87-e16

Segment No. 05-10-05

WA-10-1030

AN INVESTIGATION OF STORMWATER AND EFFLUENT DISCHARGE FROM THE BOEING COMPANY FACILITY IN AUBURN, JANUARY 1987

by

Joe Joy

Washington State Department of Ecology
Water Quality Investigations Section
Olympia, Washington 98504-6811

December 1987

ABSTRACT

A two-day cooperative survey was performed with the Boeing Commercial Airplane Company at its facility in Auburn in January 1987. Two discharges were monitored as they emptied into Government Canal, a 1.75-mile-long tributary to White River. One discharge included near-surface ground water, stormwater, noncontact cooling water, and process treatment effluent; the other contained only ground water and stormwater runoff. Stormwater was not thought to be a significant portion of the two discharges during the survey. The discharges did not fit usual stormwater quality characteristics. The former discharge contained elevated BOD, Cr, and Zn concentrations, and one low dissolved oxygen (D.O.) concentration. The latter had elevated Cd, Cu, Zn, COD, and TOC concentrations. The metals concentrations would have exceeded some USEPA freshwater aquatic life criteria had they been applicable. Samples from the canal indicated D.O. depletion below the Class A criterion as a result of the poor reaeration in the canal, possibly aggravated by the BOD and COD loads from the discharges. No other water quality problems were noted in the canal or White River. Close review of Boeing's results for four monitoring surveys in 1987, sampling of canal sediment, further periodic monitoring of the discharges, evaluation of the retention pond removal effectiveness, and complete fish habitat assessment in the canal were recommended.

INTRODUCTION

The Boeing Commercial Airplane Company (Boeing) fabrication facility in Auburn has been performing periodic on-site monitoring of its combined discharge of stormwater runoff, ground water, and process wastewater since the summer of 1986. The monitoring is part of Boeing's NPDES permit obligations. Ecology's Water Quality Investigations Section (WQIS) conducted a survey on January 28 and 29, 1987, in cooperation with Boeing at the request of the Ecology Northwest Regional Office (NWRO). There were three primary objectives to the survey:

1. Monitor and characterize the discharges reaching Government Canal and White River from the Boeing site during a winter storm event.

2. Assess the probable impact of the discharges on receiving water quality.

3. Compare Ecology and Boeing analytical results on split samples.

Although the storm event did not fully materialize as anticipated, the information obtained from this survey should help the NWRO with decisions concerning the Boeing discharge permit, and with future stormwater management decisions in the Auburn area.

Site Description and Background

The Boeing fabrication facility occupies approximately 385 acres within the corporate limits of Auburn in south-central King County (Figure 1). The plant manufactures aerospace components used at other Boeing facilities in the Puget Sound basin. Boeing purchased the site in 1964 from the U.S. General Services Administration (GSA), which still occupies an adjoining 125 acres (approximately) to the east and north of Boeing (Figure 1).

The combined 510 acres were originally developed by the GSA in 1941. Approximately 80 percent of the area is impervious--primarily as parking lots and large buildings. Drains and Government Canal were built to remove near-surface ground water and stormwater runoff from the site to White River, 1.75 miles to the south (Figure 1).

The drainage system for the combined Boeing/GSA site has two main branches (Figure 2). One branch serves 400 acres--the GSA property, and the north and central portion of the Boeing site. This branch terminates at a retention pond on the southwest corner of the Boeing facility. The pond discharges through a culvert into the head of Government Canal (SW-1). The second branch serves the southeastern 110 acres owned by Boeing. It terminates at an outfall (SW-2) at Pacific Avenue (Figure 2). From the outfall, water is carried through an 0.3-mile open ditch to Government Canal.

Boeing maintains the drainage and canal system as part of its agreement with GSA. Government Canal is generally characterized as slow-moving and quiescent, except at the outfall at the Boeing property line and the final 500 feet to the confluence with White River. The canal is dredged periodically; most recently in September and October of 1986.

Both White River and Government Canal are Class A water bodies (WAC 173-201-070). Therefore, their water quality should meet the criteria set in Table 1.

Four sources of wastewater are regulated at the Auburn site under the current Boeing NPDES permit (WA-000094-9 [Table 2]):

1. Sanitary sewage
2. Boiler blowdown
3. Process treatment effluent
4. Noncontact cooling water

Boeing sanitary sewage and boiler blowdown effluent are sent to Auburn for treatment. Noncontact cooling water and treated process wastes are discharged into the larger storm drain network, and ultimately to White River via Government Canal.

The process wastes treatment system handles independent waste streams of:

- Oil.
- Chromium.

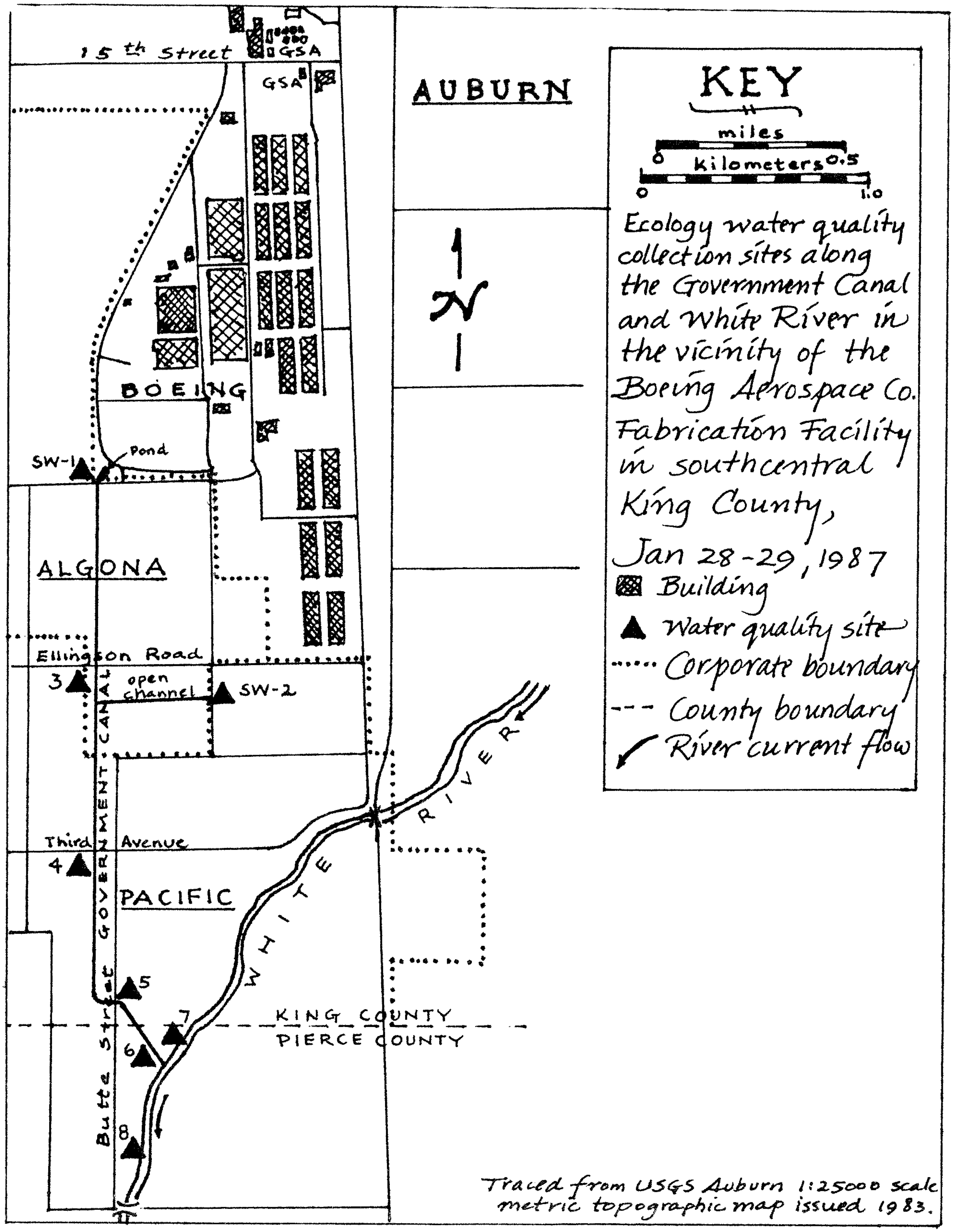


Figure 1. Survey vicinity map.

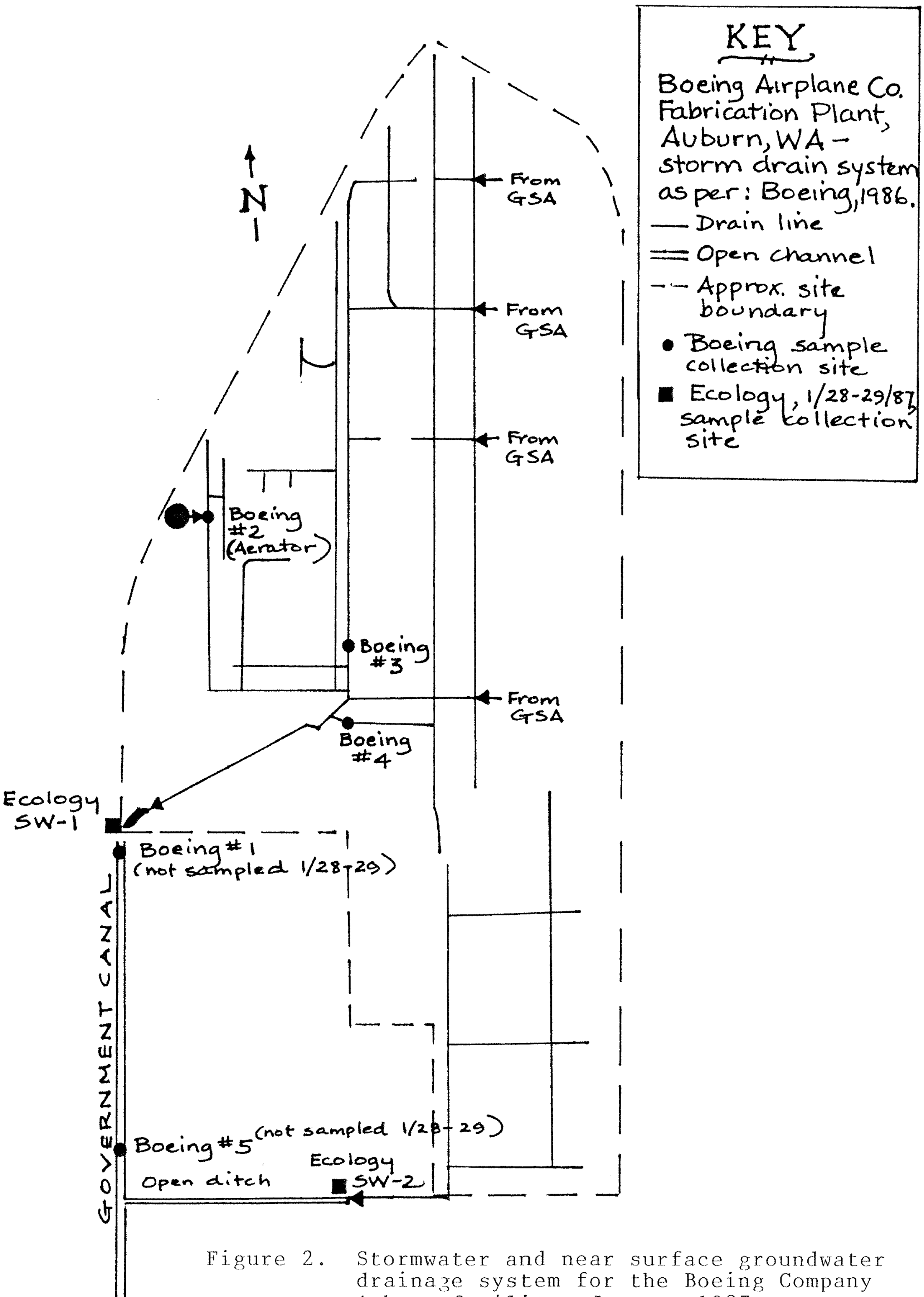


Figure 2. Stormwater and near surface groundwater drainage system for the Boeing Company Auburn facility, January 1987.

