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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

ENDICOTT WASTEWATER TREATMENT PLANT LIMITED CLASS II INSPECTION AND IMPACT OF DISCHARGE ON REBEL FLAT CREEK

by
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ABSTRACT

On October 11-13, 1988, a limited Class II inspection and receiving water survey were conducted at the Endicott Wastewater Treatment Plant (WTP). The purpose of the study was to determine WTP efficiency and assess effects of effluent discharge on Rebel Flat Creek. Biochemical oxygen demand (BOD_5) and total suspended solids (TSS) were well within permit limits, however, fecal coliform and chlorine concentrations were not. The WTP effluent had intermittent flow. The creek:effluent dilution ratio was 3:1 during a typical morning discharge cycle. Chlorine was found at toxic levels in the creek. Total maximum daily load (TMDL) modeling predicted violations of water quality criteria for chlorine, un-ionized ammonia, fecal coliform, and dissolved oxygen at critical design conditions. Recommendations include an efficiency assessment of the chlorination system, effluent removal from the creek during summer low flow, and water quality-based permit limits for the winter flow period.

INTRODUCTION

The town of Endicott is located in Whitman County approximately 55 miles south of Spokane. Endicott's wastewater treatment plant (WTP) serves a population of about 330 and discharges into Rebel Flat Creek at river mile (RM) 5.9. Built in 1951, the WTP provides primary and secondary clarification, trickling filtration, and chlorination (Figure 1). Effluent discharge is intermittent.

WTP effluent quality is stipulated by National Pollutant Discharge Elimination System (NPDES) permit No. WA-002398-1, issued July 1, 1977. The town of Endicott submitted documentation at this time to establish that it could not, despite all reasonable best effort, achieve discharge limitations by July 1, 1977. Therefore, an amendment order (Docket No. DE 77-277) was issued the same year to provide more relaxed effluent limitations. As of October 1988, the relaxed limits were still in place. Relaxed NPDES permits are often issued for older plants like Endicott which were not designed to achieve present standards for secondary treatment. A mixing-zone is not described in the NPDES permit. The existing outfall, a bank pipe about two feet above the creek's surface, discharges effluent in a turbulent manner into the creek. For the purpose of this report effluent was assumed to instantaneously mix with the receiving water.

Rebel Flat Creek, a tributary to the Palouse River is a small, low-gradient stream which drains agricultural lands near Endicott (Figure 2). The stream is slow moving, about 3-5 feet in width and 2 feet in depth. Tall grass growing in the streambed and adjacent shoreline often shades the creek. Agricultural activities are primarily dry-land farming with some livestock and pasturage. Chapter 173-201-070 of the Washington Administrative Code (WAC) classifies Rebel Flat Creek a Class A (Excellent) waterbody. Characteristic uses for Class A waters include water supply (domestic, industrial, agricultural), fish and wildlife habitat, and recreation (primary contact, sport fishing, and aesthetic enjoyment).

Staff of the Eastern Regional Office (ERO) of Ecology believed Endicott WTP was operating reasonably well, but were concerned about potential impacts on Rebel Flat Creek, especially during low stream flow conditions. Therefore, ERO asked the Surface Water Investigations Section (SWIS) of Ecology to conduct a limited Class II inspection and receiving water study at Endicott. Study objectives were:

1. Evaluate WTP removal efficiency and compliance with NPDES permit;

2. Determine the effects of WTP effluent on Rebel Flat Creek during summer low-flow; and

3. Recommend activities to improve the effectiveness of Endicott WTP and protect the quality of Rebel Flat Creek.

METHODS

Composite and grab samples of influent and effluent were collected at the WTP on October 11-12, 1988. Influent samples were collected directly downstream of the comminutor and effluent samples were collected at the end of the chlorine contact chamber (Figure 1). Sampling parameters and frequency are listed in Table 1. Conductivity data were considered questionable after a quality assurance review and therefore, have been deleted.

ISCO sample compositors collected 200 mL every half-hour over a 24-hour period. Samples were stored on ice and arrived within 24-hours to the Ecology/Environmental Protection Agency (EPA) Laboratory in Manchester, Washington. All samples were analyzed according to procedures outlined by EPA (1983), APHA *et al.* (1985), and Huntamer (1986). Total residual chlorine (TRC) was determined on site using a LaMotte-Palin DPD test kit.

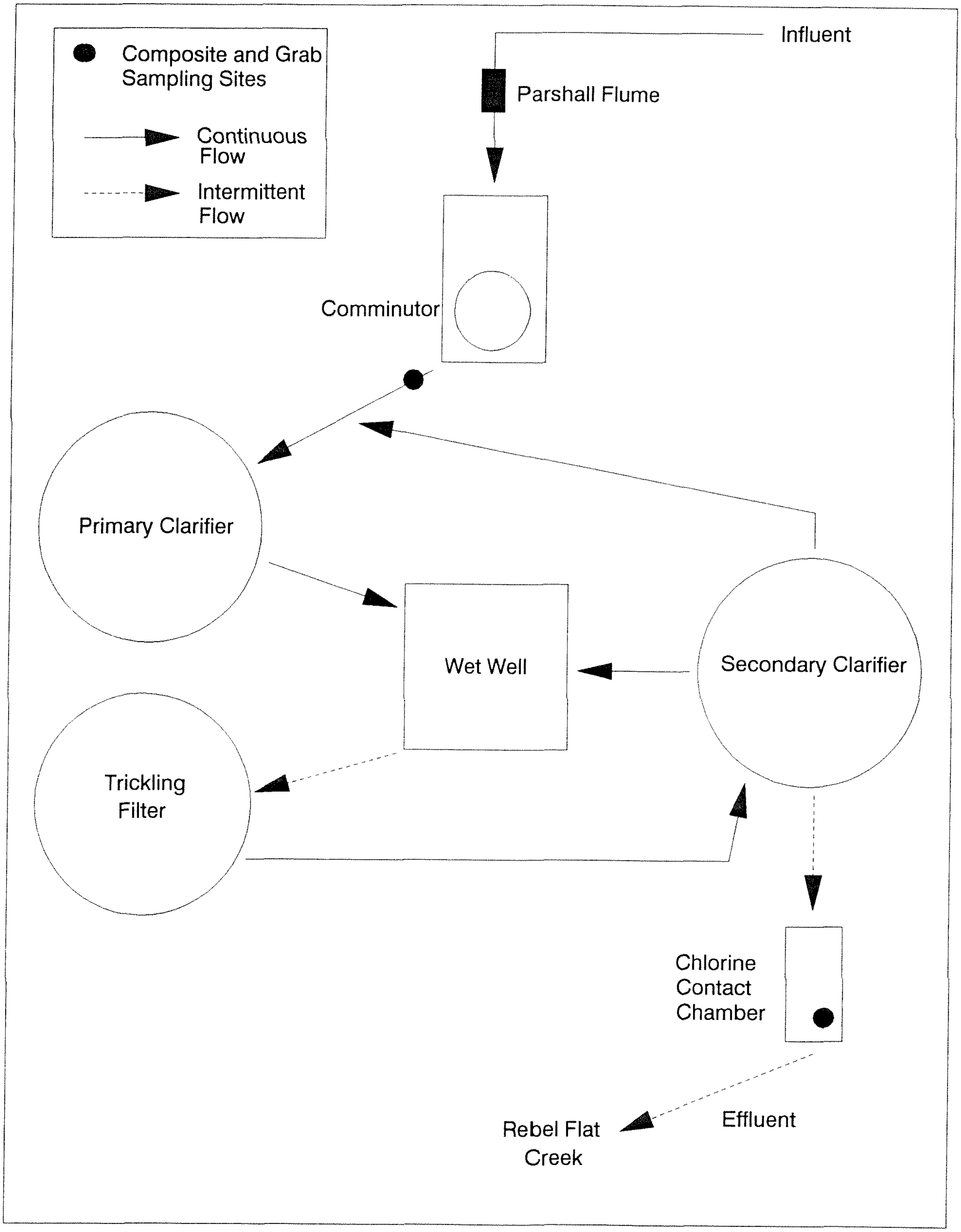

Figure 1. Diagram of Endicott WTP, showing wastewater flow and locations of composite and grab sampling sites, October 11-12, 1988.

