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TO: Norm Glenn

FROM: John Bernhardt

SUBJECT: Summary of Findings -- Effluent Biomonitoring Surveys Performed by the Water Quality Investigations Section, 1986-88

DATE: February 24, 1988

INTRODUCTION

During the past two years, Ecology has received two EPA grants supporting implementation of its pretreatment and NPDES toxics/ biomonitoring programs. Both grants included staff and laboratory resources for the Water Quality Investigations Section (WQIS) with the following outputs:

1986-87 - Perform four to six Class II compliance inspections to include biomonitoring focusing on freshwater bioassay test organisms.

1987-88 - Perform six Class II compliance inspections to include biomonitoring focusing on marine bioassay test organisms and dischargers to Puget Sound.

The purpose of these inspections is to provide Ecology with an opportunity to develop internal expertise and evaluate a range of different bioassay test organisms before incorporating such testing requirements into the NPDES permit program. To this end, WQIS is performing an expanded Class II compliance inspection at each facility. The biomonitoring consists of effluent bioassays, sediment bioassays in the receiving environment, and companion chemical analyses.

This report documents the results of the first year of testing (1986-87) and presents recommendations to management based on these findings. The discussion following the results includes comments on the "Draft Interim Policy for Biomonitoring and Toxicity Control of Point Source Discharges" recently completed by the water quality program.

Field testing under the second grant (1987-88) begins in earnest this spring. The results of these inspections as well as seven other inspections performed this year, will be documented in a future report.

METHODS

A Sanitary Engineer II was hired to perform the five 1986-87 grant inspections. When the grant was completed in 1987, this position was shifted to permanent state funding, with seven inspections scheduled for 1987-88. For the 1987-88 grant, a second Sanitary Engineer II was hired during January 1988 to perform the six biomonitoring surveys focusing on marine bioassay organisms. Information on schedules and bioassay test organisms used for the 18 inspections scheduled for 1986-88 is given in Table 1.

Facilities to be inspected were selected based on discussions with Ecology regional, headquarters, and Industrial Section staff; and the EPA Washington Operations Office. Consideration was given to type of discharge, availability of in-house laboratory facilities, potential for toxics problems, operational problems, and sensitivity of the receiving waters to pollution. The site locations are shown in Figure 1.

Each biomonitoring inspection conducted under the EPA grants included the following five components:

1. Review site plans and specifications to develop detailed treatment process schematic.

2. Collect samples and measure flows to estimate plant loadings and treatment efficiency.

3. Perform laboratory quality assurance evaluation including sample splits, for accuracy and adherence to established techniques.

4. Estimate effluent toxicity by performing a series of bioassays, including companion toxic pollutant analyses.

5. Conduct limited receiving water surveys as required.

Bioassays in the first year of testing were performed on the following test organisms:

Effluent:
- (i) Rainbow trout (_Salmo gairdneri_)
- (ii) Water flea (_Ceriodaphnia dubia_)
- (iii) Fathead minnow (_Pimephales promelas_)
- (iv) Algae (_Selenastrum capricornutum_)

Receiving water sediments:
- (v) Water flea (_Daphnia magna_)
- (vi) Freshwater amphipod (_Hyallela azteca_)
- (vii) Water flea (_Daphnia pulex_)

All test organisms weren't used during every inspection. Use depended on availability of laboratory resources and needs of the particular survey.

The 96-hour rainbow trout bioassays were run at the Manchester Environmental Laboratory using Ecology's procedure entitled "Static Acute Fish Toxicity Test" (DOE 80-12). The seven-day Ceriodaphnia and fathead minnow tests were performed at the EPA Environmental Research Laboratory (ERL) at Duluth, Minnesota. These two tests were performed using procedures outlined in the EPA manual for chronic bioassays (EPA, 1985b). The four-day Selenastrum tests were performed by EVS Consultants, Vancouver, B.C.

Sediment samples were collected from the receiving waters near the Everett, Pacific Wood Treating, and Chambers Creek outfalls. Analyses included sediment chemistry and bioassays performed using the two-day Daphnia magna test and/or four-day Hyallela azteca test. The sediment bioassays were run at EPA's Corvallis, Oregon, Environmental Research Laboratory using the procedures outlined by Nebeker and Miller (1987).

Sediment bioassay data collected during intensive surveys recently performed by the WQIS Toxics/Groundwater Survey Unit were also evaluated.