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.
Water Quality Criteria	
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.

S1. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (Treatment Plant Effluent to Storm Sewer)

During the period beginning on the date of issuance of the permit and lasting until completion of the Auburn Interceptor, the permittee is authorized to discharge process water subject to the following limitations and monitoring requirements:

Parameter	EFFLUENT LIMITATIONS Daily Average	Daily Maximum	MONITORING REQUIREMENTS Minimum Frequency	Sample Type
Flow (MGD)	0.55	2.05	Monthly	Measure
Temperature (°F)		75°F	Daily	Grab
pH	Not outside the range 8.0 - 9.5		Continuous	
Dissolved Oxygen	Not less than 8.0 mg/l		Daily	Grab
Heavy Metals (mg/l)			Daily	24 hr. composite
Cadmium	0.01	0.03 (0.2 lb/day)		
Chromium	0.10	0.25 (1.7 lb/day)		
Copper	0.05	0.10 (0.9 lb/day)		
Nickel	0.05	0.10 (0.9 lb/day)		
Zinc	0.05	0.10 (0.9 lb/day)		
Lead		0.69	Monthly	
Cyanide (mg/l)	0.01	0.02	Daily	Grab
Orthophosphate - P (mg/l)	0.3	1.0	Monthly	24 hr. composite
Total Oils (mg/l)	10 (no visible oils)	15	Weekly	24 hr. composite
Total Toxic Organics, TTO, (mg/l)		2.13	1/shift/mo	Grab

The daily maximum is defined as the greatest allowable value for any calendar day.

Temperature and dissolved oxygen samples may be taken at point of discharge of the storm water outfall at the property line.

The cyanide sample shall also be taken after cyanide treatment and before dilution with other waste streams.

All other samples shall be taken prior to dilution with non-contact cooling water.

S2. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (Non-Contact Cooling)

During the period beginning on the date of issuance of this permit and lasting until the expiration date, the permittee is authorized to discharge non-contact cooling water subject to the following limitations and monitoring requirements:

Parameter	EFFLUENT LIMITATIONS Daily Average	Daily Maximum	MONITORING REQUIREMENTS Minimum Frequency	Sample Type
Flow (MGD)	1.6	1.75	Monthly	Calculate
Temperature (°F)		70°F	Weekly	Grab
Total Oils (mg/l)	10 (no visible oils)	15	Weekly	Grab
pH	Not outside the range 6.5 - 8.5		Weekly	Grab

Table 2. Boeing Company NPDES permit WA-000094-9 for the Auburn fabrication facility.

- Cyanide.
- Zyglo (a fluorescing solution used to detect cracks in metal work).

Oils are recycled and/or retained. The other three waste streams are combined after treatment and discharged. The NPDES permit requires process treatment effluent to undergo both routine chemical monitoring and continuous effluent bioassay. Rainbow trout, Salmo gairdneri, are subjected to a mixture of one part effluent to no more than two parts uncontaminated dilution water.

Currently, neither the mixed stormwater, ground water, and process effluent discharge at SW-1, nor the SW-2 discharge is regulated by permit. Regular monitoring of water discharging from the retention pond (SW-1) or from the other branch of the drainage system (SW-2) into Government Canal had not been required in the past. Boeing was directed by the NWRO in section S6.(C) of the most recent NPDES permit (WA-000094-9), to monitor water exiting the site if Boeing wished to continue using White River via Government Canal as a wastewater discharge site.

In May 1986, Boeing submitted a monitoring plan to the NWRO for approval (Boeing, 1986). It was agreed Boeing would monitor its systems four times during 1986-87:

- Summer dry period
- Summer rainy period
- Winter relatively dry period
- Winter rainstorm period

Samples would be collected at four on-site locations and one off-site location every two hours over a 24-hour period (Figure 2). Discrete and 24-hour, hand-composite samples would be analyzed for several conventional and priority pollutant parameters. Results of the surveys are to be reported to the NWRO by October 1987.

The NWRO requested the WQIS to conduct a survey of Government Canal and White River during one or two of Boeing's surveys. Initial monitoring plans included collection and analysis of canal sediment and benthic invertebrates. However, canal dredging just prior to the planned summer rainy-period survey eliminated the usefulness of those activities. The plans were modified from the initial proposal of two cooperative monitoring events to that of monitoring only during the winter rainstorm period survey. Hal Alsid, the Boeing manager in charge of their surveys, and I set a January 1987 survey date (personal communication, 11/20/86). After a reconnaissance visit on January 26, the weather forecast appeared promising for a January 28 and 29 survey. This report discusses and summarizes results of that survey.

METHODS

Ecology station locations for the survey were selected after the January 26 reconnaissance survey. They and the Boeing stations are shown in Figures 1 and Figure 2, respectively. Descriptions and field/laboratory activities for individual Ecology and Boeing stations are listed in Table 3. Field analyses included temperature by mercury thermometer, dissolved oxygen (D.O.) using Winkler-azide modified titration, and pH and conductivity using field meters (APHA-AWWA-WPCF, 1985). Discharge data at selected sites were obtained from cross-section channel and water velocity measurements using measuring tape, staff and propeller flow meter. A Manning Dipper[R] water level recorder was set at the retention pond and calibrated to the head height flowing out the 48-inch culvert to Government Canal. Ecology water quality grab samples collected for laboratory analyses were stored in the dark on ice and received by the Ecology/USEPA Manchester Environmental Laboratories within 24 hours. All analyses were performed using approved procedures (USEPA, 1983a; APHA-AWWA-WPCF, 1985; Huntamer, 1986).

Automatic composite samplers were set by Ecology at the two outfalls--SW-1 and SW-2 (Figure 1). Samplers contained glass storage jugs and had teflon intake tubes. They had been cleaned with sequential rinses of detergent, distilled water, acid, distilled water, dichloromethane (methylene chloride), and acetone. The compositors were set to deliver 200 mL every 30 minutes for 24 hours. Samples were distributed out of the main compositor jug into various specially cleaned containers; properly preserved where necessary; kept in the dark, on ice, and delivered to the Manchester Environmental Lab within 24 hours. All analyses were performed by the lab or a designated contract lab using approved procedures.

Several quality assurance/quality control (QA/QC) measures were taken over the course of the survey. A blank sample of carbon-free water was run through the SW-1 compositor and analyzed for selected priority pollutants and metal species. Compositor samples were split with Boeing personnel for interlaboratory comparisons. Duplicate base neutral/acid extractable and volatile organic compounds grab samples were collected at SW-1. The Manchester and contract laboratory (METRO) both observed strict QA/QC procedures during their analyses under the guidance and approval of Raleigh Farlow, the Ecology QA officer (Farlow, 1987).

RESULTS

Rainfall and Discharge

The quantity and quality of stormwater runoff is dependent upon several climatic, land use, and pollutant source variables. Among the climatic variables important in this survey are:

- Rainfall volume.
- Rainfall intensity.
- Amount of time past since the last rainfall.

Table 3. Station descriptions and monitoring activities for the water quality survey samples collected from the White River and Government Canal in the vicinity of the Boeing/Auburn facility, by both Ecology and Boeing personnel, January 28-29, 1987.

Ecology Station	River Mile	Station Description	Field/Laboratory Activities
SW-1	1.75	Stormwater, groundwater & Boeing Co. facility treatment process water - 24 hr. composite at the retention basin outfall.	Pool head height,pH,conductivity/ pH conductivity,chloride,turbidity,solids(4) nutrients(3),hardness, total organic carbon, base neutral-acid extractables, metals(6), VOA,total cyanide
SW-1	1.75	Source water same as above - grab samples taken 15' below outfall south of 1st Ave.- midstream.	Discharge,pH,conductivity,dissolved oxygen temperature/fecal coliform,oil&grease, metals(6),total cyanide,phenol,total solids, VOA,base neutral-acid extractables,hardness
3	1.25	Government Canal at Ellingson Rd., 0.1 mi. above SW-2 drain confluence, midstream.	Dissolved oxygen,temperature,pH,conductivity /f. coliform,nutrients(3),chloride,turbidit total solids,hardness
SW-2	0.30	Stormwater and groundwater - 24 hr. composite at discharge into an open ditch at Pacific St. approx. 100' downstream of outfall	Same as SW-1 composite except no pool height /Same as SW-1 composite
SW-2	0.30	Source waters same as above- grab samples taken at outfall	Same as SW-1 grab/ oil & grease,phenol,total cyanides,fecal coliform
4	0.75	Government Canal approx. 10' upstream of 3rd Ave., midstream grab samples	Same as SW-1 grab/f.coliform,nutrients(3), chloride,turbidity,solids(4),hardness, metals(6)
5	0.3	Government Canal from Butte St. crossing midstream grab sample	Same as Station 3/ fecal coliform
6	0.01	Government Canal approx. 25' up from confluence with White River- midstream grab sample	Same as SW-1 grab/Same as Station 4
7		White River approx. 75' upstream of Government Canal confluence- right bank grab sample	Same as Station 3/f. coliform,nutrients(3), chloride,turbidity,total solids,hardness, metals(6).
8		White River approx. 800' downstream of Government Canal- center/right bank grab	Same as Station SW-1 grab/ Same as Station 7

Boeing Co. Station	Station Description	Field/Laboratory Activities
SW-1	Stormwater, groundwater & Boeing Co. facility treatment process water - 24 hr. composite at the retention basin outfall: Ecology split sample	Same as Ecology SW-1 composite/ BOD,COD,turbidity,f.coli,cyanide,phenol,priority pollutant metals, VOA,base neutral-acid extractables
SW-2	Stormwater and groundwater - 24 hr. composite at discharge into an open ditch at Pacific St. approx. 100' downstream of outfall: Ecology comp.	Same as Ecology SW-2 composite/ BOD,COD,VOA, f.coli
2 (Aerator)	Effluent discharge from process waste treatment plant before entering storm drain system- 24 hr. hand composite	None?/ BOD,COD,f.coli,turbidity,phenol,VOA
2 (Aerator)- DMR value	Effluent discharge from process waste treatment plant before entering storm drain system- grab sample used for discharge monitoring report (DMR)	Discharge,pH,dissolved oxygen,temperature/ cyanides,cadmium,copper,chromium,nickel,zinc
3	Storm water and groundwater runoff from the north and west portion of the facility- 24 hr. hand composite	?/ turbidity,phenol,VOA
4	Storm water and groundwater runoff from the GSA and northeast portion of the facility- 24 hr. hand composite	?/ turbidity,phenol,VOA

The Boeing facility lies within the isohyet zone best described by the National Weather Service (NWS) station at Buckley (Buffo, 1979). However, the NWS stations at Seattle-Tacoma International Airport (Sea-Tac) and at Kent lie in close geographical proximity to the facility and appear to have similar January 1987 rainfall patterns and volumes as Buckley (Figure 3). January 1987 rainfall in the area was slightly less than normal (NOAA, 1987a).

The rainfall event monitored during the survey was on the waning end of a set of storms that had started on January 22 and diminished by January 29 (Figure 3). The cumulative rainfall volumes recorded at the three NWS stations from January 22 to the eve of the survey (January 28) were:

- Buckley: 1.55 inches.
- Kent: 1.73 inches.
- Sea-Tac: 1.34 inches.

