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DEPARTMENT OF ECOLOGY
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MEMORANDUM
October 21 1986

To: Jim Milton

From: Joe Joy

Subject: Goldendale Wastewater Treatment Plant/Little Klickitat River Receiving Water Studies and Total Maximum Daily Load Evaluation

ABSTRACT

Two receiving water surveys were performed on the Little Klickitat River in the vicinity of the newly upgraded Goldendale wastewater treatment plant (WTP). Class II inspections were conducted concurrently. The purpose of the surveys was to describe the impact of the WTP effluent on river water quality during the 1985 low-flow and the 1986 high-flow periods, and compare these data to those from a receiving water study performed in 1981 prior to the WTP upgrade. The recent studies indicated the effluent has little effect on the river's water quality, especially during the high-flow period. Comparisons of low-flow period data taken in 1985 to 1981 data indicated improved dissolved oxygen profiles, less ammonia and chlorine toxicity, and lower nutrient loads in the river below the new outfall. The total maximum daily load (TMDL) evaluation showed current NPDES permit limits protect Little Klickitat water quality. However, effluent nutrients (not limited by permit) may seasonally contribute to far-field enrichment conditions.

INTRODUCTION

Two post-upgrade surveys were conducted on the Little Klickitat River in the vicinity of the Goldendale WTP--in August 1985 and March 1986. The Ecology Central Regional Office (CRO) requested the Water Quality Investigations Section (WQIS) to perform the surveys to: (1) assess the impacts of the WTP effluent on the river's water quality during high- and low-flow periods, (2) compare the data to a 1981 survey, and (3) determine the quality of the well water added to the river by Goldendale. Concurrently, Class II surveys were conducted to assess the performance of the newly constructed WTP lagoons; Heffner (1986) will report the Class II inspection findings. This body of data will provide the CRO with information necessary for verifying NPDES permit requirements of the WTP, and aid in evaluating the cost and benefit of the WTP upgrade.

BACKGROUND

The Little Klickitat River flows in south-central Washington from the Simcoe and Horse Heaven Hills to the Klickitat River (Figure 1). The 280 mi^{-2} drainage includes range, agricultural, and forest lands. The river is heavily used for irrigation and stock-watering.

The study area comprised 5.8 miles of the Little Klickitat River between river mile (r.m.) 10.5 and 16.3 (Figure 2). Major points within the study area include:

- Goldendale, located along the river between r.m. 16.3 to 14.1.
- The Goldendale well discharge into the river at r.m. 16.1.
- Bloodgood Creek, a major tributary, entering at r.m. 14.9.
- Left bank drainage ditch intermittently entering at r.m. 14.2.
- WTP outfall entering left bank at r.m. 14.1.

Prior to 1984, wastewater from Goldendale entered the river at r.m. 14.6. Although the old trickling filter plant at that site provided fairly good secondary treatment, it still created some water quality problems in the river:

- In winter, bypasses of raw sewage were necessary because the WTP system was hydraulically overloaded.
- Low in-stream flows were insufficient to adequately dilute effluent at other times of the year (see below).

The newly constructed wastewater treatment system is located approximately one mile south of the old treatment plant (Figure 2). The outfall for the new WTP is located at r.m. 14.1. Heffner (1986) has a detailed description of the lagoon with irrigation fields system that now serves approximately 3,700 people.

Briefly described, the new treatment system consists of a three-compartment lagoon, chlorination and dechlorination facilities, and optional final effluent disposal system. Effluent can be spray-irrigated to adjacent hay fields, stored in the lagoons, or diverted to the outfall.

Effluent from the WTP is allowed to discharge into the river at a minimum river-to-effluent dilution ratio of 20:1 (Ecology, 1982). When the minimum dilution ratio prevents discharge, well water is pumped by the city into the river at r.m. 16.1 at a rate equal to the diverted effluent. This satisfies water right holders downstream. This practice has been of some concern to the water right holders who fear the well water is too high in dissolved solids. One additional use of the well could be to augment low flows to obtain the

20:1 dilution ratio for continuing effluent discharge into the river. However, the cost of pumping water and the demand for the effluent on the irrigation fields has not made this option effective.

The current NPDES permit for the Goldendale WTP discharge contains the following monthly effluent limitations:

Flow	1.5 MGD; effluent discharge not to exceed 1/20th of upstream flow in Little Klickitat River
BOD_5	30 mg/L; 375 lbs/day
Suspended Solids	75 mg/L; 938 lbs/day
Total Coliform	230/100 mL
pH	6.5 - 8.5
Total Resid. Chlorine	less than 0.2 mg/L when discharging to the river

These permit limits are standard for lagoon systems except the total coliform limit. Heffner (1986) discusses these in more detail in his Class II report.

Water quality in the Little Klickitat is designated Class A and should meet those criteria (Table 1). No ambient monitoring stations have been located on the river, and the only WQIS study of river quality was performed in the vicinity of the old Goldendale WTP in 1981 (Joy, 1983). It concluded:

- Goldendale effluent has a potentially serious effect on in-stream water quality; primarily localized dissolved oxygen (D.O.) depression, chlorine and ammonia toxicity, and nutrient enrichment problems.

- The 20:1 dilution ratio guideline would probably not be met in the months of August through October, and in certain years, from June through January.

Other surface water quality problems have not been documented, but non-point sources of contamination are suspected; e.g., fertilizer runoff, livestock access, and storm runoff from urbanized areas.

METHODS

Descriptions and field and laboratory activities for individual stations are presented in Table 2. Monitoring locations are shown in Figure 2.

Similar methods were used in the low- and high-flow surveys. Field analyses included: temperature by mercury thermometer, dissolved oxygen by Winkler-azide modified titration, pH and conductivity by field meters, and total residual chlorine by the DPD ferrous titrametric method. Flow was calculated for selected sites from data obtained from cross-sectional stream measurements, and velocity measurements from a magnetic flow meter. Grab samples taken for laboratory analysis were stored in the dark on ice and shipped to the Ecology/USEPA Manchester analytical facility within 24 hours. All analyses were performed using standard procedures (USEPA, 1983; AWWA, 1985). The only difference between analytical procedures occurred with changes in nutrient collection protocol. The low-flow survey nutrient samples were acidified and unfiltered. The high-flow survey nitrate and nitrite samples were unacidified, and the orthophosphate samples were filtered in the field.

RESULTS AND DISCUSSION

Flow

The two receiving water surveys were conducted during very different in-stream flow conditions. According to historical gaging data, the flow conditions were not unusual for their respective seasons (Figure 3). The August low-flow discharge of 0.9 cfs at Station 1 (r.m. 16.3) was slightly below the mean August value (r.m. 18.0) of 2.5 cfs (USGS, 1985). The March high-flow discharge of 320 cfs (r.m. 15.8) was well above the March mean discharge (r.m. 18.0) of 131 cfs (USGS, 1985), but within the range of flows normal for that month (Figure 3).

Bloodgood Creek provided a substantial addition to the Little Klickitat River during the low-flow survey (Table 3). As discussed earlier (Joy, 1983), spring-fed Bloodgood Creek often is the dominant source of dilution water above the Goldendale WTP outfall during low-flow periods. However, its role during high-flow periods appears to be minor (Table 4).