For each inspection, the results are documented in a formal investigative report that includes recommendations for improving treatment efficiency and ensuring compliance with the NPDES permit requirements.

RESULTS

The 1986-87 survey data indicate effluent bioassays are a useful tool for effluent monitoring but caution is warranted when incorporating such testing requirements into NPDES permits. This applies mainly to the chronic tests which tend to give variable results. The acute rainbow trout test appeared to give consistent results.

Significant test organism mortalities usually did occur when toxicity was verified by chemical data. However, in some instances no mortality occurred when the chemistry data indicated toxicity based on water quality criteria. At times the reverse occurred, and in some instances tests were invalidated because of quality assurance/quality control problems at the testing laboratory (Table 2). These characteristics are reflected in the following review of the survey results by discharger:

1. Kaiser Aluminum, Spokane - The rainbow trout bioassay indicated significant toxicity. Corresponding chemistry sampling data identified aluminum as the likely cause. Interpretation of the results was complicated because of background metals toxicity in the Spokane River. An Ecology policy is needed for dealing with NPDES permits when background toxicity exists in the receiving water.

2. Everett Municipal Treatment Plant - The Ceriodaphnia test worked poorly and was invalidated because of laboratory quality assurance/ quality control problems. The fathead minnow test appeared to work. The rainbow trout bioassay worked well but ammonia may have prevented this test from detecting other toxicity. Rainbow trout are quite sensitive to ammonia. Acute toxicity due to lead was also indicated by the chemistry sampling data.

3. Pacific Wood Treating - The rainbow trout bioassay appeared to work well indicating toxicity. Pentachlorophenol and creosote were identified as possible factors based on the chemistry sampling data. Selenastrum worked poorly. This test was invalidated because particulates interfered with the procedure and the samples contained large numbers of protozoans (algal predators).

4. Cashmere Municipal Treatment Plant - The rainbow trout should have died because of chlorine toxicity but did not, presumably because the chlorine in the sample dissipated by the time the laboratory test was performed. Ceriodaphnia appeared to work indicating possible chronic toxicity at high effluent concentrations. The Selenastrum test worked poorly. The effluent appeared to stimulate productivity making it difficult to interpret the results.

5. Chambers Creek Municipal Treatment Plant (saltwater discharge) - Chlorine and ammonia exceeded the EPA Water Quality Criteria. The rainbow trout test appeared to work well reflecting this or other toxicity. Ceriodaphnia also appeared to work well even though toxicity was not indicated. Selenastrum appeared to work well indicating chronic toxicity.

The survey findings were reviewed to determine if the effluent bioassay test results detected toxicity "missed" by the chemistry sampling results. All five dischargers had toxicity based on both approaches. It was assumed that failure of a single bioassay constitutes an indication of toxicity. In a broad sense, the main value of bioassays appears to be that they demonstrate biological impacts rather than just compare chemical-by-chemical sampling results with water quality criteria.

The sediment bioassays had mixed results. Hyallela (freshwater amphipod) and Daphnia pulex worked poorly while Daphnia magna appeared to work well (Table 2).

DISCUSSION

The rainbow trout bioassay appeared to be a reliable acute toxicity test and, for the Pacific Northwest, may be an appropriate replacement for the fathead minnow which does not occur naturally in this area.

The Ceriodaphnia test worked well two out of the three times used. Quality assurance/quality control problems such as those experienced are not uncommon. Although not observed in this testing, Ceriodaphnia have been shown to have stimulated growth when exposed to some nutrient enriched wastewaters. This appears to be a good test but must be used selectively and with caution.

The fathead minnow worked the one time used. Additional testing is needed if this test organism is used regularly. Selenastrum worked poorly two out of the three times used. Caution is indicated when using this test because it appears sensitive to various interferences.

Chlorine and/or ammonia toxicity were identified at three of the five dischargers surveyed. Both pollutants are common in municipal discharges throughout Washington State. They also occur at some industries. To obtain a better understanding of the implications, effluent monitoring data for 63 dischargers inspected by Ecology since 1980 were reviewed to predict impacts if biomonitoring were incorporated into the NPDES permit process. About 70 percent of the plants would have failed because of ammonia toxicity and 86 percent would have failed because of chlorine (Table 3). Detailed data are given by discharger in Table 4.