Hourly precipitation is recorded at Sea-Tac. The record showed a maximum intensity of 0.16 inch/hour on January 24, and another period of intense rainfall on January 26 (NOAA, 1987b).

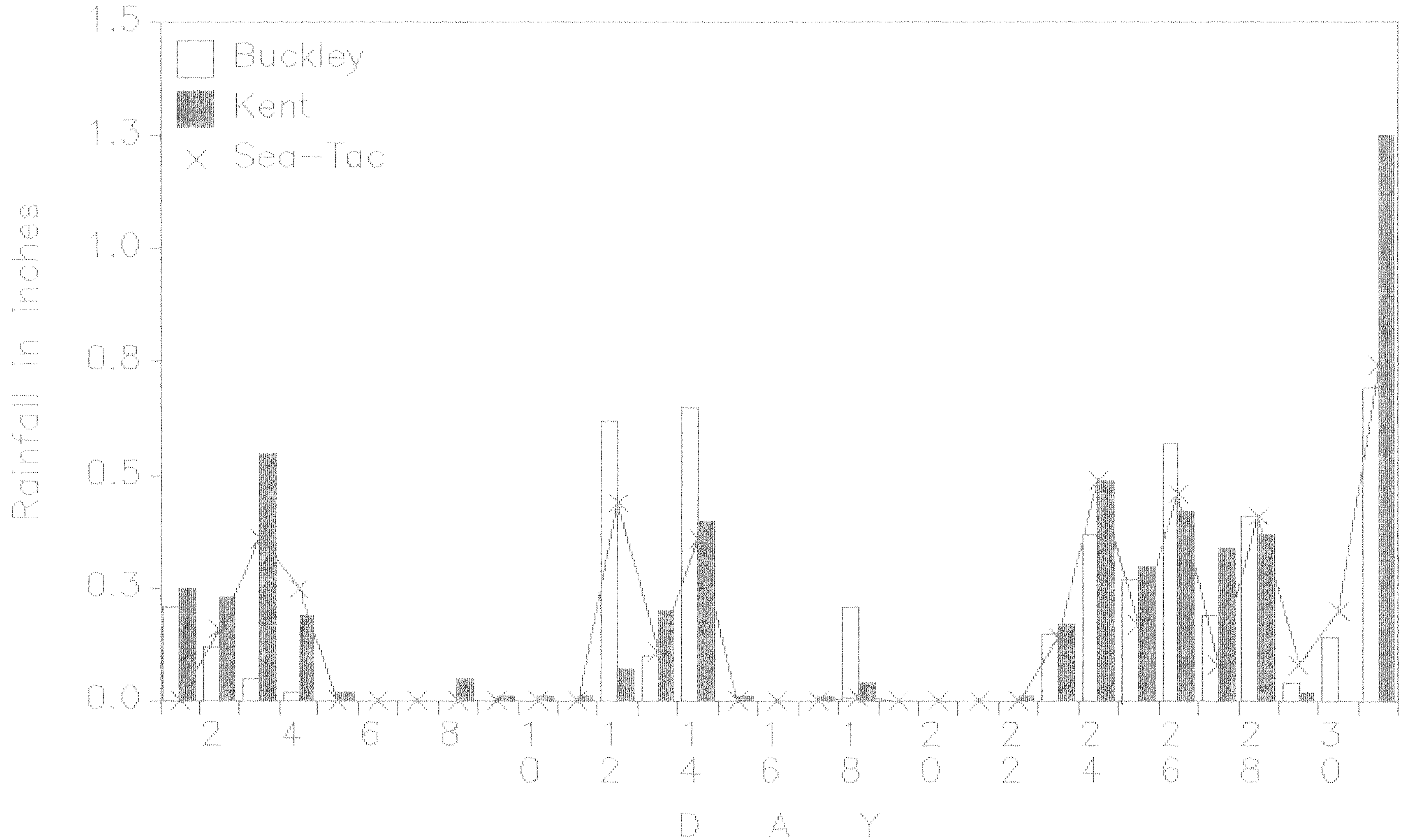
In comparison, the rainfall volumes recorded at the same stations over the two-day survey period were:

- Buckley: 0.44 inch.
- Kent: 0.39 inch.
- Sea-Tac: 0.49 inch.

However, if the Sea-Tac hourly precipitation record is an indication of the conditions at the survey site, rainfall on January 28 was heaviest in the early morning hours prior to our arrival (Figure 4). Rainfall during the time the compositors were in operation measured only 0.13 inch at Sea-Tac (NOAA, 1987b - 1000 hours to 1000 hours). The maximum rainfall intensity recorded during the compositor sampling period was 0.04 inch/hour (Figure 4).

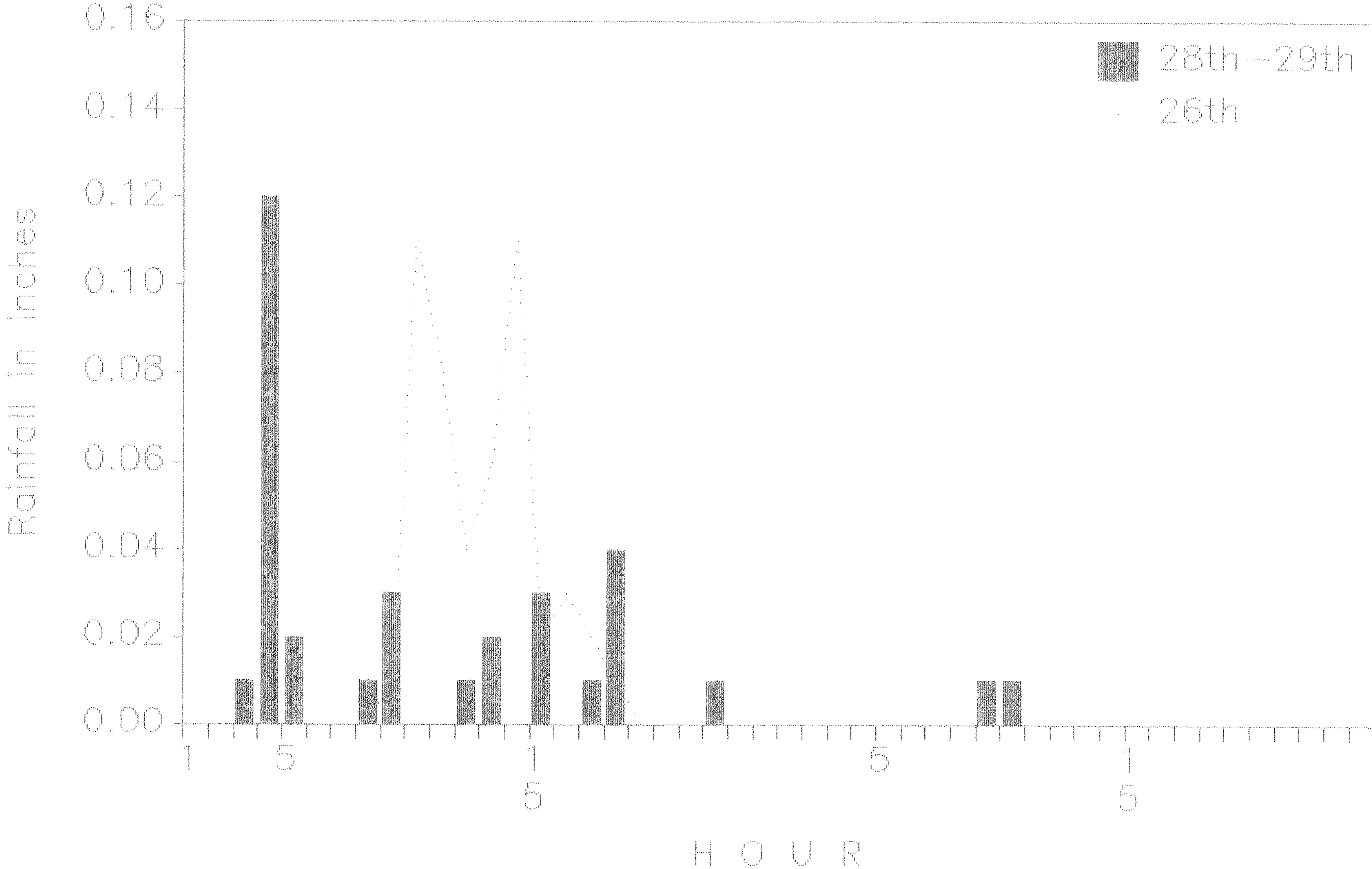
Runoff was probably not a significant portion of either of the two discharge volumes. Researchers performing studies in Bellevue (Pitt and Bissonnette, 1984) and on Washington State highways (Mar, et al., 1982) have used their data to calculate winter runoff coefficients (runoff volume/rainfall volume) for western Washington. Runoff coefficients in the Bellevue urban residential area averaged 0.25 in the winter (Pitt and Bissonnette, 1984); Mar et al. (1982) recommended using the 0.7 value for impervious areas and 0.45 for pervious areas along highway sections. Coefficients for industrial and commercially developed areas on flat slopes commonly range from 0.5 to 0.8 in most standard tables (Witecki, 1981). Peak discharge from the site during the 0.04 inch/hour rainfall was estimated using this range of coefficients (0.25 to 0.8), and the Rational formula (Mills, et al., 1985):

Figure 3. Rainfall data for January 1987 from three weather stations near Auburn-Boeing, 1987.



Data: NOAAa, 1987

Figure 4. Hourly rainfall data from Sea-Tac: Jan.26th, 28th-29th, 1987 -- Boeing/Auburn -- 1/87



Data: NOAAb, 1987

$$Q = C\ I\ A$$

where
Q= runoff volume (cfs)
C= runoff coefficient
I= rainfall intensity (inches/hour)
A= catchment area (acres)

Assuming a 510-acre catchment area, the peak discharge would have been 5 to 16 cfs. In comparison, during the reconnaissance work on January 26, the 0.11 inch/hour rainstorm shown in Figure 4 could have created a peak discharge of 14 to 45 cfs of runoff based on the same range of coefficients. Instantaneous discharge measurements made from 1100 to 1200 hours on January 26 were 17 cfs at SW-1 and 3.8 cfs at SW-2--much greater than the volumes measured during the main survey.

Consequently, it appears the major pollutant wash-off event(s) occurred prior to the survey, and the survey conditions were not "worst case." Conditions could better be portrayed as being typical wet weather with minor stormwater runoff.

The Boeing stormwater system discharge at station SW-1 is influenced by several sources:

- Ground water
- Process treatment plant discharge
- Noncontact cooling water discharge
- Stormwater runoff

The volume discharged at SW-2 appears to be dependent only upon ground water and stormwater runoff. The instantaneous discharge measurements taken at these two sites during the survey showed very little variability and had low quantities (Table 4). However, the level recorder set at the detention pond at SW-1 showed a much greater change in flow (Figure 5). The peak volume discharged at 1545 to 1700 hours on January 28 was an order of magnitude higher than was measured (instantaneous) earlier at 1230 hours. Some of the volume could have been related to rainfall, but it was more likely related to the changes in the cooling water or treatment plant discharge. The time of the sudden change in discharge coincides with the arrival of the second-shift treatment plant operators (H. Alsid, personal communication). They may have emptied a rinse tank to accommodate wastes to be received later in the shift. A recording flow meter at the plant would have been helpful in this instance, and could be helpful in the future.

The flow chart was used to estimate the average discharge over the survey period. A stage height relationship was estimated using the chart value head height during the instantaneous discharge measurements and using the Manning equation along with cross-sectional areas of the 48-inch culvert at different head heights (Appendix I). Average hourly flows were then estimated, resulting in an average flow of 2.6 cfs over the survey at SW-1.

