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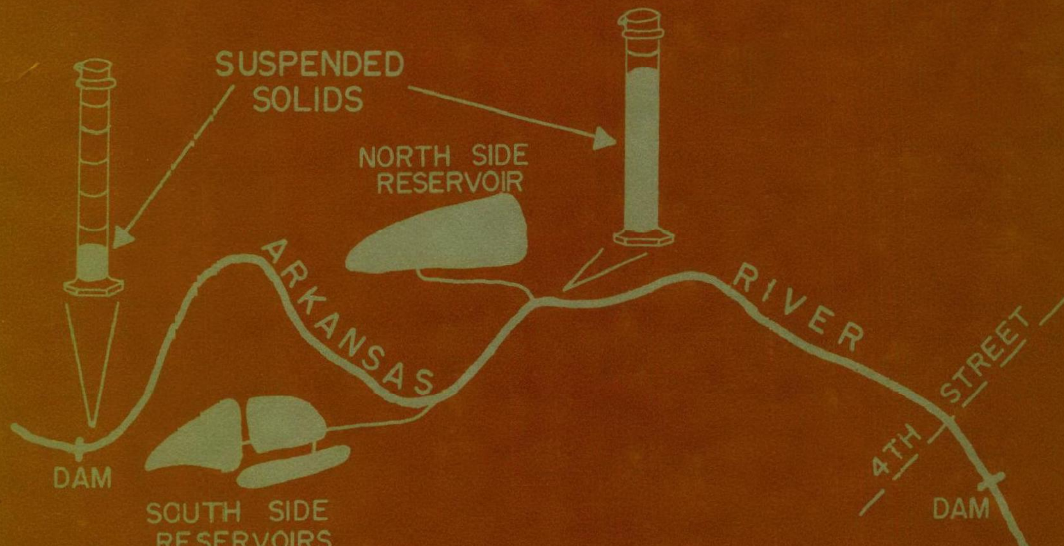
INVESTIGATION OF THE EFFECTS OF THE WASTE DISCHARGES FROM THE NORTHSIDE AND SOUTHSIDE WATER TREATMENT PLANT RESERVOIRS AT PUEBLO, COLORADO ON WATER QUALITY AND BENTHIC ORGANISM CONDITIONS IN THE ARKANSAS RIVER

OCTOBER 10-12, 1972



TECHNICAL SUPPORT BRANCH
SURVEILLANCE AND ANALYSIS DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

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INTRODUCTION

The Arkansas River originates near the Continental Divide in Central Colorado and then flows eastward through the city of Pueblo and on across the plains. As the river passes through the city of Pueblo it is diverted for various industrial and irrigation uses and, in return, it receives discharges from several sources. Two of the major sources of waste discharges are the Northside and Southside Water Treatment Plants. Each of these plants has large settling ponds used to contain the sludges produced during the chemical treatment of river water for potable use. Once each year during a two to three week period these plants dispose of the accumulated solids by flushing them directly into the Arkansas River.

Disposal of solid waste materials in this manner is not consistent with the Colorado Water Quality Standards of September, 1971 (Ref. 1). Although the standards do not list specific numerical limits for total dissolved solids (TDS) or total suspended solids (TSS) in this stream reach, there are several narrative standards which relate to solids concentrations in all waters of the State. These standards state that all wastes must be "free from substances that will form objectionable bottom deposits" and "free from substances sufficient to be harmful to human life or animal life."

STUDY DESCRIPTION

In order to assess the impact of these two water treatment plant discharges on the Arkansas River, the Technical Support Branch of the Regional EPA office conducted a study on October 10-12, 1972, during the period of pond discharge. The basic objective was to determine whether the solids in the discharges were of sufficient magnitude to cause benthic organism and water quality degradation in violation of the Colorado Water Quality Standards.

The study included chemical and biological sampling conducted at four river stations in a three mile stream reach in the area of the water treatment plants. The two pond discharges were also sampled for chemical analysis. The map in Figure 1 shows the general survey location and the sample stations. A description of the locations for chemical sampling are presented in Table 1, while the biological sample locations, which differed slightly from the water quality sampling stations, are described in Table 3. All stations are numbered consecutively from the upstream control station to downstream stations.

