Publication No. 84-e22

WA-37-1020

JOHN SPELLMAN
Governor

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, LU-11 • Olympia, Washington 98504 • (206) 753-2353

MEMORANDUM
January 10, 1984

To: Al Newman

From: Art Johnson and Joe Joy

Subject: Results of Low-flow Surveys in the Yakima River Above and Below Prosser STP, October 5-6, 1982 and September 13-14, 1983

Introduction

At the request of the Central Regional Office, water quality impacts of the Prosser STP discharge to the Yakima River were evaluated during low-flow conditions for two separate treatment regimes. The first survey on October 5-6, 1982 was done during simultaneous discharge of industrial (Twin City Foods potato processing wastewater) and domestic effluents. Marc Heffner reported conditions existing at the Prosser STP for this time period in his Class II report to you dated May 10, 1983. The second survey was made on September 13-14, 1983 when only domestic effluent was going into the river. The industrial effluent was being spray irrigated on nearby acreage -- the common practice for disposing of this waste except in freezing weather. The results of these two surveys follow.

Survey Methods

The survey area included the Yakima River, tributaries, discharges, and diversions from river mile (r.m.) 47.0 (above Prosser) to r.m. 34.2 (Figure 1). A large portion of the Yakima River flow, about 2/3* during these surveys, is diverted at r.m. 47.0 just above Prosser STP, routed through Chandler Canal, and returned to the river 11 miles downstream at Chandler power station. Other discharges between Prosser STP and the

*October 6, 1982: Yakima River above Chandler diversion = 1928 cfs; Chandler diversion = 1311 cfs.
September 13, 1983: Yakima River above Chandler diversion = 2012 cfs; Chandler diversion = 1304 cfs.
September 14, 1983: Yakima River above Chandler diversion = 2120 cfs; Chandler diversion = 1313 cfs. (Data supplied by USBR, Yakima.)

power return are the Holzinger-Seneca (fruit processor) lagoon overflow (r.m. 44.9), Spring and Snipes creeks (r.m. 41.8), and Bull Pasture Creek (r.m. 38.7). Sampling sites for the surveys reported here bracketed this reach as shown in Figure 1.

For the October 5-6, 1982 survey, the river was sampled at seven sites chosen to assess the impacts of the above discharges*. Each discharge was also sampled. Limited river access dictated most of the sampling locations. All river samples were collected from the left bank (facing downstream). Table 1 shows when and where samples were collected, the number of samples per station, and the parameters measured. Temperature, D.O. (Winkler-azide modification), and chlorine residual (DPD kit) were measured in the field. Flows were measured with a Marsh-McBirney magnetic flow meter or by using a Bureau of Reclamation staff gage. Water samples were returned on ice to the WDOE Tumwater laboratory and analyzed for other Table 1 parameters according to EPA's Methods for Chemical Analysis of Water and Wastes.

For the second survey on September 13-14, 1983, sampling was concentrated at six stations in the upper parts of the study reach because of lower effluent loading from the STP. Survey methods were as described above and in Table 1 except that fewer samples per station were collected. The river was gaged downstream of the Highway 82 bridge and very good agreement obtained with the flow data supplied by the Bureau.

The sampling dates for both surveys were selected after consulting with Onni Perala, Bureau of Reclamation Yakima Office, on the timing of low-flow conditions at Prosser.

---

*A follow-up survey was attempted on October 21, 1983 to gather more data on the portion of the river immediately below the outfall. Yakima River water was not being diverted into Chandler Canal so that a fish screen could be repaired. Since this resulted in greater effluent dilution than on the first survey, no samples were collected.

Results

1. October 5-6, 1982 - combined industrial and domestic effluent discharged

The results of water quality measurements on Prosser effluents and the Yakima River above the Prosser outfall are compared below in Table 2.

Table 2. Comparison of Prosser STP NPDES permit limits; Prosser STP effluents and Yakima River for October 5-6, 1982.

Parameter	Prosser NPDES Permit*	Prosser Domestic Effluent†	Prosser Industrial Effluent†	Prosser Combined Effluents†	Yakima R.** Above Outfall (Station 1)	Prosser Load as Percent of Combined Downstream Load
Flow (cfs)	.62	1.13	1.10	2.23	617††	(dil. ratio = 278:1)
BOD_5 (mg/L)	90	20	340	570	2 est.	
(lbs/day)	300	120	2,000	7,100	6,700	51%
TSS (mg/L)	144	17	540	380	13	
(lbs/day)	480	100	3,200	4,800	43,000	10%
F. Coli. (col/100 mL)	400	23	1.9×10^6	1.95×10^6	39	
(col/day x 10^6)		640	51×10^6	106×10^6	590,000	99%
pH (units)	6.5-8.5	8.0	8.0	7.1	8.2	
NH_3 (mg/L)		6.8	53	26	0.02	
(lbs/day)		41	310	325	67	83%
T. Inorg. N (mg/L)		14.2	53	27	1.4	
(lbs/day)		87	310	340	4,700	7%
T-PO_4-P (mg/L)		6.6	16	16	.12	
(lbs/day)		40	95	200	400	33%

*Weekly limits, Sept. 15, 1981 permit.
†Data from Heffner, M., 1983. Prosser Class II inspection - October 5-6, 1982. WDOE.
**Data from this survey.
††USBR

The Prosser domestic effluent was within NPDES permit limits except for flow. Addition of the industrial effluent to the waste stream resulted in a final effluent an order of magnitude above BOD and TSS limits and many orders of magnitude above fecal coliform limits. Even with the relatively large dilution afforded by the Yakima River (278:1), the waste loads from the Prosser combined effluents would be expected to have adverse impacts on ambient D.O., bacterial quality, ammonia, and phosphorus levels. The STP's solids and total inorganic nitrogen (TIN) loads were a relatively small fraction of those already in the Yakima upstream of the STP. The TIN load above the STP was primarily in the form of nitrate, whereas the STP TIN load was primarily in the ammonia form.

