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Governor

Publication No. 83-e48

WA-PS-0070

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, LU-11 • Olympia, Washington 98504 •

MEMORANDUM
November 14, 1983

To: Tom Eaton, S.W. Regional Office

From: Dale Clark DKC

Subject: Western Slopes, Tacoma Plant #2, Sewage Treatment Plant Class II Inspection

INTRODUCTION

On March 8-9, 1983, and again on March 22-23, 1983, Class II inspections were conducted at the Western Slopes (WS) wastewater treatment plant (WTP). Department of Ecology (WDOE) representatives in attendance during the March 8-9 inspection were Kenneth Mauermann (Southwest Regional Office) and Bill Yake and Dale Clark (Water Quality Investigations Section). WS representatives present during the inspection were Art Kujawa and George Anderson. The Tacoma Plant #1 laboratory representative present during the inspection was Chris Getchell. During the March 22-23 survey, the WDOE representative present was Dale Clark. WTP and laboratory representatives were the same. The Tacoma sewer utilities representative present was Dave Hufford.

Present during the laboratory review segment of the inspection were Dale Clark, Bill Yake, and Art Kujawa. Laboratory review took place on March 8, 1983.

Setting

The Western Slopes WTP is designed as a primary treatment facility that uses two rectangular sedimentation tanks (Figure 1). Raw influent enters the plant through a 30-inch main, then passes sequentially through a six-inch barminutor, bar screen, and a 12-inch Parshall flume. The influent is then channeled first into an aerated grit chamber and then to the sedimentation tanks where grease and solids removal takes place. The effluent overflows the launder rings, flows into the effluent trough, and is channeled into a pipeline buried in the hillside that acts as a chlorine contact chamber. The effluent is discharged through a 560-foot long, 30-inch diameter outfall line. The outfall extends approximately 420 feet out into Puget Sound at the Tacoma Narrows. Discharge of effluent takes place 80 feet below the surface.

Solids from the clarifier are pumped from the sedimentation tanks to two anaerobic digesters. Sludge is removed from the digesters once a week. Sludge is trucked to a land-application site as required. Approximately 21,000 gallons of supernatant from the digesters are pumped back to the influent line twice a week. The pumping procedure requires approximately 2-1/2 hours to complete.

INSPECTION PROCEDURE

Flow measurement at Western Slopes is accomplished by a 12-inch Parshall flume, an automatic sonic detection, and a recording system (script chart and totalizer). The flume was measured, and dimensions were within the specified limits as described in the *Stevens Water Resources Data Book* (1st ed.) and illustrated in Figure 2. The sonic detector for flow measurement appeared to be placed properly at the flume focal point (2/3 c). Some flow disturbance in the flume was evident due to turbulence created by a comminutor located four feet upstream from the flume throat (Figure 1). The turbulence may be affecting the ability of the sonic detector to accurately measure flows. A WDOE publication, *Criteria for Sewage Works Design* (1978) states that the following requirement should be observed when selecting a location for flume placement: "The flume should not be installed too close to turbulent flow, surging or unbalanced flow, or a poorly distributed velocity pattern." This requirement does not appear to be met for the Western Slopes flume.

An in-field flow measuring device (Manning dipper) was installed at the Parshall flume on March 8 and March 22, 1983 (Figure 3). The dipper was adjusted to read 100 percent at 17 inches of head or a maximum flow of 4.4 million gallons per day (MGD). On March 8-9, the device ran for 20 hours and a 24-hour flow was estimated from the totalizer reading. Records for the March 22 flow recording proved to be unacceptable due to a malfunction of the dipper's sensing probe. Total flows determined from the March 8-9 record were compared to plant records for the same period and are discussed in the Results section of this survey.

Plant influent and effluent were sampled over a 24-hour period using Manning automatic samplers by both WDOE and WS. Some adjustment of sampler placement occurred between the two surveys (Table 1). Samples were split among WDOE, WS, and the Tacoma STP #1 laboratories for analytical comparison.

Grab samples for influent and effluent were collected and analyzed in the field for specific parameters -- pH (S.U.); conductivity (μmhos/cm); and temperature (°C). Grab samples of chlorinated effluent were split and analyzed for fecal coliform (FC) and chlorine residual by WDOE and WS (Table 1).

On March 23, 1983, fluorescent dye was added to the effluent trough just prior to entering the chlorination chamber in order to estimate detention time in the contact chamber.

The holding capacity of the outfall line below the mean low low water (MLLW) line was calculated and used to determine the extra chlorine contact time that results from effluent detention in the outfall. Table 2 illustrates the outfall contact times for flows of 1.0, 2.0, and 3.0 (MGD).

A sludge grab sample was collected on March 9 for selected metals analysis and a priority pollutant scan. Analysis was conducted by the Environmental Protection Agency (EPA) laboratory located in Manchester, Washington. Results from the metals analysis, priority pollutant scan, and a comparison with results from similar sludge analyses on Tacoma Central STP samples are discussed in the following section and are found on Table 10.

RESULTS AND DISCUSSION

The Western Slopes wastewater treatment facility is required by law to comply with effluent limits for biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform (FC) bacteria, pH, chlorine residual, and monthly average effluent discharge. All of the above are specified in the state-issued National Pollution Discharge Elimination System (NPDES) permit (current permit number WA 003720-6). The original permit issued January 3, 1975, contained primary treatment limits that were to last until May 30, 1977. After July 1, 1977, the permittee was to have achieved secondary treatment. The permittee submitted documentation establishing that it could not, despite reasonable effort, achieve effluent limits for secondary treatment in the allotted time. The WDOE issued a revised permit (Docket No. DE 77-270) containing elevated effluent limits on the above parameters. Since re-issuance, these limits have remained intact pending a decision on plant upgrade to secondary treatment. Table 3 includes the revised permit effluent limitations that are now in effect.

Wastewater monitoring is performed according to the schedule set down in the current NPDES permit (Table 4).

Western Slopes' sampling procedures were generally satisfactory. Typically, FC samples were collected from an inspection manhole located 50 feet downstream from the plant's contact chamber. The samples were dechlorinated immediately. However, because of the limited capacity of the contact chamber (approximately 2,000 gallons) and the larger capacity of the offshore discharge line (approximately 15,420 gallons), it appears that the samples should be held longer prior to dechlorination if results are to accurately reflect bacterial concentrations of effluent actually discharged to the Narrows.

On March 23, a dye study using Rhodamine WT fluorescent dye was used to determine the approximate volume of the chlorine contact chamber. The volume was estimated to be 2,000 gallons or two percent of the size necessary to handle the plant's design flow (6.25 MGD), as determined using WDOE state *Criteria for Sewage Works* (WDOE, 1978). Clearly, the contact chamber is undersized and inadequate for disinfection.