As stated earlier, the NPDES permit for the Goldendale WTP authorizes discharge into the Little Klickitat River at a minimum 20:1 river-to-effluent discharge ratio (Ecology, 1982). Supplemental flow from a well operated by the city of Goldendale to the Little Klickitat River is to be discharged at r.m. 16.1 when effluent cannot be discharged. The well water is meant to provide downstream water rights holders with allocated water formerly provided by WTP effluent flows. However, the city routinely does not pump to the river (Newman, personal conversation, 1986), and the city is trying to remove its legal obligation to do so.

We requested the WTP operators, Pete Ham and Paul Halm, to discharge both the WTP effluent and the municipal make-up water to the Little Klickitat for our low-flow period survey. Based on an estimated flow of 6.0 cfs in the Little Klickitat at the staff gage above the WTP outfall (Station 3; Figure 2), 0.3 cfs was to be discharged from each source to meet the 20:1 dilution requirements of the Goldendale WTP discharge permit. The municipal make-up well discharged 0.3 cfs, but because of a misunderstanding, the WTP discharged 0.24 MGD (0.37 cfs). Therefore, the dilution ratio of the Little Klickitat water to Goldendale WTP effluent averaged 16.5:1 during the two days. Well and effluent discharging commenced at 1700 hours on August 26, 1985.

The river-to-effluent dilution ratio was estimated to be 180:1 during the high-flow period survey (Table 4). The ratio could have been somewhat higher since subsurface flow may have entered the river between our measurement site at r.m. 15.8 and the outfall (r.m. 14.1).

During the high-flow period survey, a major drainage ditch entering the river approximately 100 feet above the outfall was discharging 2.2 cfs--a volume similar to the effluent discharge volume (Table 4). The drain collects surface- and subsurface discharge from wheat fields south of Goldendale and within the southern portion of the city (Newman, 1986). The drain was dry during the low-flow period survey.

The river within the study area and below the outfall has several intermittent tributaries (Figure 2). Evidently these tributaries carried no water during the low-flow period survey, because a slight decrease in flow (1.2 cfs) between r.m. 14.1 and 10.5 was measured (Table 3). We were unable to gage flows in the same area during the high-flow survey; however, these tributaries and several small springs were observed.

Time of Travel

The low-flow period time-of-travel estimate for effluent reaching r.m. 10.5 was 0.67 day (16 hours). However, 0.8 day (20 hours) had elapsed by the time Station 6 (r.m. 10.5) was sampled on August 27, and chloride and phosphorus sample results indicated effluent had not yet reached that station (Figure 4). Braiding of the stream channel probably slowed the time of travel.

A rough estimate of the high-flow period survey time of travel between the outfall (r.m. 14.1) and r.m. 10.5 would be 2 hours. The estimate assumes a mean cross-sectional area of 125 ft^2, and a mean velocity of 2.9 ft/sec.

Effluent Effects

Effluent and receiving water quality data collected during the two surveys are shown in Tables 3 and 4.

During both surveys the impacts of the Goldendale WTP effluent on Little Klickitat River water quality appeared to be minor. The effluent met most NPDES limits during both surveys. There were no significant differences between levels of D.O., fecal coliform, turbidity, or BOD above and below the outfall (Tables 3 and 4). Low-flow survey total coliform results could not be evaluated because of test interference. Heffner (1986) discusses this problem in more detail. High-flow survey results showed no significant total coliform or fecal coliform contributions by the WTP (Table 4).

Effluent and in-stream ammonia concentrations were low and posed no aquatic toxicity hazard or oxygen demand problems. The effluent contributed noticeable amounts of nutrients to the river, especially during the low-flow period (Figure 5). The effluent concentration of total inorganic nitrogen (TIN = NO_3 + NO_2 + NH_3) and total phosphorus (TP) accounted for 37 percent and 52 percent of their respective in-stream loads at Station 4 during the low-flow survey.

The contribution of these nutrients could stimulate seasonal nuisance growths of periphyton and aquatic macrophytes. The rapid uptake of the nutrients, especially nitrogen, by aquatic life was evident from the low-flow survey results (Table 3) For example, both total inorganic nitrogen and orthophosphate in-stream loads were reduced in half between Stations 5 and 6, a distance of two miles. During the high-flow survey, the effluent contributed 11 percent and 13 percent to the respective in-stream load at Station 4. Local effects were not apparent, probably because stream velocities and low temperature and light conditions limited periphytic growth. Far-field effects are unknown.

The pH increased slightly below the outfall during the low-flow survey (Table 3). The alkalinity of the river was evidently adequate to buffer the high pH of the effluent. The effluent pH value exceeded NPDES permit limits, but such a value is natural for lagoon systems. Heffner (1986) discusses this in more detail.

Residual chlorine (TRC) concentrations exceeded non-detectable levels once during the surveys (Tables 3 and 4). The theoretical concentration downstream of the outfall (Station 4) would have exceeded the USEPA one-hour average criterion of 0.019 mg/L during the observed event (Federal Register, 1985). However, our field method was not accurate enough to confirm this. Dechlorination operations were adjusted after our observations were made, and effluent TRC concentrations returned to non-detectable levels (less than 0.1 mg/L).

Suspended solids (TSS) appear to have increased below the outfall during the low-flow period survey (Table 3). A TSS mass balance calculation for Station 4 indicates the increase can be attributed to the effluent input. Algae from a bloom in the WTP lagoons was the probable source of TSS. The cause of the greater TSS increase at Station 5 during low-flow survey is unknown. High-flow period TSS loads from the WTP effluent were insignificant (Table 4).

Comparison of 1985 to 1981 Data

Selected receiving water data from the 1981 low-flow period survey (Joy, 1983) are presented in Table 5. The outfall location of the former Goldendale WTP is indicated in Figure 2.

The major water quality impacts observed during the 1981 survey were related to poor effluent dilution during the low-flow period. These included the dissolved oxygen depression, ammonia and chlorine toxicity, and nutrient enrichment. D.O. profiles and in-stream nutrient loads for the 1981 and both 1985 surveys are compared in Figure 5. Marked improvement was evident in the data: in-stream D.O. profiles have improved, ammonia and chlorine toxicity has been eliminated, and nutrient loads have been reduced.

The effluent quality of the new WTP also showed marked improvement over the old WTP's effluent quality in critical parameters: ammonia, chlorine, nitrate, and total phosphorus. Reduction of ammonia alleviated both the in-stream oxygen demand problem and potential ammonia toxicity problems. Chlorine reduction through effluent dechlorination has removed chlorine toxicity potential. Diversion of the discharge away from the river and onto the spray fields during most of the low-flow period has probably eliminated benthic solids accumulations in low-velocity areas of the river channel and thereby reduced the sediment oxygen demand problem existing in 1981. Reduced effluent concentrations of phosphorus, ammonia, and nitrate have effectively cut the effluent's contribution of nutrients to the river (Figure 5).

The improvements in 1985 water quality compared to 1981 seems to be directly related to several aspects of the Goldendale WTP upgrade. Effluent treatment improvements, effluent diversion from the river, and meeting 20:1 dilution ratio requirements all have contibuted to improved water quality in the Little Klickitat during low-flow periods.