The receiving water and point-source data summarized in Table 3 show the impact of these loads. Above Prosser, the Yakima River was within the Class B standard which applies to it. Below the STP, theoretical dilution values calculated for various parameters show that mixing was not complete by r.m. 45.8 (station 3), so that reported values there do not reflect a cross-section of the river. This suggests a violation of dilution zone guidelines set by WDOE, especially the 300' longitudinal limit (WDOE, March 1980). Because mixing is incomplete here, data points for this station are omitted from curves drawn in some of the figures that follow. Parameters are discussed individually below.

Dissolved Oxygen

The D.O. concentrations measured during the three individual sampling runs on October 6 show an interesting D.O. pattern downstream of the outfall (Figure 2). All runs show large deficits within the effluent plume at r.m. 45.8 (station 3), then a seeming rebound at r.m. 43.7 (station 5), followed by another sag at r.m. 42 (station 6), and recovery again at r.m. 40 (station 9). The sags become less pronounced as the day progresses, and the levels at r.m. 43.7 and r.m. 35.9 (station 11) show an especially large change in D.O. over the day. No violations of the Class B 6.5 mg/L standard were observed.

The BOD and ammonia loads in the combined effluent would not be expected to have this much of an impact at the existing dilution ratio. The change in D.O. pattern is best explained by the influence of periphyton and bacterial populations in the river. Heavy growths of Sphaerotilus were observed at station 3, and periphyton covered much of the substrate at other stations downstream.

Figure 3 compares computer-simulated curves to the D.O. concentrations measured during the early-morning survey run. The computer model is a modified version of the one used for the Little Klickitat River (Joy, 1983). Curve A simulates D.O. saturation values using just those impacts directly imposed by BOD and nitrogenous oxygen demand (NOD) from the STP. Curve B includes these influences, and those theoretically imposed by heavy benthic growths of Sphaerotilus as seen immediately below the outfall, and the respiration of benthic growths observed between r.m. 42 and r.m. 36. Sphaerotilus and periphyton oxygen uptake rates were estimated to be 7 gms/m^2/day and 2.25-2.9 gms/m^2/day, respectively; average values taken from Mills, et al. (1982).

Curve B simulates the D.O. observed in the field during the early-morning run rather closely. The field data (Figure 2) from the most downstream portions of the second run and the entire third run depart from Curve B because of the oxygen production by the benthic community.

The computer simulation and the field data from all sampling runs show a D.O. sag at r.m. 42 and a fairly rapid recovery. Change in channel character (shallower, swifter water) and dilution by Spring and Snipes creeks are probably the major factors in this recovery.

Nutrients

As demonstrated in Table 2, the Prosser facility contributes a substantial amount of ammonia and phosphorus to the already enriched Yakima River. The receiving water survey showed the Prosser combined discharge caused river ammonia concentrations to increase 2 to 3 fold in the reach between the outfall and Chandler power return. A much smaller and shorter-lived increase in phorphorus concentrations was also observed.

Ammonia concentrations measured in the river were below levels where the un-ionized fraction would exceed EPA criteria for protection of aquatic life.

Ammonia loads at individual stations below the outfall varied over the course of the day and fluctuated between stations as well (Figure 4). Ammonia uptake and/or conversion is apparent between the STP outfall and station 5. The two earliest runs show an apparent secondary ammonia source between stations 6 and 9. The loads from Spring and Snipes creeks do not account for this.

The importance of nitrification on in-stream D.O. and nutrient concentrations was difficult to accurately assess because high instream nitrate concentrations, non-point sources of nitrate and ammonia, and nutrient uptake by the benthic community made nitrification rates (K_n) difficult to calculate. Values calculated ranged from K_n-3.0 to 4.1 mg/L/day between the outfall and station 6; and K_n=0 to 3.0 mg/L/day, between stations 9 and 11. The high apparent rates in the upper reach coupled with it being a favorable havitat for nitrifying bacteria, suggest nitrification could be a factor in D.O. changes seen here.

Fecal Coliform

Fecal coliform levels exceeded Class B water quality standards for at least 10 miles downstream of the STP outfall. Only after dilution with Chandler power return water did coliform levels conform to the Class B criterion.

The other discharges to this reach, Holzinger-Seneca, Snipes Creek, Spring Creek, and Bull Pasture Creek, were not important sources of bacteria. A coliform decay rate of 0.2 hr^{-1} ($r = -0.951$) was calculated by linear regression using all data and adjusting for changes in discharge. The rate is rapid compared to most fresh-water data, but is within the reported range of rates (Chamberlin and Mitchell, 1978; Zison, et al., 1978). The reasons for this could be the unusual nature of the wastewater, turbulent action of the river, predation of bacteria by organisms in the benthic community, and/or errors involved in averaging all the rates over the course of the survey.

The Class II inspection showed that the industrial rather than the municipal effluent was the source of high coliform concentrations in the combined effluent (Heffner, 1983). The predominant species of bacterial organism(s) could not be identified.

Other Point Sources

These data indicate that discharges other than Prosser STP were not having adverse effects on the river. Water quality in Snipes, Spring, and Bull Pasture creeks and in the Chandler return was not lower than that in the river, except for somewhat higher turbidity and suspended solids concentrations. The Chandler return may have contributed to the two-fold increase in turbidity and solids seen in the river downstream of the power house. Turbidity remained within Class B standards and suspended solids concentrations stayed within a range protective of aquatic life.

The results of Holzinger-Seneca lagoon samples showed the overflow had high concentrations of BOD, fecal coliform, suspended solids, ammonia, and phosphorus -- although well below those from the Prosser STP. We were not able to measure the flow, but it was generally low and highly variable. During surges of flow, increased amounts of suspended matter were discharged. The effluent followed a diffuse path through grass and brush for about 200 feet to the river. Because of the variation in quality and quantity of this discharge and its route to the receiving waters, these data may not be representative of the average effluent and probably underestimate its quality on reaching the river. On the other hand, if the low flows we observed are not typical of this discharge, it could be the most significant BOD load to this reach of the Yakima.

2. September 13-14, 1983 - domestic effluent discharged only.

The Prosser STP effluent and Yakima River results are compared in Table 4 on the following page.