Discharges measured in Government Canal at Station 4 were twice the sum of SW-1 and SW-2 flows (Table 4). Variability in the source

Table 4. Water quality data collected from the Government Canal, White River, and Boeing Company fabrication plant near Auburn, January 28-29, 1987. Samples collected by Ecology referenced to Figure 1 and Table 3. Boeing samples referenced to Figure 2 and Table 3. All values mg/L unless otherwise indicated. < = less than.

			Field Data									Laboratory Data																							
River Mile	Station Number	Location Description	Date	Tme	Discharge (cfs)	Temperature (°C)	pH (S.U.)	Spec. Cond. (umhos/cm)	Dissolved Oxygen	Diss. Oxygen (% Sat.)	Fecal Coli. (#/100 mL)	BOD_5	TOC	$NO_2 + NO_3$-N	NH_3-N	TIN	Total P	Spec. Cond. (umhos/cm)	Cl^-	Turb. (NTU)	Total Solids	TNVS	TSS	TNVSS	Oil & Grease	Phenols	Hardness as $CaCO_3$	Cadmium (ug/L)	Chromium (ug/L)	Copper (ug/L)	Lead (ug/L)	Nickel (ug/L)	Zinc (ug/L)	Cyanide	COD
1.75	SW-1	Stormwater, groundwater,	1/28	1230	1.5	12.0	7.4	440	--	--	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		and Boeing Co. facility	1/28	1542	--	13.3	7.4	495	8.7	82.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		treatment process water	1/29	0935	1.2	15.5	8.3	700	7.0	69.7	--	--	--	--	--	--	--	692	5.3		540	--	--	--	--	--	350	1.8	27	27	<5	1	4	--	--
		at outfall (48"-drain)	1/29	1545	--	18.7	8.3	630	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	<0.005	--	--	--	--	--	--	--	0.023	--
		into 'Government Canal'	--	24-hr.	--	--	8.1	490	--	--	--	--	10	3.00	0.35	3.4	0.09	489	4.3	4	370	280	6	2	--	--	240	1.0	29	35	<5	4	119	0.025	--
1.25	3	Government Canal below	1/28	1610	--	11.0	6.6	475	7.2	65.0	29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Ellingson Rd., 0.1 mi. abv SW-2 drain confl.	1/29	1535	--	13.7	6.7	515	6.0	57.4	--	--	--	3.70	0.33	4.0	0.05	--	5.1	3	390	--	--	--	--	--	240	--	--	--	--	--	--	--	--
0.30	SW-2	Stormwater & groundwater	1/28	1212	1.0	8.9	5.9	320	--	--	59	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		from Boeing facility and	1/28	1550	--	8.5	6.4	132	9.2	78.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		nearby area into side	1/29	1025	0.6	9.5	6.5	303	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		drain Gov't. Canal confl.	1/29	1525	--	9.7	--	--	6.6	57.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<1	<0.005	--	--	--	--	--	--	--	--	--
		rm 1.15	--	24-hr.	--	--	6.9	335	--	--	--	--	240	1.90	0.16	2.1	0.05	333	5.0	5	250	180	7	3	--	--	170	5.8	3	80	<5	1	254	0.003	--
0.75	4	Government Canal above	1/28	1330	4.6	9.2	6.4	310	--	--	56	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--
		3rd Avenue crossing	1/28	1620	--	9.4	6.4	346	8.2	71.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			1/29	1040	3.6	9.5	6.6	395	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			1/29	1505	--	11.2	6.6	395	7.1	64.4	--	--	--	2.30	0.26	2.6	0.05	--	4.2	3	350	250	2	1	--	--	210	0.9	6	2	<5	5	15	--	--
0.25	5	Government Canal from Butte Street	1/28	1635	--	9.1	6.4	318	8.3	71.8	44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
0.01	6	Government Canal at White	1/28	1405	5.6	8.6	6.4	245	--	--	53	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		River	1/28	1650	--	9.1	6.5	298	9.0	77.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			1/29	1100	4.1	8.8	6.6	368	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
			1/29	1455	--	10.0	6.7	392	8.0	70.6	--	--	--	1.70	0.26	2.0	0.05	--	3.7	3	310	220	5	2	--	--	130	0.8	6	3	<5	4	25	--	--
	7	White River approx. 75'	1/28	1655	--	6.8	7.0	114	12.0	98.1	720	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		abv the Government Canal	1/29	1450	--	6.7	7.5	118	13.0	106.0	--	--	--	1.30	0.11	1.4	0.11	--	4.5	3	99	--	--	--	--	--	170	0.4	<1	<1	<5	<1	<1	--	--
	8	White River approx. 800'	1/28	1710	--	6.9	7.0	128	12.0	98.4	570	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		blw the Government Canal	1/29	1440	290.0	6.9	7.4	133	12.8	104.9	--	--	--	1.30	0.12	1.4	0.11	--	4.5	3	110	--	--	--	--	--	88	0.3	<1	<1	<5	<1	<1	--	--
	2	Boeing aerator hand comp.	--	24-hr.	--	--	--	--	--	--	--	32	--	--	--	--	--	--	--	2	--	--	--	--	--	<0.005	--	--	--	--	--	--	--	--	56
		Boeing aerator - DMR value	1/28	?	1.07	12.0	8.8	--	9.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	50	50	--	30	10	<0.005	--
		Boeing aerator - DMR value	1/29	?	1.02	12.0	9.0	--	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	50	50	--	30	10	<0.005	--
	1	Boeing SW-1 split fm comp.	--	24-hr.	--	--	--	--	--	--	13	44	--	--	--	--	--	--	--	3	--	--	--	--	--	<0.005	--	1	26	41	<10	<2	130	0.010	<10
		Boeing SW-2 split fm comp.	--	24-hr.	--	--	--	--	--	--	23	<10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1200
	4	Boeing stormwater from NE	--	24-hr.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	<0.005	--	--	--	--	--	--	--	--	--
	3	Boeing stormwater from N	--	24-hr.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	<0.005	--	--	--	--	--	--	--	--	--
		Laboratory methods blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.005	--	--	--	--	--	--	--	--	--

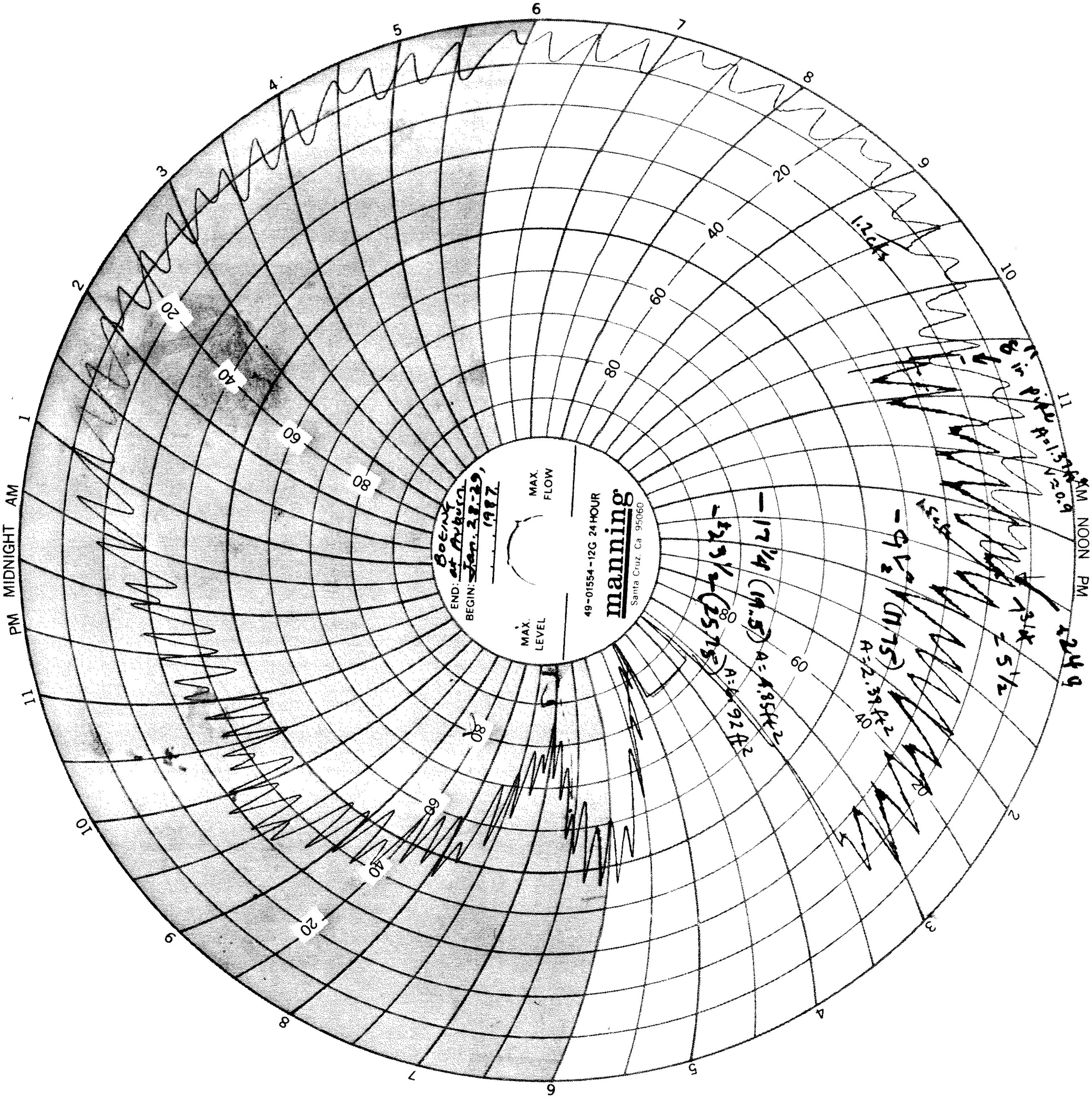


Figure 5. A 24-hour chart recording of the retention pool head height at the Boeing/Auburn facility - January 1987.

discharges and ground water input along the canal probably account for the increase. One small street drain was observed discharging into the canal (approximately 0.2 cfs) just above Station 4. Other significant surface discharges from Algona and Pacific to the canal were not seen, although Boeing fears new developments along the canal have, and will, connect unauthorized drains to it (H. Alsid, personal conversation). The canal appeared to gain another 1 cfs or less in the 0.75 mile to the confluence with White River (Table 4).

The flow of White River below Government Canal confluence was measured on January 29 (Table 4). The dilution ratio of river to canal water was approximately 70:1. Summary statistics for White River at the Sumner gaging station 7.5 miles downstream of Government Canal confluence are shown in Table 6. The White River flow was lower than the January mean monthly flow of 836 cfs (Williams, Pearson, and Wilson, 1985). The river is regulated upstream with dams and diversions, but the calculated seven-day, ten-year low flow (7Q10) at Sumner is 45 cfs. The 7Q10 would probably be experienced in July through October when monthly flows are usually lowest (Table 6). Boeing's maximum permitted discharge of mixed cooling water and process treatment effluent is approximately 5.9 cfs. If just this volume (i.e., no ground water additions) reached White River during a 7Q10 event, the dilution ratio would be approximately 7:1.

Boeing Discharge Quality

The results of the Ecology and Boeing sample analyses are presented in Tables 4 and 5. The process treatment plant (aerator) effluent results from the composite sample and the discharge monitoring report (DMR) collected by Boeing are included in the tables.

The Boeing contract lab and Ecology lab results of the metals and priority pollutant split sample, SW-1, compared very well. The large amounts of dichloromethane and acetone detected in the compositor samples by Ecology and Boeing analysts were residues from the compositor cleaning process. Otherwise, the data appeared to be satisfactory in terms of QA/QC.