Goldendale Well Water Discharge

The well used by Goldendale to augment river flows when effluent is not discharged was sampled only during the low-flow period survey (Table 3). The well water discharges from a storm drain located on the left bank at r.m. 16.1 (Figure 2). Measurement of flow volumes confirmed that no other sources were adding water to the drain. The well water had a high conductivity and elevated nitrate concentration compared to in-stream levels. The well water's sodium absorption ratio (SAR) was similar to the effluent's SAR. SAR is an estimate of cation exchange potential and indicates if irrigated soils will become poisoned by high salinity or alkali conditions. Both effluent and well waters exhibited low salinity hazards and moderate alkali hazards (Hem, 1975).

The well water did not appear to have a large downstream water quality impact. Localized in-stream increases in nitrate, conductivity, chloride, and major cations may have occurred, but they were not evident at Stations 2 or 3 (Table 3). The localized increases could stimulate in-stream periphytic growth if the discharge were continued over a longer period of time. However, the dilution of the Little Klickitat by Bloodgood Creek (1:2.25) limits the extent of the affected area. As stated earlier, the city would like to remove its legal obligation to pump water to the river, and it often does not pump as required. If the city is required to continuously discharge the well at 0.3 cfs during periods of low flow (<5 cfs above r.m. 16.1), the area below the drain including the city park reach should be checked for nuisance growths of periphyton. These growths could compromise aesthetic quality and lead to wider diurnal fluctuations of in-stream D.O.

Non-Point Sources

Now that the impact of the WTP effluent on river water quality has been decreased, the impact of non-point sources is more evident. Fecal coliform levels in Bloodgood Creek and in the Little Klickitat River below r.m. 12.6 during the low-flow survey were elevated and could not be attributed to effluent contributions (Table 3). The concentration of nutrients, especially nitrate, were elevated in Bloodgood Creek and the diversion drain (DR) entering the river at r.m. 14.2 during the high-flow survey (Table 4). TIN and fecal coliform loads continued to increase in the river downstream of the outfall during the high-flow period at the rate of approximately 40 lbs/mi/day and 1.9×10^{10} FC/mi/day, respectively. Fertilizer runoff and manure are the most likely sources of the observed nutrient and coliform increases. Livestock access to the river was observed in several places between r.m. 14.1 and 10.5. The high nitrate concentration of the sample taken from the ditch (DR) suggests fertilizer runoff from the wheatfields.

Control of non-point sources of contamination will be difficult, but data should be collected and assessed. Then the water quality benefits from alleviation of non-point source contamination can be evaluated and the most cost-effective measures for alleviation can be planned and implemented.

Total Maximum Daily Load (TMDL) Evaluation

The TMDL process is used to evaluate the ability of NPDES discharge limits to maintain state and federal fishable-swimmable water quality goals. The evaluation of the Goldendale WTP discharge is expanded here to include both high-flow and low-flow discharge conditions. Normal operational procedures at the WTP during low-flow usually call for diversion of wastewater to spray irrigation rather than discharge to the Little Klickitat River. Therefore, the low-flow conditions described in the TMDL would rarely occur.

The data used to calculate the seasonal TMDLs are presented in Table 6. Included are water quality and discharge data for the Goldendale WTP effluent and the Little Klickitat River above the WTP outfall (r.m. 14.4). The water quality data were selected from the 1981, 1985, and 1986 surveys (this report and Joy, 1983). Discharge values are seasonal mean values calculated from USGS discharge statistics obtained at station #14112000 at r.m. 18.0 (USGS, 1985), and field data of Bloodgood Creek low-flow discharges. Fecal coliform was substituted for total coliform since adequate total coliform data for the area are not available. The resulting complete mixed downstream concentrations of Goldendale WTP effluent in the Little Klickitat River are also included in Table 6. The results indicate that when the effluent meets the NPDES permit limits both in quality and in volume (i.e., 20:1 dilution requirement), all Class A water quality criteria are met downstream of the outfall. Both low- and high flow conditions yielded favorable TMDL results.

Nutrient parameters are not limited in the NPDES permit. However, Joy (1983) showed the importance of their impact on water quality in the Little Klickitat. Results in Table 6 indicate the receiving water above the outfall and the WTP effluent are nitrogen (N) limited during low-flow periods. Although phosphorus concentrations in the river would increase, the Goldendale WTP effluent would probably not stimulate nuisance growths of periphyton downstream of the outfall under normal summer operating conditions because the system is N-limited. However, if algal blooms in the lagoons were to experience an early die-off due to unseasonably cold weather or lagoon poisoning, resultant inorganic nitrogen loads to the river would stimulate periphyton growth. This could further lead to wide diurnal fluctuations of in-stream dissolved oxygen with levels falling below the 8 mg/L Class A criterion at night.

During the high-flow season, the 35 percent and 30 percent increase of N and P in the receiving water downstream of the outfall would not appreciably stimulate local periphyton growth. Low temperature and light conditions and excessive stream velocities would also be limiting. Not enough information is available to estimate the effect of the nutrient increase on water quality farther down the river system; e.g., the Klickitat River and Columbia River.

In conclusion, the TMDL evaluation shows current NPDES permit limits protect water quality in the Little Klickitat River against degradation by effluent from the Goldendale WTP. However, unusual circumstances in the lagoons during low-flow periods could cause excessive nutrient discharge (not an NPDES parameter) and consequent eutrophication problems. Also, far-field effects from nutrient discharges during high-flow periods cannot currently be assessed, but may need future consideration.

CONCLUSIONS

The surveys of the Little Klickitat River in the vicinity of Goldendale WTP have documented improved water quality directly attributable to an upgrade in the WTP. The WTP effluent has very little impact on river water quality during low-flow and high-flow periods. The improvement in effluent quality and diversion and regulation of discharge to the river during low-flow periods have eliminated many documented water quality problems. Prior to the upgrade, the effluent caused serious D.O. deficits, ammonia and chlorine toxicity problems, and nutrient enrichment problems in the river. The effluent could substantially increase in-stream nutrient loads during low-flow periods if effluent were usually discharging. During high-flow conditions, nutrient loads from the effluent contribute to existing elevated in-stream loads from non-point sources. Residual chlorine also was detected in one effluent sample before re-adjustment of dechlorination processes was made. Most other NPDES permit limits were met during the two surveys. A TMDL evaluation of the NPDES permit conditions shows they adequately protect the water quality of the river. No major impacts on river water quality by the Goldendale well were observed. The SAR of the well water was similar to effluent SAR.

RECOMMENDATIONS

- Whenever possible, continue to divert effluent from the river during low-flow periods, especially during periods of algal die-off in the lagoons.
- Monitor residual chlorine at the outfall on occasion to check effluent dechlorination efficiency.
- If the well water must discharge into the river for prolonged periods of time during low-flow conditions, check for nuisance periphyton growth problems in the river.
- Consider the Little Klickitat River in any non-point source monitoring plan.