Table 4. Comparison of Prosser NPDES permit limits, Prosser STP effluent and Yakima River for September 13-14, 1983.

Parameter	Prosser NPDES Permit*	Prosser Domestic Effluent*	Yakima R.** Above Outfall (Station 1)	Prosser Load as Percent of Combined Downstream Load
Flow (cfs)	.62	.73	758++	(dil. ratio = 1040:1)
BOD_5 (mg/L)	90	9	1.4 est.	
(lbs/day)	300	35	5,700	.6%
TSS (mg/L)	144	18	18	
(lbs/day)	480	71	74,000	.1%
F. Coli. (col/100 mL)	400	420	72	
(col/day x 10^6)		7,500	1,300,000	.6%
pH (units)	6.5-8.5	7.5	7.7	
NH_3 (mg/L)		8.2	0.02	
(lbs/day)		33	82	29%
T. Inorg. N (mg/L)		14.0	1.2	
(lbs/day)		55	4,900	1.1%
$T\text{-}PO_4\text{-}P$ (mg/L)		7.8	.08	
(lbs/day)		31	330	8.6%

*Weekly limits, Sept. 15, 1981 permit.
**Data from this survey.
++USBR

Again, except for a slightly over-limit flow, the Prosser domestic effluent was within its permit. Insignificant BOD, solids, and bacteria loads were going into the river. The major loads to the river were ammonia and phosphorus -- 29 and 0.6 percent of the combined downstream load, respectively.

As expected, the receiving water data (Table 5) showed there was no discernible impact on the river.

The D.O. field data indicated the presence of periphyton growth between stations 5 and 6 -- similar to the October 1982 indications. The change in the D.O. pattern at stations 5 and 6 between the mid-morning survey run and the late afternoon survey was pronounced (Figure 5).

Conclusions and Recommendations

It is our understanding from conversations with you and with the Prosser treatment plant operator that the future practice will be to spray irrigate potato wastewater rather than discharge it to the river. This is much preferred over discharge to the river. The Prosser domestic effluent alone does not represent a significant water quality problem for the Yakima River. As shown by the results of our first survey, the impact of potato wastewater on the river is quite severe, especially within the poorly mixed zone along the Yakima River's left bank. Every reasonable precaution should be made to ensure that industrial wastewater is not discharged to the river while flows are low.

Model simulations of D.O. concentrations resulting from combined discharge of industrial and domestic effluents were also made for various seasonal conditions (Figure 6). Curve 3 simulates a summer temperature of 22°C and flow, effluent and environmental conditions similar to the October 1982 survey morning run. Curve 1 simulates the same wasteload to a winter low flow of 1500 cfs and an in-stream temperature of 3°C. Curve 2 is the same as Curve B, Figure 3 from the October 1982 survey.

Curve 3 shows a 20 percent loss in D.O. saturation at station 6 when compared to upstream values. The primary causes of the increased deficit would be decreased reaeration rates and increased nitrification rates. The simulation suggests that early morning D.O. levels could drop below the 6.0 mg/L Class B criterion.

During winter months, combined STP effluent to river water dilution ratios are on the order of 920-3200:1 (USBR data flows for December, January, February and March; W.Y 1980 and 1981) which should be sufficient to assimilate an occasional discharge of combined Prosser effluents. USBR flow data for the above December-through-March period show that, on the average, seven days each month had flows less than 1500 cfs. The minimum flow measured was 1118 cfs. The lowest flows probably occur during the coldest weather and, therefore, would correspond to those times when spray irrigation could not be done and the industrial effluent would go to the river. Curve 1 was generated to simulate these conditions and predicts that D.O. saturation would drop about six percent below upstream values and then quickly recover.

Although this D.O. sag is minor, survival time for fecal coliform would be longer and initial counts below the outfall would be on the order of 3200 org/100 mL, assuming a concentration of 150 org/mL upstream and effluent quantity and quality similar to October 1982.

AJ:JJ:cp

Attachments

Table 1. Sampling schedule for Prosser STP/Yakima River receiving water survey.

Sampling Station	Parameter	Time	Sampling Method	Number of Samples per Station
	October 6, 1982			
A. River (7 stations)				
all stations	temperature, D.O., chlorine residual	0730-1445	grabs	4
all stations	pH, specific conductivity, turbidity, total suspended solids, NH_3-N, NO_2-N, NO_3-N, T-PO_4-P, O-PO_4-P	"	"	3
all stations	fecal coliform	"*	"	4
station #1	BOD_5	0730-1515	composite using Manning automatic sampler	1
B. Point/Non-point Discharges				
Prosser STP (see Class II report)	temperature, D.O., pH, specific conductivity, chlorine residual	0910-1345	grabs	3-4
"	turbidity, total suspended solids, NH_3-N, NO_2-N, NO_3-N, T-PO_4-P, O-PO_4-P, BOD_5	2100, Oct. 5-1100, Oct. 6	composite using Manning automatic sampler	1
"	fecal coliform	1000; 1400	grabs	2
Holzinger-Seneca Lagoon overflow	temperature, D.O.	0900; 1545	"	2
"	pH, specific conductivity, turbidity, total suspended solids, NH_3-N, NO_2-N, NO_3-N, T-PO_4-P, O-PO_4-P, BOD_5	0700-1545	composite using Manning automatic sampler	1
"	fecal coliform	"*	grabs	4
Spring/Snipes/Bull Pasture Creeks and Chandler power return	temperature, D.O.	0850-1440	"	4
"	pH, specific conductivity, turbidity, total suspended solids, NH_3-N, NO_2-N, NO_3-N, T-PO_4-P, O-PO_4-P, BOD_5	"	manual composite of (3) two-liter grabs	1
"	fecal coliform	"*	grabs	4
	September 13-14, 1983			
A. River (6 stations)				
all stations	temperature, D.O., chlorine residual	1/day	grabs	2
all stations	pH, specific conductivity, turbidity, total suspended solids. NH_3-N. NO_2-N. NO_3-N. T-PO_4-P, O-PO_4-P	"	"	2
all stations	fecal coliform	Sept. 14	"	1
station #1	BOD_5, COD	"	"	1
B. Prosser STP				
domestic effluent	temperature, D.O., pH, specific conductivity, chlorine residual	1/day	"	2
"	fecal coliform	Sept. 14	"	2
"	turbidity, total suspended solids, NH_3-N, NO_2-N, NO_3-N, T-PO_4-P, O-PO_4-P, BOD_5, COD	1345, Sept. 13-1230, Sept. 14	composite using Manning automatic sampler	1

*Due to lab load considerations, one set of fecal coliform samples was collected the afternoon of October 5.

