



# South Fork Palouse River Total Maximum Daily Load for Ammonia

## Addendum to the 1993 Report

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### Abstract

The Department of Ecology published a report in 1993 with proposed Total Maximum Daily Loads (TMDLs) for ammonia for critical points in the South Fork Palouse River. The Department of Ecology adopted an EPA modification of criteria for freshwater chronic un-ionized ammonia after the publication of the 1993 report. This addendum report supplements and supersedes information in the 1993 TMDL Report. This addendum includes revised waste load allocations for effluent discharged by the city of Pullman POTW and revised criteria for Paradise Creek at the state line.

The ammonia limits recommended in this report for Pullman POTW are approximately 20 percent higher than the limits recommended in the 1993 TMDL report. The recommended limits for Albion POTW are the same as in the 1993 TMDL Report because limits for Albion are controlled by the acute criteria, which did not change. The changes in recommended ammonia limits for Pullman POTW are due to the revised criteria for chronic un-ionized ammonia.

### Introduction

This report documents changes to the recommended Total Maximum Daily Loads (TMDLs) for ammonia in the South Fork Palouse River (SFPR). These changes supplement and supersede information in the 1993 TMDL Report (Pelletier, 1993). The changes include revised waste load allocations (WLAs) for effluent discharged by publicly-owned treatment works (POTWs) for the cities of Pullman and Albion.

The changes documented in this addendum were made to incorporate changes to the freshwater chronic un-ionized ammonia criteria. The Department of Ecology has recently decided to adopt changes to the criteria that were recommended by the U. S. Environmental Protection Agency (Ecology, 1995; USEPA, 1992). The USEPA recalculated the criteria by removing some controversial data from the basis of the criteria. The Department of Ecology is planning to include the revised criteria in the next triennial revision of the water quality standards and, in the interim, recommends use of the recalculated criteria for water quality-based permits for dischargers that are regulated under the National Pollutant Discharge Elimination System (NPDES).

The revised equations to calculate the freshwater chronic criteria for ammonia are presented in Appendix A of this addendum report. Critical conditions for all other variables were left unchanged from those presented in the 1993 TMDL Report. Discussion of assumptions for critical conditions are not included in this addendum because details are provided in the 1993 TMDL Report.

## Revised Ammonia Criteria and WLAs

### *Mixing Zone Considerations and Permit Periods*

Ecology uses WAC 173-201A-100 to define mixing zones for NPDES discharges. The mixing zone rule was applied by limiting available dilution flows to 25% of upstream flows for meeting chronic criteria and 2.5% of upstream flows for meeting acute criteria. The semi-annual periods selected in the 1993 TMDL Report were evaluated in this addendum (April-October and November-March.)

### *Criteria in Paradise Creek at the State Line*

USEPA Region 10 has authority for WLAs for Idaho discharges. The temperature and pH values listed in *Table 3 of the 1993 TMDL Report* are recommended to establish criteria for total ammonia in Paradise Creek at the state line for the Idaho WLAs, as well as in the SFPR 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	1.24	9.42
November-March	13.6	7.47	2.13	12.9

The revised chronic criteria are approximately 13 percent higher for April-October and 18 percent higher for November-March compared with the recommendations in the 1993 TMDL Report. The acute criteria in this addendum are the same as those used in the 1993 TMDL Report.

### ***TMDL, WLAs, and LAs for Total Ammonia***

Semi-annual periods for permitting were evaluated. The method used to determine WLAs for Pullman and Albion POTWs was the same as the procedure documented in the 1993 TMDL Report. The calculation procedure was as follows:

- ***Step 1:*** Select design condition temperature and pH at Ecology ambient monitoring station 34B110 (*Table 3 of the 1993 TMDL Report*). 90th percentiles were used for critical conditions. 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 percentiles of 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 of the 1993 TMDL Report*). 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 =  $(20.46)(0.9297)+2.904 = 21.93$  degrees C, and critical pH =  $(8.60)(0.6284)+2.592 = 8.00$  standard units. The corresponding ammonia criteria are 0.794 mg/L as N for chronic and 4.92 mg/L as N for acute.]
- ***Step 3:*** Estimate semi-annual POTW design flows for Pullman and Albion POTWs (*Table 2 of the 1993 TMDL Report*). 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 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 of the 1993 TMDL Report*. 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 ( $K_{20}$ ;  $\text{day}^{-1}$  base e) of  $2.95 \text{ day}^{-1}$  was assumed at  $20^\circ\text{C}$  based on the 90th percentile of 1991-92 data. Monthly and semi-annual nitrification rates ( $K$ ;  $\text{day}^{-1}$ ) were adjusted to design ambient temperature from *Table 3 of the 1993 TMDL Report*. [Example: for the April-October season, the nitrification rate between Paradise Creek at the state line and the SFPR at the Pullman POTW is  $(2.95)(1.08^{[20.46-20]}) = 3.06 \text{ day}^{-1}$  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, then use the first-order decay equation to estimate the concentration above Pullman POTW 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 the first-order decay equation to calculate the 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. Velocities equations are as follows: between Paradise Creek at the state line and Pullman POTW, velocity (ft/sec) =  $0.325 [\text{Flow at SFPR RM 22.2 (cfs)}]^{0.4}$ ; between Pullman and Albion POTW, velocity (ft/sec) =  $0.330 [\text{Flow at SFPR RM 22.2 (cfs)}]^{0.4}$ . [Example: for the Pullman POTW during the April-October season, the ammonia concentration upstream =  $(1.24)(e^{-[(3.06)(0.901)])} = 0.079 \text{ mg/L as N}$  for an initial concentration of 1.24 mg/L as N at the state line, nitrification rate of  $3.06 \text{ day}^{-1}$ , 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:

$$\text{TMDL} = \text{ALC} * (\text{Q}_{up} + \text{Q}_{potw})$$

where ALC is the aquatic life criteria for total ammonia (mg/L as N),  $\text{Q}_{up}$  is the upstream river flow from Step 4, and  $\text{Q}_{potw}$  is the critical POTW flow. [Example: for the Pullman POTW during the April-October season, the chronic ALC is 0.794 mg/L as N,  $\text{Q}_{up}$  is 4.65 cfs, and  $\text{Q}_{potw}$  is 5.82 cfs. Therefore the TMDL is  $(0.794)(4.65 + 5.82)$  multiplied by a units conversion factor of 5.3936, which equals 44.8 lbs/day of total ammonia as N].

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

$$\text{LA} = \text{Q}_{up} * C_{up}$$

[Example: for the Pullman POTW during the April-October season, the LA for upstream sources is  $(4.65 \text{ cfs})(0.079 \text{ mg/L as N})(5.3936) = 2.0 \text{ lbs/day as N}$ ].

- **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 criteria). [Example: for the Pullman POTW during the April-October season: ALC = 0.794 mg/L as N, f = 0.25, Q<sub>up</sub> = 4.65 cfs, Q<sub>potw</sub> = 5.82 cfs, and C<sub>up</sub> = 0.079 mg/L as N. Therefore, the chronic WLA = (0.794)[(0.25\*4.65+5.82)/5.82]-[0.079\*(0.25\*4.65/5.82)] = 0.94 mg/L as N. The mass loading for the WLA is calculated by multiplying the WLA concentration (0.94 mg/L as N, which was calculated as 0.936 mg/L as N before rounding of input and output variables in the previous equation) by the critical POTW flow (5.82 cfs) and the conversion factor of 5.3936 to obtain (0.936)(5.82)(5.3936) = 29.4 lbs/day as N].

- **Step 10:** Calculate water quality-based permit limits from the WLAs incorporating effluent variability using the method of USEPA (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 percentile); and Z-statistic for monthly average permit limits was 1.645 (95 percentile). [Example: for the Pullman POTW during the April-October season, following calculation procedures of USEPA 1991a (detailed in Appendix B-2), the permit limits for total ammonia were found to be a monthly average of 0.90 mg/L as N and daily maximum of 2.3 mg/L as N. These concentration limits correspond to mass load limits of a monthly average of 28 lbs/day as N and a daily maximum of 71 lbs/day as N for the critical POTW flow of 5.82 cfs].

The detailed intermediate calculations are presented in *Appendix B* of this addendum. A summary of the recommended ammonia TMDLs, background LAs, POTW WLAs, and proposed permit limits for alternative permit scenarios is presented in *Appendix B-3*. A margin of safety, which is required for assigning WLAs and LAs in a TMDL (USEPA, 1991b), was incorporated through use of conservative assumptions.