Effluent discharge takes place via a 560' x 2-1/2' (I.D.) offshore outfall line. Using MLLW as the upper limit for water in the line, the capacity of the line is approximately 15,420 gallons -- nearly eight times the volume of the contact chamber. It appears that a majority of chlorine contact occurs in the line and not the chamber. However, even with the inclusion of the line capacity in the overall contact time the plant falls short of meeting minimum state criteria: only 19 percent of the capacity required for average design flow, and 38.5 percent of the capacity required for peak flow -- therefore still inadequate.

Table 2 illustrates total effluent detention time in the plant's outfall line prior to discharge for plant flows of 1.0, 2.0, and 3.0 MGD. It would be appropriate to include these detention times as a holding period prior to dechlorination for FC samples. This procedure would improve estimates of FC concentrations in the final discharge. Furthermore, it is recognized that upgrading of the contact chamber capacity should be a high priority in any future plant modifications. This change would reduce FC concentrations thereby improving effluent quality and also would enable the plant to reduce the amount of chlorine necessary for disinfection.

Since the two WDOE survey trips to Western Slopes, plant operators have implemented a fecal coliform sample holding period of ten minutes, an average holding time based on a plant flow of 2.5 MGD. This period approximates holding times as illustrated by Table 2. Since implementation in April and May, the monthly DMR average FC concentrations have demonstrated a marked decrease over monthly averages in previous years. The daily FC concentrations were below the NPDES monthly permit requirements during these months, with the exception of two reporting days.

On March 8, the automatic flow measuring apparatus at the WTP was checked for accuracy against manual flow measuring methods by WDOE personnel. Results indicated that the 12-inch Parshall flume (Figure 2) was within acceptable design limits and the sonic measuring device was placed properly. The staff gage on the Parshall flume, which is used for sight-measuring the flow, however, was not placed properly. When the staff gage was measured against a carpenter's square, the readings were dissimilar by approximately five percent. A flow reading calculated on the basis of the gage was 2.47 MGD, while the flow calculated using the carpenter's square was determined to be 2.28 MGD, a substantial error (8 percent). Instantaneous readings of the plant script chart read 2.85 MGD for the same flow, an error of 25 percent of actual flow. During another flow comparison, a check was performed in which the totalizer appeared to be reading 38 percent above the actual flow. (Refer to Table 5 for all of the above readings.) After discovering the script chart and totalizer error, the automatic flow measuring equipment was recalibrated and subsequently was +10 percent above actual flow on one check and +22 percent above during another check. The larger error occurred during a period of low flow, suggesting that the automatic measuring system may not be linear in its flow measuring capability. Even with the error following adjustment, the recalibration substantially lowered the plant's flow, BOD_5 loading (lbs/ day), and suspended solids loading (lbs/day) submitted on the DMRs for the months of April and May over what would otherwise have been recorded. Further fine-tuning of the system is recommended to further increase the accuracy of flow measurements.

A Manning dipper was used during the WDOE survey to assess 24-hour flow during the March 8-9 survey. Total plant flow measured for the period, based on factoring a 20-hour record, was 2.31 MGD. The plant totalizer registered for the period flows of 3.14 MGD and 3.04 MGD for March 8 and 9, respectively. Based on a mean ($\overline{X}$) plant-measured flow of 3.1 MGD, the totalizer registered flows about 35 percent higher than the actual flow. These results further substantiate the flow measurement error. The Manning dipper flow results are included on Table 5.

Table 3 summarizes the results from effluent monitoring from both surveys and compares the results with NPDES permit requirements. Tables 6 and 7 report all of the conventional pollutant results for the two surveys.

Based on Table 3, Western Slopes WTP performance with respect to permit limits can be summarized as follows:

1. Measured pH values all fell within the permitted range (6.0 - 9.0 [S.U.]).

2. Effluent BOD_5 concentration and loading were both within permit limits during the March 22-23, 1983 survey. BOD_5 results from the March 8-9, 1983 survey were not available due to analytical problems.

3. Suspended solids concentration and loading were both within permit limits.

4. Fecal coliform populations met the weekly permit limits, but exceeded the monthly limits. The high counts were probably a result of the short contact time due to the small-capacity contact chamber. Even when the effluent detention time for the plant outfall line was included, the contact time fell well below state criteria for minimum chlorine contact times.

A review of data from the two surveys, observations by plant personnel, and recent discharge monitoring reports, suggest the following regarding present plant operation.

1. During dry weather, the plant may be operating somewhat below its hydraulic design capacity. Based on the surface area of the primary clarifier (surface loading), the plant's average design flow is 2.54 MGD. According to the DMRs, the plant serves a population of 23,000 which would typically result in wastewater flow of 2.3 MGD and a BOD load of 4,600 lbs/day (WDOE, 1978). Survey and DMR data suggest a service population closer to 15,000 (Table 8). Influent strength for BOD and suspended solids was as expected for a plant that handles mainly domestic wastewater, at least during periods of low stormwater input and infiltration. During the winter when runoff is high, DMR data indicate that BOD and suspended solids strength may drop as much as 50 percent.

2. Recent records suggest flows as high as 4.51 MGD for a given day (1/5/83). Plant personnel indicated that flooding of the facility does occur, with influent overflowing into the facility parking area. During periods of high flow, influent BOD strength (mg/L) is reduced by approximately one half; however, the loading values (lbs/day) appear to be similar to or slightly higher than, those from periods of low flow.

   Another source of inflow occurs when a pump station located south of the plant on the Tacoma Narrows at Titlow Beach is flooded with saltwater. According to plant personnel, flooding occurs whenever high tides of approximately +10 feet or greater occur. The flooding results in increased flow to the plant. The potential adverse effects of this saline water on biological treatment should be addressed when the plant is upgraded to a secondary treatment.

LABORATORY PROCEDURES AND COMPARISON OF SPLIT SAMPLE RESULTS

Laboratory procedures were reviewed for BOD, suspended solids, and fecal coliform analyses with plant personnel during the March 8-9, 1983 survey. In addition, compositor samples were split and analyzed by the WDOE laboratory in Tumwater, the WTP, and the laboratory at Tacoma Central (Plant #1). The split sample results from both surveys for the above parameters are summarized on Table 9.

BOD_5 - In general, Western Slopes' and Tacoma Central's BOD results compared well with each other, while WDOE results were somewhat higher. This discrepancy was particularly marked for the influent sample collected by Western Slopes and the chlorinated effluent sample collected by WDOE.

The reasons for those discrepancies are not entirely clear, but it noteworthy that WDOE COD results are also generally higher than those reported by the Tacoma Central laboratory. Table 10 displays the BOD:COD ratios for each of the three laboratories based on the analysis of the March 22-23, 1983 samples.

Table 10. BOD-to-COD ratios for WDOE, Western Slopes, and Tacoma Central laboratories.