ı. 46.7 - 34.2), October 6, 1982.

l (units)	Spec. Cond. (μmhos/cm)	Fecal Coliform (col/100 mL)	Turb. (NTU)	Total Susp. Solids (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	T-PO_4-P (mg/L)	O-PO_4-P (mg/L)
2*	302 (294-309)	39 (20-61)	7 (6-8)	13 (12-13)	.02 (.02-.03)	.04*	1.3 (1.2-1.5)	.12 (.11-.13)	.08*
1	*1,200*	*1.9 x 10[6]; 2.0 x 10[6]*	*200*	*380*	*26*	*.25*	*0.7*	*16*	*5.7*
9 .8-8.0)	318 (313-321)	28,000 (21,000-39,000)	4 (3-5)	16 (14-18)	.23 (.17-.30)	.07 (.06-.07)	1.4 (1.3-1.4)	.28 (.27-.28)	.13 (.13-.14)
4	*1,210*	*<10-4,000[d]*	*34*	*64*	*.75*	*<.05*	*<.05*	*1.6*	*.25*
2 .0-8.3)	362 (334-393)	3,700 (2,200-4,600)	4 (3-5)	10 (9-10)	.06 (.04-.07)	.05 (.04-.05)	1.5 (1.4-1.7)	.14 (.13-.14)	.08 (.07-.09)
1 .0-8.2)	316 (315-318)	2,800 (2,400-3,500)	4 (3-6)	10*	.05 (.04-.06)	.04*	1.4 (1.4-1.5)	.13 (.13-.14)	.08*
3	*335*	*240 (230-250)*	*21*	*51*	*.02*	*.05*	*1.7*	*.13*	*.07*
2	*165*	*260 (110-230)*	*9*	*21*	*.01*	*<.01*	*.25*	*.07*	*.04*
2 .1-8.3)	303 (300-307)	1,200 (1,000-1,400)	5 (4-6)	12 (11-13)	.06 (.04-.10)	.02 (<.01-.03)	1.2 (1.2-1.3)	.11 (.11-.12)	.08 (.07-.10)
5	*211*	*180 (120-270)*	*15*	*28*	*.02*	*.02*	*.52*	*.12*	*.07*
1 1-8.5)	311 (310-312)	360 (230-460)	4 (3-5)	9 (8-10)	.04 (.03-.05)	.04*	1.2*	.10*	.08 (.07-.08)
·	*293*	*44 (32-53)*	*5*	*21*	*.03*	*.03*	*1.3*	*.12*	*.08*
1-8.3)	312 (310-316)	90 (20-160)	8 (5-10)	18 (15-24)	.03 (.02-.05)	.04*	1.3 (1.2-1.4)	.14 (.11-.17)	.11 (.08-.14)

.7 - 42.0', September 13-14, 1983.

L)	pH (units)	Spec. Cond. (µmhos/cm)	Fecal Coliform (col/100 mL)	Turbidity (NTU)	Total Susp. Solids (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	T-PO_4-P (mg/L)	O-PO_4-P (mg/L)
1)	7.7*	274 (268-280)	72	7 (7-8)	18*	.02*	.02*	1.2 (1.1-1.3)	.08*	**
	7.5 (7.4-7.5)	706	420 (260-580)	29	18	8.2	.55	5.2	7.6	0.8
	7.7*	277 (272-281)	100	7 (7-8)	21 (20-22)	.02*	<.02 (<.01-.02)	.92 (.84-1.0)	.07 (.07-.08)	**
	7.7 (7.6-7.8)	284 (278-290)	73	8*	17 (16-18)	.04*	.03 (.02-.03)	1.3*	.10 (.08-.12)	**
	7.8*	280 (276-284)	80	7 (7-8)	17 (16-18)	.03 (.02-.04)	.03 (.02-.03)	1.2 (1.1-1.3)	.11 (.09-.12)	**
	7.9 (7.6-8.2)	289 (281-297)	44 est.	5 (4-7)	17 (11-23)	.02*	.03 (.02-.03)	1.3 (1.2-1.3)	.07 (.06-.07)	**
	7.7 (7.6-7.7)	283 (281-284)	87 est.	7 (5-8)	21 (19-23)	.03 (.02-.03)	.02*	1.2 (1.0-1.3)	.06*	**