These data clearly show that biomonitoring would have a substantial impact on municipal treatment plants throughout the state and, further, that the issues of chlorine and ammonia must be addressed before Ecology incorporates biomonitoring into the NPDES permit process. If these issues are not addressed early on, biomonitoring at many facilities will only serve to confirm what is already known--chlorine and ammonia are toxic. Possible options are exemptions, chlorine disinfection policy, and ammonia removal policy.

Dechlorination is not overly expensive and straight-forward to address, but ammonia removal is technically difficult and expensive. The ammonia problem can be addressed to some degree through process control (nitrification) but there are limitations particularly during the colder winter months.

In the case of Cashmere, chlorine in the effluent sample appeared to dissipate during transit to the laboratory. Thus, the effluent passed the acute bioassay test even though toxic to aquatic life. In-situ (in-the-field) biomonitoring is appropriate for dischargers where a potential for volatile toxics exists. A policy is needed for such instances. This issue is not addressed in the "Interim Policy and Guidelines" document.

The Interim Guidelines state "If the effluent toxicity test results at any time indicate the presence of acute or chronic toxicity (defined in the Guidelines), the permittee shall investigate the cause and reduce toxicity." Because of the level of uncertainty with the chronic bioassay tests at this time, it would be appropriate to leave the decision for follow-up to the Ecology permit writer for the first year of monitoring.

The Interim Guidelines ask the question "Where must the demonstration of 'no acute toxicity' be made in the receiving water?" This question is very appropriate and needs to be answered before implementing the guidelines. A requirement that acute toxicity not be allowed at the end of the pipe is very restrictive and would trigger many more Toxicity Reduction Evaluations (TREs) than if acute toxicity had to be met at the edge of the dilution zone. A similar situation exists with chronic toxicity.

RECOMMENDATIONS

1. A policy needs to be developed for establishing NPDES permit requirements in cases where background toxic conditions exist in the receiving waters. This is a long-standing issue that cropped up again in the Kaiser Aluminum inspection.

2. Existing data indicate biomonitoring will identify chlorine toxicity problems at some 86 percent of the municipal treatment plants throughout the state. A policy for handling this issue is needed early on. A dechlorination policy is the most likely option. Also, there is a need to monitor chlorine during the bioassays.

3. Existing data also indicate biomonitoring will identify ammonia toxicity as a problem at about 68 percent of the municipal treatment plants throughout the state. A

policy is needed for this pollutant which will be much more difficult to address than chlorine.

4. The rainbow trout acute toxicity test has been used for years and appears to consistently give positive results when toxic conditions exist. Its use is now limited to major industries and a small number of other dischargers. This test could be fully integrated into the NPDES program when items (2) and (3) are in place.

5. The rainbow trout test appears to be a viable alternative to the fathead minnow test promoted by EPA. The latter species does not occur naturally in the Pacific Northwest. Indigenous species should be used whenever approved testing protocols exist and the test is appropriate.

6. Chronic bioassays are potentially a valuable tool for the NPDES permit program. However, the survey results are generally too variable to recommend this as a definitive test at this time. An alternative approach may be to require such monitoring for the first year with no further testing requirements for failures, except at the discretion of the permit writer.

7. A biomonitoring procedure is needed for dischargers with volatiles in the effluent. In-situ bioassays should be explored as an option for such cases.

8. Dilution is a key issue which must be addressed before the biomonitoring guidelines progress very far. Requiring demonstration of no acute toxicity at the end of the pipe is quite restrictive and will have far reaching implications for issues like chlorine and ammonia. Alternate approaches are to require that acute toxicity not be allowed after initial dilution or at the edge of the dilution zone.

9. Although not a part of the biomonitoring inspections performed, it is nevertheless important that financial impacts be fully evaluated before the biomonitoring guidelines become fact.

