = 45, 30, 20, 10, 0

1 EFFLUENT CHARACTERISTICS (Pullman WTP)						
Discharge (cfs) (max monthly avg during April-Oct)	5.82	5.82	5.82	5.82	5.82	5.82
CBOD5 (mg/L) (max weekly avg)	45	30	20	10	5	0
Ammonia (mg/L) (assume max monthly avg estimates max weekly avg)	0.76	0.76	0.76	0.76	0.76	0.76
NBOD (mg/L)	3.473	3.473	3.473	3.473	3.473	3.473
Dissolved Oxygen (mg/L)	8.040	8.040	8.040	8.040	8.040	8.040
Temperature (deg C)	21 93	21.93	21.93	21 93	21.93	21 93
2 RECEIVING WATER CHARACTERISTICS (Quality of SFPR above Pullman and physical data in SFPR)						
Upstream Discharge (cfs)	4.7	4.7	4.7	4.7	4.7	4.7
Upstream CBOD5 = max of 2 or remaining from decay in Paradise Cr (mg/L)	2.000	2.000	2.000	2.000	2.000	2.000
Upstream NBOD = max of 0.2 or remaining from decay in Paradise Cr (mg/L)	0.200	0.200	0.200	0.200	0.200	0.200
Upstream Dissolved Oxygen (mg/L) (assume at sat'n w/ temp)	8.04	8.04	8.04	8.04	8.04	8.04
Critical Sag Temperature (deg C) (regression est of 90%tile in mixing zone)	21.93	21.93	21.93	21.93	21.93	21.93
Elevation (ft NGVD)	2300	2300	2300	2300	2300	2300
Downstream Average Channel Slope (ft/ft)	0.00316	0.00316	0.00316	0.00316	0.00316	0.00316
Downstream Average Channel Depth (ft) (Jul&Oct avg of SF2-9)	0.756	0.756	0.756	0.756	0.756	0.756
Downstream Average Channel Velocity (fps) (Jul&Oct avg of SF2-9)	0.597	0.597	0.597	0.597	0.597	0.597
3. REAERATION RATE (Base e) AT 20 deg C (day^-1)	7.82	7.82	7.82	7.82	7.82	7.82
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Churchill	11.23	11.23	11.23	11.23	11.23	11.23
O'Connor and Dobbins	15.23	15.23	15.23	15.23	15.23	15.23
Owens	25.64	25.64	25.64	25.64	25.64	25.64
Tsivoglou-Wallace	7.82	7.82	7.82	7.82	7.82	7.82
4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1)	3.25	3.25	3.25	3.25	3.25	3.25
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Wright and McDonnell, 1979	3.25	3.25	3.25	3.25	3.25	3.25

OUTPUT

1 INITIAL MIXED RIVER CONDITION						
CBOD5 (mg/L)	25.8	17 5	12.0	6.4	3.7	0.9
NBOD (mg/L)	2.0	2.0	2.0	2.0	2.0	2.0
Dissolved Oxygen (mg/L)	8.0	8.0	8.0	8.0	8.0	8.0
Temperature (deg C)	21.9	21 9	21.9	21 9	21 9	21 9
2 TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)						
Reaeration (day^-1)	8.18	8.18	8.18	8.18	8.18	8.18
BOD Decay (day^-1)	3.55	3.55	3.55	3.55	3.55	3.55
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU						
Initial Mixed CBODU (mg/L)	37.9	25.7	17.6	9.4	5.4	1 3
Initial Mixed Total BODU (CBODU + NBOD, mg/L)	39.9	27 7	19.6	11.5	7 4	3.3
4. INITIAL DISSOLVED OXYGEN DEFICIT						
Saturation Dissolved Oxygen (mg/L)	8.040	8.040	8.040	8.040	8.040	8.040
Initial Deficit (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days)	0.18	0.18	0.18	0.18	0.18	0.18
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles)	1 76	1 76	1 76	1 76	1 76	1 76
7. CRITICAL DO DEFICIT (mg/L)	9.14	8.35	4.49	2.62	1.69	0.76
8. CRITICAL DO CONCENTRATION (mg/L) [negative value indicates DO = 0]	-1 10	1.69	3.55	5.42	6.35	7.28