#### ***Recommended Permit Limits for Pullman and Albion POTWs***

Recommended semi-annual permit limits for the Pullman and Albion POTWs are as follows from Appendix B-2 and B-3 [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 (0.19 cfs) POTWs]:

	Apr-Oct		Nov-Mar	
	mg/L	lbs/day	mg/L	lbs/day
Pullman POTW Total Ammonia-N				
Monthly Avg	0.90	28.	2.3	68.
Daily Max	2.3	71.	5.7	170.
Albion POTW Total Ammonia-N				
Monthly Avg	5.9	5.9	11.	11.
Daily Max	12.	12.	23.	23.

The ammonia limits recommended in this report for Pullman POTW are approximately 20 percent higher than the limits recommended in the 1993 TMDL report. The recommended limits for Albion POTW are the same as in the 1993 TMDL Report because limits for Albion are controlled by the acute criteria, which did not change. The changes in recommended ammonia limits for Pullman POTW are due to the revised criteria for chronic un-ionized ammonia. The revised and originally recommended limits for Pullman POTW are presented in the following table for comparison:

Discharger	Season	Ammonia Permit Limit	Units of Total Ammonia as N	Revised Recommendations (this Addendum)	Original Recommendations (1993 TMDL Report)
Pullman	Apr-Oct	Monthly Avg	mg/L	0.90	0.76
			lbs/day	28.	24.
		Daily Max	mg/L	2.3	1.9
			lbs/day	71.	60.
	Nov-Mar	Monthly Avg	mg/L	2.3	1.9
			lbs/day	68.	57.
		Daily Max	mg/L	5.7	4.8
			lbs/day	170.	144.

## Conclusions and Recommendations

- This report documents changes to the recommended Total Maximum Daily Loads for ammonia in the South Fork Palouse River. These changes supplement and supersede information in the 1993 TMDL Report. The changes include revised criteria for Paradise Creek at the state line and revised waste load allocations for effluent discharged by the city of Pullman POTW.
- The changes documented in this addendum were made to incorporate changes to the freshwater chronic un-ionized ammonia criteria. The Department of Ecology has recently decided to adopt changes to the criteria that were recommended by the U.S. Environmental Protection Agency. The Department of Ecology is planning to include the revised criteria in the next triennial revision of the water quality standards and, in the interim, recommends use of the recalculated criteria for water quality-based permits for dischargers that are regulated under NPDES.
- USEPA Region 10 has authority for WLAs for Idaho discharges. 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	1.24	9.42
November-March	13.6	7.47	2.13	12.9

- Recommended semi-annual permit limits for the Pullman and Albion POTWs are as follows [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				
Monthly Avg	0.90	28.	2.3	68.
Daily Max	2.3	71.	5.7	170.
Albion POTW Total Ammonia-N				
Monthly Avg	5.9	5.9	11.	11.
Daily Max	12.	12.	23.	23.

- The ammonia limits recommended in this report for Pullman POTW are approximately 20 percent higher than the limits recommended in the 1993 TMDL report. The recommended limits for Albion POTW are the same as in the 1993 TMDL Report because limits for Albion are controlled by the acute criteria, which did not change. The changes in recommended ammonia limits for Pullman POTW are due to the revised criteria for chronic un-ionized ammonia.

## References

- Ecology. 1995. Permit Writer's Manual. Procedures for Writing Wastewater Discharge Permits. Washington State Department of Ecology. Water Quality Program. Publication Number 92-109. Revised March 14, 1995.
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- USEPA. 1991a. Technical support document for water quality-based toxics control. U.S. Environmental Protection Agency. EPA/505/2-90-001.
- USEPA. 1991b. Guidance for water quality-based decisions: the TMDL process. U. S. Environmental Protection Agency. Office of Water Regulations and Standards. EPA 440/4-91-001.
- USEPA. 1992. Memorandum. Subject: Revised Tables for Determining Average Freshwater Ammonia Concentrations. From: Margarete Heber, Chief, Water Quality Criteria Section, and Kent Ballentine, Chief, Regulation and Policy Section. To: Water Quality Standards Coordinators. U.S. Environmental Protection Agency. Office of Water. Washington, D.C. July 30, 1992.