oil & grease = 4

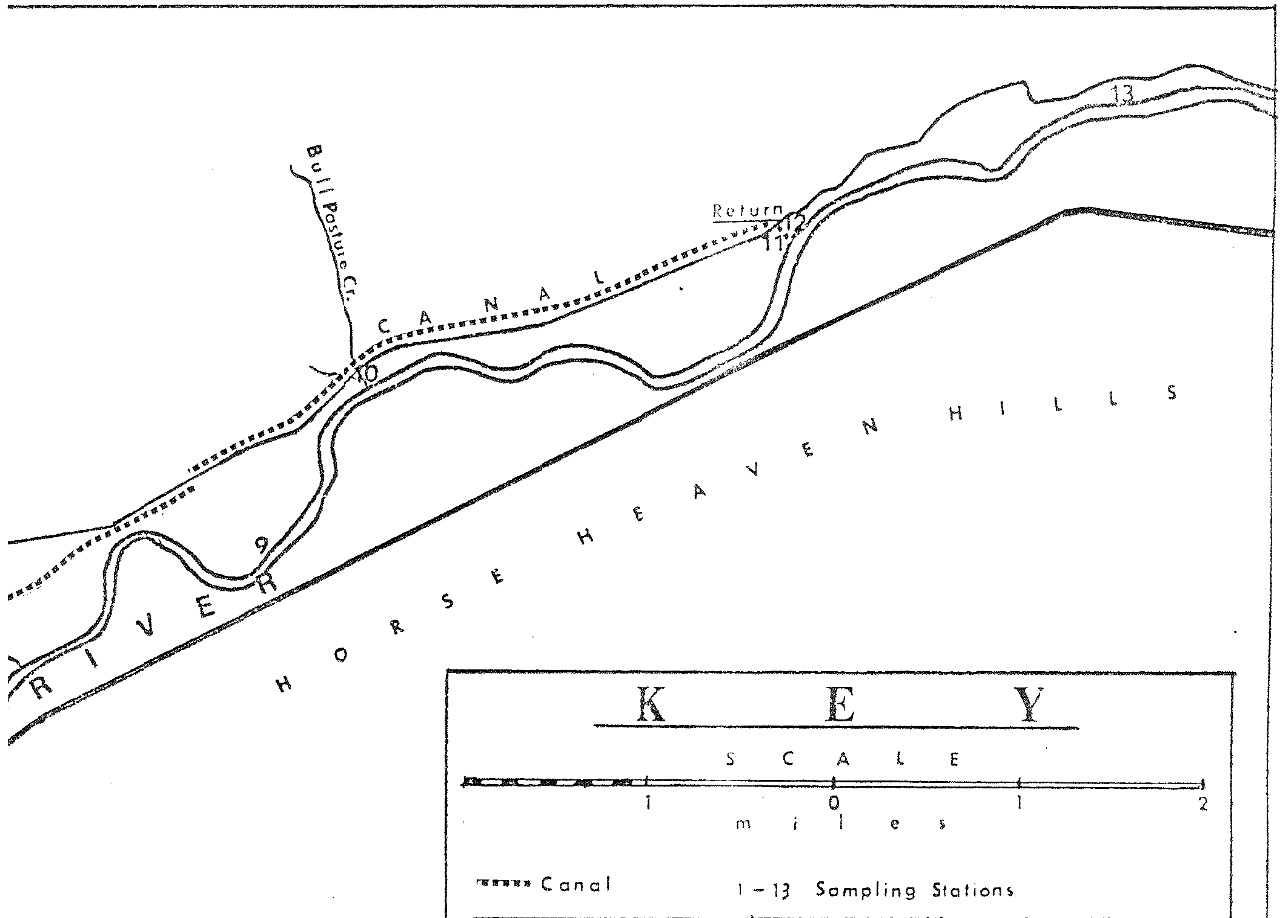

Figure 1. WDOE sampling stations for low-flow surveys in the Yakima River above and below Prosser STP, October 5-6, 1982 and September 13-14, 1983.