Sample Location	Sampling Entity	WDOE Lab	Western Slopes Lab*	Tacoma Central Lab
Influent	WDOE	.53	.46	.52
Influent	WS	.52	.55	.54
Effluent	WDOE	.53	.35	.40
Effluent	WS	.48	.47	.49

*Western Slopes did not run COD; ratios based on Tacoma Central's COD results.

As can be noted from Table 10, the agreement between BOD:COD ratios for the three laboratories is much better than the agreement between BOD results. This leads one to suspect that a substantial amount of the discrepancy might be explained by actual differences in the composition of the aliquots tested by the three laboratories. The simplest explanation for this discrepancy would be that samples tested by the laboratories at Western Slopes and Tacoma Central were not adequately agitated before aliquots were obtained for analysis.

All samples should be shaken and mixed well immediately before aliquots are removed for analysis.

Referring again to Table 10, it appears that the BOD:COD ratios for these samples generally fell in the 0.45 to 0.55 range. Only two results fall outside this range: Western Slopes' and Tacoma Central's analyses of WDOE's chlorinated effluent sample. Although effluent samples were dechlorinated by Western Slopes, they were not re-seeded. This may help to explain why Western Slopes' BOD result for this sample was so low.

It should be pointed out that the effluent sample at Western Slopes is usually collected prior to chlorination and, thus, there is usually no reason to either dechlorinate or re-seed.

Review of BOD laboratory procedures led to several additional recommendations noted below:

1. The pH of the influent and effluent BOD samples should be checked. pH values outside the 6.0 - 9.0 range should be neutralized and seeded.

2. The PAO used for the dissolved oxygen should be checked to confirm proper normality. At present, PAO is prepared at the Tacoma Central STP laboratory. However, as a further assurance, the PAO should be checked against a known bi-iodate standard as described in *Standard Methods* (Ibid.) by Western Slopes prior to use as a titrant.

3. Initial dilution water dissolved oxygen (D.O.) was somewhat low (approximately 8.0 mg/L). The D.O. concentration should approach saturation: 9.2 mg/L at 20°C. At present, dilution water is aged for 24 hours at 20°C which may not be long enough to achieve saturation. To achieve saturation, aeration is recommended as described in the WDOE BOD manual (1980).

Suspended Solids - Split sample agreement for suspended solids is generally good. Agreement was within ± 20 percent in four out of five samples split with the WS laboratory. Samples split with the Tacoma Central laboratory #1 were also generally good. The WS laboratory uses the approved Whitman 940 A/H filters for filtering the solids.

Fecal Coliform - Split samples demonstrated mixed results for FC analysis agreement. As noted previously, immediate dechlorination of final effluent resulted in elevated FC counts. April and May DMRs suggest that using the outfall detention time as a holding period prior to dechlorination should give a better estimate of FC levels in the final effluent.

Other Constituents - Laboratory procedures for other constituents were not reviewed in detail. Brief comments regarding split sample results and further recommendations are noted below.

Chlorine Residual - Results demonstrated good comparison; WS chlorine meter worked well.

PRIORITY POLLUTANTS AND METALS ANALYSIS

A single grab sample of sludge from the Western Slopes digester (1 of 2) was analyzed for metals and priority pollutants. Results are summarized in Table 11. In addition, sludge analysis results from a Class II survey carried out at the Tacoma Central WTP are included in Table 11 for comparative purposes.

A total of seven priority pollutants and 13 metals were detected in the sludge sample. Yake (1982) observed that fewer organic priority pollutants were detected in sludge samples than wastewater samples, probably due to difficulties encountered in extracting compounds from the sludge matrix. Therefore, it is probable that more compounds were in the sludge than were actually identified.

Table 11 compares results from sludge analysis of Western Slopes and Tacoma Central. For most of the compounds found, analyses indicates that Western Slopes' sludge had substantially lower values. Concentrations of arsenic, cadmium, chromium, lead, mercury, and nickel were lower. Similar concentrations of copper were observed and somewhat higher values for zinc were also noted. Antimony, beryllium, selenium, silver, and thallium were also detected in the Western Slopes sample. Of the four comparable organic compounds, only PCB-1260 was (slightly) higher in concentration. Two compounds (bis[2-ethylhexyl] phthalate and benzo[b]flouranthene) were found in the Western Slopes sample and not in the Tacoma Central sludge. The bis(2-ethylhexyl) phthalate, a compound commonly found in plastics, can be detected as a result of contamination in the analytical process.

Table 12 compares metals values from WDOE and WS influent and effluent composites as analyzed by the individual laboratories and compares results between the laboratories for the sample splits. WDOE analyses of the split WDOE and WS composites were carried out at the Environmental Protection Agency Region X laboratory located at Manchester, Washington. The WS analyses were carried out at the Tacoma Central WTP laboratory located in Tacoma, Washington.

The split samples analyzed by the EPA laboratory demonstrated good comparability of results between the two influent composites and also between the two effluent composites with the exception of arsenic. Arsenic results were substantially different for both influent and effluent samples, respectively (WDOE composite 27 μg/L; WS composite 3 μg/L and WDOE 30 μg/L; WS 2 μg/L).

Split samples analyzed for metals by the Tacoma Central laboratory indicated more variability between the composites. The three specific metals analysis that demonstrated marked differences in effluent sample analytical results included iron (640 μg/L vs. 820 μg/L), nickel (31 μg/L vs. 101 μg/L), and zinc (156 μg/L vs. 196 μg/L). Comparison of influent analysis was not possible due to lack of sufficient WS sample. Results between the two laboratories for each metal was substantially different from each other. Review of results did not suggest any clear pattern to explain the reason for the discrepancies.

Sludge analysis demonstrated favorable comparison for all results with the exception of arsenic and selenium (Table 12).

Table 13 compares the concentration of metals found in the WDOE effluent composite for March 9, 1983 to receiving water criteria for these pollutants. The sample-to-criteria ratios represent the approximate dilution ratios which would be required to meet these criteria if diluted with uncontaminated receiving waters. Both saltwater and freshwater criteria are included even though the discharge is located in saltwater. Three metals (copper, lead, and zinc) were in high enough concentrations during the survey to require dilution to meet the EPA criteria for acute and/or chronic toxicity to aquatic life. Copper was found at high enough concentration to require a 13.5:1 dilution ratio to meet the chronic criterion. The "carcinogenic risk criteria" based on human consumption of contaminated fish were exceeded for arsenic and beryllium. The degree to which arsenic concentrations exceeded this criterion were substantial (1,740 x); all others were either substantially less than the criteria or marginal.

Priority pollutant loadings for each of the metals are also included on Table 12 to provide an estimate of the loading value for each pollutant from the Western Slopes plant to the receiving water each day.

RECOMMENDATIONS AND CONCLUSIONS

1. Include discharge line detention time in FC sample dechlorination for estimating FC concentrations prior to discharge from the outfall.