## **Appendices**

## Appendix A

### *Revised Chronic Freshwater Ammonia Criteria*

The 4-day average concentration of un-ionized ammonia (in mg/L as NH<sub>3</sub>) shall not exceed the numeric value given by 0.80/FT/FPH/RATIO, where:

FT	= 10 <sup>(0.03(20-TCAP))</sup> ;	TCAP ≤ T ≤ 30
	= 10 <sup>(0.03(20-T))</sup> ;	0 ≤ T ≤ TCAP
FPH	= 1 ;	8 ≤ pH ≤ 9
	= (1 + 10 <sup>(7.4-pH)</sup> ) / 1.25 ;	6.5 ≤ pH ≤ 8
TCAP	= 15 degrees C ;	salmonids present
	= 20 degrees C ;	salmonids absent
RATIO	= 13.5 ;	7.7 ≤ pH ≤ 9
	= [(20.25)(10 <sup>(7.7-pH)</sup> )] / (1+10 <sup>(7.4-pH)</sup> ) ;	6.5 ≤ pH ≤ 7.7

The revised criteria were incorporated into a spreadsheet that made the following conversions:

- converted units from un-ionized ammonia to total ammonia by calculating the fraction of un-ionized ammonia, and
- converted from units of mg/L as NH<sub>3</sub> to mg/L as N by using the conversion factor of 0.822 mg N per mg NH<sub>3</sub>.

The formulas for the spreadsheet calculations of ammonia criteria, in Lotus® 1-2-3® format (Lotus Development Corporation, Cambridge, MA), are as follows:

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A1: PR [W60] 'Calculation of un-ionized ammonia concentration and criteria.
A2: PR [W60] 'Based on EPA Gold Book (EPA 440/5-86-001) and revised by Heber (1992).
A4: PR [W60] 'Lotus File NH3FRES2.WK1 Revised 12-Dec-94
A5: PR [W60] \_
B5: PR [W12] \_
A7: PR [W60] 'INPUT
A9: PR [W60] ' 1. Temperature (deg C; 0<T<30):
B9: (F1) U [W12] 20
A11: PR [W60] ' 2. pH (6.5<pH<9.0):
B11: (F2) U [W12] 7.25
A13: PR [W60] ' 3. Total Ammonia (ug N/L):
B13: (F1) U [W12] 200
A15: PR [W60] ' 4. Acute TCAP (Salmonids present- 20; absent- 25):
B15: U [W12] 20
A17: PR [W60] ' 5. Chronic TCAP (Salmonids present- 15; absent- 20):
B17: U [W12] 15
A20: PR [W60] \_
B20: (F4) PR [W12] \_
A22: PR [W60] 'OUTPUT
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A24: PR [W60] ' 1. Intermediate Calculations:  
 A26: PR [W60] ' Acute FT:  
 B26: (F4) PR [W12]  
 @IF(B9>=B15#AND#B9<=30,10^(0.03\*(20-B15)),@IF(B9>=0#AND#B9<B15,10^(0.03\*(20-B9)),@ERR))  
 A27: PR [W60] ' Chronic FT:  
 B27: (F4) PR [W12]  
 @IF(B9>=B17#AND#B9<=30,10^(0.03\*(20-B17)),@IF(B9>=0#AND#B9<B17,10^(0.03\*(20-B9)),@ERR))  
 A28: PR [W60] ' FPH:  
 B28: (F4) PR [W12] @IF(B11>8#AND#B11<=9,1,@IF(B11>=6.5#AND#B11<=8,(1+10^(7.4-B11))/1.25,@ERR))  
 A29: PR [W60] ' RATIO:  
 B29: (F4) PR [W12]  
 @IF(B11>=7.7#AND#B11<=9,13.5,@IF(B11>=6.5#AND#B11<7.7,20.25\*(10^(7.7-B11))/(1+10^(7.4-B11)),@ERR))  
 A30: PR [W60] ' pKa:  
 B30: (F4) PR [W12] 0.09018+2729.92/(273.2+B9)  
 A31: PR [W60] ' Fraction Of Total Ammonia Present As Un-ionized:  
 B31: (P4) PR [W12] 1/((10^(B30-B11))+1)  
 A34: PR [W60] ' 2. Sample Un-ionized Ammonia Concentration (ug/L as NH3-N):  
 B34: (F1) PR [W12] +B31\*B13  
 A37: PR [W60] ' 3. Un-ionized Ammonia Criteria:  
 A39: PR [W60] ' Acute (1-hour) Un-ionized Ammonia Criterion (ug/L as NH3-N):  
 B39: (F1) PR [W12] 1000\*(0.52/B26/B28/2)\*0.822  
 A40: PR [W60] ' Chronic (4-day) Un-ionized Ammonia Criterion (ug/L as NH3-N):  
 B40: (F1) PR [W12] 1000\*(0.8/B27/B28/B29)\*0.822  
 A43: PR [W60] ' 4. Total Ammonia Criteria:  
 A45: PR [W60] ' Acute Total Ammonia Criterion (ug/L as NH3-N):  
 B45: (,0) PR [W12] +B39/B31  
 A46: PR [W60] ' Chronic Total Ammonia Criterion (ug/L as NH3-N):  
 B46: (,0) PR [W12] +B40/B31  
 A48: PR [W60] \\_  
 B48: PR [W12] \\_