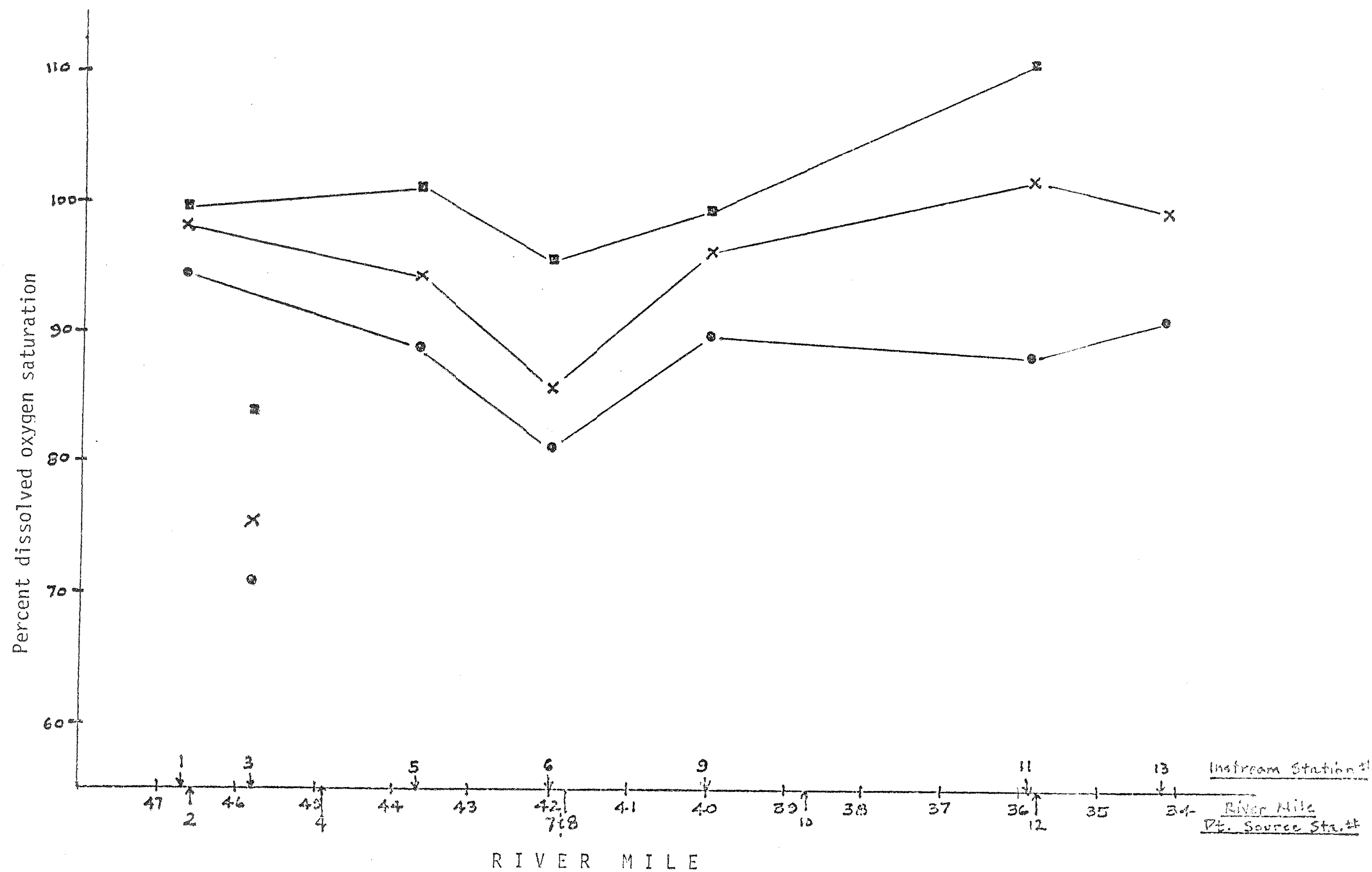

Figure 2. Dissolved oxygen saturation percentages calculated from field data taken from the Yakima River above and below Prosser STP, October 6. 1982. Station numbers refer to those locations identified in Figure 1, and described in Table 3. Survey run times: ● - 0730 to 1000; × - 1030 to 1210; ■ - 1310 to 1445. Station 3 data excluded from curve because within effluent plume.

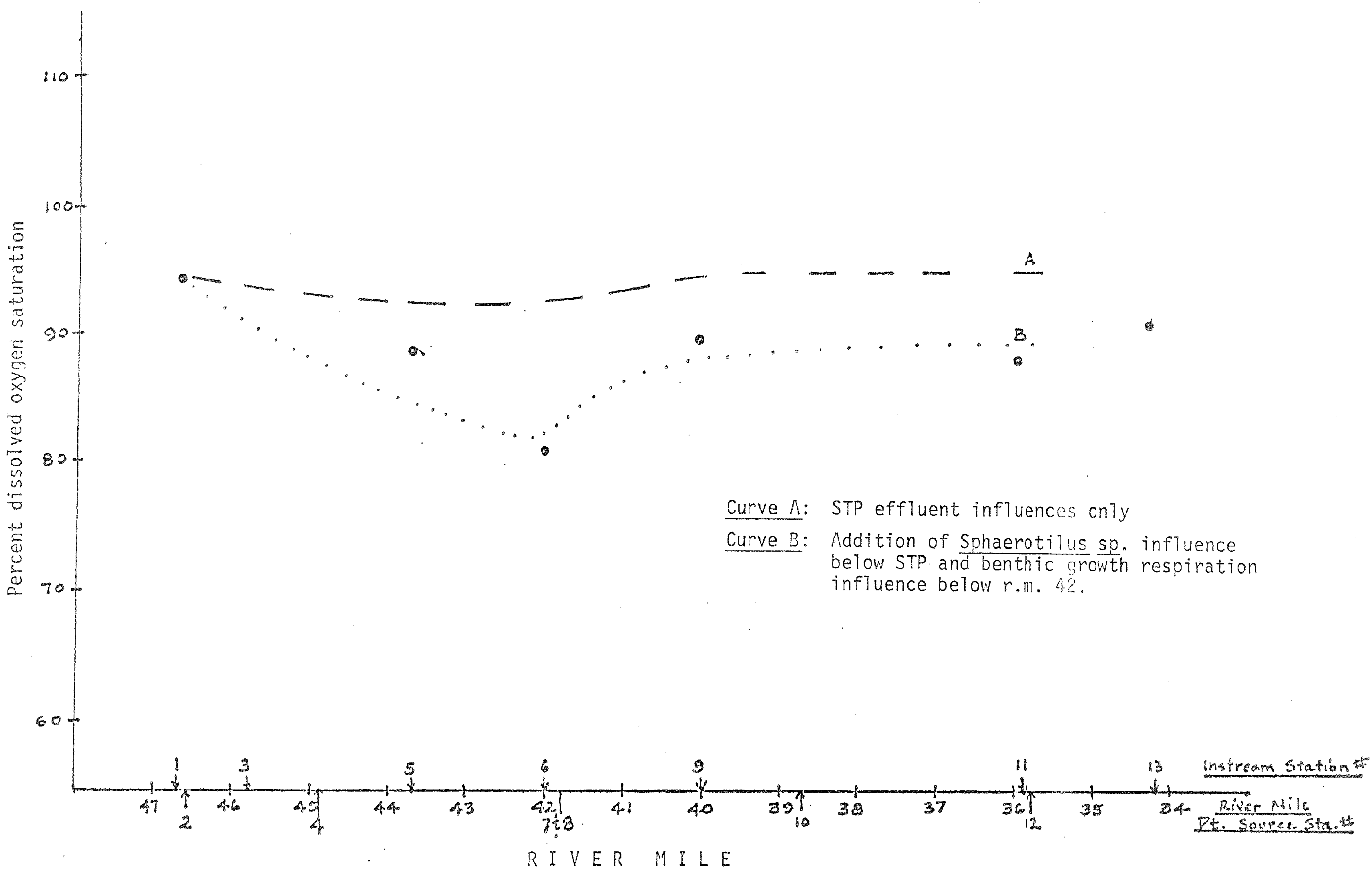

Figure 3. Computer model simulations of dissolved oxygen saturation values, curve A and B, and actual river data (●) for the early-morning run for the October 6, 1982 survey of the Yakima River below Prosser STP (Sta. 2). Station numbers refer to those locations identified in Figure 1 and described in Table 3. See text for explanation of simulation conditions.