2. Evaluate chlorine contact chamber capacity and consider increasing chamber size to meet minimum state criteria for detention time. The plant is presently meeting NPDES permit requirements with the exception of plant flow (winter stormwater) and FC concentrations. The plant chlorine contact chamber is inadequate for handling present effluent volume. Increasing chlorine contact chamber capacity would be appropriate during future plant construction.

3. It appears that the plant may be serving a somewhat smaller population (perhaps near 15,000 population equivalents) than that listed on the DMRs (23,000).

DC:cp

Attachments

REFERENCES

APHA-AWWA-WPCF, 1980. *Standard Methods for the Examination of Water and Wastewater*. 15th Ed. 1134 pp.

Clark, D. and T. Determan, 1980. Burley Lagoon water quality survey, August 1980.

Kjosness, D., 1977. Laboratory test procedure for the biochemical oxygen demand of water and wastewater. 21 pp.

Stevens Water Resource Data Book. 1st Ed., Leopold and Stevens Inc. Pub. Beaverton OR

WDOE, 1978. *Criteria for Sewage Works Design*. Wash. Dept. Ecology, Feb. 1978, 357 pp.

Yake, B., 1982. Tacoma Central (#1) sewage treatment plant class II (priority pollutants) surveys: August 25-26, 1981, and February 16-17, 1982.

Figure 1. Tacoma Western Slopes (Plant #2) Water Treatment Plant flow diagram for WDOE March 1983 Class II inspection.

△ WDOE and WS influent and effluent composite sampling locations for March 22, 23, 1983 survey; WDOE and WS influent and WDOE effluent composite sampling locations for March 8, 9, 1983 survey.

○ WS sampling location for March 8, 9, 1983 survey.

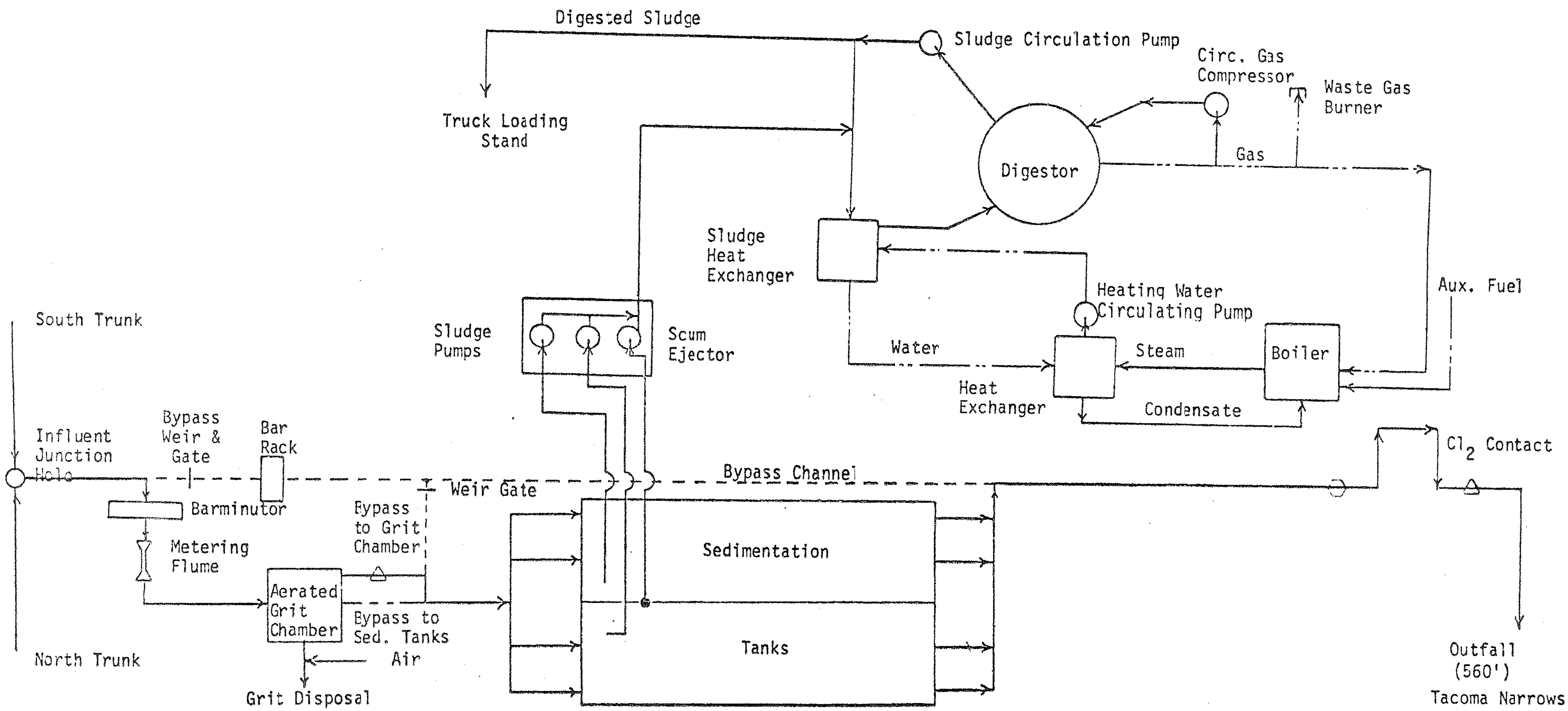
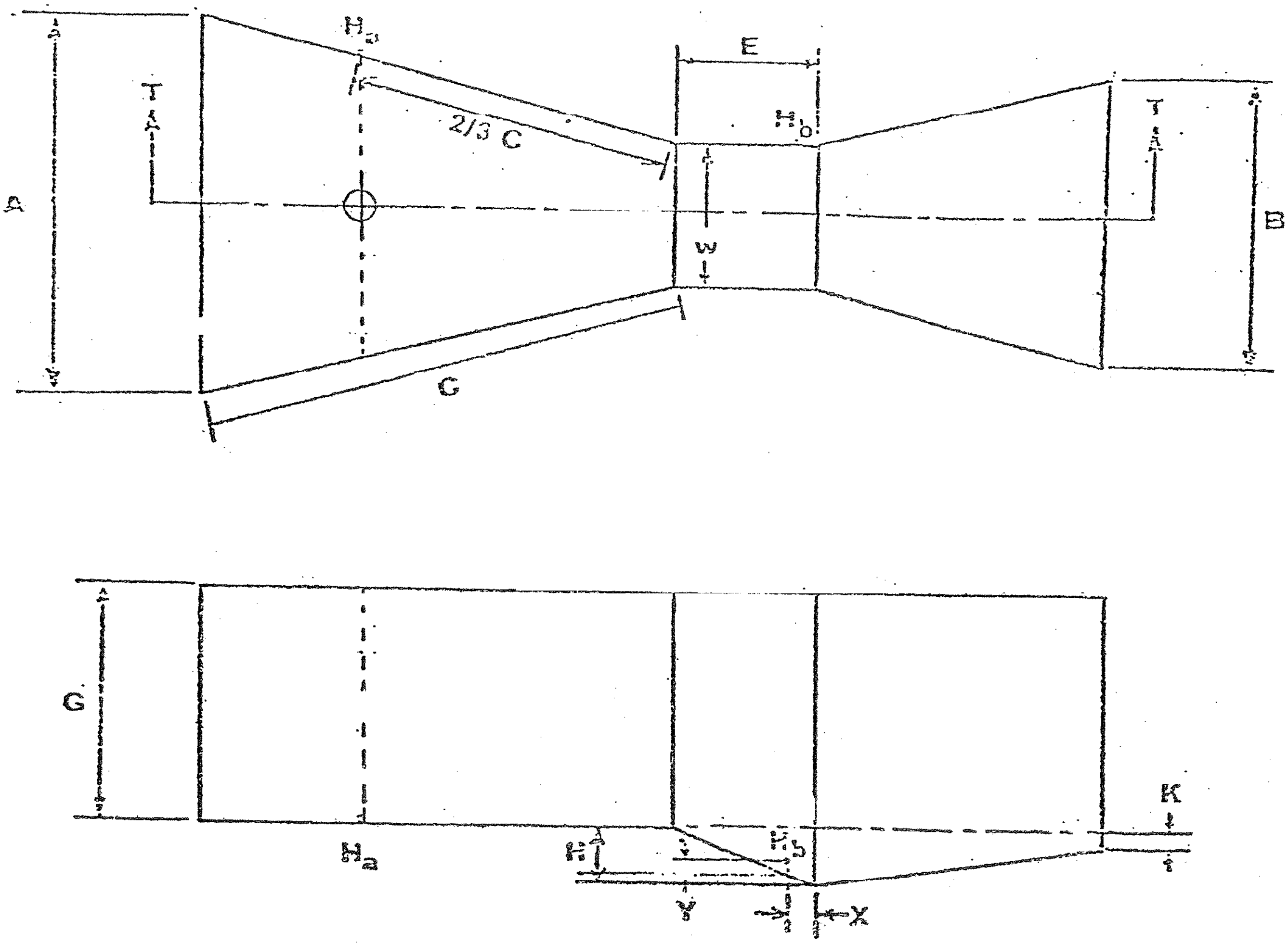