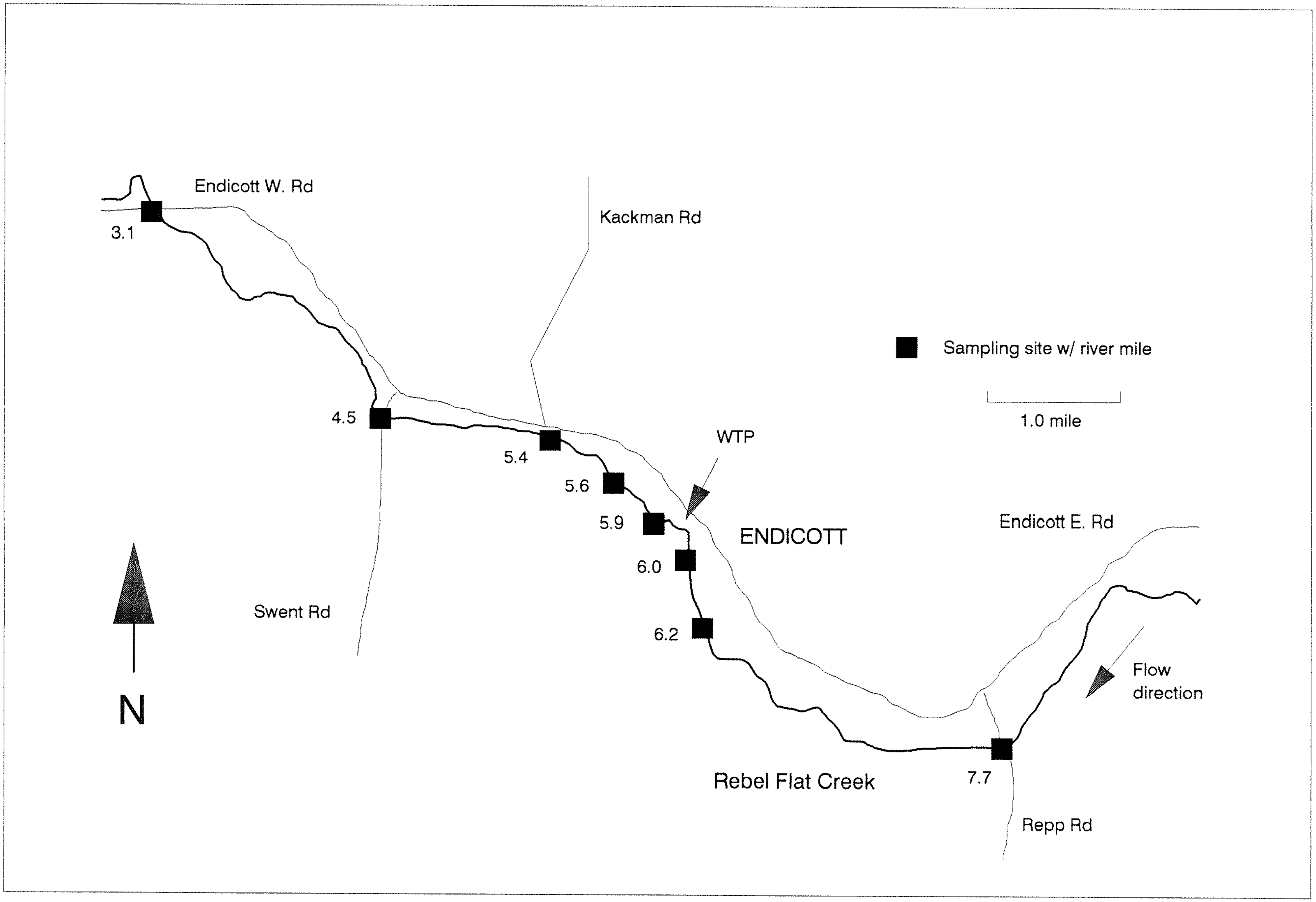

Figure 2. Map of study area with locations of sampling sites and Endicott WTP.

Table 1. Sampling design for Endicott WTP limited Class II inspection and receiving water survey conducted October 11-12, 1988.

Sample Type	Date	Time	Flow	Temp	pH	D.O.	TRC	FC	TSS	TNVSS	TS	TNVS	BOD_5	COD	$NUTS_3$	OG
			Parameter*													
CLASS II																
Influent Grab	10/11	0815	-	X	X	-	-	-	X	-	-	-	-	X	X	X
		1515	X	X+	X+	-	-	-	X+	-	-	-	-	X+	X+	-
	10/12	0750	X	X	X	-	-	-	-	-	-	-	-	X	X	-
		1140	X	X	X	-	-	-	X	-	-	-	-	X	X	-
Influent Comp.	10/12	0800	-	-	-	-	-	-	X	X	X	X	X	X	X	-
Effluent Grab	10/11	0828	-	X	X	X	X	X	X	-	-	-	-	X	X	X
		1540	XJ	X+	X+	X+	X	X+	X+	-	-	-	-	X+	X+	-
	10/12	0805	XJ	X	X	X	X	X	-	-	-	-	-	X	X	-
		1115	-	X	X	X	X	X	X	-	-	-	-	X	X	-
Effluent Comp.	10/12	0815	XJ	-	-	-	-	-	X	X	X	X	X	X	X	-
Drain near Outfall	10/12	1145	-	X	X	-	-	X	-	-	-	-	-	-	-	-
RECEIVING WATER																
RM 3.1	10/11	1000	X	X	X	X	-	X	X	-	-	-	-	X	X	-
	10/12	0925	X	X	X	X	-	X	X	-	-	-	-	X	X	-
RM 4.5	10/11	1025	-	X	X	X	-	X	X	-	-	-	-	X	X	-
	10/12	0945	-	X	X	X	-	X	X	-	-	-	-	X	X	-
RM 5.4	10/11	1053	-	X	X	X	X	X	X	-	-	-	-	X	X	-
	10/12	1005	-	X	X	X	-	X	X	-	-	-	-	X	X	-
RM 5.6	10/11	1125	X	X	X	X	X	X	X	-	-	-	-	X	X	-
	10/12	1025	X+	X	X	X	X	X	X	-	-	-	-	X	X	-
RM 5.9	10/11	1140	-	X+	X+	X+	-	X+	X+	-	-	-	-	X+	X+	-
	10/12	1050	-	X+	X+	X+	X+	X+	X+	-	-	-	X	X+	X+	-
RM 6.0	10/11	1335	-	X	X	X	-	X	X	-	-	-	-	X	X	-
	10/12	1125	-	X	X	X	-	X	X	-	-	-	-	X	X	-
RM 6.2	10/11	1356	X+	X	X	X	-	X	X	-	-	-	-	X	X	-
	10/12	1300	X	X	X	X	-	X	X	-	-	-	-	X	X	-
RM 7.7	10/11	1417	X	X	X	X	-	X	X	-	-	-	-	X	X	-
	10/12	1325	X	X	X	X	-	X	X	-	-	-	-	X	X	-

* - = No Sample
X = Sample collected
X+ = Replicate sample collected
XJ = Estimated value

Temp = Temperature
D.O. = Dissolved Oxygen
TRC = Total Residual Chlorine
FC = Fecal Coliform
TSS = Total Suspended Solids
OG = Oil and Grease

TNVSS = Total Nonvolatile Suspended Solids
TS = Total Solids
TNVS = Total Nonvolatile Solids
BOD_5 = 5-Day Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
$NUTS_3$ = Nutrients: ammonia, nitrate+nitrite, total phosphorus

Composite samples collected by Ecology and grab samples collected by the WTP operator were split to compare BOD_5 and TSS results. The operator transported his sample splits to the Colfax WTP Laboratory for analysis.

Influent flow at the WTP was measured at the Parshall flume upstream of the comminutor. Effluent flow was estimated by timing discharge cycles in the morning and afternoon and correcting influent flow rates accordingly. During the morning (0805) discharge cycle, effluent discharged for 9 min. 20 sec. during a 15 min. 28 sec. timed cycle. In the afternoon (1545), flow was considerably shorter at 6 min. 45 sec. during a 15 min. 30 sec. timed cycle.

Eight surface water sites were sampled on Rebel Flat Creek from October 11-13, 1988. Three of these sites were upstream of the WTP discharge and five were located downstream (Figure 2). Sample parameters and frequency are listed in Table 1. Weather during the survey was dry and warm. Summer low flow conditions were observed.

Temperature and pH were measured on site using a Beckman meter. Dissolved oxygen was determined using the Winkler method. All samples were collected at mid-channel. Streamflow measurements were made with a Swoffer current meter and top-setting wading rod. Methods for remaining field measurements and lab analyses are the same as those described earlier.

Dissolved oxygen surveys were conducted on the afternoon of October 12 and at dawn the next day. The surveys were performed to measure daily maximum and minimum oxygen levels in the stream and assess the effect of WTP discharge. Temperature, pH, and dissolved oxygen were measured at six sites within a one-hour period to minimize temporal variability.

Field work was conducted by Will Kendra and Barbara Carey from SWIS and Debbie Charloe, Deborah Cornell, and Jim Prudente from ERO. Otis Hampton, WTP Technical Assistant Specialist, conducted a review with the operator, John Britton.