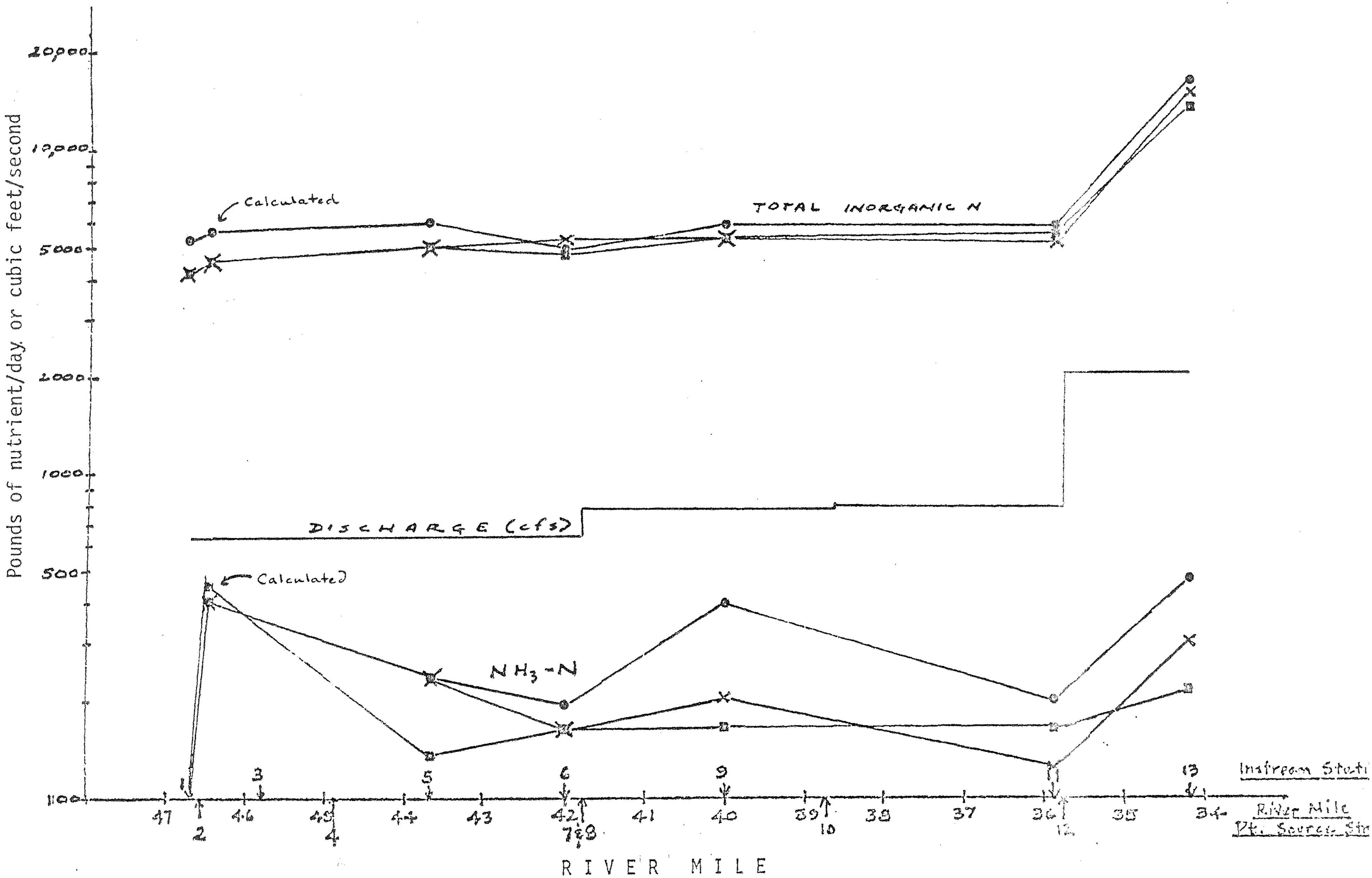

Figure 4. In-stream loads (lbs/day) of ammonia (NH_3) and total inorganic nitrogen from samples taken during three runs on the Yakima River near Prosser on October 6, 1982. Run times: ● - 0730 to 1000; x - 1030 to 1210; ■ - 1310 to 1445. Discharge also shown in cubic feet per second. Station numbers refer to locations identified in Figure 1 and described in Table 3.