Figure 2. Western Slopes' 12-inch Parshall flume dimensions taken during the March 8-9, 1983 Class II inspection.

PARSHALL FLUME:

Dimensions & Flow



Code	Spec's	Measured
A		
B		
C	54	54-1/2
2/3 C	36	36
E	24	24
G		
H		
K		
W	12	Top 11-7/8, Bottom 12-1/16
X		
Y		

Time	H_a	H_b	Theoretical Flow	Recorded F…

Figure 3. Manning dipper script chart from March 8-9, 1983 flow measurement taken during the Western Slopes WTP Class II inspection.

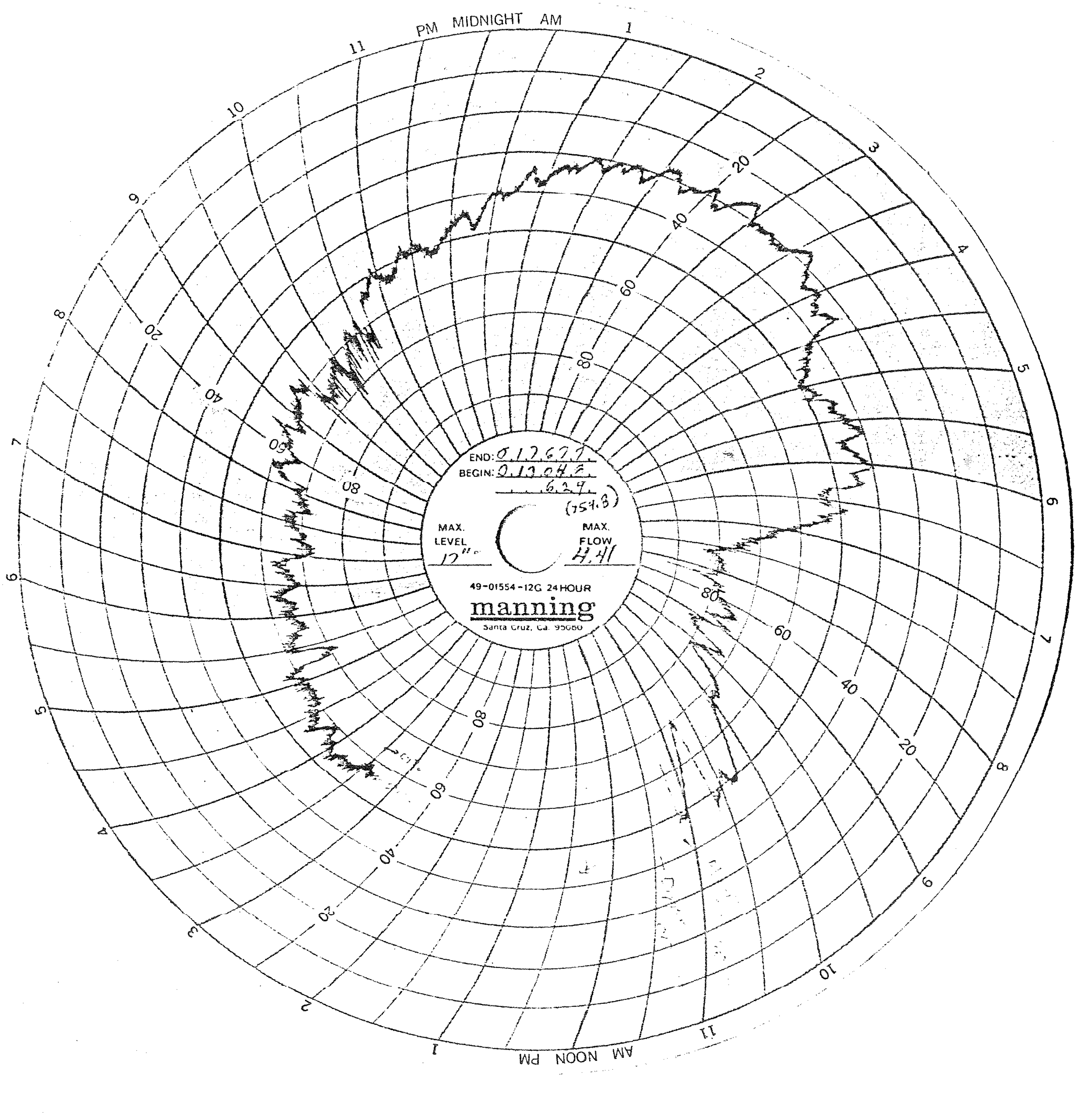


Table 1. Tacoma Waste Treatment Plant (WTP) #2 (Western Slopes) Class II 24-hour composite sampler and grab sample schedule.

