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TO: Ed O'Brien

THROUGH: Lynn Singleton

FROM: Joe Joy and Barb Carey

SUBJECT: Analysis of Potential Receiving Water Effects from Municipal Wastewater Treatment Plant Effluents Related to the 1988 Drought

DATE: August 15, 1988

The attached report was written in response to your request for an analysis of imminent surface water quality problems due to reduced dilution of municipal wastewater treatment plant effluent.

Please contact either of us if you have any questions or comments.

JJ/BC:sk

Attachment

DROUGHT-RELATED WATER QUALITY IMPACTS FROM MUNICIPAL WASTEWATER TREATMENT PLANTS

Introduction

Drought conditions were predicted in 1988 for much of Washington because of lower than normal snowpack in the mountains and below normal precipitation in the fall, winter, and spring of 1987-88. The drought may reduce the volume of water available for dilution at some municipal wastewater treatment plant (WTP) discharges. This could result in significant water quality impacts in receiving waters.

Ed O'Brien of the Water Quality Program, Point Source Section, requested the Surface Water Investigations Section conduct an analysis of likely WTP impacts on receiving waters where dilution could be less than 100:1 this summer. Concerns include fisheries' impacts as well as water quality standards and criteria violations. The objectives of the analysis were to provide him:

1. A list of priority watershed and dischargers based on drought forecasts and information provided by Ecology and other resource agency staff.

2. A comparison of design flows (20:1 or 100:1 at the 7-day 10-year low flow) to the forecasted situation for highly impacted receiving waters.

3. A discussion of most probable receiving water quality impacts, including ammonia and chlorine toxicity, and dissolved oxygen.

4. Recommendations for preventive or corrective action at WTPs where the risk of problems warrant.

Methods

We used a two-phased approach in analyzing drought effects: 1) screened for WTPs potentially affected by drought based on estimated dilution, and 2) evaluated effluent constituent concentrations for specific downstream toxicity criteria violations.

We consulted Ecology staff in the regional offices and Water Resources Program initially for their analysis of drought conditions. We targeted watersheds where expected streamflows were less than 70 percent of the long-term average based on Ecology staff information and data from the June 1, 1988, Washington Water Supply Outlook (U.S. Soil Conservation Service, 1988). Streamflows projected in the Water Supply Outlook are based on snowpack levels and do not take into consideration ground water contributions. Since information on ground water inflow was not available, we assumed snowpack to be the main factor controlling streamflow variation.

Central and Eastern Regional Office staff supplied June-October 1987, Discharge Monitoring Reports (DMRs) and the Wastewater Discharge Inventory System (WDIS) data for treatment plants in targeted watersheds.

We also added receiving waters in nearby watersheds that we suspected from experience to be potentially affected.

We used summaries of long-term gaging records and data from the U.S. Bureau of Reclamation (U.S. Geological Survey, 1985; Perala, 1988) to estimate normal monthly streamflows. We multiplied the forecasted percent of average flow (U.S. Soil Conservation Service, 1988) by the mean monthly streamflow to obtain the forecasted flow near the WTP. We then used the maximum WTP discharge value for each month in 1987 to obtain dilution ratios for August, September and October 1988.

Wastewater treatment plants with estimated discharge dilution ratios less than or near 100:1 were further examined. We used the corresponding 1987 monthly maximum DMR values for the following parameters at each WTP to determine potential receiving water problems during August, September, and in a few cases October 1988:

- Treatment plant flow
- Effluent total residual chlorine (TRC)
- Effluent ammonia
- Effluent biochemical oxygen demand (BOD)

Many of the WTPs do not monitor for ammonia. Where available, ammonia data from Ecology Water Quality Investigation Section Class 2 Inspection Reports were used. Where no ammonia data were available, a literature estimate of effluent ammonia typical of the level of waste treatment was used, e.g., activated sludge, trickling filter, or lagoon (Mills, et al, 1985).

Temperature and pH values from Class 2 inspections, if available, were used to calculate unionized ammonia concentrations in receiving waters (U.S. EPA, 1986). Otherwise temperature and pH conditions that would produce ammonia concentrations exceeding water quality criteria (U.S. EPA, 1986) were determined. If these values were in the range of likely temperature and pH for that water body, then the plant discharge was classified as a potential problem.

Results

The watersheds and WTPs evaluated in the first phase of the drought effects analysis are listed in Table 1. Included are the forecasted percentages of average streamflow expected in each watershed (U.S. Soil Conservation Service, 1988).