RESULTS AND DISCUSSION

Limited Class II Inspection

Results from the limited Class II inspection at Endicott WTP are listed in Table 2. Influent flow measurements seemed consistent from day to day. Highest flow was recorded in the morning (0750). Effluent flow occurred only when there was surface overflow from the secondary clarifier to the chlorine contact chamber. Average effluent flow was estimated at 0.06 MGD, which was the estimated average influent flow.

Replicate samples collected by Ecology were consistent for all parameters except fecal coliform, which was high and quite variable.

Nutrient results indicate that partial nitrification was occurring in the plant. Influent and effluent composite samples show that the net loss of ammonia was nearly equal to the net gain of nitrate-nitrite. Additional in-plant nitrification could lower effluent ammonia concentrations further. Instream ammonia results will be discussed in detail later.

Assessment of NPDES permit compliance during the survey is presented in Table 3. Effluent composite samples indicate that BOD_5 and TSS concentrations were well below relaxed permit limits as well as more stringent minimum secondary treatment requirements. Removal for both parameters

Table 2. Results from the limited Class II inspection at Endicott WTP, October 11-12, 1988.

Sample Type	Date	Time	Sampler	Lab	Flow (MGD)	Temp. (°c)	pH (S.U.)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	TSS (mg/L)	TNVSS (mg/L)	TS (mg/L)	TNVS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO_3-N + NO_2-N (mg/L)	Nutrients: Total-P (mg/L)	Oil and Grease (mg/L)
Influent Grab	10/11/89	0815	Ecol.	Ecol.	-	18.5	8.2	-	-	-	-	180	-	-	-	-	300	26.0	2.0	1.20	26
		1515	Ecol.	Ecol.	0.05	17.6	7.7	-	-	-	-	20	-	-	-	-	94	9.4	1.6	0.68	-
	Repl.	1518	Ecol.	Ecol.	-	17.8	7.7	-	-	-	-	19	-	-	-	-	79	9.9	1.8	0.61	-
	10/12/89	0750	Ecol.	Ecol.	0.10	18.3	8.0	-	-	-	-	-	-	-	-	-	1300	33.0	0.8	3.20	-
		0818	WTP	Ecol.	-	-	7.4	-	-	-	-	880	-	-	-	510	-	-	-	-	-
		0818	WTP	WTP	-	-	-	-	-	-	-	1221	-	-	-	295	-	-	-	-	-
		1140	Ecol.	Ecol.	0.06	17.9	7.6	-	-	-	-	150	-	-	-	-	340	12.0	1.4	2.00	-
Influent Comp.	10/12/89	0800	Ecol.	Ecol.	-	-	-	-	-	-	-	82	16	560	350	83	210	13.0	1.6	0.92	-
		0800	Ecol.	WTP	-	-	-	-	-	-	-	74	-	-	-	130	-	-	-	-	-
Effluent Grab	10/11/89	0828	Ecol.	Ecol.	-	15.3	7.7	7.30	74	2.2	2200	7	-	-	-	-	41	2.5	6.8	0.86	2
	10/11/89	1540	Ecol.	Ecol.	0.10 J	17.4	7.7	6.55	69	2.0	1100	9	-	-	-	-	56	9.6	7.2	0.96	-
	Repl.	1542	Ecol.	Ecol.	-	17.2	7.6	6.55	69	-	16000 J	4	-	-	-	-	53	9.9	7.4	1.00	-
	10/12/89	0805	Ecol.	Ecol.	0.16 J	14.9	8.0	7.40	74	1.5	5400	-	-	-	-	-	35	5.6	8.9	0.82	-
		0820	WTP	Ecol.	-	-	7.4	7.60	76	0.9	-	4	-	-	-	5	-	-	-	-	-
		0820	WTP	WTP	-	-	-	-	-	-	18666	5	-	-	-	10	-	-	-	-	-
		1115	Ecol.	Ecol.	-	15.5	7.6	7.00	71	1.5	7300	17	-	-	-	-	53	5.9	8.6	0.83	-
Effluent Comp.	10/12/89	0815	Ecol.	Ecol.	0.06 J	-	-	-	-	-	-	10	5	610	290	10	88	7.9	7.3	0.90	-
		0815	Ecol.	WTP	-	-	-	-	-	-	-	7	-	-	-	14	-	-	-	-	-
Drain near Outfall	10/12/89	1145	Ecol.	Ecol.	-	14.2	7.2	-	-	-	6	-	-	-	-	-	-	-	-	-	-

J = Estimated value
Repl. = Replicate sample

Table 3. Assessment of NPDES permit compliance during a limited Class II inspection at Endicott WTP on October 11-12, 1988.

Parameter	Units	NPDES Permit Limits Monthly Average	NPDES Permit Limits Weekly Average	Order Limitations* Monthly Average	Order Limitations* Weekly Average	(Ecology) Effluent Quality Grab	(Ecology) Effluent Quality Composite
BOD_5	mg/L	30	45	60	90	-	10
	lbs/day	38	56	75	113	-	5
	% removal**	85	-	85	-	-	88
TSS	mg/L	30	45	60	90	-	10
	lbs/day	38	56	75	113	-	5
	% removal**	85	-	85	-	-	88
Fecal Coliform	#/100 mL	200	400	200	400	3100***	-
Total Residual Chlorine	mg/L	-	-	$0.1 \leq TRC \leq 0.5$	1.8	-	
pH	S.U.	$6.5 \leq pH \leq 8.5$		$6.5 \leq pH \leq 8.5$		$7.6 \leq pH \leq 8.0$	-
Flow	MGD	0.15	-	0.15	-	-	0.06

* Order; Docket No. DE 77-277.
** When influent BOD_5 or TSS are less than 200 mg/L.
*** Geometric mean; does not include estimated values.

was 88 percent. Influent BOD_5 and TSS concentrations were weak at 83 mg/L and 82 mg/L, respectively (Metcalf and Eddy 1972). The most likely explanation of such a weak influent is infiltration and inflow (I & I) into the sewage collection system. A review of discharge monitoring reports (DMRs) from August 1987 to October 1988 indicated consistently weak influent BOD_5 and TSS concentrations.

Fecal coliform counts were extremely high during the survey, with a geometric mean nearly sixteen times as high as the monthly permit limit average. Total residual chlorine exceeded the permit limit by three-fold. The WTP operator was adding a chlorine load of two pounds/day in an attempt to combat high fecal concentrations, but we advised that he drop the load to one pound/day. It appears that holding time in the chlorine contact chamber and outfall line is too short to achieve disinfection. As a result, high fecal coliform and TRC loads are discharged into Rebel Flat Creek. According to the Criteria for Sewage Works Design (Ecology 1985) chlorine contact chambers shall provide a minimum design flow of one hour detention at average daily design flow and 20 minutes at peak daily design flow, whichever is greater.

Split sample comparisons for BOD_5 and TSS are illustrated in Figure 3. In general, samples split between Ecology's lab and the Colfax lab were not very comparable. Split sample pairs were compared by calculating the relative percent difference (RPD), defined as the difference of two samples divided by their mean. The RPD's for BOD_5 and TSS lab splits ranged from 10 to 67 percent, with an average of 37 percent.