Composite Sampler	Sample Aliquot	Sampling Period	Location	Parameters Tested
Influent (WDOE)	250 mL/30 min	3/8/83 - 0950 to	grit chamber	pH, temp., cond.
Influent (WS)	100 mL/30 min	3/9/83 - 1000	grit chamber	
Unchlor. Eff. (WDOE)	250 mL/30 min	3/8/83 - 1010 to	effluent trough after chlorination	pH, temp., cond.
Unchlor. Eff. (WS)	100 mL/30 min	3/9/83 - 1015	effluent trough prior to chlorination	
Influent (WDOE)	250 mL/30 min	3/22/83 - 1058 to	grit chamber	pH, temp., cond.
Influent (WS)	250 mL/30 min	3/23/83 - 1103	grit chamber	
Chlor. Effluent (WDOE)	250 mL/30 min	3/22/83 - 1105 to	effluent trough after chlorination	pH, temp., cond.
Chlor. Effluent (WS)	250 mL/30 min	3/23/83 - 1110		

Grab Sample	Date - Time	Location	Field Parameters Tested
Influent	3/8/83 - 0955	below comminutor	pH, temp., cond.
Influent	3/9/83 - 0945	below comminutor	pH, temp., cond.
Final Chlor. Eff.	3/8/83 - 1010	effluent channel	pH, temp., cond., TCR
Final Chlor. Eff.	3/9/83 - 0955	after chlorination	pH, temp., cond., TCR
Influent	3/22/83 - 1100	below barminutor	pH, temp., cond.
Influent	3/23/83 - 1100	below barminutor	pH, temp., cond.
Final Chlor. Eff.	3/22/83 - 1110	effluent channel	pH, temp., cond., TCR
Final Chlor. Eff.	3/23/83 - 1115	after chlorination	pH, temp., cond., TCR

Table 2. Tacoma Western Slopes WTP chlorine contact time (C_t) at various flows for the chlorine contact chamber and effluent discharge line. Included are state criteria for chlorine contact times at average and peak plant flow.

Plant Flow (MGD)	Chlorine Contact Chamber Retention Time (R_t)(Min)	Effluent Discharge Line Retention Time (R_t)(Min)	Total Contact Time (TC_t)(Min)[2/]	State (WDOE) Contact Time Criteria[3/](Min)
1.0	2.9	22.2	25.1	
2.0 (avg.)[1/]	1.4	11.1	12.5	60
3.0 (peak)[1/]	1.0	7.4	8.4	20

[1/] As defined in Western Slopes NPDES Permit (WA-003720-6)

[2/] Equivalent to 19 percent (avg.) and 38.5 percent (peak) of the respective criteria

[3/] Taken from *Criteria for Sewage Works Design,* State of Washington, Department of Ecology, February 1978 publication

NOTE: Chamber contact time based on dye study (March 23, 1983) which demonstrated a 91-second retention time at 1.95 MGD or an estimated 2,000-gallon chamber capacity.

Effluent discharge line retention time (R_t) based on a length of 420 feet from MLLW) and a diameter of 30 inches (ID) so that $R_t = 22.2/Q$ where Q = instantaneous flow in MGD.

Table 3. Permit compliance, Tacoma Western Slopes WTP.

Parameter (units)	Final Chlorinated Effluent Values		Permit Requirements	
	March 8-9	March 22-23	Weekly	Monthly
Flow (MGD)	2.38	1.72		3.0
BOD (mg/L)	†	150	200	170
(lbs/day)	†	2,154	5,004	4,253
Suspended Solids (mg/L)	90	100	150	125
(lbs/day)	1,789	1,436	3,753	3,128
pH (standard units)	7.4*	7.1*		
	7.2*	7.2*		
	7.3	7.2*	Range 6.0 - 9.0	
Fecal Coliform (#/100 mL)	270[1/]	360[1/]	400	200

† = BOD results rejected, analysis questionable

[1/] Values were based on retention times (R_t) of +7 and +9 minutes, respectively

*Grab samples, field analysis

Table 4. Western Slopes WTP wastewater monitoring schedule (obtained from current NPDES permit #WA 003720-6).

Tests	Sample Point	Sampling Frequency	Sample* Type
Temperature	raw sewage	daily	
	digester(s)	daily	
pH	raw sewage	daily	
	final effluent	daily	
	clarifier effluent	daily	
	digester(s)	daily	
Flow	influent	daily	Continuous & recording
Chlorine residual	final effluent	daily	
Dissolved oxygen	raw sewage	daily	
	final effluent	daily	
BOD	raw sewage	weekly	24 hr. composite
	final effluent	weekly	24 hr. composite
Settleable solids	raw sewage	daily	
	final effluent	daily	
Suspended solids	raw sewage	weekly	24 hr. composite
	final effluent	weekly	24 hr. composite
Total solids	raw sludge	3-5/week	
	primary sludge	monthly	
	secondary sludge	monthly	
Vol. solids	raw sludge	monthly	
	primary sludge	monthly	
	secondary sludge	monthly	
Gas. Anal. & Vol.	primary digester	daily	
Alk.	primary supernatant	3-5/week	
	secondary supernatant	1-3/week	
Vol. Acids	primary supernatant	3-5/week	
Fecal coliform	effluent	daily	

*All samples grab unless otherwise noted.

Table 5. Western Slopes - flow measurement and comparison with Western Slopes script chart and totalizer.

March 8, 1983	Measured Flow	Percent Error of Flow[1/]	Comments
Flow based on head measurement:	= 2.28 MGD		In-place weir staff gage demonstrated a +5 percent error in measurement when compared to head measurement obtained with a carpenter square [square = .92 vs. staff = .97']
Flow based on staff gage	= 2.47 MGD	+8	
Flow based on script chart	= 2.85 MGD	+25	
Totalizer Comparison to Head Measurement			
Flow based on head measurement	= 2.28 MGD		Totalizer error calculated using the following formula: $\frac{2.85 \text{ MGD H.M.}}{2.28 \text{ MGD S.C.}} \times \frac{3.22 \text{ MGD T.}}{2.81 \text{ MGD S.C.}} = 138\%$ of flow
Flow based on script chart	= 2.85 MGD	+25	
Flow based on script chart	= 2.81 MGD		
Flow based on totalizer	≃ 3.22 MGD	+38	
Flow estimate based on Manning dipper	= 2.31 MGD		24-hr. flow estimated from time period 1504 March 8 to 1115 March 9
March 23, 1983			
Flow based on head measurement	= 2.37 MGD		Flow measurement for comparison following adjustment of plant's automatic flow sensing system. Automatic flow measurement of ± 15 percent of actual flow considered acceptable by WDOE.
Flow based on script chart	= 2.60 MGD	+10	
Flow based on head measurement	= 1.43 MGD		
Flow based on script chart	= 1.75 MGD	+22	

[1/] Percent error of flow was based on head measurement determined by direct measurement with a carpenter square.