JB:cp
Attachments

REFERENCES

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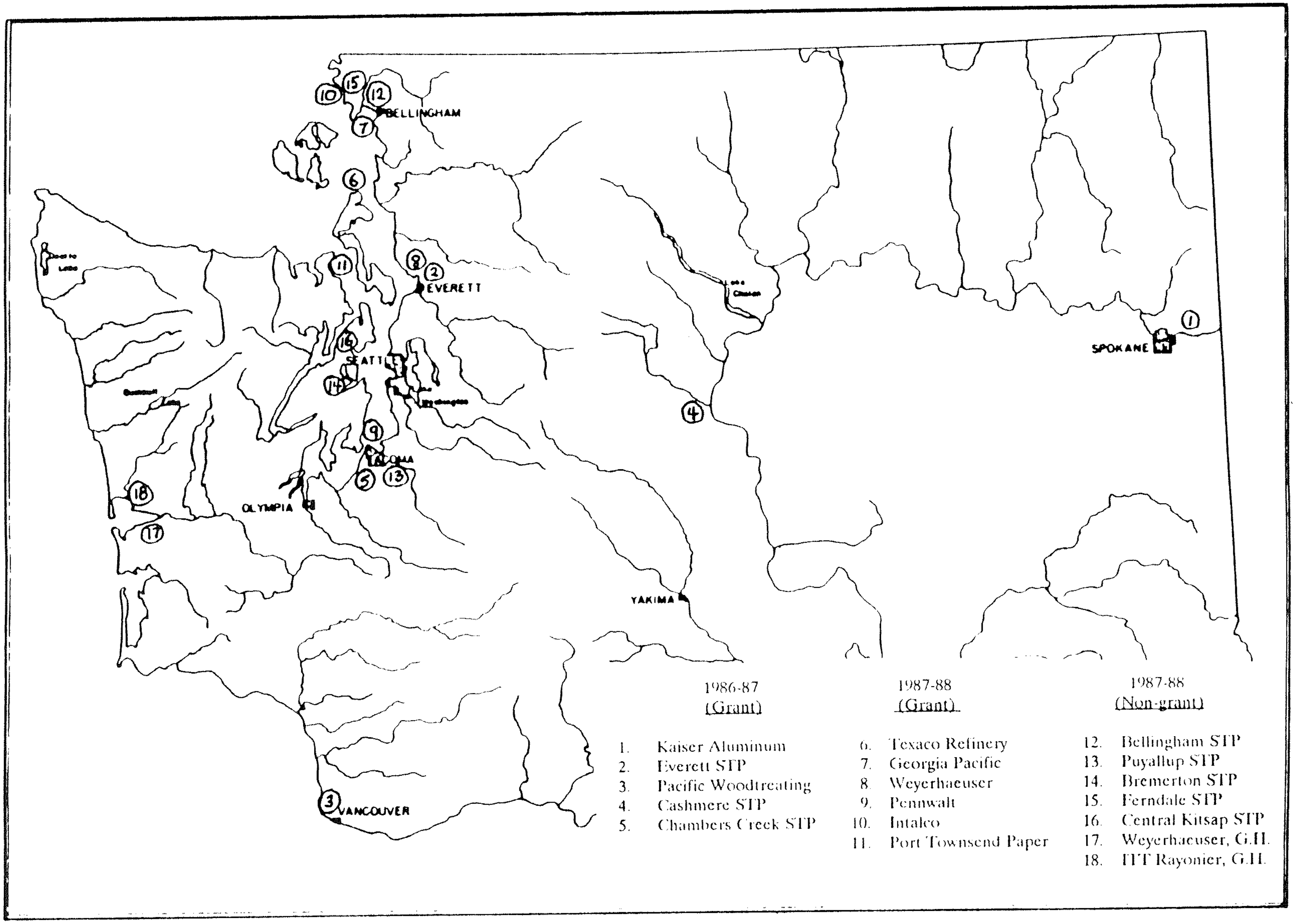

Figure 1. Location of compliance inspections (Class II) performed by Ecology using EPA 104(b)(3) biomonitoring grant funds.

Table 1. List of Ecology Class II inspections scheduled for biomonitoring during 1986-1988.

1986-87 Grant - Freshwater Dischargers

Inspection	Dates of Field Work	Rainbow Trout: Acute	Fathead Minnow Acute/ Chronic	Cerio-daphnia Acute/ Chronic	Selen-astrum Chronic	Daphnia Magna (sediment) Acute	Hyallela (sediment) Acute
Kaiser Aluminum, Spokane	5/6-7/1986	X					
Everett STP	8/12-13/1986	X	X	X		X	X
Pacific Woodtreating, Battle Ground	1986 - 1987	X		X	X	X	
Cashmere (Treetop) STP	12/8-11/1986	X		X	X		
Chambers Creek, Tacoma	2/16-18/1987	X		X	X		X