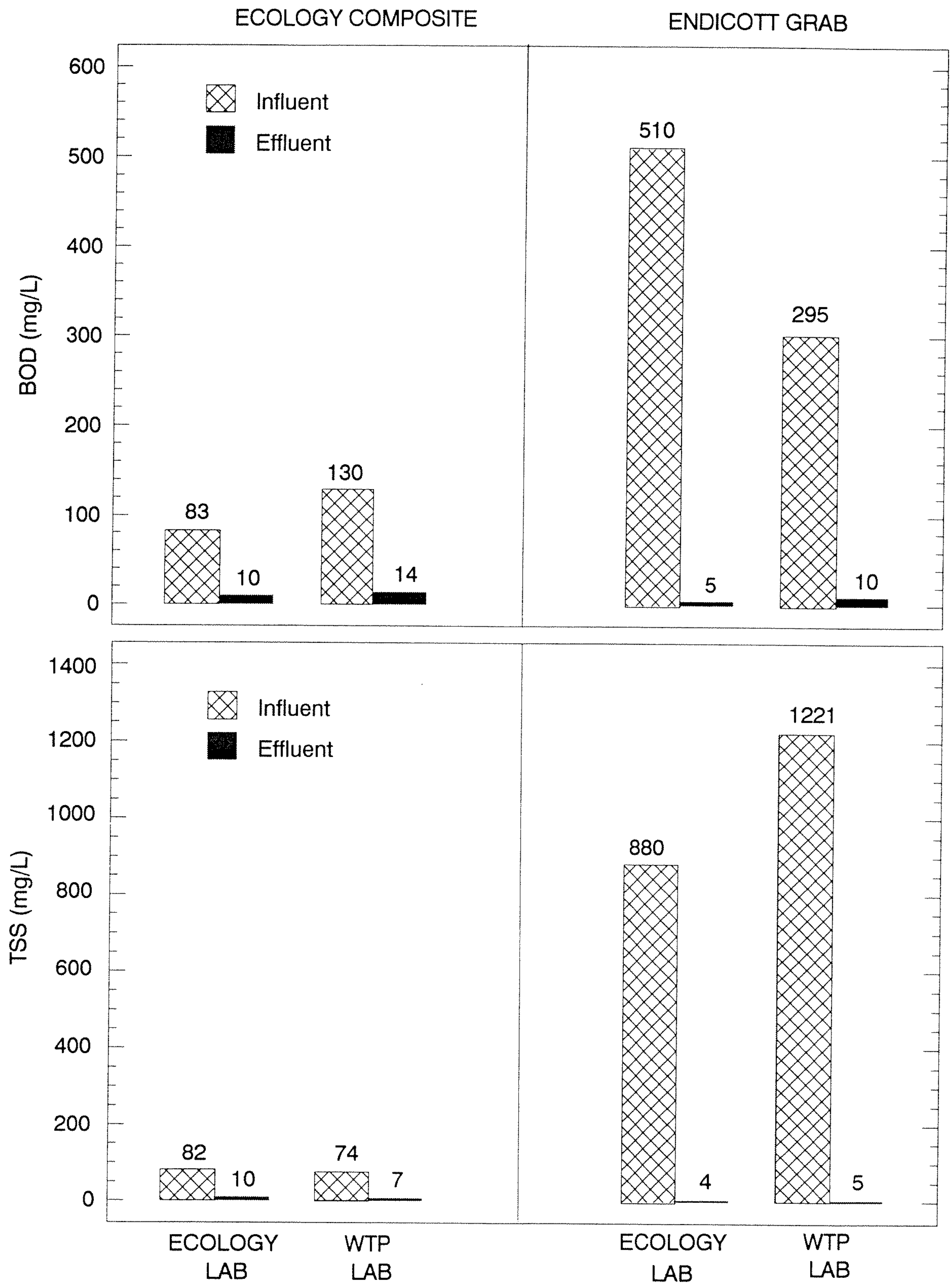

Figure 3. Comparison of BOD-5 and TSS sample splits.

Perhaps of greater concern is the fact that the operator was biasing his results by collecting a single grab instead of a composite. In general, this yielded a stronger influent sample and a weaker effluent sample, thus favoring permit compliance. During the inspection, the operator was advised to composite BOD_5 and TSS samples over an 8-hour period.

Receiving Water Survey

Table 4 summarizes results from the receiving water study on Rebel Flat Creek. In general, replicate samples and measurements showed good laboratory and field precision.

Flow measurements ranged from an upstream low of 0.8 cfs to a downstream high of 1.7 cfs. Since the WTP is the only discharge (approximately 0.1 cfs) in the study reach and there are no tributary streams, it appears that ground water flux was adding considerably to the flow of Rebel Flat Creek.

As mentioned earlier, the design of Endicott WTP results in intermittent effluent flow. The creek:effluent dilution ratio was 9:1 assuming a continuous average effluent discharge (0.09 cfs). However, due to the intermittent nature of discharge, the dilution ratio is actually 3:1 during a typical morning pulse cycle (0.25 cfs). The exposed bank discharge may be a health risk if children play in the immediate vicinity.

Total residual chlorine (TRC) concentrations of 0.1 mg/L and 0.2 mg/L were recorded at RM 5.9 and 5.4, respectively. Variability in TRC below the WTP outfall was believed to be the result of intermittent effluent discharge. Effluent concentrations at the end of the chlorine contact chamber ranged from 1.5 to 2.2 mg/L. Dechlorination is not provided. Both effluent and instream concentrations are excessive. The chlorine contact chamber should be inspected for design flaws that result in poor disinfection (e.g., limited retention time).

Figure 4 shows the effect of point and non-point sources of fecal coliform on Rebel Flat Creek. High concentrations were found at RM 7.7 and RM 5.4, most likely due to livestock which had access to the creek in those areas. Fecal coliform contamination ranging from 470-1700 fc/100 mL was also observed 300 feet below the WTP outfall (RM 5.9), easily violating the Class A water quality standard of 100 fc/100 mL. Low fecal coliform concentrations were detected on successive sampling days at RM 5.6 (1600 feet below WTP discharge). This finding, in conjunction with instream chlorine results, indicates that disinfection continues to occur in Rebel Flat Creek.

Nutrient loads and concentrations in Rebel Flat Creek are presented in Figure 5. All nutrients show increased concentrations and loads as a result of WTP discharge. Nitrate-nitrite concentrations show an initial increase due to effluent discharge, followed by a second peak and then a decline. Loads of nitrate-nitrite increased after discharge and continued to increase further downstream, indicating that incoming ground water contained nitrate-nitrite. Agricultural fertilizers used in the drainage and/or livestock wastes are the most likely sources. Ammonia concentrations and loads increased after effluent discharge and then decreased to near background levels. A mass-balance equation predicted chronic ammonia toxicity at existing dilution in the vicinity of outfall. However, measured ammonia 300 feet below the outfall was well below chronic criteria. This indicates that some other process was influencing downstream ammonia concentrations, such as instream nitrification and/or variability due to sampling time. Total phosphorus (TP-P) concentrations and loads also increased following WTP discharge. While the TP-P load remained constant between RM 5.6 and 3.1, the concentration fell, indicating an influx of low TP-P ground water. All loading data are provided in Appendix A.

Table 4. Results of water quality survey conducted on Rebel Flat Creek on October 11-12, 1988. WTP effluent results are also added for comparison.

Sampling Site	River Mile	Date	Time	Flow (cfs)	Temp. (°C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO_3-N + NO_2-N (mg/L)	Nutrients: Total-P (mg/L)
Endicott West Rd. crossing	3.1	10/11	1000	1.7	11.0	8.2	10.25	94	-	110	11	-	10	0.01	4.6	0.26
		10/12	0925	1.6	9.6	8.2	10.35	92	-	88	8	-	7	0.03	4.5	0.27
Swent Rd. crossing	4.5	10/11	1025	-	10.8	7.8	9.45	87	-	69	10	-	8	0.01	4.7	0.33
		10/12	0945	-	9.7	7.7	9.45	85	-	100	9	-	9	0.04	5.0	0.41
Near Kackman Rd.-Endicott West Rd. intersection	5.4	10/11	1053	-	11.4	7.8	8.75	81	0.2	670	10	-	10	0.03	4.3	0.28
		10/12	1005	-	9.7	7.8	8.70	78	-	1700	12	-	10	0.04	4.5	0.26
1600 ft. below WTP outfall	5.6	10/11	1125	1.3	11.0	7.8	8.65	80	<0.1	49	10	-	9	0.04	4.4	0.35
		10/12	1025	1.2	11.6	7.8	8.65	81	<0.1	29	9	-	9	0.07	4.5	0.33
		Repl.	1025	1.1	-	-	-	-	-	-	-	-	-	-	-	-
300 ft. below WTP outfall	5.9	10/11	1140	-	12.2	7.9	9.45	90	-	1700	16	-	10	0.38	4.6	0.53
		Repl.	1140	-	12.1	7.9	9.35	88	-	1900	21	-	10	0.27	4.6	0.45
		10/12	1050	-	10.0	8.0	9.50	86	0.1	470	9	<5	11	0.25	4.8	0.20
		Repl.	1050	-	10.1	8.0	9.50	86	0.1	700	11	-	9	0.28	4.8	0.53
Endicott WTP effluent	5.95	10/11	0828	-	15.3	7.7	7.30	74	2.2	2200	7	-	41	2.5	6.8	0.86
		10/11	1540	0.16 J	17.4	7.7	6.55	69	2.0	1100	9	-	56	9.6	7.2	0.96
		10/12	0805	0.25 J	14.9	8.0	7.40	74	1.5	5400	-	-	35	5.6	8.9	0.82
		10/12	1115	-	15.5	7.6	7.00	71	1.5	7300	17	-	53	5.9	8.6	0.83
G Street Bridge	6.0	10/11	1335	-	11.0	7.7	9.85	91	-	510	10	-	8	0.01	4.3	0.13
		10/12	1125	-	9.7	7.7	10.10	90	-	290	8	-	10	0.02	4.3	0.12
5th Street Bridge	6.2	10/11	1356	0.9	11.0	7.9	10.00	92	-	670	10	-	9	0.02	4.0	0.13
		Repl.	1356	0.8	-	-	-	-	-	-	-	-	-	-	-	-
		10/12	1300	0.9	9.9	8.0	10.20	92	-	420	10	-	8	0.02	4.0	0.13
Repp Rd. crossing	7.7	10/11	1417	0.9	11.0	8.1	10.40	96	-	2000	110	-	9	0.01	3.9	0.12
		10/12	1325	0.8	9.9	8.0	10.50	94	-	680	11	-	8	0.01	3.8	0.12