Table 6. Tacoma Western Slopes WTP, conventional pollutant results, March 8-9, 1983.

Parameter	Influent WDOE Samples	Influent WS Samples	Chlorinated Effluent WDOE Samples	Unchlorinated Effluent WS Samples	Chlorinated Effluent WS Samples
Flow (MGD)†	2.38				
BOD_5 (mg/L)	††	82	110	110	
(lbs/day)	††	1,630	2,186	2,186	
TSS (mg/L)	110	59	53	90	
(lbs/day)	2,186	1,173	1,053	1,789	
Conductivity (μmhos/cm)	725,** 925,** 875		1,020** >1,000** 775		
Temperature (°C)	13.8** 14.0**		13.7** 13.8**		
pH (S.U.)	7.5 7.7** 7.4** 7.6***	7.7	7.3 7.4** 7.2** 7.3***	7.4	
Total Chl. Resid. (mg/L)			1.9**		1.8*
Fecal Coliform (#/100 mL)			740*		
FC (D_t = 7.03 min)			270*		
Turbidity (NTU)	78	38	53	68	
Total Solids (mg/L)	590	510	510	540	
Tot. Non-vol. Solids (mg/L)	400	350	370	380	
TNVSS (mg/L)	19	4	12	15	
NH_3-N (mg/L)	13	12	12	14	
NO_2-N (mg/L)	0.03	0.04	0.01	0.03	
NO_3-N (mg/L)	0.40	0.55	0.40	0.35	
O-PO_4-P (mg/L)	2.4	2.9	3.1	3.4	
T-PO_4-P (mg/L)	5.3	5.1	5.3	5.8	
COD (mg/L)	180	110	170	160	

*Grab sample, lab analysis
**Grab sample, field analysis
***Composite sample, field analysis

†Adjusted totalizer plant flow was 38% high
††BOD results rejected, analysis questionable
†††Composite sample, field analysis

Table 7. Tacoma Western Slopes WTP, conventional pollutant results, March 22-23, 1983.

Parameter	Influent		Chlorinated Effluent	
	WDOE Samples	WS Samples	WDOE Samples	WS Samples
Flow (MGD)	1.72			
BOD_5 (mg/L)	180	220	150	130
(lbs/day)	2,585	3,160	2,154	1,867
TSS (mg/L)	170	240	100	89
(lbs/day)	2,442	3,447	1,436	1,278
Conductivity (μmhos/cm)	1,090 670** 395** >1,000†††	1,090	929 660** 975** 990†††	999
Temperature (°C)	13.5** 13.8**		14.6** 14.3**	
pH (S.U.)	7.1 7.4** 7.4** 7.3†††	7.1	7.2 7.4** 7.1** 7.2†††	7.4
Total Chl. Resid. (mg/L)				1.2**
Fecal Coliform (#/100 mL)			3,000*, [1,500]* 740*, [360]*	
Turbidity (NTU)	140	150	80	78
Total Solids (mg/L)	770	850	620	450
Tot. Non-vol. Solids (mg/L)	530	560	420	450
TNVSS (mg/L)	32	56	21	18
NH_3-N (mg/L)	9.3	18	16	18
NO_2-N (mg/L)	<0.01	<0.01	0.02	0.02
NO_3-N (mg/L)	0.17	0.12	0.14	0.21
O-PO_4-P (mg/L)	3.9	4.3	4.4	4.6
T-PO_4-P (mg/L)	6.7	8.5	7.8	7.9
COD (mg/L)	340	420	280	270

*Grab sample, lab analysis
**Grab sample, field analysis
††BOD results rejected, analysis questionable
†††Composite sample, field analysis
[ ] Brackets = D_t time prior to dechlorination, equivalent to time of travel for chlorinated effluent prior to discharge (refer to Table 2)

Table 8. Recalculated estimate of the population served by the Western Slopes WTP. The estimate is based upon influent loading data from two monthly WTP DMRs (April, May 1983) and the March 22-23, 1983 WDOE Class II survey. Influent loading estimates were calculated for a population of 23,000 (City of Tacoma population served figure) and actual loadings were compared to these values to determine a percentage of the influent estimates. The recalculated population served estimate was based upon the mean ($\overline{X}$) of the percentages.

Parameter	Design Base[1]	Influent Estimate[2]	DMR #1[3]	% Inf. Est.[4]	DMR #2	% Inf. Est.	Survey	% Inf. Est.	DMR #1, DMR #2, Survey, $\overline{X}$, (S.D.)[5]	Population Estimate[6]
Flow (MGD)	1×10^{-4}	2.3	1.53	67%	1.63	71%	1.72	75%	1.63 (.1)	16,300 (1,000)
BOD_5 (lbs/day)	.2	4,600	2,530	55%	2,232	49%	2,585	56%	2,400 (190)	12,000 (950)
SS (lbs/day)	.2	4,600	3,577	78%	3,320	72%	2,442	53%	3,100 (600)	15,500 (3,000)
Mean ($\overline{X}$)[7]				66.7%		65%		61.4%		
Standard Deviation (S.D.)[7]				11.5%		13.0%		11.9%		
Population[8] Estimate				15,300		14,700		14,100		
S.D.[8]				±2,600		±2,900		±2,700		
$\overline{X}$ Population[9] Estimate							(65%)	14,700 ~~14,720~~		14,600[10]
$\overline{X}$ S.D.[9]							(10.8)	~~±2,700~~ ± 2,479 (2,480)		±(1,650)

[1]/As taken from WDOE criteria for Sewage Works Design (1978, Revised 3/80).

[2]/Calculated from design base and population served of 23,000.

[3]/Two DMRs from the WTP (April 1983, May 1983) and WDOE survey (March 22, 1983), DMR data are monthly means ($\overline{X}$).

[4]/The percentage of the influent estimate actually observed in DMR and survey data.

[5]/Mean ($\overline{X}$) and standard deviation (S.D.) for each parameter.

[6]/Population estimate based on the mean of each parameter and the design base.

[7]/Mean and standard deviations of the percent influent estimates for individual surveys.

[8]/Population estimates and standard deviation based on the DMR given population of 23,000 and the mean of the % influent estimates of the individual surveys.

[9]/Final population estimates and standard deviations based on the mean of the combined % influent estimates for all three surveys.

[10]/Population estimate based on the combined influent estimates of the individual parameters.

Table 9-a. Comparison of laboratory results, including Tacoma Central lab results for split composite samples from the March 8-9, 1983, Class II field survey.

Compositor	Influent						Unchlorinated Effluent			Chlorinated Effluent		
	WDOE Composite			WS Composite			WS Composite			WDOE Composite		
Parameter	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab
BOD (mg/L)	a/	87	95	a/	b/	b/	a/	b/	89	a/	75	81
Susp. Solids (mg/L)	114	94	113	59	b/	b/	90	b/	91	53	55	41
COD (mg/L)	183	--	215	113	b/	b/	161	b/	163	174	--	185
F. Coli. (#/100 mL)c/										270	40	

Table 9-b. Comparison of laboratory results, including Tacoma Central lab results for split composite samples from the March 22-23, 1983, Class II field survey.