In most respects, the discharge quality at SW-1 was different from SW-2 (Tables 4 and 5). Some differences were expected considering the additional sources contributing to the SW-1 discharge and the removal by the retention pond at SW-1 of some sediments with adsorbed contaminants. Results from the single SW-2 compositor sample and the SW-1 compositor and grab samples showed:

- The two discharges lacked significant organic priority pollutant and lead concentrations.
- The discharges had similar fecal coliform, chloride, and total phosphorus levels.
- SW-1 had higher pH, hardness, conductivity, and temperature values than SW-2. It also had higher concentrations of BOD, total solids, inorganic nitrogen, chromium, cyanide and oil and grease.

Table 5. Base-neutral/ acid extractable (BNA) fraction, and volatile organic analyses (VOA) sample results from Ecology and Boeing laboratories. All values ug/L.
Blanks denote analysis not performed; -- denotes compound not detected in sample. T denotes trace amount, not quantifiable.

COMPOUND	Detection Limits	SW-1 COMPOSITE 24 hr.	SW-1 GRAB 1425	SW-1 GRAB* 1545	SW-1 GRAB 1545	SW-2 COMPOSITE 24 hr.	SW-2 GRAB 1525	TRANSFER BLANK	BOEING LAB SW-1(split) 24-hr.	BOEING LAB SW-2(split) 24-hr.	BOEING LAB Aerator eff. 24-hr.	BOEING LAB Sta. 4 24-hr.	BOEING LAB Sta. 3 24-hr.	BOEING LAB Methods Blank
Phenol	6-8	--	--	--	--	--		--	--					--
2-chlorophenol	2-3	--	--	--	--	--		--	--					--
2-nitrophenol	1	--	--	--	--	--		--	--					--
2,4-dimethylphenol	1	--	--	--	--	--		--	--					--
2,4-dichlorophenol	1	--	--	--	--	--		--	--					--
4-chloro-3-methylphenol	3	--	--	--	--	--		--	--					--
2,4,6-trichlorophenol	6-7	--	--	--	--	--		--	--					--
2,4,5-trichlorophenol	6-7	--	--	--	--	--		--	--					--
2,4-dinitrophenol	3-9	--	--	--	--	--		--	--					--
4-nitrophenol	3-5	--	--	--	--	--		--	--					--
4,6-dinitro-o-cresol	2-4	--	--	--	--	--		--	--					--
Pentachlorophenol	1-8	--	--	--	--	--		--	--					--
bis(2-chloroethyl)ether	1	--	--	--	--	--		--	--					--
bis(2-chloroisopropyl)ether	2-3	--	--	--	--	--		--	--					--
bis(2-chloroethoxy)methane	1	--	--	--	--	--		--	--					--
4-chlorophenyl phenyl ether	1	--	--	--	--	--		--	--					--
1,3-dichlorobenzene	1-2	--	--	--	--	--		--	--					--
1,4-dichlorobenzene	1-2	--	--	--	--	--		--	--					--
1,2-dichlorobenzene	1-2	--	--	--	--	--		--	--					--
1,2,4-trichlorobenzene	1-2	--	--	--	--	--		--	--					--
Hexachloroethane	2-6	--	--	--	--	--		--	--					--
Nitrobenzene	1	--	--	--	--	--		--	--					--
Hexachlorobenzene	1	--	--	--	--	--		--	--					--
2,6-dinitrotoluene	1	--	--	--	--	--		--	--					--
2,4-dinitrotoluene	1	--	--	--	--	--		--	--					--
Isophorone	1	--	--	--	--	--		--	--					--
Nitrosodiphenylamine	1	--	--	--	--	--		--	--					--
Hexachlorobutadiene	2-5	--	--	--	--	--		--	--					--
Hexachlorocyclopentadiene	2-5	--	--	--	--	--		--	--					--
2-chloronaphthalene	1	--	--	--	--	--		--	--					--
Acenapthene	1	--	--	--	--	--		--	--					--
Acenaphthylene	1	--	--	--	--	--		--	--					--
Fluorene	1	--	--	--	--	--		--	--					--
Naphthalene	2-3	--	--	--	--	--		--	--					--
Phenanthrene	1	--	--	--	--	--		--	--					--
Anthracene	1	--	--	--	--	--		--	--					--
Fluoranthene	1	--	--	0.6	--	--		--	--					--
Pyrene	1	--	--	--	--	--		--	--					--
Benzo(a)anthracene	1	--	--	--	--	--		--	--					--
Chrysene	1	--	--	--	--	--		--	--					--
Benzo(b)fluoranthene	1-2	--	--	--	--	--		--	--					--
Benzo(k)fluoranthene	1-2	--	--	--	--	--		--	--					--
Benzo(a)pyrene	1	--	--	--	--	--		--	--					--
Dibenzo(a,h)anthracene	1-2	--	--	--	--	--		--	--					--
Indeno-1,2,3-c,d-pyrene	1	--	--	--	--	--		--	--					--
Benzo(g,h,i)perylene	1	--	--	--	--	--		--	--					--
Diethylphthalate	1-3	--	--	--	--	--		--	--					--
Di-n-butylphthalate	1	--	--	--	--	--		--	--					--
Benzyl butylphthalate	1	--	--	--	--	--		--	--					6.0
bis(2-ethylhexyl)phthalate	1	--	--	--	--	--		--	3.0					--
Di-n-octyl phthlate	1	--	--	--	--	--		--	--					--
Dimethylphthalate	1-10	--	--	--	--	--		--	--					--
														--
Chloromethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Bromomethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Vinylchloride	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Chloroethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	1.0	*	--	--	--	--	--	*	530,000*	27,000*	T	T	--	--
1,1-dichloroethylene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,1-dichloroethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,2-dichloroethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,2-dichloroethylene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Chloroform	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,1,1-trichloroethane	1.0		14	14	12	--	--	--	--	--	39.0	--	--	--
1,1,2-trichloroethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Bromodichloromethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,2-dichloropropane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-dichloropropene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
trans-1,3-dichloropropene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,1,2-trichloroethylene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Benzene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Chlorodibromomethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Bromoform	1.0		--	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-tetrachloroethane	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethylene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Toluene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	1.0		--	--	--	--	--	--	--	--	--	--	--	--
Acetone	1.0	*						*	320,000*	2600*	67.0	7.0	10.0	--
2-butanone	1.0								--	--	--	--	T	--
Acrolein	5.0								--	--	--	--	--	--
Carbon disulfide	1.0								--	--	--	--	--	--
Vinyl acetate	1.0								--	--	--	--	--	--
4-methyl-2-pentanone	1.0								--	--	--	--	--	--
2-hexanone	1.0	-							--	--	--	--	--	--
Styrene	1.0								--	--	--	--	--	--
o-xylene	1.0								--	--	--	--	--	--
Acrylonitrile	5.0								--	--	--	--	--	--

Boeing SW-1 and SW-2 split samples were taken from Ecology automatic compositors- Jan. 28-29, 1987.
* Indicates chemical was used in the compositor cleaning process and was probably of that origin.

Table 6. A summary of discharge statistics for the White River near Sumner USGS station 12100500, at river mile 4.9 - Williams, Pearson, and Wilson, 1985

Water body	Station Number	Period of Record	Statistic	M O N T H (C F S) OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL	LOW FLOW 7Q10 *
WHITE R.	12100500	1945-1970	Mean monthly:	238.0	632.0	1001.0	836.0	749.0	335.0	506.0	1077.8	1342.4	379.0	144.3	117.3	615.5	45.3
			Max. monthly:	981.0	2177.0	2565.0	2229.0	2718.0	1550.0	1173.0	2920.0	3576.0	1550.0	517.0	374.0	1000.0	
			Min. monthly:	54.0	49.9	61.1	134.0	123.0	135.0	164.0	279.0	315.0	59.9	61.2	60.0	219.0	

* 7Q10 = Seven day, 10-year flow event

- SW-2 had higher concentrations of cadmium, copper and zinc than SW-1. The total organic carbon (TOC) and COD concentrations were *also much higher, but the carbon did not appear to be biologically* available (low BOD).

The loading of the Boeing site discharges are summarized in Figure 6. The loading values assume an average flow of 2.6 cfs and a 400-acre catchment at SW-1, and 0.8 cfs flow and a 110-acre catchment at SW-2. The values suggest the total 510-acre site contributed less than a pound per day per acre of most constituents. The transformation of the data also suggests the inorganic nitrogen and solids loadings for the two discharges are similar on an areal basis.

As mentioned earlier, the retention pond just above SW-1 may have removed some contaminants emanating from the stormwater system. Galvin and Moore (1982) cited work by Whipple and Hunter (1980) where stormwater detained in a basin for 32 hours lost 90 percent of its particulate matter, 70 percent of its lead and hydrocarbons, 50 percent of its copper and nickel, and 40 percent of its zinc. If the Boeing retention pond is trapping a large portion of the contaminants, the stormwater quality of the site would be more contaminated than calculated here. However, the data are not available to compare how much material enters the basin, is retained by it, or is discharged through it. Boeing should determine the pond's efficiency in its report to evaluate its treatment options at SW-1 and SW-2.

The discharges appeared to be stronger than simple subsurface ground water, but lacked TSS, turbidity, and other major characteristics of stormwater runoff. Table 7 shows the water quality characteristics of the SW-1 and SW-2 discharges compared to urban runoff and municipal treatment plant effluent monitored in other studies such as the National Urban Runoff Program (NURP). In general, the Boeing discharge results do not conform well to either group of wastewaters. Lead, total suspended solids, turbidity, and total phosphorus are prominently absent characteristics in the Boeing discharges. The BOD, Cr, and Cu in SW-1 and Cd, Cu, TOC, and COD in SW-2, are somewhat higher than concentrations found in most runoff discharges, but within the range documented for WTP effluents.

The elevated BOD, COD, and metals were somewhat surprising considering the lack of significant rainfall and the high probability that the major wash-off events occurred earlier in the week. It is unlikely that many stormwater-related pollutants entered the storm system during the survey because:

1. The rainfall during the seven days prior to the survey had been more intense and of greater volume.
2. This antecedent rainfall had also minimized the accumulation of any pollutants contributed by the traffic or precipitation.
3. There was probably not enough rainfall volume or intensity during the survey to drive significant amounts of remaining pollutants into the storm drain systems.

Figure 6. A comparison of loads on a pounds per acre basis from the two Boeing discharges - January 28-29, 1987.