J = Estimated value; measurement taken during effluent pumping cycle, average discharge rate over the day was estimated to be 0.09 cfs.
Repl. = Replicate sample

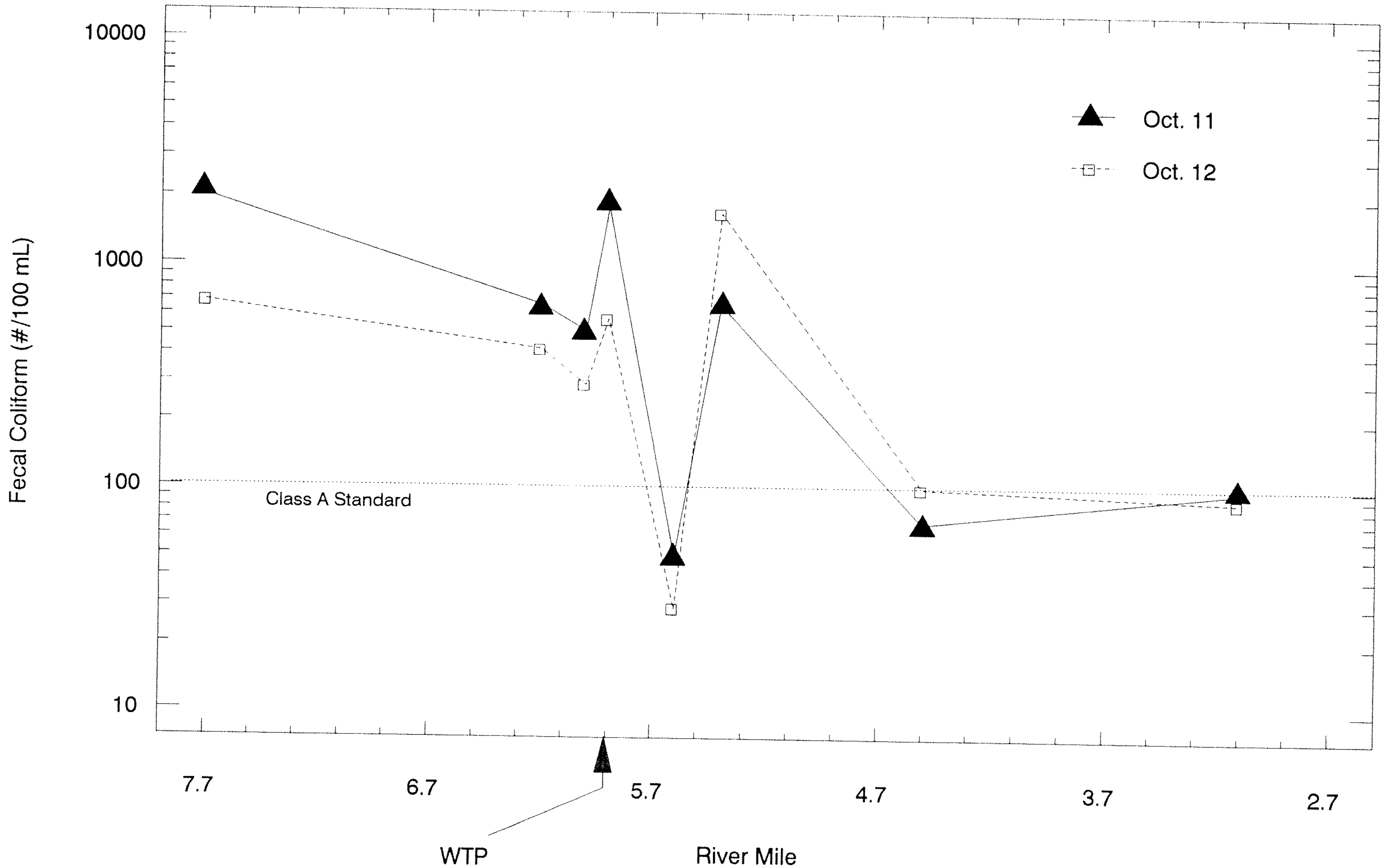

Figure 4. Fecal coliform concentrations in Rebel Flat Creek above and below Endicott WTP, October 11-12, 1988.

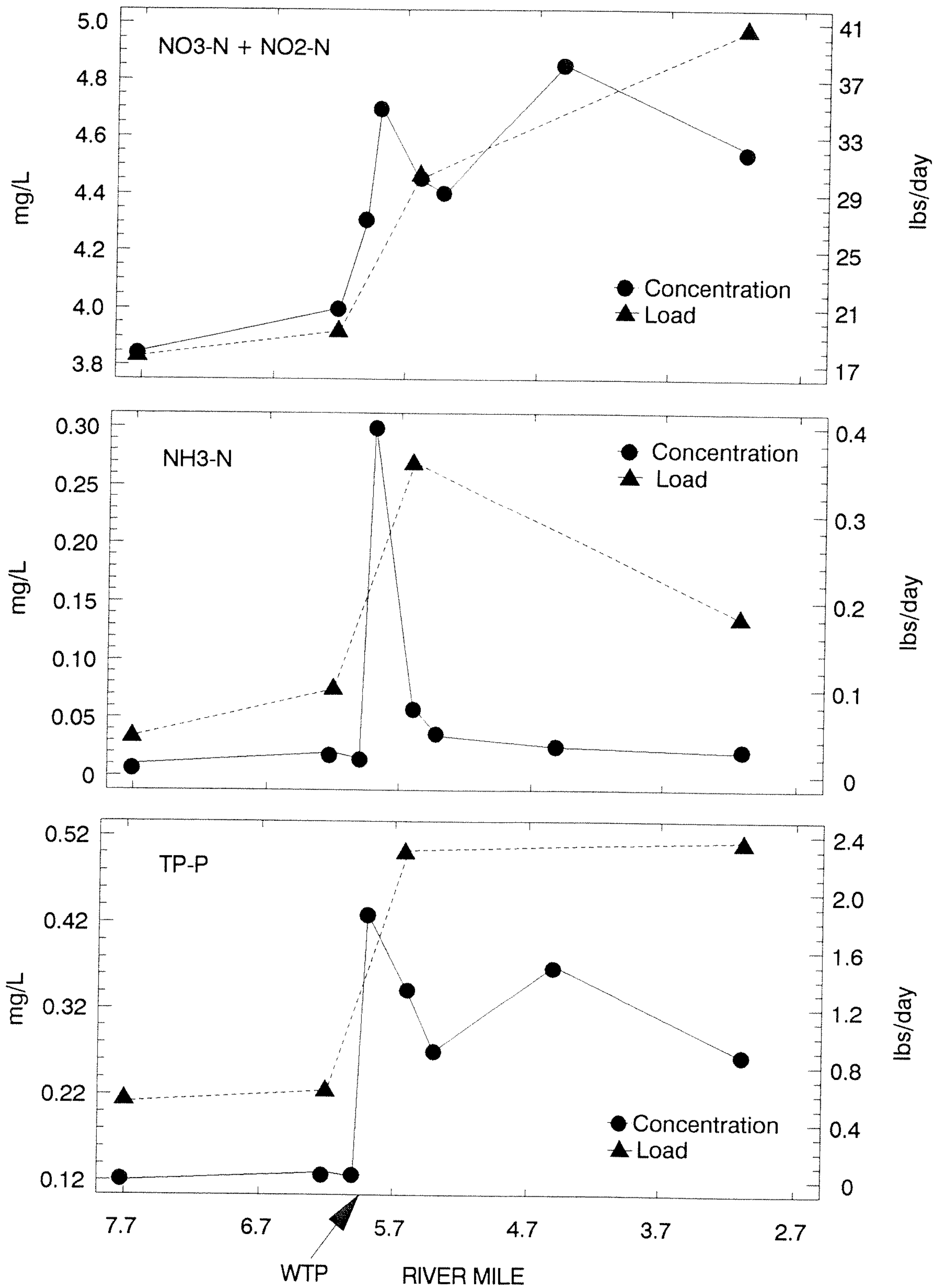

Figure 5. Nutrient concentrations and loads for Rebel Flatt Creek above and below the Endicott WTP. Values represent the mean of samples collected on October 11-12, 1988.

Dissolved oxygen (D.O.) surveys indicated a sag immediately downstream of the WTP discharge (Figure 6). This sag can be explained by addition of low D.O. effluent and instream decay of effluent BOD. Early morning D.O. concentrations were only slightly lower than afternoon concentrations at all sampling sites, indicating little primary productivity in the creek. The lowest D.O. recorded during the survey was 8.25 mg/L at RM 5.6 (1600 feet below the WTP discharge). The Class A water quality standard of 8.0 mg/L was not violated. Complete D.O. survey data are provided in Appendix B.