Compositor	Influent						Unchlorinated Effluent			Chlorinated Effluent		
	WDOE Composite			WS Composite			WS Composite			WDOE Composite		
Parameter	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab	WDOE Lab	WS Lab	Tacoma Lab
BOD (mg/L)	180	140	158	220	167	165	130	113	119	150	85	98
Susp. Solids (mg/L)	170	193	158	240	272	236	89	85	68	100	70	68
COD (mg/L)	340	--	302	420	--	306	270	--	242	281	--	243
F. Coli. (#/100 mL)c/										360	380	

a/BOD rejected, questionable results

b/No analysis due to insufficient composite sample

c/Split grab sample not from composite

-- = COD analysis not performed

Table 11. Tacoma Western Slopes WTP - priority pollutants and metals for sludge (μg/Kg dry weight) from March 9, 1983. Table includes for comparison purposes metals and priority pollutant data from sludge sample taken during Tacoma Central Class II inspection (Yake, 1983).

Parameter	Western Slopes 3/09/83	Tacoma Central 2/17/81	Tacoma Central 8/26/81
Percent Solids	6.3	7.1	9.2
Metals (total)			
Antimony	3,600	--	--
Arsenic	10,300	23,000	22,000
Beryllium	80	--	--
Cadmium	8,200	14,000	21,000
Chromium	31,700	74,000	160,000
Copper	540,000	500,000	520,000
Lead	238,000	480,000	610,000
Mercury	3,300	6,300	--
Nickel	31,700	79,000	100,000
Selenium	10,000	--	--
Silver	7,900	--	--
Thallium	62	--	--
Zinc	2,300,000	1,600,000	1,800,000
Base/neutral Extractables			
flouranthene	1,600	--	2,280
bis(2-ethylhexyl) phthalate	20,600[1/]	--	98,000
benzo(b)flouranthene	1,200	--	--
phenanthrene	1,900	--	3,900
pyrene	1,200	T	2,200
Acid Extractables			
2,4-dimethyl phenol	159	--	--
Pesticides			
PCB-1260	1,100	980	--

-- = None detected

[1/] Possible contaminant during analysis

T = Trace; compound present, concentration less than limit of quantification.

Table 12. Metals analyses results and laboratory comparison for Western Slopes WTP from March 9, 1983 24-hour composites. WDOE Class II survey results from EPA laboratory and Tacoma Central laboratory.

	Influent (μg/L)				Effluent (μg/L)				Sludge (μg/Kg dry weight)	
	WDOE Composite		WS Composite		WDOE Composite		WS Composite			
Parameter	EPA Lab	Tacoma Lab	EPA Lab	Tacoma Lab	EPA Lab	Tacoma Lab	EPA Lab	Tacoma Lab	WDOE Lab	Tacoma Lab
Antimony	<1	--	1	--	2	--	1	--	3,600	--
Arsenic	27	6	3	†	30	8	2	6	10,300	1,320
Barium	--	70	--	†	--	54	--	69	--	330,000
Beryllium	<1	--	<1	--	<1	--	<1	--	80	--
Cadmium	0.6	1.1	0.4	†	0.6	.9	0.6	0.13	8,300	6,300
Chromium	3	7.2	2	†	3	6.3	2	7.6	32,000	31,000
Copper	58	98	48	†	54	92	57	110	540,000	497,000
Iron	--	860	--	†	--	640	--	820	--	10,400,000
Lead	49	132	40	†	47	12.7	52	9	238,000	181,000
Manganese	--	72	--	†	--	69	--	76	--	171,000
Mercury	.38	<4	.25	†	†	<4	†	<4	3,300	6,500
Nickel	5	87	5	†	2	31	5	101	32,000	23,400
Potassium	--	9,640	--	†	--	8,380	--	9,640	--	862,000
Selenium	<1	<1	<1	†	<1	<1	<1	<1	10,000	<100
Silver	1	32	1	†	1	61	1	76	8,000	18,800
Sodium	--	110,800	--	†	--	82,100	--	101,900	--	3,230,000
Thallium	.4	--	.5	--	.2	--	.5	--	60	--
Zinc	120	200	120	†	110	156	120	196	2,330,000	1,740,000

† = Insufficient sample for analysis
-- = Analysis not performed

Table 13. Water quality criteria for aquatic life.

Pollutant	Effluent Load[1/] (lbs/day)	Effluent Conc. (µg/L)	Freshwater Criteria (µg/L) Acute	Chronic	Freshwater Sample/Critera Ratio Acute	Chronic	Saltwater Criteria (µg/L) Acute	Chronic	Saltwater Sample/Criteria Ratio Acute	Chronic	Human Health Food (fish) Intake Criteria (µg/L)	Sample/Criteria Ratio
Antimony	.04	2	9,000	1,600	2×10^{-4}	1.3×10^{-3}	**	**	--	--	4.5×10^{4}	4.4×10^{-5}
Arsenic	.61	30	440[2/]	40[2/]	.07	.75	508	**	.06	--	.0175	/1714/
Cadmium	.012	0.6	1.5[3/]	.012[3/]	.40	/50/	59	4.5	.01	.133	**	--
Chromium[5/]	.061	3	2200[3/]	44	1.36×10^{-3}	.07	10.3×10^{3}	**	2.9×10^{-4}	--	3.43×10^{6}[4/]	8.75×10^{-7}
Copper	1.1	54	12[4/]	5.6[3/]	/4.5/	/9.6/	23	4.0	/2.35/	/13.50/	**	--
Lead	.96	47	74	.75	.64	/63/	668	25	.07	/1.88/	**	--
Nickel	.04	2	1100[3/]	56[3/]	.002	.04	140	7.1	.01	.28	100[4/]	.02
Selenium	<.02	<1	260	35	<.004	<.003	410	54	<.003	<.02	10[4/]	<.1
Silver	.02	1	1.2[3/]	.12[3/]	.83	/8.33/	2.3	**	.42	--	50[4/]	.02
Thallium	.04	.2	1400	40	1.0×10^{-3}	5.0×10^{-3}	2130	**	1×10^{-4}	--	48[4/]	4.2×10^{-3}
Zinc	2.25	110	180	47	61	/2.3/	170	58	.65	/1.90/	**	--

[1/] Effluent load based on corrected plant flow for March 9, 1983, of 2.45 MGD

[2/] Criteria for trivalent inorganic arsenic

[3/] Based on total hardness of 50 mg/L as $CaCO_3$

[4/] Criteria based on toxicity rather than carcinogenic risk

[5/] Criteria based on trivalent form

/ / = Sample/criteria ratio >1

** = No criterion presently available