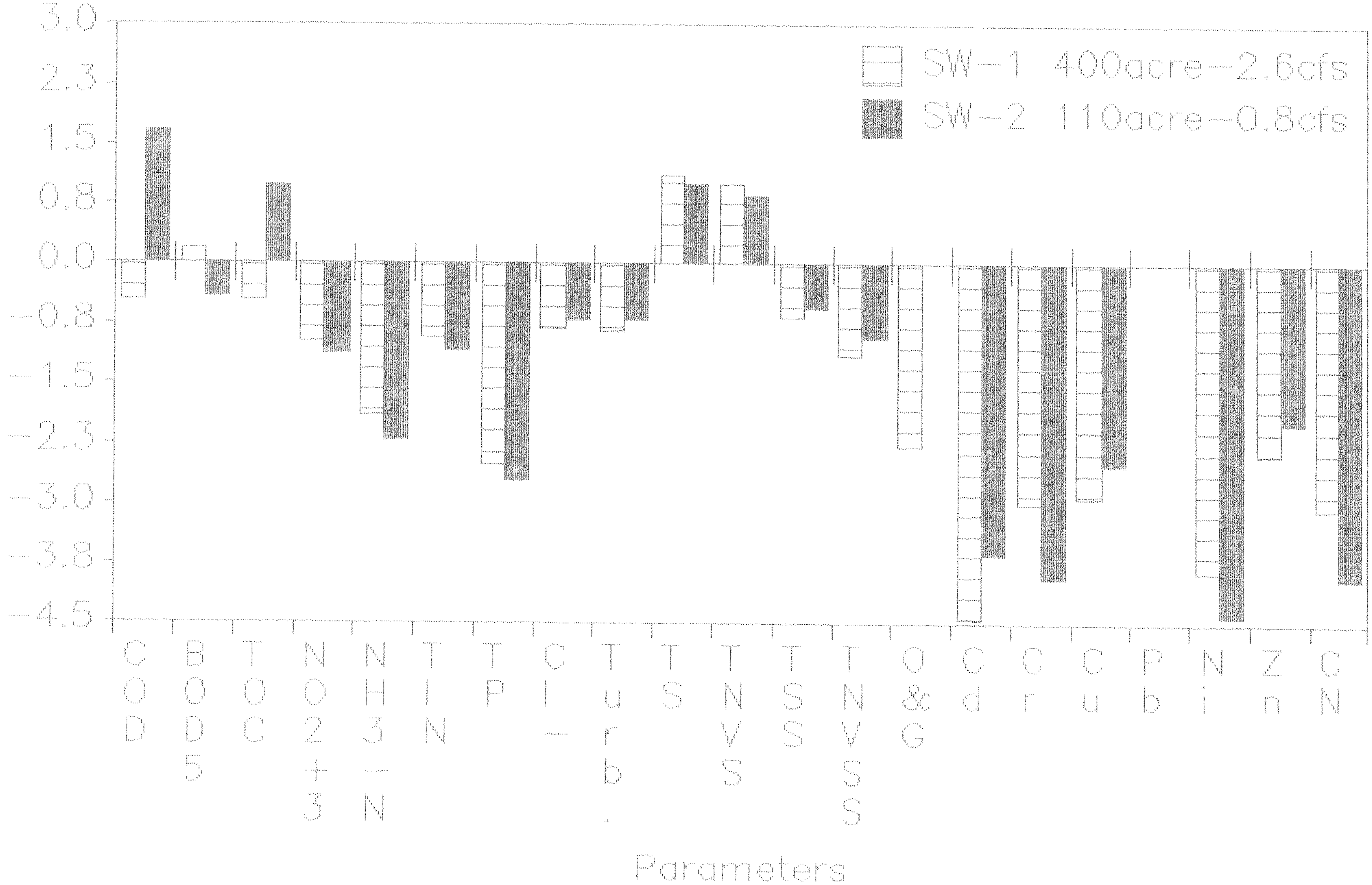


Table 7. Constituent concentrations in Boeing survey samples compared to those found in other studies.

Parameter	Boeing : SW-1 Min	Boeing : SW-1 Max	Boeing : SW-1 Mean	Boeing : SW-2 Min	Boeing : SW-2 Max	Boeing : SW-2 Mean	Seattle Mean	Seattle +/- s.d.	Bellevue Min	Bellevue Max	Bellevue Mean
Cd ug/L	1.0	1.8				6	<4		<0.1	2	1
Cr ug/L	27	29				3			2	19	7
Cu ug/L	27	35				80			4	46	20
Pb ug/L	<5	<5				<5	220	140	4	1800	
Ni ug/L	1	4				1			3	32	11
Zn ug/L	4	119				254	220	130	28	250	110
Spec. Cond	440	700	550	132	335	270			12	1480	
pH s.u.	7.4	8.3		5.9	6.9				3.4	7.9	
Turb.			4			5			4	150	19
Tot.Solids	370	540				250			24	620	190
TSS			6			7			1	2740	
COD			<10			1200			8	780	
Tot. Phos.			0.1			0.1			0.002	9.2	
NO3+NO2			3.0			1.9			<0.01	5	
BOD			44			<10			<0.1	40	
F.coli			13			59					

Parameter	NURP Min	NURP Max	NURP Mean	Durham, N.C. Min	Durham, N.C. Max	Durham, N.C. Mean	Highway Runoff Min	Highway Runoff Max	Highway Runoff Mean	Secondary WWTP Min	Secondary WWTP Max	Secondary WWTP Mean
Cd ug/L	<0.1	14										<2.0
Cr ug/L	1	190	14	60	470	230						22
Cu ug/L	1	100	31	40	500	150						10
Pb ug/L	6	460	105	100	2860	460	0	830				<20
Ni ug/L	1	182	23	90	290	150						20
Zn ug/L	10	2400	124	90	4600	360	0	2500				52
Spec. Cond												
pH s.u.												
Turb.												
Tot.Solids				194	8620	1440						
TSS				27	7340	1223	3	250				19
COD				20	1047	170	10	500				57
Tot. Phos.				0	16	1	0.04	3.8				
NO3+NO2							0.1	5.5				
BOD							4	45				25
F.coli				1	2000	230						

References: Seattle - Farris et al, 1979 in Galvin & Moore, 1982.
Bellevue - Pitt & Bissonnette, 1984 (Tables 25, 26, 27)
NURP - Galvin & Moore, 1982 (Table 13) and USEPA, 1983
Durham, N.C. - Colston and Tafuri, 1975 (Table 2)
Highway Runoff - Mar et al, 1982 (Table 6)
WWTP - USEPA, 1981 (Table 22-5, 22-6) weekly averages for a 8 mgd activated sludge plant.

The source of these constituents may be within the drain system or from other discharges on the site. On the other hand, Mar, et al. (1982) noted that "first-flush" behavior is not a general rule on western Washington streets and highways. Since rainfall is not intense but is of long duration, solids and associated contaminants gradually move down a stormwater system. However, more data are required for better characterization of the discharges, especially identification of the sources of TOC, COD, and cadmium in SW-2.

There are no specific criteria on which to assess the quality of these discharges since they are unregulated. However, some criteria can be used to provide points of reference. For example, metals concentrations in the discharge samples are compared to USEPA ambient freshwater criteria in Table 8. The criteria are based on dissolved metal concentrations, whereas the sample results are total metal concentrations. Also, the criteria are stated in terms of 4-day (chronic) and 1-hour (acute) average concentrations not to be exceeded more than once in three years outside a defined mixing zone, whereas the survey samples are single grab or 24-hour composites from a system without a defined mixing zone. With these limitations in mind, concentrations in the SW-2 sample exceeded the 4-day cadmium, copper, and zinc criteria, and the one-day copper criterion at the hardness concentration of the sample. The copper concentration in the SW-1 sample also exceeded the 4-day criterion.

Fluoranthene and 1,1,1-trichloroethane (TCE) were the only organic priority pollutants detected in the discharge samples analyzed by Ecology (Table 5). The concentrations of TCE and fluoranthene were very minor and are far below the very few available USEPA ambient water quality criteria. Acute freshwater aquatic life toxicity from TCE and fluoranthene exposure occur as low as 18,000 ug/L and 3,980 ug/L, respectively. Fluoranthene is a polycyclic aromatic hydrocarbon (PNA) commonly detected in urban stormwater runoff (16 percent of the NURP samples), and originates from oils and automobile exhaust (USEPA, 1983). Trichloroethane is a common solvent used especially for degreasing (USEPA, 1980). TCE was detected in the aerator effluent sample taken by Boeing (Table 5). In most urban stormwater runoff, several more PNA's and other priority pollutants are usually found (Table 9). Acetone was detected in all of Boeing's field-collected samples (Table 5). However, since the Ecology samples were contaminated with acetone prior to sampling, the presence of acetone needs further confirmation.

The NPDES permit states that Boeing may measure temperature and D.O. at the SW-1 discharge site as the process plant effluent DMR values. Temperature and D.O. met the limits of the permit on January 28, but the D.O. was below 8 mg/L on January 29. All other treatment plant parameters measured at the plant aerator were within limits according to the Boeing DMR and are summarized in Table 2 (Ecology, 1987).

Since the D.O. was found to be below permit limits on one of the two days of monitoring, it is likely this occurs several times over the

Table 8. USEPA metals criteria for the protection of aquatic life compared to total metals concentrations in samples collected during the Boeing/Auburn survey, Jan. 28-29, 1987.
All values are ug/L, except mg/L total hardness as CaCO3.

Site	Date	Hardness	Cd	Cd-acute	Cd-chronic	Cr	Cr-acute	Cr-chronic	Cu	Cu-acute	Cu-chronic	Pb	Pb-acute	Pb-chronic	Ni	Ni-acute	Ni-chronic	Zn	Zn-acute	Zn-chronic
SW-1	1/29	350	1.8	16.1	3.0	27	4845	577	27	58	34	<5	402	15.7	1	4093	455	4	338	306
SW-1 comp.	--	240	1.0	10.5	2.3	29	3557	424	35	40	25	<5	249	9.7	4	2974	331	119	246	223
SW-2 comp.	--	170	5.8	7.1	1.7	3	2682	320	80	29	19	<5	160	6.3	1	2222	247	254	183	166
4	1/29	210	0.9	9.1	2.0	6	3188	380	2	36	22	<5	210	8.2	5	2657	295	15	219	199
6	1/29	130	0.8	5.3	1.4	6	2153	257	3	23	15	<5	114	4.4	4	1771	197	25	146	132
7	1/29	170	0.4	7.1	1.7	<1	2682	320	<1	29	19	<5	160	6.3	<1	2222	247	<1	183	166
8	1/29	88	0.3	3.4	1.0	<1	1564	186	<1	16	11	<5	69	2.7	<1	1273	142	<1	105	95

Table 9. Priority pollutant concentrations in stormwater runoff from NURP and Bellevue studies (USEPA, 1983 - Table 6-19; Pitt and Bissonnette, 1984)

C O M P O U N D	N U R P Range ug / L	Frequency %	B e l l e v u e Range ug / L	Frequency %
Phenol	1-13	14	3*	5
2-chlorophenol	2	1		
2-nitrophenol	1	1		
2,4-dimethylphenol	1-10	8		
2,4-dichlorophenol		--		
4-chloro-3-methylphenol	1.5	1		
2,4,6-trichlorophenol		--		
2,4,5-trichlorophenol		--		
2,4-dinitrophenol		--		
4-nitrophenol	1-37	10.0		
4,6-dinitro-o-cresol		--		
Pentachlorophenol	1-115	19	3-115	19.0
bis(2-chloroethyl)ether		--		
bis(2-chloroisopropyl)ether		--		
bis(2-chloroethoxy)methane		--		
4-chlorophenyl phenyl ether		--		
1,3-dichlorobenzene		--		
1,4-dichlorobenzene		--		
1,2-dichlorobenzene		--		
1,2,4-trichlorobenzene		--		
Hexachloroethane		--		
Nitrobenzene		--		
Hexachlorobenzene		--		
2,6-dinitrotoluene		--		
2,4-dinitrotoluene		--		
Isophorone	10	3		
Nitrosodiphenylamine		--		
Hexachlorobutadiene		--		
Hexachlorocyclopentadiene		--		
2-chloronaphthalene		--		
Acenapthene		--		
Acenaphthylene		--		
Fluorene	1	1		
Naphthalene	0.8-2.3	9		
Phenanthrene	0.3-10	12	0.3-7	19.0
Anthracene	1-10	7	1	5
Fluoranthene	0.3-21	16	0.3-12	19.0
Pyrene	0.3-16	15	0.3-10	19.0
Benzo(a)anthracene	1-10	4	1,3	10
Chrysene	0.6-10	10	2-3	14
Benzo(b)fluoranthene	1-5	5		
Benzo(k)fluoranthene	4-14	3	4	5
Benzo(a)pyrene	1-10	6	1,2	10
Dibenzo(a,h)anthracene	1	1		
Indeno-1,2,3-c,d-pyrene	4	1		
Benzo(g,h,i)perylene	5	1		
Diethylphthalate	1-10	6		
Di-n-butylphthalate	0.5-11	6		
Benzyl butylphthalate	1-10	6		
bis(2-ethylhexyl)phthalate	4-62	22		
Di-n-octyl phthlate	0.4-2	6	0.4	5
Dimethylphthalate	1	1		
Chloromethane		--		
Bromomethane		--		
Vinylchloride		--		
Chloroethane		--		
Methylene chloride	5-14.5	11		
1,1-dichloroethylene	1.5-4	2		
1,1-dichloroethane	1.5-3	3		
1,2-dichloroethane	4	1		
1,2-dichloroethylene	1-3	4		
Chloroform	0.2-12	9	0.2	5
1,1,1-trichloroethane	1.6-10	6		
1,1,2-trichloroethane	2-3	2		
Carbon tetrachloride	2-3	2		
Bromodichloromethane	2	1		
1,2-dichloropropane	3	1		
cis-1,3-dichloropropene	1-2	2		
trans-1,3-dichloropropene		--		
1,1,2-trichloroethylene	0.3-12	6		
Benzene	1-13	5	10,13	10
Chlorodibromomethane	2	1		
Bromoform	1	1		
1,1,2,2-tetrachloroethane	2-3	2		
Tetrachloroethylene	1-43	5		
Toluene	3-9	3		
Chlorobenzene	1-10	5		
Ethylbenzene	1-2	6		

* Expected contaminated

Bellevue study measured concentrations in 21 samples year. The problem may be related to certain waste loads in the retention pond, or it may be part of a daily cycle. In any case, the problem warrants further investigation.