1987-88 Grant - Saltwater Dischargers

Inspection	Dates of Field Work	Rainbow Trout: Acute	Oyster: Acute/ Chronic	Micro-tox: Acute/ Chronic	Sea Urchin: Acute/ Chronic	Lamin-aria Chronic	Cerio-daphnia Acute/ Chronic	Rhepoxinius Amphipod (sediment) Acute
Port Townsend Paper	12/1-2/1987	X	X	X			X	
Pennwalt, Tacoma	?							
Intalco, Cherry Point	?							
Texaco Refinery, Anacortes	?							
Georgia Pacific, Bellingham	?							
Weyerhaeuser Pulp Mill, Everett	?							

1987-88 (Non-Grant) Dischargers

Inspection	Dates of Field Work	Rainbow Trout: Acute	Oyster: Acute/ Chronic	Micro-tox: Acute/ Chronic	Sea Urchin: Acute/ Chronic	Lamin-aria Chronic	Cerio-daphnia Acute/ Chronic	Rhepoxinius Amphipod (sediment) Acute
Bellingham STP	8/25-26/1987	X	X	X				X
Puyallup STP	12/8-9/1987	X		X				
Bremerton STP	1/26-27/1988	X		X			X	X
Ferndale STP	2/23-24/1988							
Central Kitsap STP	?							
Weyerhaeuser Pulp Mill, Grays Harbor	?							
ITT Rayonier Pulp Mill, Grays Harbor	?							

Table 2. Summary of test results for Class II biomonitoring inspections performed by the Ecology during 1986 and 1987.

Survey	Bioassay Test Organism	Acute/ Chronic	Exposure Period	Endpoint	Significant Mortality Observed?	Chemical Contamination Observed?	Value of Bioassays
Effluent Monitoring							
1. Kaiser Aluminum, Spokane	Rainbow Trout (S. gairdneri)	Acute	4 days	Death	Yes. 100% at 65% effluent	Yes. Aluminum identified as likely reason for death.	Good
2. Everett Municipal Treatment Plant	Ceriodaphnia (C. dubia)	Acute/ chronic	7 days	Death/ reproduction	No.	Yes. Lead and ammonia exceeded EPA water quality criteria.	Poor. Test invalidated because of low survival with the control test.
	Fathead Minnow (P. promelas)	Acute/ chronic	7 days	Death/ growth	No.	Same as above.	Good.
	Rainbow Trout (S. gairdneri)	Acute	4 days	Death	Yes.	Same as above.	Good. Rainbow trout are very sensitive to ammonia.
3. Pacific Wood-treating	Rainbow Trout (S. gairdneri)	Acute	4 days	Death	Yes.	Yes. Pentachlorophenol and creosote compounds.	Good.
	Algae (S. capricornutum)	Chronic	4 days	Productivity	Yes.	Yes. Same as above.	Poor. Particulates interfered with the test. All samples contained large numbers of protozoans (predation).
4. Cashmere Municipal	Rainbow Trout (S. gairdneri)	Acute	4 days	Death	No.	Yes. High effluent chlorine concentration.	Poor. Effluent chlorine may have dissipated by time bioassay run.
	Ceriodaphnia (C. dubia)	Acute/ chronic	7 days	Death/ reproduction	Death, no. Reduced productivity, yes.	Same as above.	Good.
	Algae (S. capricornutum)	Chronic	4 days	Productivity	No.	Same as above.	Poor. Effluent stimulated productivity making it difficult to interpret results.
5. Chambers Creek Municipal Treatment Plant	Rainbow Trout (S. gairdneri)	Acute	4 days	Death	Yes.	Clorine & ammonia exceeded EPA water quality criteria.	Good.
	Ceriodaphnia (C. dubia)	Acute/ chronic	7 days	Death/ reproduction	No.	Same as above.	Good.
	Algae (S. capricornutum)	Chronic	4 days	Productivity	Yes.	Same as above.	Good.

Table 2 - continued.