JJ:cp

Attachments

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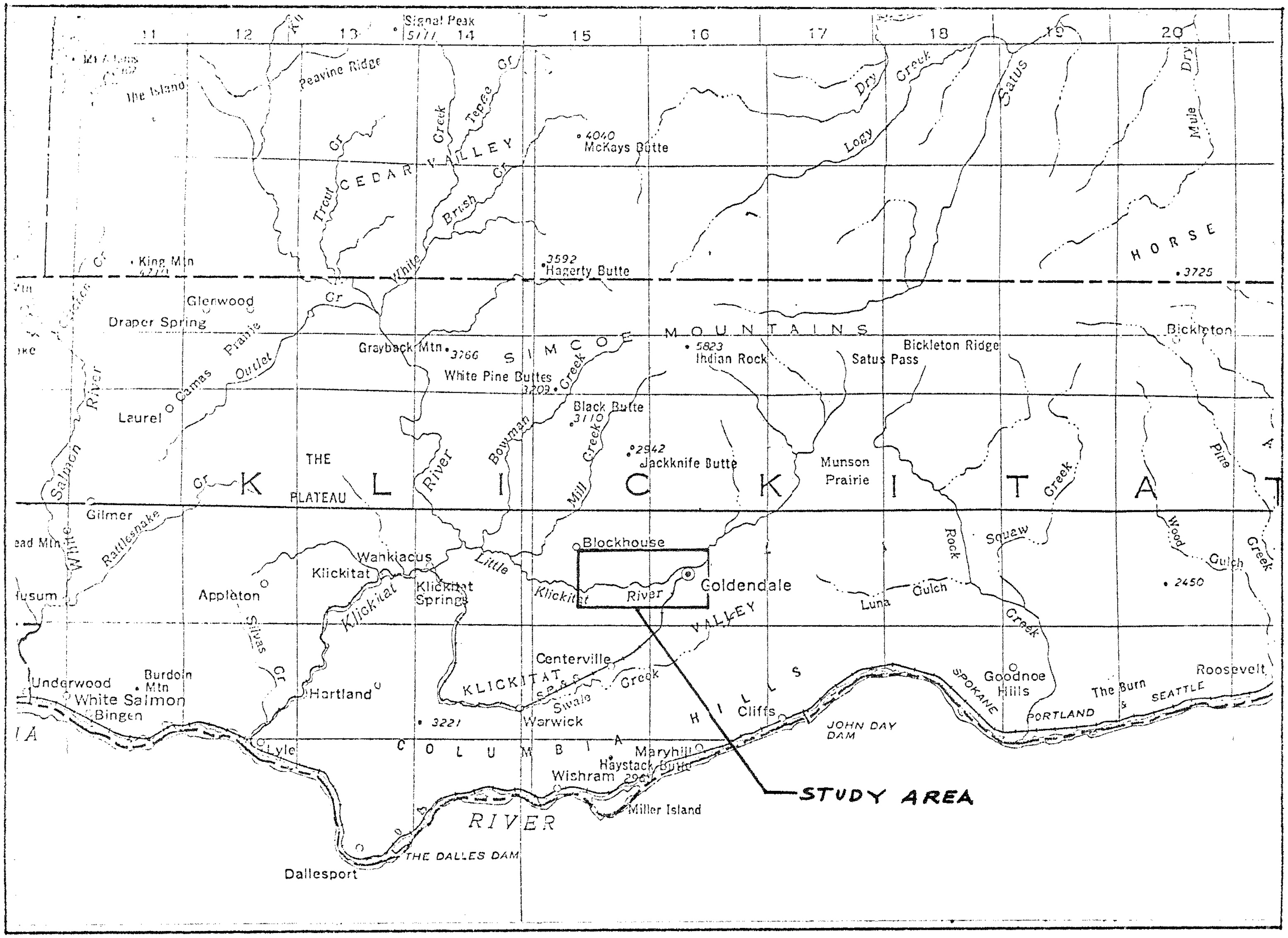


Figure 1. Location of the Little Klickitat River drainage in southcentral Washington, and the receiving water study area near Goldendale wastewater lagoons, 1985 and 1986.

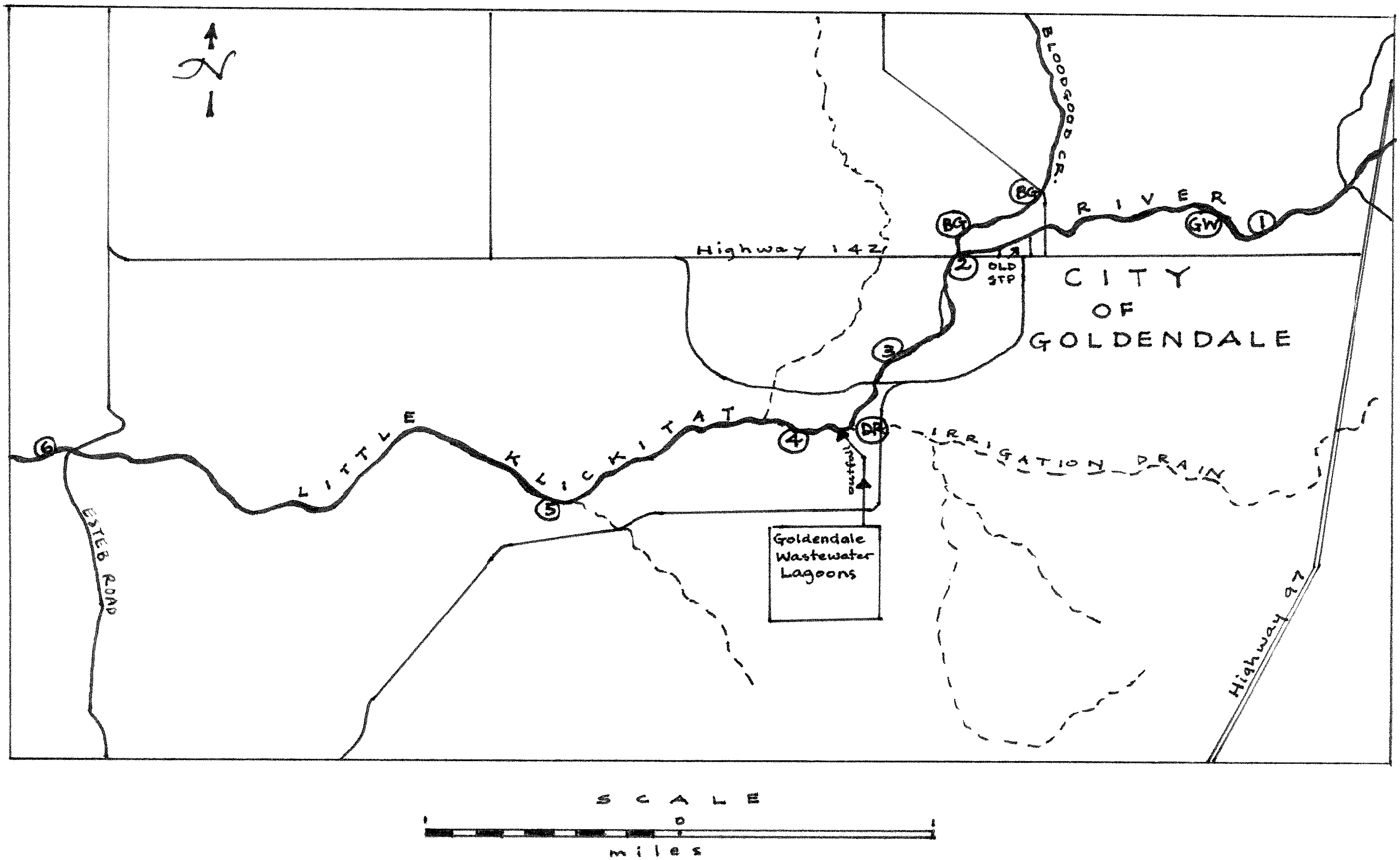


Figure 2. Receiving water study area showing water quality monitoring stations (O) used during the 1985 low-flow and 1986 high-flow period surveys.