All watersheds examined are in eastern Washington. Watersheds in southwest Washington were initially thought to be threatened by drought. Lower than normal fall and winter precipitation may have caused significantly less than average aquifer recharge. Lower ground water recharge was expected to diminish supplies to streams during late summer when most of the streamflow comes from ground water. However, spring and early summer rains diminished this threat. Streamflows and aquifers appeared to be at normal levels by early summer, according to Southwest Regional Office staff (personal conversations with W. Bergstrom and T. Eiler).

Table 1. Rivers and wastewater treatment plants where dilution ratios and potential drought impacts were evaluated.

River	Discharger	Forecast % Average Flow
Okanogan River		66 %
	Oroville WTP	
	Omak WTP	
	Okanogan WTP	
	Methow River	64 %
	Winthrop WTP	
	Twisp WTP	
Colville River		62 %
	Chewelah WTP	
	Colville WTP	
Yakima River		63 %
	Cle Elum WTP	
	South Cle Elum WTP	
	Ellensburg WTP	
	Selah WTP	
	Yakima WTP	
	Moxee WTP	
	Toppenish WTP	
	Zillah WTP	
	Granger WTP	
	Mabton WTP	
	Prosser WTP	
	Benton City WTP	
Naches River		70 %
	Naches WTP	
Spokane River		52 %
	Liberty Lake WTP	
	Millwood WTP	
	Spokane Municipal WTP	
	Northwest Terrace WTP	
Wenatchee River		70 %
	Leavenworth WTP	
	Cashmere/Tree Top WTP	
	Palouse/Touchet River	50 %
	Palouse WTP	
	Pullman WTP	
	Colfax WTP	
	Garfield WTP	
	Dayton WTP	
Crystal Creek		60 %
	Roslyn WTP	
Cooke Creek		60 %
	Kittitas WTP	
Sulfur Creek		63 %
	Sunnyside WTP	

Although streamflows for the Walla Walla River basin were projected to be 40% of average (U.S. Soil Conservation Service, 1988), we excluded the two WTPs in the basin (Walla Walla and College Place WTPs), since their discharges are diverted to irrigation districts during the critical period (O'Brien, 1988).

Projected dilution at twelve WTPs is less than 100:1 under the forecasted drought conditions. Ammonia, TRC, and BOD impacts from these discharges were assessed for August and September (and October in some cases) under two dilution conditions:

1. The most probable forecasted percent streamflows for June-September (U.S. Soil Conservation Service, 1988)

2. The 7-day 10-year low flow (7Q10) (U.S. Geological Survey, 1985).

The 7Q10 calculation was included as a worst case example for comparison to the projected drought condition. We assumed complete mixing of effluent and receiving water, i.e., the fact that most of these WTPs lack diffusers and are bank discharges was ignored. We also assumed that ammonia, TRC, and BOD concentrations upstream of the WTP discharge were insignificant. These are probably not valid assumptions at some discharge points, e.g., elevated ammonia concentrations upstream of the Pullman WTP discharge, incomplete mixing below most bank discharges.

We compared the estimated downstream concentrations of TRC and un-ionized ammonia in the receiving water to EPA Water Quality Criteria (U.S. EPA, 1984, 1986).

The current TRC criteria are not to be exceeded more than once in three years to prevent irreparable harm to aquatic life: a 4-day average of 0.011 mg/L; and a one-hour concentration of 0.019 mg/L. Since violation of the TRC criteria could have severe, long-term consequences, a threshold concentration was established at 10% of the one-hour limit (or 0.002 mg/L) and the 4-day average limit. The threshold limit corresponds to the former TRC criterion for protection of salmonid species (U.S. EPA, 1977). Calculated downstream concentrations between the threshold concentration and the toxicity criteria could damage biota depending on the frequency and duration of occurrence. Actual dilution and dispersion characteristics below the outfall would also affect the degree harm from this intermediate TRC level. Estimated monthly receiving water concentrations that exceed the current TRC criteria indicate possible substantial, long-term damage to the biota.

The un-ionized ammonia criteria are pH and temperature dependent, and are calculated for 4-day average and one-hour concentrations (U.S. EPA, 1986). Like the TRC criteria, the critical ammonia concentrations are not to be exceeded more than once every three years. The data available suggests that ammonia would be a problem in only a few cases where it would not be a problem under average flow conditions.