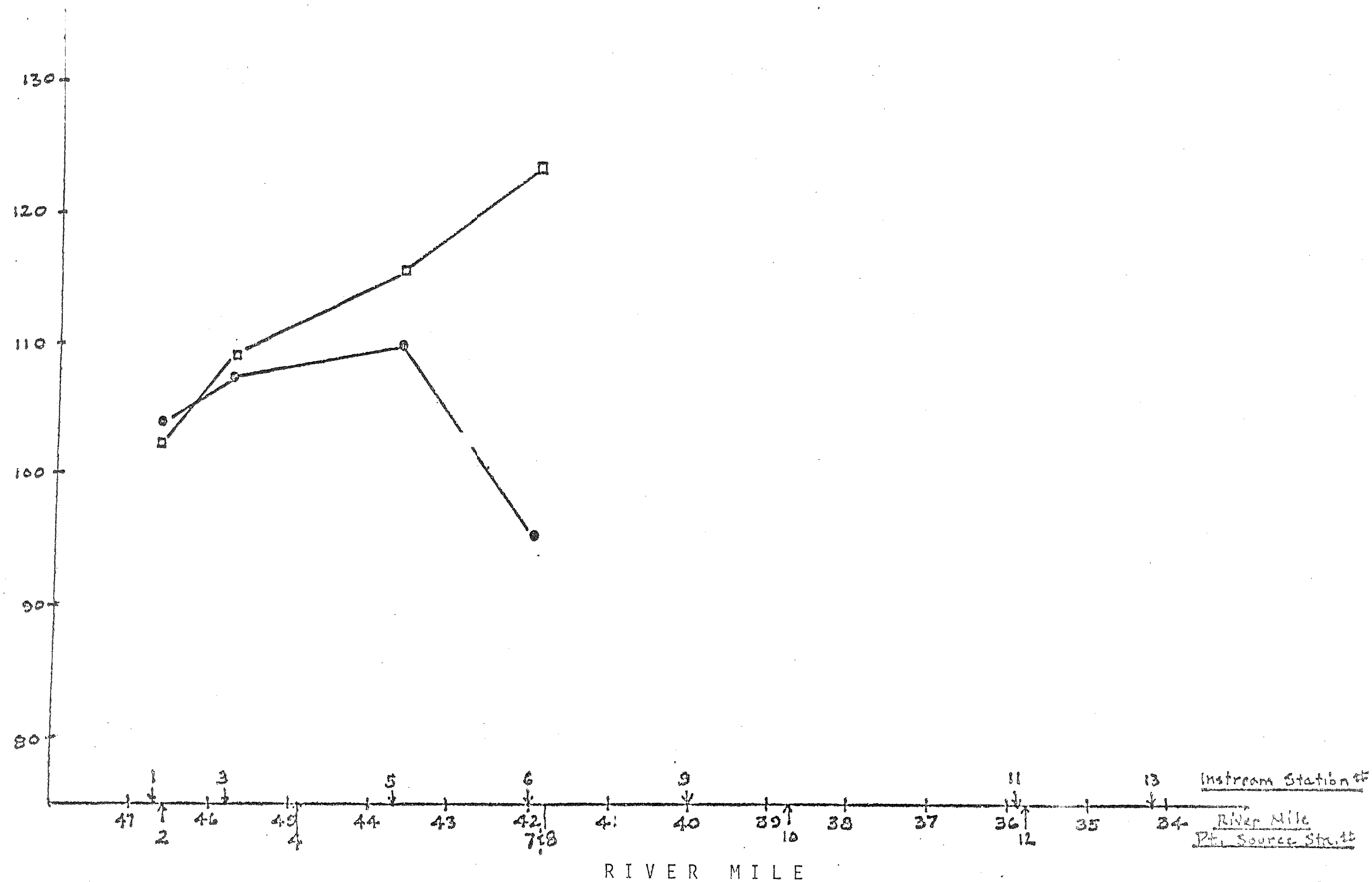

Figure 5. Field data for dissolved oxygen saturation percentages for the Yakima River below Prosser STP, Station #2, September 13-14, 1983. Survey run times: ● - September 14, 0945 to 1035; □ - September 13, 1530 to 1645. Station numbers refer to those identified in Figure 1 and described in Table 3.

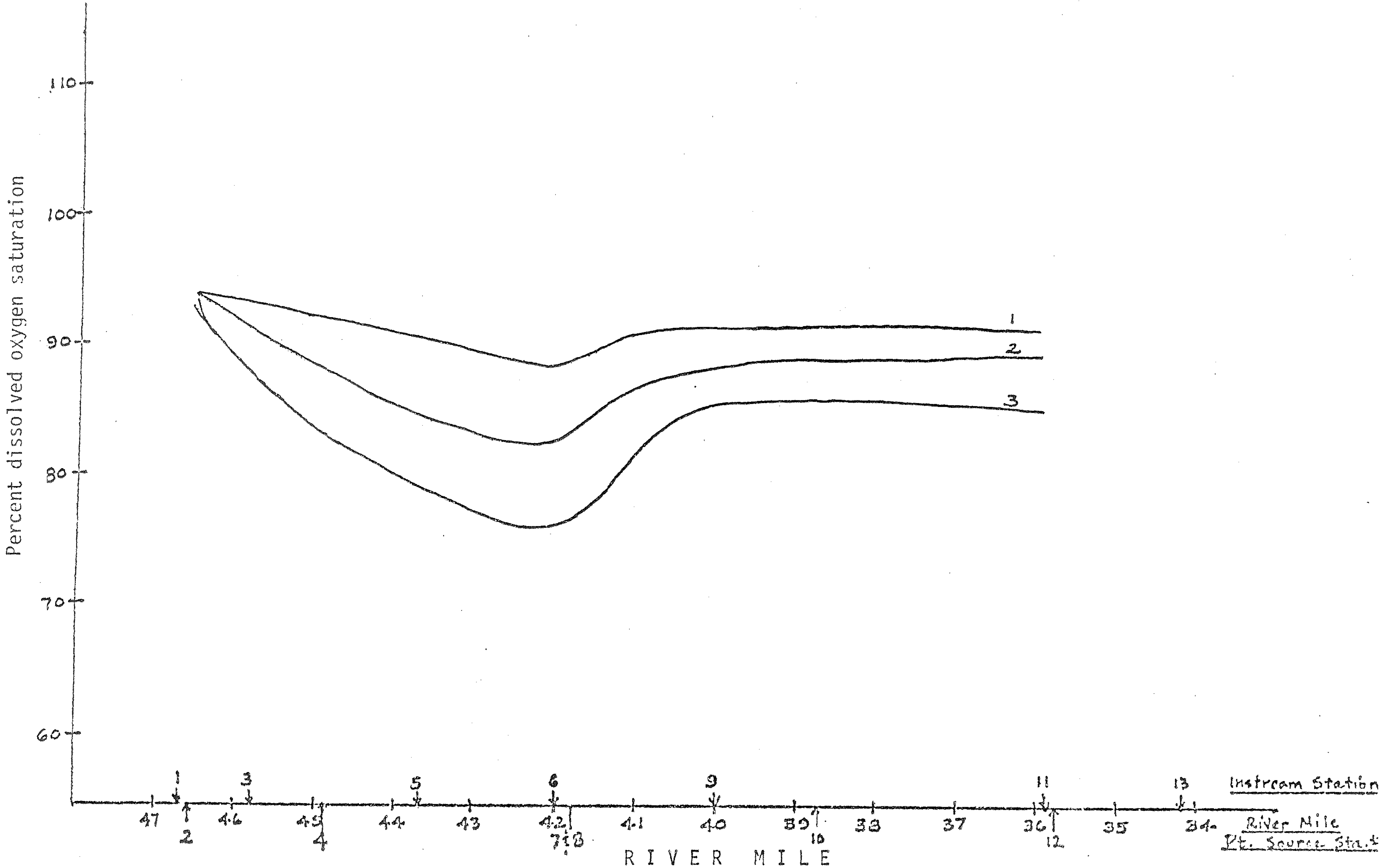

Figure 6. Computer model simulated curveys showing dissolved oxygen saturation values in the Yakima River below Prosser STP, Station #2, during different seasons.

Curve 1: winter, 3°C, 1500 cfs above Prosser STP
Curve 2: fall, 13.8°C, 617 cfs above Prosser STP
Curve 3: summer, 22°C, 617 cfs above Prosser STP

See text for details.