Survey	Bioassay Test Organism	Acute/ Chronic	Exposure Period	Endpoint	Significant Mortality Observed?	Chemical Contamination Observed?	Value of Bioassays
Receiving Water Sediments							
1. Everett Municipal Treatment Plant	Daphnia (D. Magna)	Acute	2 days	Death	Yes.	Not collected.	Uncertain. Salinity a problem factor.
	Freshwater Amphipod (H. azteca)	Acute	4 days	Death	No.	Not collected.	Uncertain. Known to be a tolerant organism.
2. Chambers Creek	Freshwater Amphipod (H. azteca)	Acute	4 days	Death	No.	No.	Good.
Other WQIS Receiving Water Sediment Bioassays							
3. Lake Roosevelt	Freshwater Amphipod (H. azteca)	Acute	10 days	Death	No.	Yes. Zn, Cu, Pb, As, Cd, Hg, 1 to 2 orders of magnitude above background.	Poor.
	Daphnia (D. pulex)	Acute	2 days	Death	No.	Yes. (see above)	Poor. Test invalidated due to high mortality in control.
4. Paine Field	Freshwater Amphipod (H. azteca)	Acute	10 days	Death	No.	Yes. PCBs to 20 ppm.	Poor.
	Daphnia (D. pulex)	Acute	2 days	Death	Yes.	Yes. High volatiles.	Good.
5. Lower Columbia River	Freshwater Amphipod (H. azteca)	Acute	10 days	Death	No.	No.	Good.
	Daphnia (D. magna)	Acute	2 days	Death	No.	No.	Good.

Table 3. Summary of 1986 to present compliance inspection data showing percent of plants violating water quality criteria for chlorine and ammonia.

Parameter	Number of Plants Exceeding Criteria	Total Number of Plants With Available Data	Percent of Plants Exceeding Criteria	Number of Plants Exceeding Criteria with 100:1 Dilution Ratio	Percent of Plants Exceeding Criteria with 100:1 Dilution Ratio
NH_3-N in Effluent	31	45	68.9	0	0
NH_3 at Bioassay Conditions	40	60	66.7	0	0
Chlorine in Effluent (1-hour criteria)	38	44	86.4	11	25
Chlorine in Effluent (4-day criteria)	38	44	86.4	18	40.9

Table 7. Summary of Ammonia and Chlorine Effluent Data Collected During WQIS Class II Inspections, 1980 - present.