Appendix B-1: (NH3CR19 WK1,appd-b.1) Criteria used for monthly and semi-annual permit limit analysis for ammonia (replaces Appendix F-1 of the 1993 TMDL Report).

A. Monthly Permit Limits

B. Semi-Annual Limits

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
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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	8.18	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	1.00	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	13.60	14.80	16.60	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	15.07	13.50	13.50
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)	15.5	16.8	16.1	34.5	34.5	34.5	34.5	34.5	34.4	33.3	23.0	15.2	34.4	23.0

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)	2,279	2,210	2,168	922	594	377	655	653	1,042	1,386	1,954	2,230	794	1,954

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	19.37	19.92	20.71	15.32	14.75	13.50	15.96	15.90	16.49	17.08	18.64	20.04	16.49	18.64
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%	1.86%	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)	11.0	12.2	12.7	23.6	25.0	28.8	22.1	22.2	20.9	19.7	15.3	11.5	20.9	15.3

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	11,581	12,900	14,084	9,422	12,900
Chronic Total Ammonia Criterion (ug N/L)	2,192	2,149	2,123	1,759	1,377	1,230	1,176	1,187	1,551	1,784	2,129	2,162	1,245	2,129

Appendix B-2: (NH3CR19 WK1,appd-b2) Monthly and semi-annual WLAs and permit limits for ammonia discharge from Pullman and Albion POTWs (mixing zones based on 25% and 2.5% of flow for chronic and acute criteria )  
 (replaces Appendix F-2 of the 1993 TMDL Report.)

	A. Monthly Permit Limits												B. Semi-Annual Limits		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar	
<b>MONTHLY TMDL/WLA GENERAL INPUT ASSUMPTIONS</b>															
1. Monthly Design Flows (cfs):															
Paradise Creek at Stalene	5.03	5.96	5.42	4.74	4.24	2.60	2.16	2.56	3.67	3.96	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	0.82	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	0.19	
5. In-stream nitrification rates:															
Nitrification rate at 20 deg C (day <sup>-1</sup> )	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.95	
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	20.46	8.76	
Nitrification rate at ambient temperature (day <sup>-1</sup> )	0.84	1.07	1.27	1.86	2.65	3.11	3.33	3.29	2.22	1.82	1.24	0.99	3.06	1.24	
6. In-stream Percent Reduction in Total Ammonia															
Estimated Flow at SF PRM 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 Stalene 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%	

Appendix B-2 (continued)

B Semi-Annual Limits

A: Monthly Permit Limits

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Nov-Mar Apr-Oct

INPUT ASSUMPTIONS FOR PULLMAN WTP WLAS/PERMIT LIMITS

1. Aquatic Life Criteria at Pullman WTP (Total Ammonia mg/L as N)	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
Acute (one-hour) Criteria	2.28	2.21	2.17	0.92	0.59	0.38	0.66	0.65	1.04	1.39	1.95	2.23	0.79	1.95
Chronic (n-day) Criteria														
2. Receiving Water Concentration Upstream from Pullman WTP	1.07	0.91	0.80	0.36	0.14	0.05	0.05	0.05	0.20	0.35	0.84	0.96	0.079	0.86
Upstream Concentration for Acute Condition	1.07	0.91	0.80	0.36	0.14	0.05	0.05	0.05	0.20	0.35	0.84	0.96	0.079	0.86
Upstream Concentration for Chronic Condition														
3. Dilution Factors (1/(Effluent Volume Fraction))	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 Acute Dilution Factor	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Fraction of River Flow to Allow for Chronic Dilution Factor	1.019	1.023	1.028	1.021	1.026	1.021	1.017	1.021	1.019	1.021	1.034	1.027	1.020	1.035
Acute Receiving Water Dilution Factor	1.193	1.232	1.279	1.206	1.262	1.207	1.166	1.206	1.193	1.205	1.344	1.272	1.200	1.355
Chronic Receiving Water Dilution Factor														
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