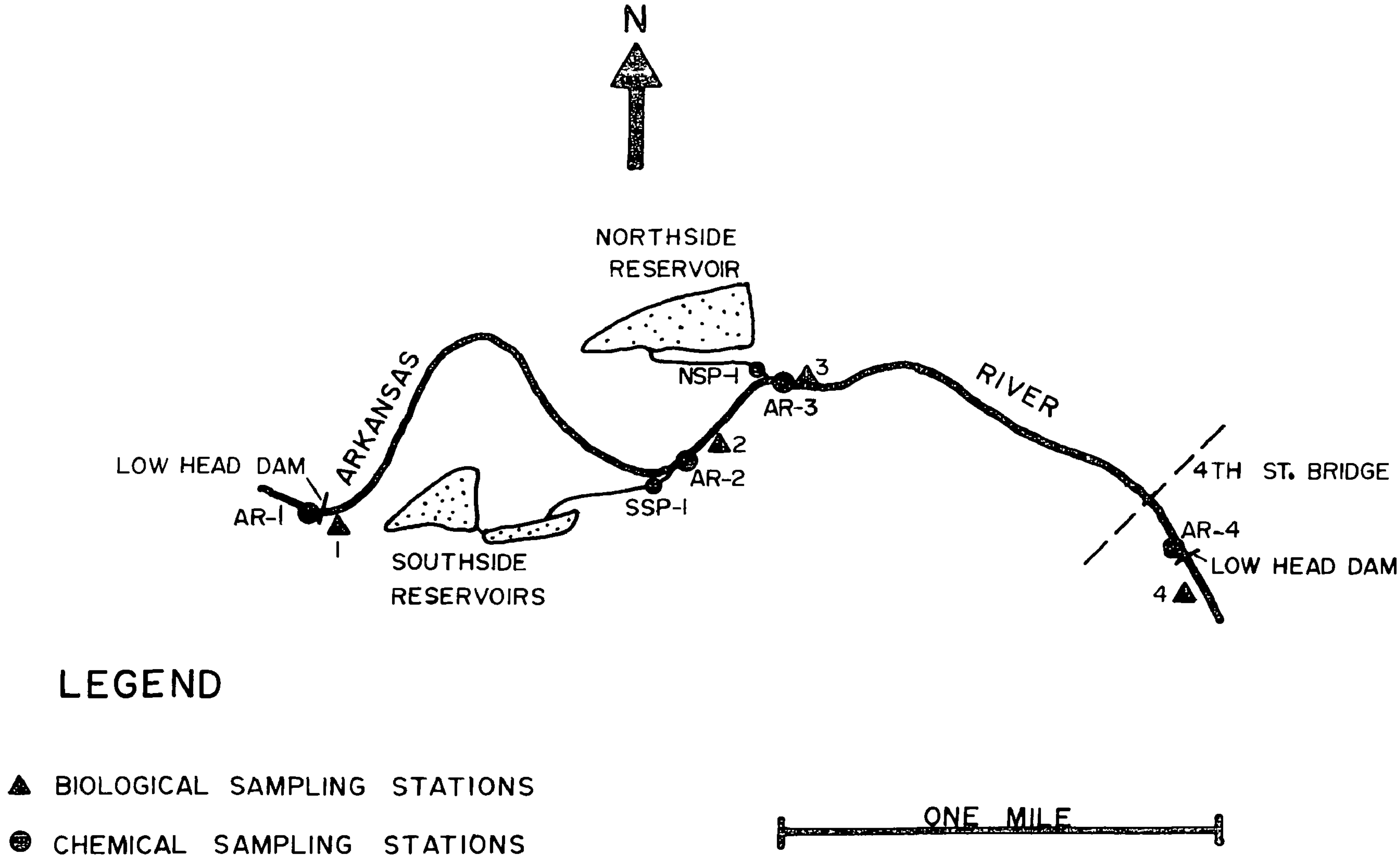


FIGURE 1 Map of Arkansas River Survey Area

TABLE 1

Sample Station Locations for Chemical Sampling

Station Number	Description
AR-1	Arkansas River upstream from the effluent from the two plants at the low head dam near the Southside Plant Water Intake.
SSP-1	Effluent from the Southside Water Treatment Plant in drainage ditch about 100 feet above confluence with the Arkansas River.
AR-2	Arkansas River approximately 30 feet downstream from the Southside Plant discharge to the river.
NSP-1	Effluent from the Northside Water Treatment Plant in drainage ditch about 50 feet above confluence with the Arkansas River.
AR-3	Arkansas River approximately 30 feet downstream from the Northside Plant discharge to the river.
AR-4	Arkansas River downstream from the two water plants at the low head dam near the 4th Street Bridge.

CHEMICAL SURVEY

Methods

The collection of water samples for chemical analysis was conducted at the six locations described in Table 1. At each location a one-liter sample was collected for laboratory analysis for total dissolved solids (TDS), total suspended solids (TSS), volatile suspended solids (VSS), and pH. In addition, a 300 ml dissolved oxygen (DO) sample was collected and preserved for later analysis in the laboratory. At the same time various field measurements were made. They included the following:

pH
Conductivity
Temperature
DO (one day only)

Results and Discussion