Full solution DO deficit (Chapter 6.4.4 of Thomann and Mueller 1987 eqns a, b, c. e and f):

1 Reaction Rates (same Ka and Kd as above, Kn may be different)						
Ka = reaeration (d^-1 base e at ambient temperature)	8.18	8.18	8.18	8.18	8.18	8.18
Kd = BOD decay (d^-1 base e at ambient temperature)	3.55	3.55	3.55	3.55	3.55	3.55
Kr = overall BOD loss rate (d^-1 base e at ambient temp)	3.55	3.55	3.55	3.55	3.55	3.55
Kn = nitrification (d^-1 base e at ambient temperature)	3.48	3.48	3.48	3.48	3.48	3.48
pa = daily averaged gross photosynthesis (mg/L/d)	17.03	17.03	17.03	17.03	17.03	17.03
R = daily averaged gross respiration (mg/L/d)	4.26	4.26	4.26	4.26	4.26	4.26
half of diurnal DO range (mg/L)	2.66	2.66	2.66	2.66	2.66	2.66
(a) = initial value of DO deficit (mg/L)	0.000	0.000	0.000	0.000	0.000	0.000
(b) = deficit due to CBOD (mg/L)	8.681	5.886	4.025	2.163	1.232	0.301
(c) = deficit due to NBOD (mg/L)	0.454	0.454	0.454	0.454	0.454	0.454
(e) = deficit due to gross photosynthesis (mg/L)	-1.605	-1.605	-1.605	-1.605	-1.605	-1.605
(f) = deficit due to gross respiration (mg/L)	0.401	0.401	0.401	0.401	0.401	0.401
D = a+b+c+e+f = total DO deficit at point of critical sag (mg/L)	7.932	5.136	3.276	1.414	0.482	-0.449
DO = DOsat - D = daily avg DO at point of critical sag (mg/L)	0.109	2.902	4.764	6.626	7.558	8.489
DOmin = DO - (half diurnal range) = diel min DO at point of critical sag (mg/L)	-2.551	0.242	2.104	3.966	4.898	5.829
[negative values for DO or DOmin indicate DO = 0]						
Remaining CBOD5 and NBOD above Albion WTP						
Travel time from SFPR RM 21.3 to 14.1 (days)	0.737	0.737	0.737	0.737	0.737	0.737
CBOD5 remaining at SFPR RM 14.1 above Albion WTP (mg/L)	1.880	1.275	0.872	0.468	0.267	0.065
NBOD remaining at SFPR RM 21 3 above Albion WTP (mg/L)	0.156	0.155	0.155	0.155	0.155	0.155

Daily Averaged Gross Photosynthesis and Respiration (pa and R) estimated from
Diurnal min/max DO data for S Fork Palouse River
using eqn 6.44 and 6.46 of Thomann and Mueller 1987:

River Mile	DATE	DOmax (mg/L)	DOmin (mg/L)	pa (mg/L/d)	R (mg/L/d)	Half Diurnal Range (mg/L)
22.2	910724	12.25	7 80	14.24	3.56	2.23
21.4	910724	13.10	4.80	26.56	6.64	4.15
21.2	910724	11.05	4.50	20.96	5.24	3.28
18.7	910724	14.30	4.35	31.84	7.96	4.98
14.9	910724	11.30	5.30	19.2	4.8	3.00
14.0	910724	11.00	6.00	16	4	2.50
13.1	910724	10.05	5.00	16.16	4.04	2.53
22.2	911001	12.85	9.05	12.16	3.04	1.90
21.4	911001	12.75	7.70	16.16	4.04	2.53
21.2	911001	9.60	6.70	9.28	2.32	1.45
18.7	911001	15.10	5.20	31.68	7.92	4.95
14.9	911001	10.50	7.40	9.92	2.48	1.55
14.0	911001	11.10	8.10	9.6	2.4	1.50
13.1	911001	11.80	6.90	15.68	3.92	2.45
8.9	911001	10.10	8.20	6.08	1.52	0.95
AVG:				17 03	4.26	2.66