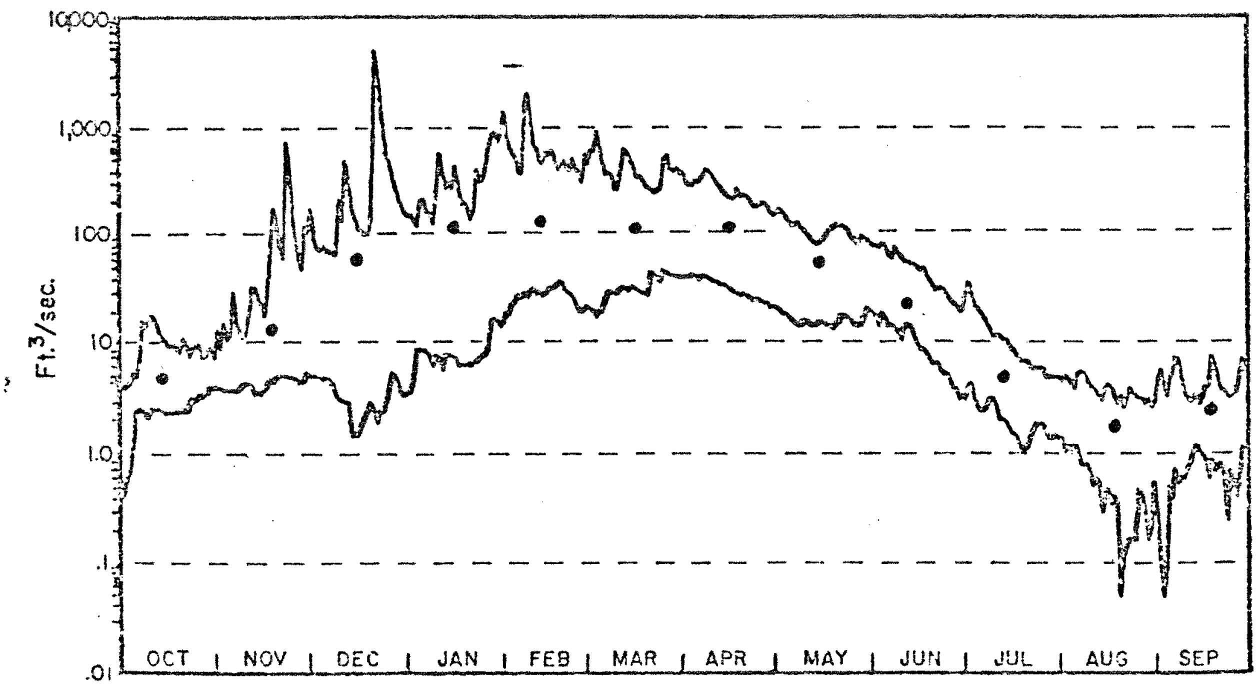
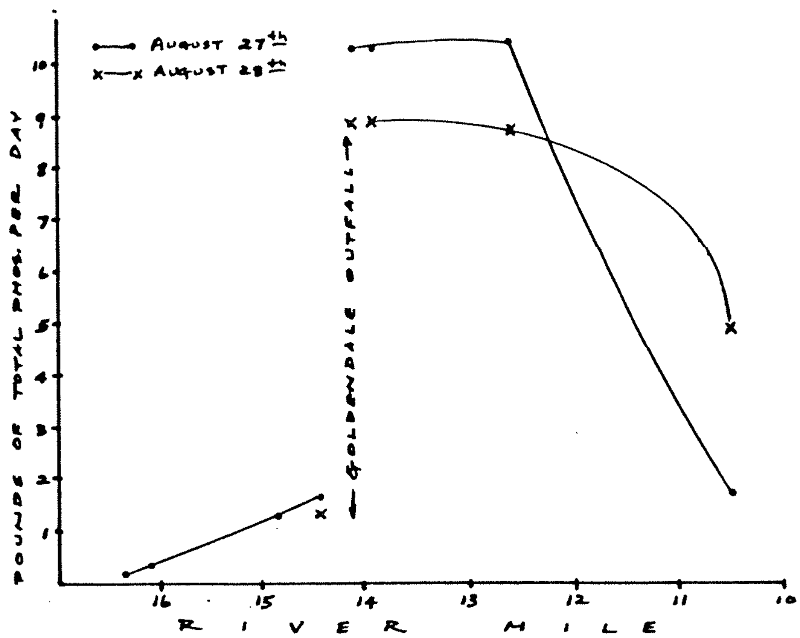


Figure 3. Minimum-maximum discharge and mean monthly discharge (●), 1958-1970. Little Klickitat near Goldendale at river mile 18.0 (Brown, 1979).



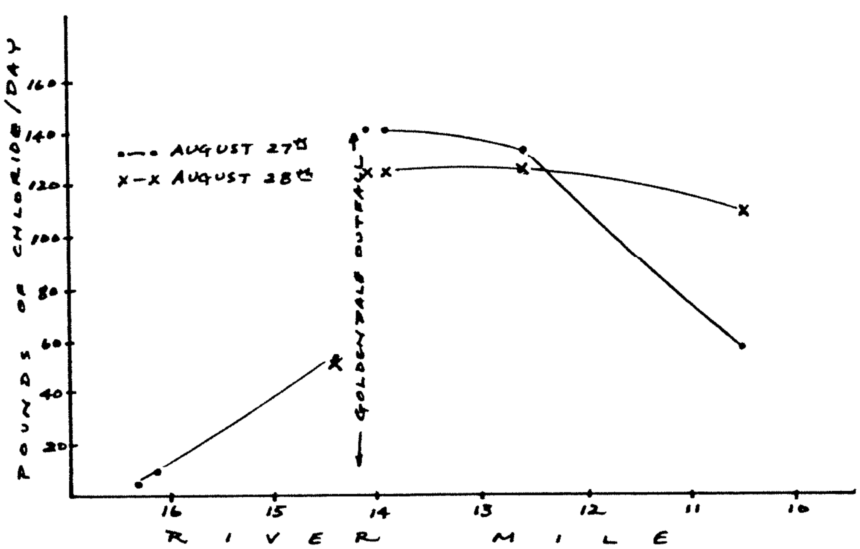


Figure 4. Total phosphorus (as P) and chloride loads in the Little Klickitat River in the vicinity of the Goldendale WTP outfall on August 27 and 28, 1985.