The complete chemical results are presented in Table 1 in the Appendix. These results are presented as average values for each parameter in Table 2. It is of interest to compare the results from the downstream station (AR-4) with the results from the upstream control station (AR-1). These two stations are located about three miles apart and bracket the pond discharges. Results at these stations will, therefore, reflect the change in water quality of the Arkansas River due to the pond discharges.

Several significant changes in water quality are evident from Table 2. The average dissolved oxygen content in the stream dropped from 9.2 mg/l to 7.2mg/l within the three mile reach separating the upstream and downstream stations, representing a decrease of about 22%. This decrease can be partially attributed to the relatively lower DO values observed in the two discharges at SSP-1 and NSP-1. These average values were 6.8 mg/l and 7.2 mg/l, respectively. However, it should be pointed out that the DO in the river at all sample stations exceeded the minimum recommended limit ($\geq$3 mg/l) specified in the existing stream standard (Class C) for this reach of river.

A second significant change in water quality is related to the vastly increased TSS concentrations observed at the downstream station (AR-4). Table 2 shows that the average TSS value increased from 21 mg/l at AR-1 to 150 mg/l at AR-4. This increase is also depicted in Figure 2. The increase in TSS can be directly related to the Southside and Northside Plant discharges, which averaged 5900 mg/l and 36,300 mg/l TSS, respectively. It should be pointed out that the TSS and VSS concentrations