Downstream BOD values were compared to 2.25 mg/L and 1.5 mg/L, the instream values expected at a 20:1 dilution ratio for NPDES permit limits of 45 mg/L BOD (daily maximum) and 30 mg/L BOD (monthly average), respectively.

Results of these comparisons are summarized in Table 2 and tabularized in Appendix I. The results in Table 2 and Appendix I indicate:

- In most cases, forecast dilution ratios are about one-half the long-term average, monthly ratios.

- In smaller rivers the forecast dilution is at the 7Q10 condition.

- TRC is the most likely effluent component to create toxicity problems in receiving water:

    - o Many WTPs have historically maintained effluent TRC residuals at concentrations above 0.5 mg/L (median value of the plants assessed was 1.2 mg/L), which can cause toxicity problems during low-flow conditions.

Table 2. Comparison of instream ammonia, total residual chlorine (TRC), and BOD concentrations to criteria under forecast drought and 7 day, 10 yr. low flow conditions

		Forecast Conditions with Complete Mix							Low-flow Conditions with Complete Mix					
Treatment Plant	Month	Normal Dilution	Forecast Dilution	NH3 4-Day	NH3 1-Hour	TRC 4-Day	TRC 1-Hour	BOD 45/30	7Q10 Dilution	NH3 4-Day	NH3 1-Hour	TRC 4-Day	TRC 1-Hour	BOD 45/30
Spokane AWT	August													
	September													
Pullman (est. from Class 2)	August													
	September													
Palouse (est. from Class 2)	August													
	September													
Dayton (est. from Class 2)	August													
	September													
Ellensburg	August													
	September													
	October													
Yakima	August													
	September													
Sunnyside	August													
	September													
Roslyn (est. from Class 2)	August													
	September													
Garfield (est. from Class 2)	August													
	September													
Kittitas (est. from Class 2)	August													
	September													
Colville	August													
	September													
	October													
Chewelah	August													
	September													

Dilution: ->100:1 -Between 100:1 and 20:1 -< 20:1

Ammonia: -Meets criterion -May exceed at high pH or Temperature -Would probably exceed criterion

TRC: -Meets criterion -Exceeds 0.002 mg/L (old EPA) criterion -Exceeds new criterion

BOD: -Not a problem -Between 2.25 and 1.5 mg/L ->2.25 mg/L

- Ellensburg, Yakima, Sunnyside, Colville, and Chewelah effluents may create toxicity exceeding the 4-day TRC criterion.

- Palouse, Garfield, Roslyn, Dayton, and Kittitas WTPs have had historical receiving water TRC problems under normal conditions. These could become worse during this drought season.

- WTPs where estimated receiving water TRC concentrations exceed the danger threshold of 0.002 mg/L but are below the 4-day average criterion may cause problems if dilution is inadequate. Risk of environmental damage is greatest where values are closer to the 4-day criterion.

- Ammonia toxicity is a less likely problem than TRC:

  - Pullman, Garfield, and Palouse effluents may create localized toxicity problems when pH exceeds 7.75 and temperature exceeds 20 degrees C.

  - Kittitas and Spokane effluents could create toxicity problems under the conditions listed above, and if the dilution zone is inadequate.

- BOD problems and resultant oxygen sags may occur below WTPs that are poorly diluted under normal low flow conditions, e.g., Pullman, Garfield, Roslyn and Kittitas.

- If 7Q10 conditions occur this summer, most plants evaluated will create ammonia toxicity problems.

Conclusions and Recommendations

This analysis provides a rough estimate of potential effluent water quality effects from the projected drought. Recent projections indicate that the drought will be less severe in most parts of the state than originally predicted (Press release from J.Bucknell; July 1988). However, conditions at or near the 7Q10 could occur at some WTPs.

TRC is the effluent constituent with the potential for causing toxic effects at the largest number of locations. Projected effluent TRC concentrations at several WTPs could severely damage the downstream aquatic environment. Based on U.S. EPA data, recovery could take three years or more (U.S. EPA, 1984).

Fewer ammonia toxicity problems are indicated by this analysis than TRC problems. However, fewer "hard data" were available for effluent ammonia upon which to base conclusions. In addition, un-ionized ammonia is difficult to accurately calculate for the area in or below the dilution zone. Therefore, we suggest an extra degree of caution when using results of this study for anticipating ammonia impacts.