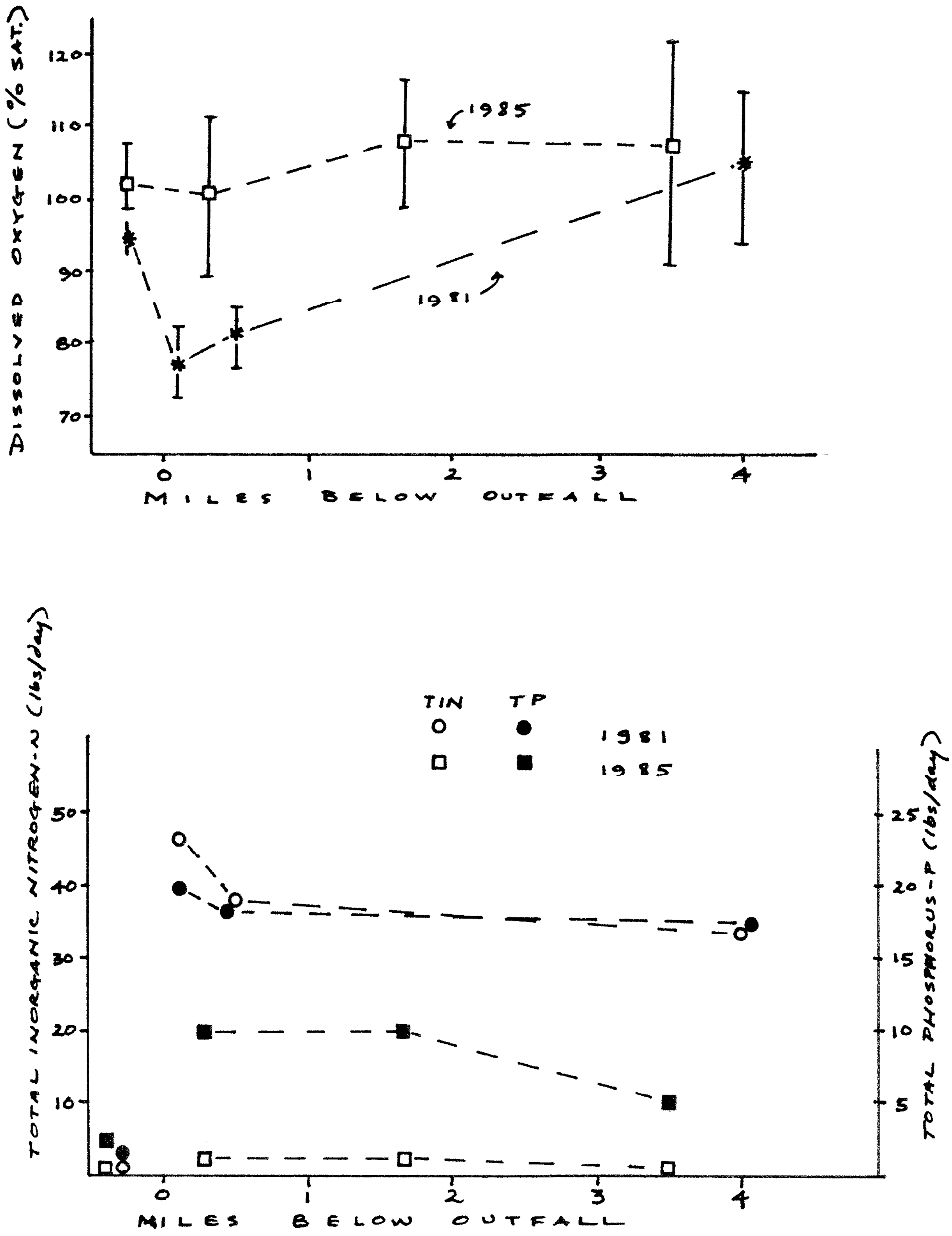


Figure 5. Dissolved oxygen profile and nutrient loads in the Little Klickitat River before wastewater treatment upgrade (1981) and after upgrade (1985) - low-flow data.

Table 1. Class A (excellent) water quality standards (WAC 173-201-045) and characteristic uses..

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

Table 2. Station descriptions and monitoring activities for two water quality surveys on the Little Klickitat River near Goldendale: low-flow, August 27-28, 1985; high-flow, March 11-12, 1986.

Station Number	River Mile	Station Description	Survey	Field/Laboratory Activities
1	16.3	Approx. 50' below Pipeline Rd. at mid-stream	low-flow	Discharge, temperature, pH, cond., dissolved oxygen/ f.coliform, nutrients(5), turbidity, chloride, Na+, Ca++, Mg++
GW	16.1	Left bank storm drain outfall	low-flow	Same as Station 1
2	14.9	Approx. 10' above confluence with Bloodgood Cr.	low-flow	Discharge, temperature, pH, cond., dissolved oxygen/ f.coliform
	14.8	Approx. 50' below confluence with Bloodgood Cr. and under hwy. bridge	high-flow	Temperature, pH, cond., dissolved oxygen/ f. coliform, NH3-N, NO2-N, NO3-N, filtered ortho-phosphate-P, total P, turbidity, solids(4), COD, chloride
BG	-	Bloodgood Cr., 10' above confluence with Little Klickitat R.	low-flow	Same as Station 1 + BOD5
		Bloodgood Cr. at Fairgrounds Rd., approx. r.m. 0.5	high-flow	Same as Station 2, high-flow w/o solids(4), only TSS
3	14.4	Little Klickitat, approx. 50' ab. bridge at stream gage, mid-stream	low-flow	Same as Bloodgood Cr., low-flow
		Little Klickitat, approx. 50' ab. bridge at stream gage, right bank	high-flow	Same as Station 2, high-flow + total coliform & BOD5
DR	14.1	Irrigation drain entering above WTP outfall, left bank	high-flow	Same as Station 3, high-flow
EFF	14.1	Goldendale WTP outfall, left bank	low-flow	Same as Station 3, low-flow + TRC and COD
4	13.9	Little Klickitat, 1000' below WTP outfall, mid-channel	low-flow	Same as Station EFF
		Little Klickitat, 1000' below WTP outfall, left bank	high-flow	Same as Station 3, high-flow
5	12.6	Little Klickitat, through field of house at bend in Horseshoe Loop Rd. mid-channel	low-flow	Same as Station 3, low-flow w/o Na+ Ca++, Mg++
		Little Klickitat, through field of house at bend in Horseshoe Loop Rd. left bank	high-flow	Same as Station 2, high-flow
6	10.5	Little Klickitat, approx. 50' below Esteb Rd. bridge, mid-channel	low-flow	Same as Station 5, low-flow w/o solids(4)
		Little Klickitat, approx. 50' below Esteb Rd. bridge, right bank	high-flow	Same as Station 2, high-flow

Table 3. Field and laboratory data from samples taken from the Litle Klickitat River near Goldendale on August 27-28, 1985. All values mg/L unless otherwise noted.