			Effluent Conditions							Bioassay Conditions*					
Plant	Inspection Date	Type	temp (C)	pH (SU)	total NH3-N (mg/L)	TRC (mg/L)	union. NH3-N (mg/L)	4 day union. NH3-N criteria (mg/L)	dilution required to meet criteria	union. NH3-N (mg/L)	4 day union. NH3-N criteria (mg/L)	dilution required to meet criteria	dilution required to meet 4 day chlorine criteria	dilution required to meet 1 hour chlorine criteria	comments:
Asotin	4/85	2	n/a	7.100	0.130	n/a	n/a	0.005		0.000	0.005		n/a	n/a	
Battle Ground	12/83	2 RBC	12.500	7.100	1.500	n/a	0.004	0.005		0.004	0.005		n/a	n/a	
Beverly Beach	6/85	2 AB	20.000	7.400	0.200	1.900	0.002	0.017		0.001	0.010		173:1	100:1	
Blaine	2/83	2 RBC	5.000	7.400	1.400	n/a	0.004	0.006		0.008	0.010		n/a	n/a	
Camas	10/81		n/a	7.400	10.000	0.400	n/a	0.010		0.054	0.010	5.4:1	36:1	21:1	
Cashmere/Tree Top	1/87	AL	1.300	6.700	1.500	5.000	0.001	0.001		0.002	0.002		455:1	263:1	0% mortality in trout bioassay
Cashmere/Tree Top	2/81	AL	10.500	8.700	0.100	0.400	0.009	0.021		0.010	0.024		36:1	21:1	
Centralia	5/86	2 TF	n/a	7.400	16.000	n/a	n/a	0.010		0.087	0.010	8.7:1	n/a	n/a	
Centralia	2/85	2 TF	n/a	7.600	9.700	n/a	n/a	0.016		0.083	0.016	5.2:1	n/a	n/a	
Centralia	8/80	2 TF	19.000	7.100	10.000	0.600	0.046	0.008	5.8:1	0.027	0.005	5.4:1	55:1	32:1	
Chambers Creek	2/87	2 AS	7.200	7.000	17.000	0.400	0.025	0.003	8.3:1	0.037	0.004	9.3:1	36:1	21:1	97% mortality in trout bioassay
Chelan	7/83	2 AS	20.000	7.200	8.200	0.600	0.051	0.011	4.6:1	0.028	0.006	4.7:1	55:1	32:1	
Chehalis	8/80	2 AB/TF	18.800	6.900	21.000	2.200	0.060	0.005	12.0:1	0.036	0.003	12.0:1	200:1	116:1	
Chehalis	2/85	2 AB/TF	n/a	7.600	9.700	n/a	n/a	0.016		0.083	0.016	5.2:1	n/a	n/a	
Chewelah	5/83	2 L	17.900	8.100	3.900	1.000	0.160	0.036	4.4:1	0.104	0.024	4.3:1	91:1	53:1	
Clarkston	10/82	2 AS	n/a	7.500	1.200	n/a	n/a	0.012		0.008	0.012		n/a	n/a	
Colfax	8/82	2 AB	19.300	7.800	0.300	0.070	0.007	0.035		0.004	0.021		6.4:1	4:1	
Conconully	7/86	2 L	18.000	7.900	1.100	n/a	0.029	0.034		0.019	0.022		n/a	n/a	
Coupeville	3/85	2 OD	18.000	8.000	0.500	1.500	0.017	0.036		0.011	0.024		136:1	79:1	
Cowlitz	4/85		n/a	7.400	4.900	n/a	n/a	0.010		0.027	0.010	2.7:1	n/a	n/a	
Dayton	11/80	2 TF	11.600	7.500	1.400	0.800	0.009	0.012		0.010	0.012		73:1	42:1	
Elma	5/84	2 AL	12.400	7.600	16.000	1.500	0.142	0.016	8.9:1	0.137	0.016	8.7:1	136:1	79:1	
Enumclaw/Farm Bros	3/86	2 RBC	5.200	7.200	n/a	n/a	n/a	0.004		n/a	0.006		n/a	n/a	
Ferndale	4/81	2 AL	9.800	7.300	12.000	9.800	0.137	0.018	7.6:1	0.163	0.021	7.8:1	891:1	516:1	
Friday Harbor	8/85	2	19.700	7.500	20.000	1.500	0.243	0.021	11.6:1	0.137	0.012	11.4:1	136:1	79:1	
Friday Harbor	5/83	2	14.000	7.400	15.000	3.500	0.095	0.011	8.6:1	0.082	0.010	8.2:1	318:1	184:1	
Gig Harbor	7/83	2 AS	20.400	7.000	14.000	2.500	0.057	0.007	8.1:1	0.030	0.004	7.5:1	227:1	132:1	
Everett	8/86	2 L	22.000	9.000	11.000	n/a	3.462	0.041	84.4:1	1.967	0.024	82.0:1	n/a	n/a	80% mortality in trout bioassay
Goldendale	8/85	2 L	20.000	9.000	0.410	n/a	0.117	0.041	2.9:1	0.073	0.024	3.0:1	n/a	n/a	
Goldendale	2/86	2 L	10.000	8.500	2.800	n/a	0.156	0.021	7.4:1	0.180	0.024	7.5:1	n/a	n/a	
Granite Falls	3/83	2 OD	18.100	6.500	n/a	1.500	n/a	0.002		n/a	0.001		136:1	79:1	