The following recommendations are based on our drought analysis:

- For the short term, inform WTPs with projected TRC criteria violations to keep effluent TRC concentrations as low as possible. Concentrations at or below 0.3 mg/L should reduce TRC toxicity potential at most of the WTPs evaluated.

- Dechlorination, alternative means of disinfection or alternative disposal plans are necessary for WTPs with chronically inadequate dilution, e.g. Kittitas, Roslyn, and Garfield. Any small WTPs not included in this study should be included in such a plan after consultation with regional office staff.

- Pullman and Spokane WTPs should keep effluent ammonia levels as low as possible to avoid toxicity.

- This analysis did not address impacts from industrial discharges. The regional offices should be alerted that industrial discharges may have a severe impact on water quality in drought-affected areas.

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Appendix I. Estimated values for dilution ratio, receiving water ammonia (NH_3), total residual chlorine (TRC), and Biochemical oxygen demand (BOD) under forecasted and 7Q10 flow.

	Month	Plant Flow cfs	Average Dilution	Forecast Dilution	Forecast Conditions Complete Mixed in River NH3 Max'87	TRC Max'87	BOD Max'87	7Q10 Dilution	Low-flow Conditions Complete Mixed in River NH3 Max'87	TRC Max'87	BOD Max'87
								7Q10= 888			
Spokane AWT	August	46.4	38	20	0.32	NA	1.18	19	0.33	NA	1.25
	September	44.9	40	21	0.28	NA	0.48	20	0.29	NA	0.51
					permit			7Q10= 0.7			
Pullman (est. from Class 2)	August	5.5	1.4	1.2	0.82	NA	16.42	1.1	0.89	NA	17.74
	September	5.5	1.5	1.2	0.80	NA	16.06	1.1	0.89	NA	17.74
								7Q10= 1.0			
Palouse (est. from Class 2)	August	0.1	87	44	0.29	0.032	0.54	8.2	1.59	0.171	2.93
	September	0.1	76	39	0.34	0.036	0.62	8.2	1.59	0.171	2.93
					est.			7Q10= 20			
Dayton (est. from Class 2)	August	0.6	76	39	0.13	0.041	0.31	36	0.14	0.045	0.33
	September	0.5	80	41	0.12	0.032	0.15	38	0.13	0.034	0.16
					est.			7Q10= 104			
Ellensburg	August	7.0	379	235	0.02	0.004	0.01	16	0.38	0.056	0.19
	September	6.5	258	160	0.02	0.007	0.03	17	0.35	0.071	0.29
	October	6.3	110	68	0.05	0.010	0.23	17	0.34	0.039	0.92
					permit			7Q10= 560			
Yakima	August	32.2	111	70	0.02	0.014	0.37	18	0.09	0.052	1.41
	September	29.2	98	62	0.03	0.014	0.37	20	0.08	0.045	1.14
								7Q10= Unknown			
Sunnyside	August	2.3	127	80	0.19	0.010	0.36				
	September	2.3	134	85	0.18	0.009	0.29				
								7Q10= 0.7			
Roslyn (est. from Class 2)	August	0.3	7.0	4.6	0.02	0.272	2.17	3.8	0.03	0.329	2.63
	September	0.3	7.0	4.6	0.02	0.272	2.17	3.8	0.03	0.329	2.63
								7Q10= ?			
Garfield (est. from Class 2)	August	0.2	1.4	1.2	9.11	1.657	33.14				
	September	0.2	1.4	1.2	9.11	1.160	27.34				
								7Q10= 1.5			
Kittitas (est. from Class 2)	August	0.4	13.5	8.8	0.25	0.069	1.49	4.8	0.46	0.126	2.74
	September	0.4	9.6	6.3	0.35	0.095	2.06	5.3	0.42	0.114	2.46

Colville	August	1.2	60	37	0.01	0.003	0.35	15	0.03	0.007	0.87
	September	1.4	59	37	0.01	0.003	0.41	13	0.04	0.008	1.19
	October	1.3	82	51	0.01	0.006	0.29	14			
Chewelah	August	0.1	79	49	0.07	0.004	0.14	32	0.12	0.006	0.22
	September	0.1	75	46	0.09	0.011	0.28	26	0.15	0.019	0.50
Omak	August	1.0	1370	907	0.00	0.002	0.00	338	0.00	0.005	0.01
	September	0.8	1252	823	0.00	0.002	0.00	416	0.00	0.004	0.01