1. Z Statistics	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
LTA Derivation (99%ile)	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%ile)	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
Monthly Average Permit Limit (95%ile)														
2. Calculated Waste Load Allocations (WLA's)	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
Acute (one-hour) WLA	2.51	2.51	2.55	1.04	0.71	0.45	0.76	0.78	1.20	1.60	2.34	2.58	0.936	2.34
Chronic (n1-day) WLA														
3. Back-Calculation of Long Term Averages (LTA's)	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
Sigma (same for acute and chronic)	1.037	1.095	1.196	0.190	0.038	-0.420	0.128	0.128	0.460	0.579	0.890	1.126	0.323	0.890
Mu for Acute WLA	0.667	0.667	0.682	-0.217	-0.592	-1.063	-0.534	-0.506	-0.069	0.215	0.595	0.692	-0.320	0.597
Mu-n1 for Chronic WLA	0.520	0.519	0.534	-0.365	-0.740	-1.211	-0.682	-0.654	-0.216	0.067	0.447	0.545	-0.467	0.449
Mu for Chronic WLA	3.29	3.49	3.85	1.41	1.21	0.77	1.32	1.33	1.85	2.08	2.84	3.60	1.61	2.84
LTA for Acute (one-hour) WLA	1.96	1.96	1.99	0.81	0.56	0.35	0.59	0.61	0.94	1.25	1.82	2.01	0.73	1.83
LTA for Chronic (n1-day) WLA	1.96	1.96	1.99	0.81	0.56	0.35	0.59	0.61	0.94	1.25	1.82	2.01	0.73	1.83
Most Limiting LTA (minimum of acute and chronic)														
4. Derivation of Permit Limits From Limiting LTA	0.520	0.519	0.534	-0.365	-0.740	-1.211	-0.682	-0.654	-0.216	0.067	0.447	0.545	-0.467	0.449
Mu for daily maximum permit limit	0.664	0.664	0.679	-0.220	-0.595	-1.066	-0.537	-0.509	-0.072	0.212	0.592	0.689	-0.323	0.594
Mu-n2 for monthly average 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
Sigma 2-n for monthly avg permit limit														
Daily Maximum Permit Limit	6.1	6.1	6.2	2.5	1.7	1.1	1.8	1.9	2.9	3.9	5.7	6.3	2.3	5.7
Monthly Average Permit Limit	2.4	2.4	2.5	1.0	0.69	0.43	0.73	0.75	1.2	1.5	2.3	2.5	0.90	2.3

A. Monthly Permit Limits B. Semi-Annual Limits

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

INPUT ASSUMPTIONS FOR ALBION WTP WLAs/PERMIT LIMITS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar
1. Water Quality Standards/Criteria (Concentration)														
Acute (one-hour) Criteria	10.63	11.70	4.31	3.68	4.92	8.57							4.92	8.57
Chronic (n-day) Criteria	2.21	2.17	0.92	0.59	0.79	1.95							0.79	1.95
2. Upstream Receiving Water Concentration														
Upstream Concentration for Acute Condition	0.86	0.73	0.20	0.06	0.06	0.70							0.06	0.70
Upstream Concentration for Chronic Condition	0.86	0.73	0.20	0.06	0.06	0.70							0.06	0.70
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%
Fraction of River Flow to Allow for Chronic Dilution Factor	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%							2.5%	2.5%
Acute Receiving Water Dilution Factor	2.728	2.802	2.537	2.332	2.410	2.807							2.410	2.807
Chronic Receiving Water Dilution Factor	18.28	19.02	16.37	14.32	15.10	19.07							15.10	19.07
4. Coefficient of Variation for Effluent Concentration	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
6. Number of samples (n2) per month to base permit on	4	4	4	4	4	4							4	4