Kittitas	2/84		1.400	7.500	15.000	0.200	0.044	0.006	7.3:1	0.103	0.012	8.6:1	18:1	11:1	
Liberty Lake	8/83	2 AS	21.500	6.100	0.040	<0.100	0.000	0.001		0.000	0.000		<9:1	5:1	
Leavenworth	6/84	2 OD	15.500	6.600	0.200	0.400	0.000	0.002		0.000	0.002		36:1	21:1	
Lynden	1/81	2 OD	11.500	7.900	15.000	0.800	0.245	0.022	11.1:1	0.255	0.022	11.6:1	73:1	42:1	
McCleary	8/86	2 TF	20.000	7.600	0.180	<0.100	0.003	0.027		0.002	0.016		<9:1	<5:1	
Monroe	2/80	2 RBC	n/a	6.400	6.900	0.900	n/a	0.001		0.004	0.001	4.0:1	82:1	47:1	
Mukilteo	3/82	1	11.000	7.000	10.000	0.300	0.020	0.004	5.0:1	0.022	0.004	5.5:1			
Olympus Terrace	11/84	2 OD	13.000	7.300	1.200	0.600	0.006	0.009		0.005	0.008		55:1	32:1	
Othello	7/84	2 L	25.400	7.700	9.600	2.001	0.274	0.034	8.1:1	0.104	0.020	5.2:1	182:1	105:1	
Pasco	6/84	2 TF	n/a	7.800	19.000	n/a	n/a	0.021		0.257	0.021	12.2:1	n/a	n/a	
Pomeroy	7/80	2 TF	20.600	7.600	10.000	<0.100	0.163	0.027	6.0:1	0.086	0.016	5.4:1	<9:1	5:1	
Pomeroy	9/84	2 TF	n/a	7.900	10.000	n/a	n/a	0.022		0.170	0.022	7.7:1	n/a	n/a	
Port Orchard	9/80	1	18.400	6.500	19.000	2.800	0.021	0.002	10.5:1	0.013	0.001	13.0:1	255:1	147:1	
Prosser	10/82	2 TF	19.700	7.100	6.800	0.000	0.033	0.008	4.1:1	0.019	0.005	3.8:1	0	0	
Pullman	9/86	2 AS	21.500	7.300	2.000	0.100	0.018	0.014	1.3:1	0.009	0.008	1.1:1	9:1	<5:1	
Richmond Beach	6/85	1	17.800	7.200	n/a	4.500	n/a	0.009		n/a	0.006		409:1	237:1	
Ridgefield	7/82		n/a	7.500	1.000	0.400	n/a	0.012		0.009	0.012		36:1	21:1	
Roche Harbor	9/84	2 AS	18.500	7.300	27.000	<0.100	0.190	0.012	15.8:1	0.117	0.008	14.6:1	<9:1	<5:1	
Seashore Villa	7/85	2	18.000	6.700	4.000	3.500	0.067	0.003	22.3:1	0.004	0.002	2.0:1	318:1	184:1	
Selah	5/81	2 AS	n/a	7.400	0.550	n/a	n/a	0.010		0.003	0.010		n/a	n/a	
Steilacoom	7/82	1	14.300	8.000	0.100	3.000	0.003	0.028		0.002	0.024		273:1	158:1	
Stevens Pass	2/84	2	4.800	7.200	22.000	0.100	0.013	0.004	3.3:1	0.023	0.006	3.8:1	9:1	5:1	
Tacoma Central	8/81	1	21.300	7.300	22.000	0.200	0.198	0.014	13.8:1	0.095	0.008	11.9:1	18:1	11:1	50% mortality in daphnid bioassay
Tacoma Central	2/83	1	11.200	6.900	4.400	1.200	0.007	0.003	2.3:1	0.008	0.003	2.7:1	109:1	63:1	
Tahoshan	6/85	2 AS	18.000	7.400	4.700	2.500	0.040	0.015	2.7:1	0.028	0.010	2.8:1	227:1	132:1	
Vancouver Eastside	5/85		n/a	7.800	20.000	n/a	n/a	0.021		0.271	0.021	12.9:1	n/a	n/a	
Vancouver Westside	4/86		n/a	7.400	0.180	n/a	n/a	0.010		0.001	0.010		n/a	n/a	
Walla Walla	2/81	2	10.400	7.400	3.600	0.450	0.017	0.009	1.9:1	0.020	0.010	2.0:1	41:1	24:1	
West Point	5/82	1	17.100	7.000	15.000	1.000	0.048	0.006	8.0:1	0.032	0.004	8.0:1	91:1	53:1	
Western Slopes	7/83	1	13.800	7.300	12.000	1.900	0.060	0.009	6.7:1	0.052	0.008	6.5:1	173:1	100:1	
Winthrop	8/84	2 L	19.300	9.400	2.600	n/a	1.265	0.039	32.4:1	0.919	0.024	38.8:1	n/a	n/a	
Yakima	7/86	2 AS	18.500	6.900	0.050	0.500	0.000	0.005		0.000	0.003		45:1	26:1	

[box] = exceeded criteria

n/a = not available

* Temperature = 20 C; pH = effluent pH

NOTE: 1 hour chlorine criteria = 0.019 mg/L; 4 day chlorine criteria = 0.011 mg/L

Type: 1 = primary treatment; 2 = secondary treatment; AB = Aerated Basin; AL = Aerated Lagoon; AS = Activated Sludge; L = Lagoon; RBC = Rotating Biological Contactor; OD = Oxidation Ditch; TF = Trickling Filter