Appendix H-3
S FORK PALOUSE RIVER DO PREDICTIONS BELOW ALBION WTP

Temperature = 22.27 degrees C

Albion WTP NH3-N = 5.9, BOD5 = 45, 30, 20, 10, 0

1 EFFLUENT CHARACTERISTICS (Albion WTP)						
Discharge (cfs) (max monthly avg during April-May)	0.19	0.19	0.19	0.19	0.19	0.19
CBOD5 (mg/L) (max weekly avg)	45	30	20	10	5	0
Ammonia (mg/L) (assume max monthly avg estimates max weekly avg)	5.9	5.9	5.9	5.9	5.9	5.9
NBOD (mg/L)	26.963	26.963	26.963	26.963	26.963	26.963
Dissolved Oxygen (mg/L)	8.040	8.040	8.040	8.040	8.040	8.040
Temperature (deg C)	21.93	21.93	21.93	21.93	21.93	21.93
2 RECEIVING WATER CHARACTERISTICS (Quality of SFPR above Pullman and physical data in SFPR)						
Upstream Discharge (cfs)	10.52	10.52	10.52	10.52	10.52	10.52
Upstream CBOD5 = max of 2 or remaining from decay below Pullman (mg/L)	2.000	2.000	2.000	2.000	2.000	2.000
Upstream NBOD = max of 0.2 or remaining from decay below Pullman (mg/L)	0.200	0.200	0.200	0.200	0.200	0.200
Upstream Dissolved Oxygen (mg/L) (assume at sat'n w/ temp)	8.04	8.04	8.04	8.04	8.04	8.04
Critical Sag Temperature (deg C) (regression est of 90%tile in mixing zone)	21.93	21.93	21.93	21.93	21.93	21.93
Elevation (ft NGVD)	2300	2300	2300	2300	2300	2300
Downstream Average Channel Slope (ft/ft)	0.00316	0.00316	0.00316	0.00316	0.00316	0.00316
Downstream Average Channel Depth (ft) (Jul&Oct avg of SF2-9)	0.756	0.756	0.756	0.756	0.756	0.756
Downstream Average Channel Velocity (fps) (Jul&Oct avg of SF2-9)	0.597	0.597	0.597	0.597	0.597	0.597
3. REAERATION RATE (Base e) AT 20 deg C (day^-1)	7.82	7.82	7.82	7.82	7.82	7.82
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Churchill	11.23	11.23	11.23	11.23	11.23	11.23
O'Connor and Dobbins	15.23	15.23	15.23	15.23	15.23	15.23
Owens	25.64	25.64	25.64	25.64	25.64	25.64
Tsivoglou-Wallace	7.82	7.82	7.82	7.82	7.82	7.82
4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1)	3.22	3.22	3.22	3.22	3.22	3.22
Reference	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value	Suggest Value
Wright and McDonnell, 1979	3.22	3.22	3.22	3.22	3.22	3.22

OUTPUT

1 INITIAL MIXED RIVER CONDITION						
CBOD5 (mg/L)	2.6	2.5	2.3	2.1	2.1	2.0
NBOD (mg/L)	0.7	0.7	0.7	0.7	0.7	0.7
Dissolved Oxygen (mg/L)	8.0	8.0	8.0	8.0	8.0	8.0
Temperature (deg C)	21.9	21.9	21.9	21.9	21.9	21.9
2 TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)						
Reaeration (day^-1)	8.18	8.18	8.18	8.18	8.18	8.18
BOD Decay (day^-1)	3.52	3.52	3.52	3.52	3.52	3.52
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU						
Initial Mixed CBODU (mg/L)	4.1	3.7	3.4	3.1	3.0	2.9
Initial Mixed Total BODU (CBODU + NBOD, mg/L)	4.7	4.3	4.1	3.8	3.7	3.6
4. INITIAL DISSOLVED OXYGEN DEFICIT						
Saturation Dissolved Oxygen (mg/L)	8.040	8.040	8.040	8.040	8.040	8.040
Initial Deficit (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days)	0.18	0.18	0.18	0.18	0.18	0.18
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles)	1.77	1.77	1.77	1.77	1.77	1.77
7. CRITICAL DO DEFICIT (mg/L)	1.08	0.99	0.93	0.87	0.84	0.81
8. CRITICAL DO CONCENTRATION (mg/L) [negative value indicates DO = 0]	6.96	7.05	7.11	7.17	7.20	7.23