Total Maximum Daily Load (TMDL) Analyses

TMDL analyses were conducted to predict impacts of worst-case conditions on Rebel Flat Creek. Generally, worst-case conditions include: design streamflow (7Q10 or 1Q10), WTP flow at design capacity, and effluent quality at permit limits (full population build-out). The probability of these "ultimate" worst-case conditions occurring in a small agricultural community like Endicott is low. Therefore, a preliminary analysis with more probable conditions was simulated using design streamflow (7Q10 or 1Q10) and existing effluent flow and quality. An effluent flow rate (0.16 MGD) reflecting the instantaneous discharge was used for the toxic compounds whereas the BOD evaluation used the average early morning flow rate (0.03 MGD). A review of DMRs indicated that effluent BOD_5 and TSS concentrations have historically been consistent with results found during the survey.

Because a continuous gage station was not located on Rebel Flat Creek, the 7Q10 and 1Q10 flows were estimated using data from a nearby gage on the Palouse River at Colfax (USGS 1978). The following relationship was used to estimate design flows (7Q10 and 1Q10) on Rebel Flat Creek.

$$\frac{\text{survey flow at Palouse gage}}{\text{design flow at Palouse gage}} = \frac{\text{survey flow on Rebel Flat Creek}}{\text{design flow for Rebel Flat Creek}}$$

This analysis estimated a 7Q10 flow of 0.18 cfs and 1Q10 flow of 0.15 cfs for Rebel Flat Creek. EPA recommends the use of 7Q10 as critical design flow for chronic criteria and 1Q10 for acute criteria (EPA 1986a; EPA 1986b). Since design flows on Rebel Flat Creek were estimated without historical flow data to provide a check, an uncertainty analysis was performed. Uncertainty was simulated by doubling the design flows and re-calculating the TMDLs.

Results of the preliminary TMDL analysis indicated water quality criteria violations for all parameters (Table 5). TMDL mass-balance equations projected instream TRC concentrations which exceed acute and chronic toxicity limits for aquatic organisms. Ammonia mass-balance calculations projected exceedance of the chronic toxicity criterion for total ammonia. At ambient temperature and pH, the chronic toxicity threshold for un-ionized ammonia is attained at a total ammonia concentration of 2.1 mg/L (EPA 1986a). For fecal coliform the TMDL mass-balance equation predicted a downstream concentration of 280 fc/100 mL, which exceeds the Class A water quality criterion of 100 fc/100 mL.

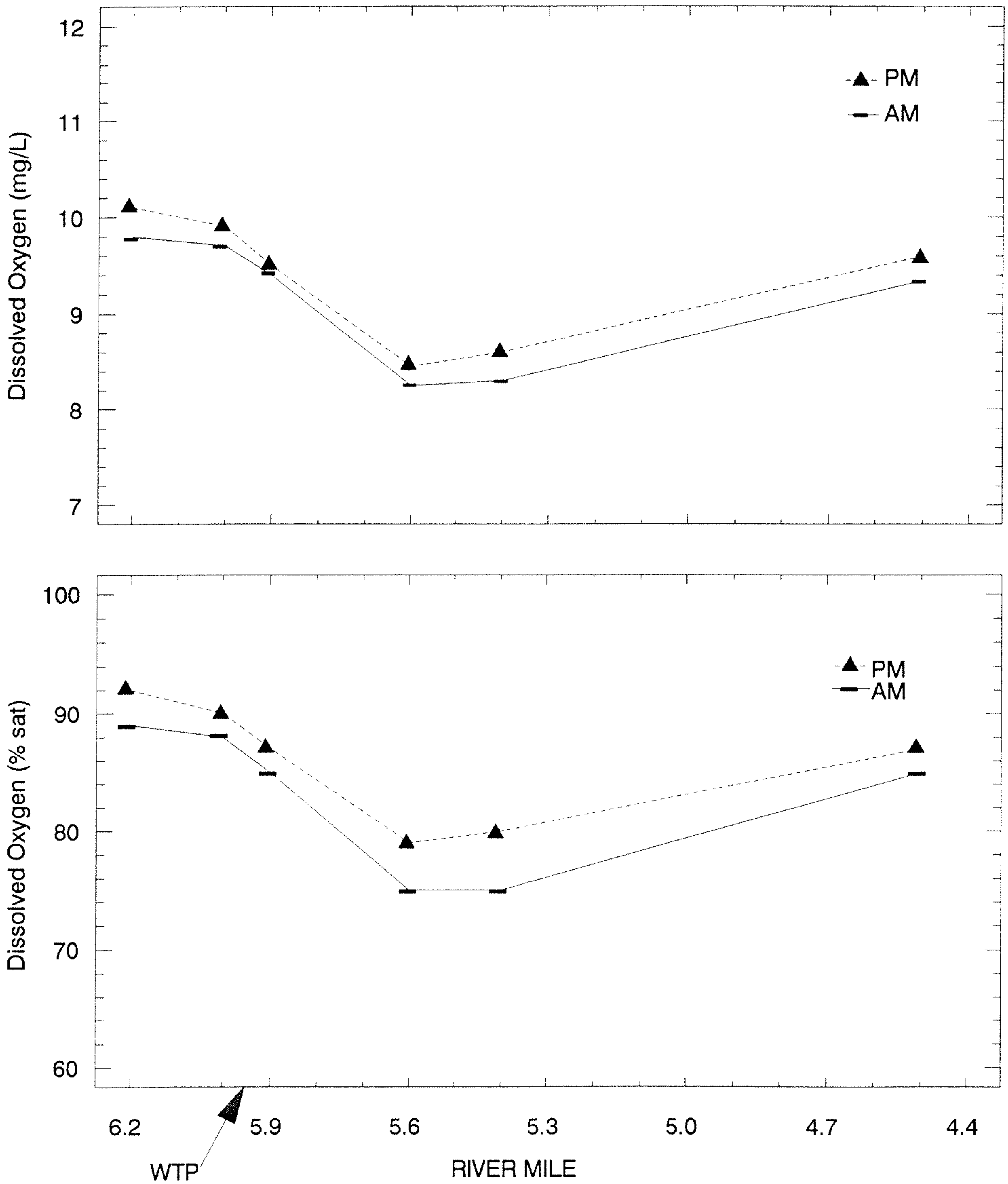

Figure 6. Dissolved oxygen profiles for early morning and afternoon surveys on Rebel Flat Creek, October 12-13, 1988.

Table 5. Preliminary TMDL analysis using design streamflow (7Q10 or 1Q10) and existing effluent flow and quality. Oxygen model parameters are provided in Appendix D.

Parameters	Acute (1Q10)		Chronic (7Q10)	
	WQ Criteria	Predicted	WQ Criteria/Class A	Predicted
Total Residual Chlorine (mg/L)	0.019	0.31	0.011	0.29
Total NH_3-N (mg/L)	10.9	4.9	2.1	4.6
Fecal coliform (#/100 mL)	-	-	100	280
Dissolved Oxygen (mg/L)	-	-	8.0	5.0

A Streeter-Phelps model was used to predict D.O. depletion under 7Q10 conditions (Mills, et al., 1985). The model was calibrated using conditions observed during the dawn D.O. survey. A dawn effluent average flow of 0.05 cfs was assumed to be appropriate. The critical D.O. predicted under these calibration conditions was 8.4 mg/L, within 0.15 mg/L of measured D.O. (8.25 mg/L). The model predicted D.O. violations under existing conditions if stream discharge falls below 0.57 cfs (11:1 dilution) during the critical dawn period. At the 7Q10 stream flow of 0.18 cfs, D.O. was predicted to drop well below the Class A standard (Table 5). If effluent ammonia was reduced to 2 mg/L via in-plant nitrification, a D.O. violation would still be expected to occur at 7Q10 flow.

Uncertainty analyses demonstrated that even when the 7Q10 streamflow estimate was doubled, TMDL calculations still predicted water quality violations for TRC, ammonia, fecal coliform, and D.O. (assuming no in-plant nitrification).

Thus, the preliminary TMDL analysis predicted water quality violations for fecal coliform, chlorine, un-ionized ammonia, and dissolved oxygen even when effluent quality and flow were well below existing permit limits. In-plant modifications may correct chlorine and ammonia violations. However, D.O. violations will persist, simply due to poor dilution during low flow. Effluent BOD_5 is already low (10 mg/L), and further reduction is not practical. Land application of WTP effluent during the summer low flow season (June-October) is the only way to prevent D.O. violations in Rebel Flat Creek during critical flow years.

A second TMDL analysis was conducted to predict impacts of worst-case conditions during winter so that water quality-based effluent limits could be developed for those months when land application of effluent would be unnecessary. A critical winter low design flow was estimated using monthly mean discharge exceedance probabilities for the Palouse River (USGS 1978) and then correcting for the relationship, as stated earlier, between Rebel Flat Creek and the Palouse River. The critical wet winter (November-May) design flow was estimated to be 2.06 cfs.