				Field Data							Laboratory Data					
River Mile	Sta. No.	Location	Date	Discharge (cfs)	Temp. (°C)	pH (S.U.)	Cond. (umhos/cm)	D.O. (mg/L)	D.O. % Sat.	TRC	F. Coli. (org/100 mL)	NO_3-N	NO_2-N	NH_3-N	O-PO_4-P	T-PO_4-P
16.3	1	L. Klickitat	27	0.8	16.5	8.2	140	9.0	91.4		*	0.02	<0.01	0.03	0.01	0.04
		@ Pipeline Rd.	28	0.9	19.5	7.8	170	--								
16.1	GW	Municipal Well	27	0.3	17.1	7.2	575	9.2	94.1		*	0.55	<0.01	0.03	0.06	0.07
14.9	2	L. Klickitat @	27	--	≈15	--	--	10.6	≈103		*					
		Bloodgood Cr.	28	1.6	15.5	8.0	145	--			26					
			28	--	14.1	--	--	8.4	81.2							
--	BG	Bloodgood Cr.	27	3.6	11.3	7.4	110	11.0	100.0		*	0.09	<0.01	0.02	0.04	0.05
			28	3.5	11.9	7.6	110	--			150	0.07	<0.01	0.2	0.05	0.05
			28	--	9.9	--	--	10.2	89.9							
14.4	3	L. Klickitat @	27	6.1	14.0	7.8	125	11.2	108.5		*	0.05	<0.01	0.02	0.03	0.05
		Stream Gage	28	--	14.0	8.3	--	10.5	101.3		47	0.04	<0.01	0.02	0.04	0.04
			28		11.8	--	--	9.4	86.4							
--	LE**	Goldendale Eff.		0.40	21.0G	9.7G	20G		--	0.1G	<4G	0.33	0.01	0.11	0.12	2.3
		(24-hr comp)			17.9G	7.8G	295G			0.3G	<4G	0.29	0.23	0.41	1.9	2.0
14.1	EFF	L. Klickitat @	27		17.2	9.1	230	10.0	103.1	<0.1	*	0.20	<0.01	0.09	1.00	1.68
		Goldendale	28		17.3	9.5	250	--		0.3	60	0.23	<0.01	0.14	1.3	1.97
		Outfall														
13.9	4	L. Klickitat	27	--	14.9	8.2	150	10.8	106.2	<0.1	*	0.06	<0.01	0.03	0.18	0.29
		approx. 1000'	28	--	13.6	8.5	150	10.2	97.5	<0.1	57	0.05	<0.01	0.03	0.12	0.25
		blw Outfall	28	--	12.5	--	--	9.0	84.0							
12.6	5	L. Klickitat	27	5.7	16.6	8.2	145	11.2	114.1		*	0.02	<0.01	0.02	0.23	0.34
			28	6.0	13.4	7.6	130	9.8	93.2		100	0.03	<0.01	0.02	0.19	0.27
			28	--	--	--	--	--	--							
10.5	6	L. Klickitat	27	5.3	19.2	8.3	125	11.2	120.8		*	<0.01	<0.01	0.02	0.04	0.06
		@ Esteb Rd.	28	5.4	14.6	7.7	135	9.9	96.7		96	<0.01	<0.01	0.02	0.12	0.17
			28	--	14.1	--	--	8.6	83.1							

				Laboratory Data - continued													
River Mile	Sta. No.	Location	Date	pH (S.U.)	Sp. Cond. (umhos/cm)	Turb. (NTU)	TS*	TNVS*	TSS*	TNVSS*	BOD_5	COD	Chloride	Na+	Ca+	Mg+	SAR
16.3	1	L. Klickitat	27	7.6	128	1							1.5	7.9	9.7	6.5	0.48
		@ Pipeline Rd.	28														
16.1	GW	Municipal Well	27	7.5	454	3							3.9	31.6	16.7	22.2	1.19
14.9	2	L. Klickitat @	27														
		Bloodgood Cr.	28														
--	BG	Bloodgood Cr.	27	7.7	87	2	100	54	7	3			1.0	2.6	8.6	3.7	0.18
			28	7.7	82	2	120	74	5	3	<4		0.91				
14.4	3	L. Klickitat	27	8.0	100	2	120	66	8	3			1.7	6.3	8.7	4.3	0.43
		@ Stream Gage	28	8.1	115	2	120	82	6	4	<4		1.6				
--	LE**	Goldendale Eff.		--	234	8	280	130	48	4	26	120	30	41.0	12.1	4.5	2.56
		(24-hr comp)			232	6	280	82	24	4	26	100	30	38.9	9.3	4.2	
14.1	EFF	L. Klickitat @	27	9.0	202	7	200	120	17	6	--	70	15.8	18.4	11.8	4.6	1.65
		Goldendale	28	9.1	195	6	--	--	--	--	18	76	19				
		Outfall															
13.9	4	L. Klickitat	27	8.2	113	2	120	63	10	4		14	4.0	7.7	7.4	4.4	0.54
		approx. 1000'	28	8.2	--	3	150	80	6	1	<4	11	3.5				
		blw Outfall															
12.6	5	L. Klickitat	27	8.3	113	2					--		4.4				
			28	7.9	117	3	120	71	44	17	--		3.9				
10.5	6	L. Klickitat	27	8.5	100	2					--		2.0				
		@ Esteb Rd.	28	7.9	110	2					<4		3.8				

*Samples exceeded recommended holding periods
< = Less than
SAR = Sodium absorptin ratio
**Data from Heffner (1986)
G = Grab sample, not from composite

Table 4. High-flow data collected from the Little Klickitat River near Goldendale, March 11-12,1986
All values mg/L unless otherwise indicated. See Table 2 for complete station description.

			Field Data							
Station Number	Location Description	Date	Discharge (cfs)	Temp. (deg.C)	pH (s.u.)	Sp.Cond. (umhos/cm)	Diss. O2	Diss. O2 (% sat.)	F. coli. (#/100mL)	Tot. coli. (#/100mL)
BG	Bloodgood Cr. at	3/11		10.1	8.0	110	10.8	95.5	93	
	Fairgrounds Rd. bridge	3/12	15	9.4	7.7	110	10.7	93.1	39	
2	Little Klickitat blw.	3/11		6.9	7.9	72	11.3	92.6	21	
	Bloodgood Creek	3/12	335	5.5	7.7	65	11.9	94.2	15	
3	Little Klickitat at	3/11		6.7	7.9	72	11.3	92.2	24	240
	stream gage	3/12		5.5	7.8	77	11.8	93.4	16	330
DR	Irrigation drain at	3/11		9.4	8.1	215	12.8	111.4	1	100
	confluence w/ river	3/12	2.2	7.0	7.8	230	12.0	98.6	1	1700
LE*	Goldendale WTP effluent			x9.7	x8.3	x271			x<4	49,100,11
	24-hr. composite		1.9	g10.2	8.5	285			g<4	180,410
4	Little Klickitat blw.	3/11		6.4	7.8	75	11.3	91.4	27	220
	Goldendale WTP	3/12		5.4	7.9	80	11.7	92.3	21	530
5	Little Klickitat blw.	3/11		6.4	7.7	76	11.5	93.0	35	
	Goldendale WTP	3/12		5.3	7.9	81	11.7	92.1	25	500
6	Little Klickitat blw.	3/11		6.4	7.2	80	11.6	93.8	36	
	Goldendale WTP	3/12		5.5	8.1	82	11.6	91.8	29	240