Full solution DO deficit (Chapter 6.4.4 of Thomann and Mueller 1987 eqns a, b, c, e, and f):

1 Reaction Rates (same Ka and Kd as above, Kn may be different)						
Ka = reaeration (d^-1 base e at ambient temperature)	8.18	8.18	8.18	8.18	8.18	8.18
Kd = BOD decay (d^-1 base e at ambient temperature)	3.52	3.52	3.52	3.52	3.52	3.52
Kr = overall BOD loss rate (d^-1 base e at ambient temp)	3.52	3.52	3.52	3.52	3.52	3.52
Kn = nitrification (d^-1 base e at ambient temperature)	3.48	3.48	3.48	3.48	3.48	3.48
pa = daily averaged gross photosynthesis (mg/L/d)	17.03	17.03	17.03	17.03	17.03	17.03
R = daily averaged gross respiration (mg/L/d)	4.26	4.26	4.26	4.26	4.26	4.26
half of diurnal DO range (mg/L)	2.66	2.66	2.66	2.66	2.66	2.66
(a) = initial value of DO deficit (mg/L)	0.000	0.000	0.000	0.000	0.000	0.000
(b) = deficit due to CBOD (mg/L)	0.925	0.836	0.776	0.717	0.687	0.658
(c) = deficit due to NBOD (mg/L)	0.152	0.152	0.152	0.152	0.152	0.152
(e) = deficit due to gross photosynthesis (mg/L)	-1.608	-1.608	-1.608	-1.608	-1.608	-1.608
(f) = deficit due to gross respiration (mg/L)	0.402	0.402	0.402	0.402	0.402	0.402
D = a+b+c+e+f = total DO deficit at point of critical sag (mg/L)	-0.128	-0.217	-0.277	-0.336	-0.366	-0.396
DO = DOsat - D = daily avg DO at point of critical sag (mg/L)	8.169	8.258	8.317	8.376	8.406	8.436
DOmin = DO - (half diurnal range) = diel min DO at point of critical sag (mg/L)	5.509	5.598	5.657	5.716	5.746	5.776
[negative values for DO or DOmin indicate DO = 0]						
Remaining CBOD5 and NBOD above Albion WTP						
Travel time from SFPR RM 21.3 to 14.1 (days)	0.737	0.737	0.737	0.737	0.737	0.737
CBOD5 remaining at SFPR RM 14.1 above Albion WTP (mg/L)	0.206	0.186	0.173	0.160	0.153	0.147
NBOD remaining at SFPR RM 21.3 above Albion WTP (mg/L)	0.052	0.052	0.052	0.052	0.052	0.052

Daily pa and R estimated from
Diurnal min/max DO data for S Fork Palouse River
using eqn 6.44 and 6.46 of Thomann and Mueller 1987:

River Mile	DATE	DOmax (mg/L)	DOmin (mg/L)	pa (mg/L/d)	R (mg/L/d)	Half Diurnal Range (mg/L)
22.2	910724	12.25	7.80	14.24	3.56	2.225
21.4	910724	13.10	4.80	26.56	6.64	4.15
21.2	910724	11.05	4.50	20.96	5.24	3.275
18.7	910724	14.30	4.35	31.84	7.96	4.975
14.9	910724	11.30	5.30	19.2	4.8	3
14.0	910724	11.00	6.00	16	4	2.5
13.1	910724	10.05	5.00	16.16	4.04	2.525
22.2	911001	12.85	9.05	12.16	3.04	1.9
21.4	911001	12.75	7.70	16.16	4.04	2.525
21.2	911001	9.60	6.70	9.28	2.32	1.45
18.7	911001	15.10	5.20	31.68	7.92	4.95
14.9	911001	10.50	7.40	9.92	2.48	1.55
14.0	911001	11.10	8.10	9.6	2.4	1.5
13.1	911001	11.80	6.90	15.68	3.92	2.45
8.9	911001	10.10	8.20	6.08	1.52	0.95
AVG:				17.03	4.26	2.66