A steady-state waste load allocation (WLA) procedure was used to derive water quality-based permit limits for chlorine and ammonia. The procedure addresses effluent variability when setting permit limits for toxics (EPA 1985). TMDL results, water quality criteria, waste load allocations, and suggested permit limits for the winter flow season are presented in Table 6.

The TMDL mass-balance equation predicted instream TRC concentrations would exceed acute and chronic toxicity limits. The WLA is 0.08 mg/L for acute and 0.05 mg/L for chronic conditions; these can only be achieved through dechlorination. The recommended permit limit for TRC is <0.1 mg/L (detection limit) for both the daily maximum and monthly average.

Table 6. TMDL analysis using estimated winter low flow conditions and secondary permit limits. Included are the WLAs and recommended permit limits for the winter flow season. Calculations are detailed in Appendices C-1, C-2, and D.

	Acute (1Q10)			Chronic (7Q10)			Permit Limits	
Parameters	WQ Criteria	Predicted	WLA	WQ Crit/Class A	Predicted	WLA	Daily Max.or Weekly Ave.*	Monthly Ave.
Total Residual Chlorine (mg/L)	0.019	0.118	0.08	0.011	0.102	0.05	<0.1	<0.1
Total NH_3-N (mg/L)	10.9	1.9	46.3	2.1	1.6	10.2	16.7	8.3
Fecal coliform (#/100 mL)	-	-	-	100	343	-	200	400
Dissolved Oxygen (mg/L)	-	-	-	8.0	8.7	63 **	45 **	30 **

* Weekly average for fecal coliform and BOD_5 permit limits.
** BOD_5 (mg/L)

The mass-balance equation projected that downstream ammonia concentrations would be well below toxicity limits. The WLA was 46.3 mg/L and 10.2 mg/L for acute and chronic conditions, respectively. A daily maximum of 16.7 mg/L and monthly average of 8.3 mg/L are recommended as total ammonia permit limits to achieve the WLA.

TMDL mass-balance calculations predicted a downstream fecal coliform concentration of 343 fc/100 mL, which exceeds the Class A water quality criterion. Endicott's WLA for fecal coliform is essentially zero because upstream concentrations are already well above the allocatable load. Non-point sources of fecal coliform loading will need to be controlled in order to achieve compliance with the fecal coliform criterion. If existing permit limits for fecal coliform are retained, nonpoint/background sources would need to be allocated a maximum load of 74 fc/100 mL to be within the standard.

Streeter-Phelps analysis predicted oxygen concentrations above the Class A criterion, based on secondary effluent limitations and an average dawn effluent discharge of 0.08 cfs. The WLA for BOD_5 based on D.O. modeling was 63 mg/L (assumes NBOD rate at recommended NH_3-N permit limit of 8.3 mg/L). BOD_5 permit limits of 45 mg/L for a weekly average and 30 mg/L for a monthly average are recommended.

SUMMARY AND CONCLUSIONS

Limited Class II Inspection

- BOD_5 and TSS were below relaxed permit limits as well as more stringent minimum secondary treatment requirements. Percent removal for both parameters was 88 percent.
- Effluent fecal coliform and total residual chlorine concentrations were excessive.
- Sample splits between Ecology's lab and the Colfax lab were not very comparable for BOD_5 and TSS.
- The WTP operator was biasing his monitoring results by collecting only a single morning grab.

Receiving Water Survey

- Creek:effluent dilution was 9:1, based on an average effluent flow rate. However, due to the intermittent nature of discharge, the dilution ratio actually decreased to 3:1 during a typical morning discharge cycle.
- Fecal coliform and total residual chlorine concentrations violated water quality criteria downstream of the WTP outfall. High instream chlorine resulted in apparent disinfection between RM 5.9 and 5.6.
- Instream nutrient concentrations and loads increased as a result of WTP discharge. Ground water inflow appears to have a high nitrate-nitrite load, probably due to agricultural fertilizer usage or livestock wastes.
- Dissolved oxygen surveys indicated a D.O. sag downstream of the WTP discharge; however, the water quality criterion of 8 mg/L was not violated.
- TMDL analyses predicted water quality criteria violations at 7Q10 streamflow for chlorine, fecal coliform bacteria, un-ionized ammonia, and dissolved oxygen. D.O. violations are expected to occur during the critical dawn period when stream discharge falls below 0.57 cfs (11:1 dilution at existing WTP dawn flow).

RECOMMENDATIONS

The following recommendations are offered to improve the operation of Endicott WTP and protect water quality in Rebel Flat Creek.

- The Colfax laboratory did not perform well on split sample comparisons. Earlier sample splits with Colfax have shown similar results (Determan 1987; Kendra 1988; Carey 1989). A thorough review of laboratory procedures is in order.
- The WTP operator should hand-composite BOD_5 and TSS samples at two-hour intervals over the eight-hour work period.
- Design of the chlorination system should be subjected to an engineering review and any flaws corrected.

- The region should refer the agricultural nonpoint problem to the Whitman County Conservation District for action under the Agricultural Compliance Memorandum of Agreement. Under this agreement, water quality management plans containing best management practices are developed and implemented to correct and prevent agricultural nonpoint source water quality problems.

Based on TMDL analyses for 7Q10 design low flow, seasonal removal of WTP effluent from the receiving water is warranted. Land application of WTP effluent during summer low flow (June-October) would adequately protect the stream against chlorine and ammonia toxicity and prevent D.O. violations. At present WTP discharge rates, a dilution of 11:1 is required to avoid D.O. violations during the critical dawn period. If early morning effluent flows average 0.05 cfs, WTP diversion should occur when stream discharge drops below 0.57 cfs. At permitted WTP design flow conditions (0.15 MGD) a stream discharge of 2.7 cfs is needed to avoid D.O. violations. During a drought year (7Q10) D.O. violations would likely occur from June through October.

Separate water quality-based permit limits should be developed for the winter flow period. TMDL analyses predicted that D.O. violations and ammonia toxicity would not occur under winter design flows and secondary treatment limits. It appears from this survey and DMRs that Endicott can achieve present standards for secondary treatment. Therefore, we recommend that the existing order with relaxed limits be revoked, and that the water quality-based permit limits developed here be adopted for use during winter months.

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APPENDICES

Appendix A. Constituent loads in Rebel Flat Creek on October 11-12, 1988.

Sampling Site	River Mile	Date	Time	Flow (cfs)	Fecal Coliform (#/sec)	TSS (lbs/day)	COD (lbs/day)	NH_3-N (lbs/day)	NO_3-N + NO_2-N (lbs/day)	Total-P (lbs/day)
Endicott West Rd. crossing	3.1	10/11	1000	1.7	53000	100	92	0.09	42	2.4
		10/12	0925	1.6	40000	69	60	0.26	39	2.3
1600 ft. below WTP outfall	5.6	10/11	1125	1.3	18000	70	63	0.28	31	2.5
		10/12	1025	1.2	9800	58	58	0.45	29	2.1
Endicott WTP Effluent	5.95	10/12	0815	0.09	80000 *	5	43	6.0	3.5	0.44
5th Street Bridge	6.2	10/11	1356	0.9	170000	49	44	0.10	19	0.63
		10/12	1300	0.9	110000	49	39	0.10	19	0.63
Repp Rd. crossing	7.7	10/11	1417	0.9	510000	530	44	0.05	19	0.58
		10/12	1325	0.8	150000	47	35	0.04	16	0.52

* Calculated from geometric mean of effluent grab samples, excluding estimated values.

Appendix B. Results of dawn/mid-afternoon dissolved oxygen surveys conducted on Rebel Flat Creek, October 12-13, 1988.

Sampling site	River Mile	Date	Time	Temp (°C)	pH (S.U.)	Dissolved Oxygen (mg/L)	(% Sat.)
Swent Rd. crossing	4.5	10/12	1415	10.2	7.8	9.60	87
		10/13	0615	10.3	8.0	9.35	85
Near Kackman Rd.-Endicott West Rd. intersection	5.4	10/12	1420	11.4	7.9	8.60	80
		10/13	0625	10.2	8.0	8.30	75
1600 ft. below WTP outfall	5.6	10/12	1430	11.4	7.8	8.45	79
		10/13	0640	10.2	8.0	8.25	75
300 ft. below WTP outfall	5.9	10/12	1440	10.9	8.0	9.50	87
		Repl.	1442	10.9	7.9	9.50	87
		10/13	0650	10.3	8.1	9.40	85
		Repl.	0651	10.3	8.1	9.40	85
Endicott WTP Effluent	5.95	10/11	0828	15.3	7.7	7.30	74
		10/11	1540	17.4	7.7	6.55	69
		Repl.	1542	17.2	7.6	6.55	69
		10/12	0805	14.9	8.0	7.40	74
		10/12	1115	15.5	7.6	7.00	71
G Street Bridge	6.0	10/12	1455	10.3	7.9	9.90	90
		10/13	0700	10.1	8.2	9.70	88
5th Street Bridge	6.2	10/12	1505	10.3	7.9	10.10	92
		10/13	0710	10.2	8.2	9.80	89

Appendix C-1. WLA and permit limits for total residual chlorine. Based on EPA WLA procedure for setting water quality-based permit limits.