Discharge Effects on the Receiving Waters

Water quality data collected at the four sites along Government Canal and two sites along White River are presented in Table 4. The Government Canal data indicated:

- A dissolved oxygen sag with a maximum loss at river mile (r.m.) 0.75, Station 4, with Stations 3's and 4's D.O. falling below Class A criteria (Figure 7).

- Low fecal coliform levels that met Class A criteria (Table 1).

- Dilution of metals concentrations and apparently significant reductions of Cu, Cr, and Zn loads between the Boeing discharges and White River confluence (Figure 8). Ni and Cd loads were not significantly reduced.

The D.O. losses in Government Canal may be directly related to the BOD and COD levels in the Boeing discharges and the quiescent nature of the canal. Reaeration rates would be low and would not easily overcome oxygen demand rates. However, sediment demands and other factors may have a role in the D.O. losses. The D.O. problem requires further monitoring and investigation.

The absence of significant fecal coliform additions to the canal suggests that there are few septic wastes or runoff problems along the canal corridor. The increase in inorganic nitrogen (TIN) loads along the canal may indicate either ground water sources or variability in discharge concentrations. The ammonia fraction of the TIN did not change between SW-1 and White River confluence.

Metal concentrations in Government Canal below Station 4 were at acceptable levels during the survey according to USEPA criteria (Table 8). The majority of the metal loads may have settled out in the canal. Metals are easily adsorbed to sediment and solids particles. The low velocities in the canal would tend to settle out the particles and their associated metals. Canal dredge spoils have not been tested to confirm this deposition process. Future surveys should address sediment contamination.

The fishery habitat in Government Canal appeared to be poor to fair. The canal has little riparian cover except along the side canal leading to Station SW-2 (Figure 1). Most of the canal is quiescent and relatively shallow. There were few undercut banks or pool areas to provide protection for fish. Siltation appeared common and the channel was choked with grass and weeds prior to dredging. However, the periodic dredging of the canal would seriously disrupt any fish population

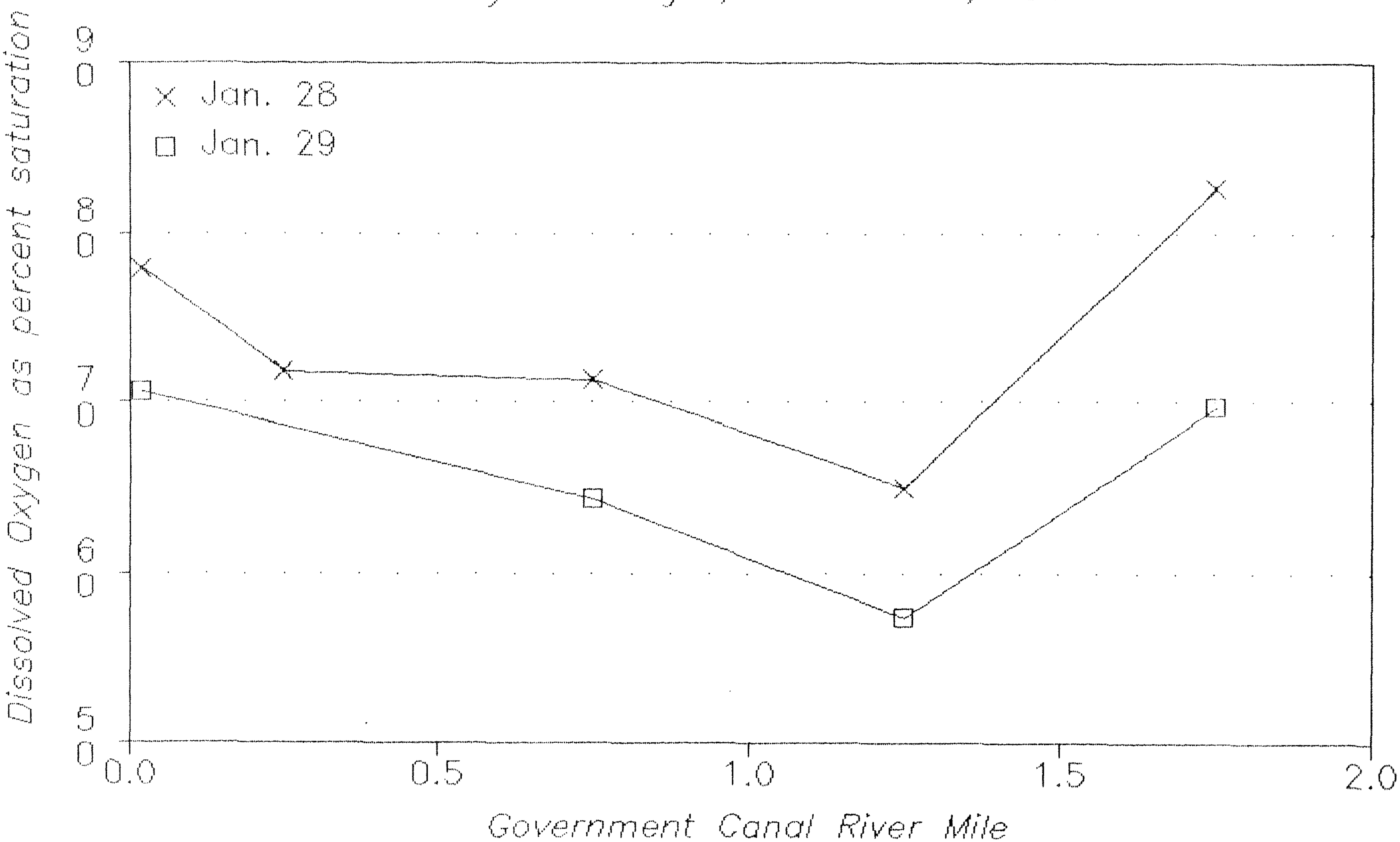
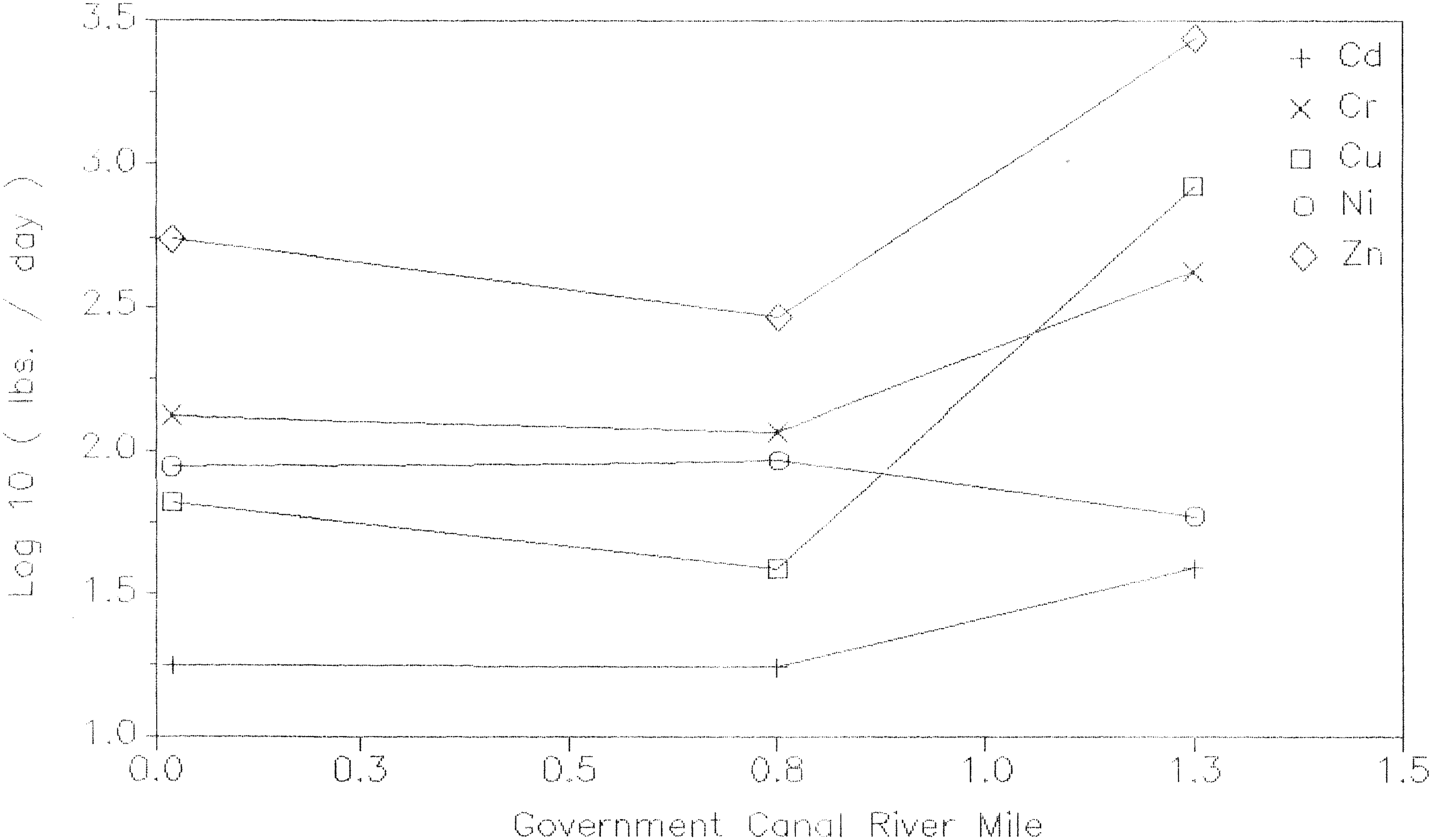


Figure 7. Dissolved oxygen profiles in the Government Canal below the Boeing facility discharges, Jan. 28–29, 1987.

Figure 8. Metal loads in the Government Canal downstream of the Boeing discharge – January 1987.



Metals discharge at r.m. 1.25 represent the sum of the two Boeing discharge concentrations from the 24-hr. compositors.

present. A more complete assessment of the canal's potential as a fishery habitat should be performed to anticipate potential degradation from discharges into the canal.

White River water quality data are presented in Table 4. Government Canal did not create significant changes in water quality in White River for the parameters analyzed. The 70:1 river-to-canal dilution factor appeared adequate to minimize the metals and nutrient loads of the canal (Figure 9).