Laboratory Data															
Station Number	BOD5	COD	NO3-N	NO2-N	NH3-N	TIN	OPO4-P	Total P	pH (s.u.)	Sp. Cond. (umhos/cm)	Cl-	Turb. (NTU)	Total Solids	T.N.V. Solids	T.Susp. Solids	T.N.V.S. Solids
BG		91	0.52	<0.01	0.02	0.54	0.06	0.08	7.4	106	1.4	15			8	
		15	0.49	<0.01	0.03	0.52	0.05	0.07	7.5	109	1.4	12			6	
2		11	0.14	<0.01	0.03	0.17	0.05	0.07	7.0	74	1.6	9	92	62	15	9
		11	0.11	<0.01	0.03	0.14	0.03	0.03	7.5	75	1.8	8			10	
3		15	0.17	<0.01	0.02	0.19	0.04	0.06	7.1	76	1.6	8	89	56	11	7
	4	11	0.13	<0.01	0.02	0.15	0.03	0.03	7.5	77	1.6	8	90	62	13	10
DR		91	2.40	<0.01	0.02	2.42	0.07	0.09	7.9	217	4.7	13			5	
	4	23	2.40	<0.01	0.03	2.43	0.05	0.07	7.7	230	4.3	6			4	
LE*		g55	x0.79	<0.01	x3.0	x3.8	x1.4	x1.7	x8.1	x274	x17	x8			x37	
	14	91	0.73	<0.01	2.80	3.53	1.40	1.80	8.3	273	16.0	8	220	130	40	4
4		19	0.20	<0.01	0.03	0.23	0.06	0.07	7.1	78	1.6	9	110	61	14	9
	4	11	0.15	<0.01	0.04	0.19	0.04	0.07	7.5	79	1.7	8	88	57	12	12
5		34	0.22	<0.01	0.04	0.26	0.06	0.07	7.1	82			91	55	17	11
		11	0.21	<0.01	0.03	0.24	0.04	0.05	7.5	81					13	
6		19	0.26	<0.01	0.03	0.29	0.06	0.08	7.1	82	2.4	10	110	85	22	18
		11	0.23	<0.01	0.03	0.26	0.04	0.07	7.5	83	1.8	8			13	

* Data from Heffner(1986)
x =Mean of two or more values from grab samples
g =Grab sample, not from composite

Table 5. Mean values from samples taken on the Little Klickitat River, October 27 and 28, 1981. All values are in mg/L unless otherwise noted. Mean value ± standard deviation (number of observations).

Station Number	Location	River Mile	Temperature (°C)	pH (S.U.)	Dissolved Oxygen % Saturation	NO_3^--N	NO_2^--N	NH_3-N
1	Pipeline Road	16.3	10.3 ± 0.7(3)	8.2 ± 0.1(2)	98.3 ± 2.7(3)	<0.01(2)	<0.01(2)	<0.02 ± 0.01(2)
1A	Bloodgood Creek	14.9	10.8 ± 1.4(2)	7.9(1)	94.9(1)	0.03(2)	0.01(2)	0.04 ± 0.01(2)
2*	Highway 142 Bridge	14.8	10.4 ± 0.7(3)	7.97 ± 0.06(3)	94.2 ± 1.5(3)	0.02 ± 0.01(3)	<0.01(3)	<0.03 ± 0.02(3)
EFF	Effluent Channel	14.6	13.2 ± 0.9(2)	7.2(2)	25.1 ± 2.9(2)	0.48 ± 0.01(2)	0.18 ± 0.01(2)	9.2 ± 1.1(2)
3*	Below Outfall	14.5	10.2 ± 1.0(3)	7.7 ± 0.1(3)	78.7 ± 4.3(3)	0.13 ± 0.02(3)	0.02(3)	0.8 ± 0.1(3)
4	Future Outfall	14.1	10.1 ± 0.6(3)	7.65 ± 0.07(2)	81.5 ± 2.6(3)	0.24 ± 0.01(2)	0.02(2)	0.48 ± 0.06(2)
5	Esteb Road Bridge	10.5	10.3 ± 1.1(2)	8.5 ± 0.7(2)	104.9 ± 10.2(2)	0.46 ± 0.03(2)	0.02 ± 0.01(2)	0.09(2)

Station Number	Un-ionized NH_3-N	O-PO_4-P	Total Phos.-P	Chlorides	Sp. Cond. (umhos/cm)	Total Solids	Total Susp. Solids	Discharge[1/] (cfs)
1	<0.001(2)	0.02 ± 0.01(2)	0.04 ± 0.01(2)	1.9 ± 0.6(2)	125 ± 7(2)	88 ± 1(2)	6 ± 6(2)	4.2(1)
1A	<0.001(1)	0.06 ± 0.02(2)	0.06 ± 0.02(2)	2.7 ± 0.6(2)	100(2)	120(1)	5(1)	≈5(1)
2*	<0.001(3)	0.07 ± 0.05(3)	0.06 ± 0.03(3)†	1.9 ± 0.6(2)	107 ± 4(3)	120 ± 60(3)	20 ± 30(3)	8.8 ± 2.1(2)
EFF	0.04 0.01(2)	3.8 ± 0.3(2)	3.7 ± 0.6(2)†	22 ± 1(2)	352 ± 4(2)	160 ± 80(2)	5(2)	0.69 ± 0.02(3)
3*	0.007 ± 0.002(3)	0.39 ± 0.04(3)	0.33 ± 0.09(3)†	3.4 ± 0.5(2)	138 ± 3(3)	120 ± 20(3)	12 ± 16(3)	10.0 ± 1.3
4	0.004 ± 0.001(2)	0.55 ± 0.01(2)	0.34 ± 0.01(2)†	3.8(2)	130 ± 10(3)	110 ± 10(2)	10(2)	10.0 ± 1.3(1)
5	0.008 ± 0.009(2)	0.29 ± 0.01(2)	0.28 ± 0.01(2)†	3.4 ± 0.5(2)	122 ± 11(2)	170 ± 70(2)	18 ± 17(2)	10.6 ± 1.4(1)

*Includes results from compositor samples
**Field measurement
†Results with interference problems included
[1/]Most discharge values estimated for two days from one measurement at each station

Table 6. Total maximum daily load (TMDL) evaluation data for the Little Klickitat River in the vicinity of Goldendale WTP outfall under low- and high-flow conditions. All values are in mg/L unless otherwise noted.

	Low-Flow (July - October)			High-Flow (December - April)		
Parameter	Upstream	Effluent	Downstream[1]	Upstream	Effluent	Downstream[1]
†BOD_5	<4	30	4.2	<4	30	4.5
†Total Susp. Solids	8	75	10	12	75	13.1
†pH (S.U.)	8.0	8.5(9.6)*	8.01(8.02)	7.6	8.5	7.6
Temperature (°C)	15	20	15.2	6.0	10	6.1
†T. Residual Chlorine	0	0.2	0.009	0	0.2	0.003
Fecal Coliform (org/100 mL)	50	200	57	25	200	28
T. Inorg. Nitrogen-N	0.06	0.5(3.7)	0.08(0.22)	0.17	3.7	0.23
Orthophosphate-P	0.04	1.9	0.12	0.04	1.3	0.06
Ammonia-N	0.02	0.11(3.1)	0.02(0.15)	0.02	3.1	0.07
†Discharge (cfs)	8.6	0.4**	9.0	130	2.3**	132

[1]Downstream values are the calculated complete mix values.

†Goldendale WTP effluent NPDES permit limited parameters. Maximum allowable values are used in effluent column

*Values in parentheses are extreme values from survey data (Heffner, 1986; Joy, 1983; this report).

**Goldendale WTP discharge value for low-flow period is the 20:1 dilution volume for the mean seasonal upstream flow (8.6 cfs). The high-flow WTP discharge is the maximum NPDES permitted discharge.