INPUT

1. Water Quality Standards/Criteria (Concentration)
   - Acute (one-hour) Criteria 0.019
   - Chronic (n-day) Criteria 0.011

2. Upstream Receiving Water Concentration
   - Upstream Concentration for Acute Condition (1Q10) 0.000
   - Upstream Concentration for Chronic Condition (7Q10) 0.000

3. Dilution Factors (1/{Effluent Volume Fraction})
   - Acute Receiving Water Dilution Factor at 1Q10 .... 4.250
   - Chronic Receiving Water Dilution Factor at 7Q10 .... 4.890

4. Coefficient of Variation for Effluent Concentration (use 0.6 if data are not available) 0.600

5. Number of days (n1) for chronic average (usually four or seven; four is recommended) 4

6. Number of samples (n2) per month to base permit on 20

OUTPUT

1. Z Statistics
   - LTA Derivation (99%tile) 2.326
   - Daily Maximum Permit Limit (99%tile) 2.326
   - Monthly Average Permit Limit (95%tile) 1.645

2. Calculated Waste Load Allocations (WLA's)
   - Acute (one-hour) WLA 0.081
   - Chronic (n1-day) WLA 0.054

3. Back-Calculation of Long Term Averages (LTA's)
   - Sigma (same for acute and chronic) 0.5545
   - Mu for Acute WLA .... -3.8062
   - Mu-n1 for Chronic WLA .... -3.6055
   - Mu for Chronic WLA .... -3.7161
   - LTA for Acute (one-hour) WLA 0.0259
   - LTA for Chronic (n1-day) WLA 0.0284
   - Most Limiting LTA (minimum of acute and chronic) 0.0259

4. Derivation of Permit Limits From Limiting LTA
   - Mu for daily maximum permit limit .... -3.8062
   - Mu-n2 for monthly average permit limit .... -3.6614
   - Sigma^2-n for monthly avg permit limit 0.0178

   Daily Maximum Permit Limit 0.081

   Monthly Average Permit Limit 0.032

Appendix C-2. WLA and permit limits for un-ionized ammonia. Based on EPA WLA procedure for setting water quality-based permit limits.

INPUT

1. Water Quality Standards/Criteria (Concentration)
   - Acute (one-hour) Criteria 10.900
   - Chronic (n-day) Criteria 2.100

2. Upstream Receiving Water Concentration
   - Upstream Concentration for Acute Condition (1Q10) 0.020
   - Upstream Concentration for Chronic Condition (7Q10) 0.020

3. Dilution Factors (1/{Effluent Volume Fraction})
   - Acute Receiving Water Dilution Factor at 1Q10 .... 4.250
   - Chronic Receiving Water Dilution Factor at 7Q10 .... 4.890

4. Coefficient of Variation for Effluent Concentration
   (use 0.6 if data are not available) 0.600

5. Number of days (n1) for chronic average
   (usually four or seven; four is recommended) 4

6. Number of samples (n2) per month to base permit on 4

OUTPUT

1. Z Statistics
   - LTA Derivation (99%tile) 2.326
   - Daily Maximum Permit Limit (99%tile) 2.326
   - Monthly Average Permit Limit (95%tile) 1.645

2. Calculated Waste Load Allocations (WLA's)
   - Acute (one-hour) WLA 46.260
   - Chronic (n1-day) WLA 10.191

3. Back-Calculation of Long Term Averages (LTA's)
   - Sigma (same for acute and chronic) 0.5545
   - Mu for Acute WLA 2.5445
   - Mu-n1 for Chronic WLA 1.6387
   - Mu for Chronic WLA 1.5280
   - LTA for Acute (one-hour) WLA 14.8533
   - LTA for Chronic (n1-day) WLA 5.3752
   - Most Limiting LTA (minimum of acute and chronic) 5.3752

4. Derivation of Permit Limits From Limiting LTA
   - Mu for daily maximum permit limit 1.5280
   - Mu-n2 for monthly average permit limit 1.6387
   - Sigma^2-n for monthly avg permit limit 0.0862

   Daily Maximum Permit Limit 16.741

   Monthly Average Permit Limit 8.345

Appendix D. Streeter-Phelps analysis of critical dissolved oxygen sag on Rebel Flat Creek below the Endicott WTP outfall.

INPUT

	Model Calibration	Min. Flow w/o D.O. violation	7Q10 Flow	7Q10 Flow (uncertainty)	7Q10 Flow w/nitrificat. (2mg/L NH_3-N)	7Q10 Flow w/nitrificat. (2 mg/L NH_3-N) (uncertainty)	Winter flow BOD_5 at 30 mg/L NH_3-N at 8.3 mg/L	Winter flow BOD_5 at 65 mg/L NH_3-N at 8.3 mg/Ly
1. UPSTREAM DISCHARGE (cfs).......................:	0.80	0.57	0.18	0.36	0.18	0.36	2.06	2.06
2. EFFLUENT DISCHARGE (cfs).......................:	0.05						0.08	0.08
3. UPSTREAM D.O. CONCENTRATION (mg/L).............:	9.80						10.50	10.50
4. EFFLUENT D.O. CONCENTRATION....................:	7.10							
5. UPSTREAM CBOD (Ultimate) CONCENTRATION (mg/L)..:	1.50							
6. EFFLUENT CBOD (Ultimate) CONCENTRATION (mg/L)..:	15						44*	94
7. UPSTREAM NBOD CONCENTRATION (mg/L).............:	0.1							
8. EFFLUENT NBOD CONCENTRATION (mg/L).............:	36				9	9	38**	38
9. STREAM VELOCITY (fps)..........................:	0.05							
10. STREAM DEPTH (ft).............................:	1.50							
11. STREAM SLOPE (ft/ft)...........................:	0.0015							
12. AVERAGE ELEVATION OF RIVER REACH (FT MSL).......:	525							
13. STREAM TEMPERATURE (deg C)......................:	11							
14. REAERATION RATE (Base e) AT 20 deg C (day^-1)...:	1.30						1.28	1.28

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Value
Churchill	1.5 - 6	2 - 50	0.32
O'Connor and Dobbins	.1 - 1.5	2 - 50	1.58
Owens	.1 - 6	1 - 2	1.37
Tsiviglou-Wallace	.1 - 6	.1 -2	0.58

15. BOD DECAY RATE (Base e) AT 20 deg C (day^-1)....: 2

CALCULATED VALUES

	Model Calibration	Min. Flow w/o D.O. violation	7Q10 Flow	7Q10 Flow (uncertainty)	7Q10 Flow w/nitrificat. (2mg/L NH_3-N)	7Q10 Flow w/nitrificat. (2 mg/L NH_3-N) (uncertainty)	Winter flow BOD_5 at 30 mg/L NH_3-N at 8.3 mg/L	Winter flow BOD_5 at 65 mg/L NH_3-N at 8.3 mg/Ly
1. D.O. SATURATION CONCENTRATION (mg/L)............:	10.8	10.80	10.80	10.80	10.80	10.80	10.8	10.8
2. INITIAL D.O. CONCENTRATION (mg/L)...............:	9.6	9.60	9.20	9.50	9.20	9.50	10.40	10.40
3. INITIAL D.O. DEFICIT (mg/L).....................:	1.2	1.20	1.60	1.30	1.60	1.30	0.4	0.4
4. INITIAL DOWNSTREAM BOD CONCENTRATION (mg/L)......:	4.51	5.58	12.34	7.62	6.47	4.33	4.61	6.47
5. REARATION RATE AT STREAM TEMPERATURE (day^-1)....:	1.05	1.05	1.05	1.05	1.05	1.05	1.03	1.03
6. BOD DECAY RATE AT STREAM TEMPERATURE (day^-1)....:	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
7. TRAVEL TIME TO CRITICAL D.O. CONCENTRATION (days):	0.66	0.69	0.75	0.72	0.67	0.62	0.78	0.80
8. DISTANCE TO CRITICAL D.O. CONCENTRATION (miles)..:	0.54	0.56	0.61	0.59	0.54	0.51	0.64	0.66
9. CRITICAL D.O. DEFICIT (mg/L)....................:	2.4	2.80	5.80	3.70	3.4	2.4	2.1	2.9
10. CRITICAL D.O. CONCENTRATION (mg/L).............:	8.4	8.0	5.0	7.10	7.4	8.4	8.7	7.9

* CBOD = 30 mg/L X 1.47
** NBOD = 8.3 mg/L X 4.57