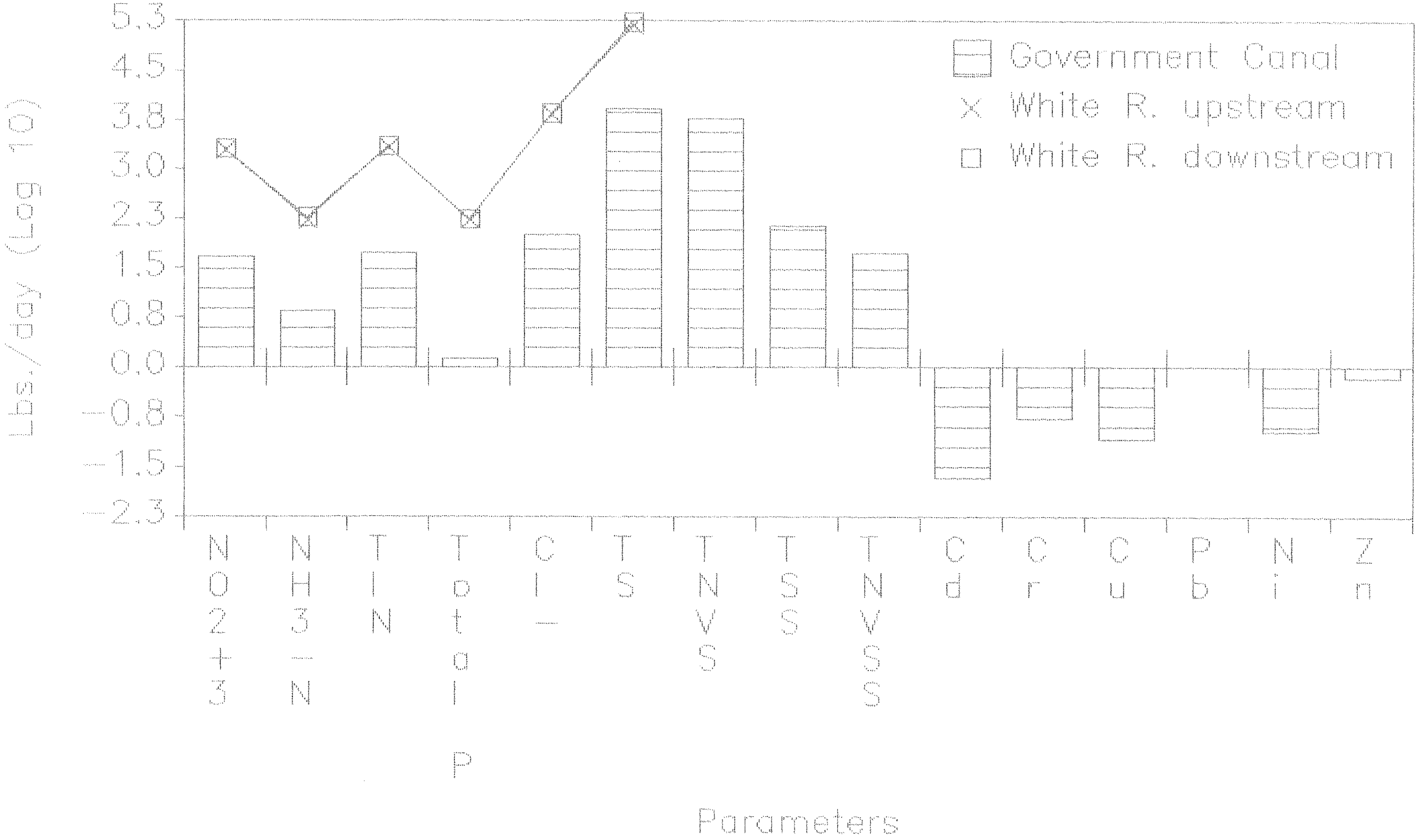
There are insufficient data to accurately predict the metals and nutrient loads in Government Canal and their impact on White River water quality during a 7Q10 event. There could be significant changes in contaminant transport and transformation through Government Canal to the river, and changes in river contaminant loads as well. Data collected during Boeing's dry-weather surveys should be used for a more accurate analysis of the low-flow situation.

CONCLUSIONS AND RECOMMENDATIONS

The January 1987 survey of the Boeing facility discharges at Auburn and the receiving water was undertaken during average wet-weather conditions. Very little stormwater runoff was present in the discharges. The two discharge sites (SW-1 and SW-2) had dissimilar chemical characteristics. This was probably the result of process wastewater and noncontact cooling water being discharged into the SW-1 storm drain system and not into the SW-2 system. Also, the retention pond at SW-1 may have improved the quality of the discharge by removing some sediments and associated contaminants. The samples taken at the two discharge sites did not match the water quality characteristics of urban storm runoff or wastewater treatment effluent exhibited in other studies. They both had low TSS and lead concentrations which are commonly high in stormwater runoff. On the other hand, copper and chromium in both discharges, BOD in SW-1, and TOC and COD in SW-2, were elevated compared to most storm runoff.

The discharge water quality, though not directly regulated by USEPA freshwater ambient criteria, would have exceeded various criteria for cadmium, copper, and zinc. The D.O. measured on the second day at the SW-1 discharge was below the 8 mg/L NPDES permit level set for the process effluent, but usually recorded for the DMRs at that site. The unregulated BOD and COD concentrations in the two discharges may have been directly responsible for the D.O. sag in Government Canal. The quiescent canal environment may have assisted in removing most of the metals loads to the canal sediment, although sediment was not analyzed because of recent dredging. No other effects on Government Canal water quality were apparent. The canal appeared to provide fair to poor fish habitat. The contaminant removal processes in the canal and the 70:1 White River to Government Canal dilution ratio during the survey were effective in preventing water quality degradation of White River at the canal confluence.

Figure 9. Load of selected constituents from the Government Canal to the White River, Jan. 28–29, 1987.



The following recommendations are made:

1. Closely review the data presented by Boeing from its on-site surveys to (a) better characterize the quality of the stormwater in the discharges, (b) determine the portion of SW-1 that originates as storm runoff compared to noncontact cooling water or process treatment effluent, (c) identify potential sources of cadmium, copper, COD, and TOC in SW-2 discharge, and (d) provide a better estimate of Government Canal impacts on the White River during a low-flow event.

2. Analyze sediments for metals and priority pollutants and/or perform sediment bioassays from Government Canal downstream of the discharges in a deposition area before dredging takes place.

3. Evaluate the contaminant removal efficiency of the retention pond at the primary discharge (SW-1) and consider improving it if necessary. Also, consider such a pond for stormwater quality control at the SW-2 discharge.

4. Consider requiring routine or seasonal monitoring of discharge volume, D.O., BOD, COD, selected metals, and related parameters at both discharge locations.

5. Further evaluate the D.O. sag in Government Canal--the severity, duration, and cause(s) of the sag.

6. Verify that adequate fish spawning and rearing areas are absent from the canal.

REFERENCES

APHA-AWWA-WPCF, 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition, American Public Health Assoc., Washington, D.C.

Buffo, J., 1979. Water Pollution Control Early Warning System, Section 1-Non-point Source Loading Estimates. Municipality of Metropolitan Seattle report, Seattle, WA. October, 1979. 47pgs.

Boeing, 1986. "Water quality monitoring plan Government Canal." Boeing document FRC-1337, received by Ecology Northwest Regional Office, Redmond, WA. May 6, 1986, 4pgs.

Colston, N., and A. Tafuri, 1975. "Urban land runoff considerations," pg. 120-128, in: Urbanization and Water Quality Control, W. Whipple, Jr., editor. American Water Resources Assoc., Minneapolis, MN.

Farlow, R., 1987. "Boeing plant data transmittal," Feb. 27 memorandum to J. Joy of Ecology Water Quality Investigations Section, Olympia, WA. from Ecology Manchester Laboratory.

Farris, G., J. Buffo, K. Clark, D. Sturgill, and R. Matsuda, 1979. Urban Drainage Stormwater Monitoring Program, Municipality of Metropolitan Seattle, 97pgs.

Galvin, D. and R. Moore, 1982. Toxicants in Urban Runoff. METRO Toxicant Program Report #2 Municipality of Metropolitan Seattle Water Quality Division, Seattle, WA.

Huntamer, D., 1986. Department of Ecology Laboratory User's Manual Manchester, WA., Dec. 8, 1986. 139pgs.

Mar, D., R. Horner, J. Ferguson, D. Spyridakis, and E. Welch, 1982. Summary -- Washington State Highway Runoff Water Quality Study, 1977-1982 Washington Dept. of Transportation report WA-RD 39.16. Olympia, WA. 81pgs.

Mills, W.B., D.B. Porcella, M.J. Ungs et al., 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water (Revised 1985) Vol. 1, USEPA report 600/6-85/002a, U.S. Environmental Research Laboratory, Athens, GA, 609pgs.

NOAA, 1987a. Washington Climatological Data Monthly Summary - January, 1987. U.S. Dept. of Commerce, NOAA-National Climatic Data Center, Asheville, N.C.

NOAA, 1987b. Local Climatological Data Monthly Summary: Seattle-Tacoma Airport, Jan. 1987. U.S. Dept. of Commerce, NOAA-National Climatic Data Center, Asheville, N.C.

Pitt, R., and P. Bissonnette, 1984. Bellevue Urban Runoff Program Summary Report. City of Bellevue, WA., August 1984, 174pgs.

USEPA, 1980. Ambient Water Quality Criteria-Chlorinated Ethanes. U.S. Environmental Protection Agency Criteria and Standards Div., Washington, D.C.

USEPA, 1981. Treatability Manual Vol. 3 U.S. Environmental Protection Agency 600/2-82-001b, Washington, D.C.

USEPA, 1983a. Methods for the Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency Support Laboratory, Cincinnati, OH.

USEPA, 1983b. Results of the Nationwide Urban Runoff Program: Vol. 1 - Final Report. December 1983. NTIS No. PB84-185552 U.S. Environmental Protection Agency, Water Planning Div., Washington, D.C.

Williams, J.R., H. Pearson, and J. Wilson, 1985. Streamflow Statistics and Drainage-basin Characteristics for the Puget Sound Region, Washington: Vol.1. U.S. Geological Survey Open-file report 84-144a, Tacoma, WA. 330pgs.

Whipple, W., and J. Hunter, 1980. Detention Basin Settleability of Urban Runoff Pollution New Brunswick, New Jersey: Rutgers University, Water Resources Research Institute, 29pgs.

Witecki, M., 1981. Class notes and handouts for Hydraulics taught at South Puget Sound Community College, Olympia, WA.

APPENDIX I

Calculation of the SW-1 discharge was extrapolated from a relationship calculated for instantaneous flow measurements at the outfall at specific head height in the retention pond. The head height chart recording was used to estimate flows over the survey period based on the Manning equation and the stage height relationship.

Manning equation : $V = (1.486 / n) * R^{2/3} * S^{1/2}$

where, V = velocity (fps)
n = roughness coefficient
S = slope (ft/ft)
R = hydraulic radius

after which discharge is calculated using :

$Q = V * A$

where, Q = discharge (cfs)
A = area (ft^2)

For specific head heights shown in Figure 5, using a roughness coefficient of 0.025 for corrugated metal flume (the outfall), R values in a 48 inch flume, and a slope of 0.008, the following velocities and discharges were calculated:

Head	R	V	A	Q (est.)	Q (measured)
7.75	0.3994	1.05	1.3	1.4	1.2
8.0	0.4093	1.07	1.37	1.5	1.5
11.75	0.5764	1.35	2.39	3.0	
19.5	0.8724	1.77	4.85	9.0	
25.75	1.048	2.01	6.92	14.0	

Hourly average discharges over the 24 hour survey period were estimated from Figure 5, and the relationship described above was used with a result of 2.6 cfs average discharge.