WLAs and PERMIT LIMITS FOR ALBION WTP

1. Z Statistics														
LTA Derivation (95%tile)	2.326	2.326	2.326	2.326	2.326	2.326							2.326	2.326
Daily Maximum Permit Limit (95%tile)	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
2. Calculated Waste Load Allocations (WLA's)														
Acute (one-hour) WLA	27.51	31.47	10.63	8.50	11.77	22.79							11.77	22.79
Chronic (n1-day) WLA	25.46	28.02	12.02	7.65	11.15	24.55							11.15	24.55
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
Mu for Acute WLA	2.025	2.159	1.073	0.850	1.176	1.837							1.176	1.837
Mu-n1 for Chronic WLA	2.983	3.079	2.292	1.780	2.158	2.947							2.158	2.947
Mu for Chronic WLA	2.835	2.931	2.084	1.633	2.010	2.799							2.010	2.799
LTA for Acute (one-hour) WLA	8.83	10.10	3.41	2.73	3.78	7.32							3.78	7.32
LTA for Chronic (n1-day) WLA	19.87	21.87	9.38	5.97	8.70	19.16							8.70	19.16
Most Limiting LTA (minimum of acute and chronic)	8.83	10.10	3.41	2.73	3.78	7.32							3.78	7.32
4. Derivation of Permit Limits From Limiting LTA														
Mu for daily maximum permit limit	2.025	2.159	1.073	0.850	1.176	1.837							1.176	1.837
Mu-n2 for monthly average permit limit	2.135	2.270	1.184	0.960	1.286	1.947							1.286	1.947
Sigma*2-n for monthly avg permit limit	0.086	0.086	0.086	0.086	0.086	0.086							0.086	0.086
Daily Maximum Permit Limit	28	31	11	8.5	12	23							12	23
Monthly Average Permit Limit	14	16	5.3	4.2	5.9	11							5.9	11

Appendix B-3. (NH3CR19.WK1appd-b3) Summary of ammonia TMDL WLAs for POTWs, and permit limits for POTWs (replaces Appendix F-4 of the 1993 TMDL Report.)  
 Units are total ammonia in lbs/day as NH3-N or mg/L as NH3-N as noted

	A. Monthly Permit Limits												B. Semi-Annual Limits		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr-Oct	Nov-Mar	
<b>MIXING ZONE MAX OF 25% and 2.5% of UPSTREAM FLOW FOR CHRONIC AND ACUTE.</b>															
<b>PULLMAN POTW</b>															
TMDL:	142.0	153.0	156.5	56.7	31.7	15.4	22.7	29.6	58.0	77.7	138.8	134.0	44.8	141.4	
lbs/day NH3-N															
Nonpoint/Background LA:	28.0	30.4	30.4	9.9	3.8	0.9	0.7	1.0	5.0	8.8	34.5	30.1	2.0	36.5	
POTW WLA:	88.4	90.1	87.0	35.1	18.6	9.9	15.8	19.3	37.8	49.2	69.9	74.1	29.4	70.1	
Reserve Unallocated Load:	24.6	32.5	39.1	11.7	9.3	4.5	6.3	9.3	15.2	19.6	34.4	29.9	13.4	34.8	
POTW WLA:	2.5	2.5	2.6	1.04	0.71	0.45	0.76	0.78	1.2	1.6	2.3	2.6	0.94	2.3	
mg/L NH3-N															
<b>PERMIT LIMITS:</b>															
Daily Max:	6.1	6.1	6.2	2.5	1.7	1.08	1.8	1.9	2.9	3.9	5.7	6.3	2.3	5.7	
Monthly Avg:	2.4	2.4	2.5	1.00	0.69	0.43	0.73	0.75	1.16	1.5	2.3	2.5	0.90	2.3	
Daily Max:	215	219	211	85	45	24	38	47	92	120	170	180	71	170	
Monthly Avg:	85	87	84	34	18	10	15	19	36	47	67	71	28	68	
<b>ALBION POTW</b>															
TMDL:		155.2	158.7	57.7	32.3								45.6	143.4	
lbs/day NH3-N															
Nonpoint/Background LA:		59.9	53.0	12.3	3.4								3.3	50.9	
POTW WLA:		27.5	31.5	10.6	8.5								11.8	22.8	
Reserve Unallocated Load:		67.8	74.2	34.7	20.3								30.5	69.6	
POTW WLA:		28	31	11	8.5								12	23	
mg/L NH3-N															
<b>PERMIT LIMITS:</b>															
Daily Max:		28	31	11	8.5								12	23	
Monthly Avg:		14	16	5.3	4.2								5.9	11	
Daily Max:		28	32	11	8.5								12	23	
Monthly Avg:		14	16	5.3	4.2								5.9	11	