TABLE 2

Average Chemical Data for Arkansas River Survey

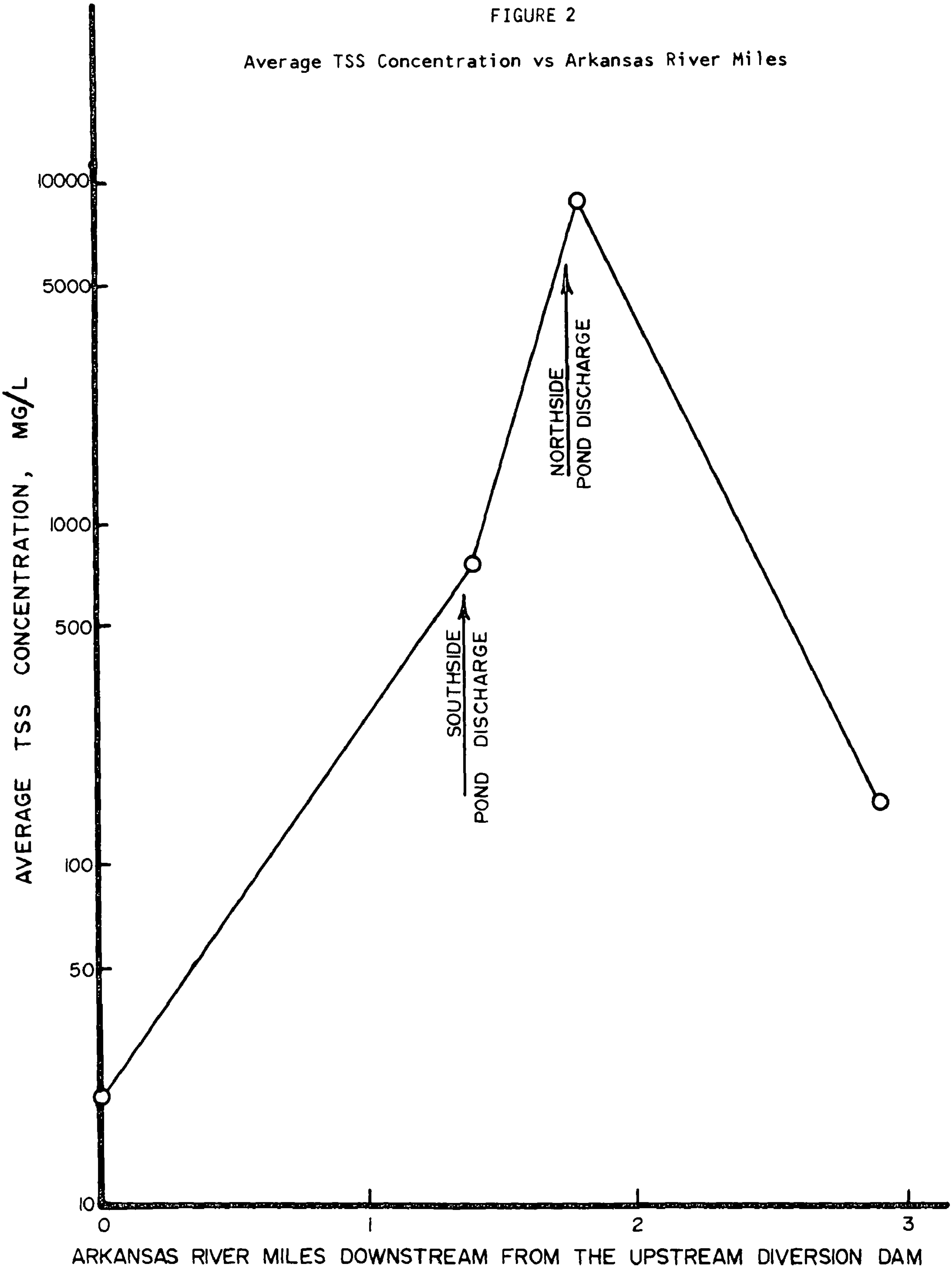
Station	River Miles	Parameter Average Value for 3 Measurements							
		Temp °C	pH Field	pH Lab	DO mg/l	Conduc. µmhos/cm	TDS mg/l	TSS mg/l	VSS mg/l
AR-1	0	14.5	8.5	8.2	9.2	790	520	21	2
SSP-1	1.4	15.0	8.4	7.7	**6.8	870	570	5900	460
AR-2	1.4	15.0	8.5	8.0	8.8	845	560	760	60
NSP-1	1.8	15.5	8.0	7.3	*7.2	750	520	36300	2650
AR-3	1.8	16.0	8.2	7.6	*8.6	815	535	8520	550
AR-4	2.9	16.0	7.7	7.9	7.2	820	560	150	15

* One Measurement

** Two Measurements

FIGURE 2

Average TSS Concentration vs Arkansas River Miles



measured in the pond discharges varied over a wide range. For example, Table 1 in the Appendix shows that the TSS concentration in the Northside discharge varied from a low of 640 mg/l on 10/12 to 73,400 mg/l on 10/10. This variation is primarily due to the time of sample collection in relation to the pond flushing operation. The nature of the pond flushing operation is variable in itself, due to the fact that it consists simply of men with high pressure water hoses scouring the pond bottom free of accumulated solids. It is thought, however, that the samples collected are fairly representative of the normal discharge during the flushing operation.

The values for TSS and VSS in Table 2 for Stations AR-2 and AR-3 are much higher than at the downstream Station (AR-4). The reason for this is because samples at Stations AR-2 and AR-3 were collected a short distance downstream from the Southside and Northside discharges, respectively, at which point the solids had not been uniformly diluted with the full river flow. The physical condition of the stream at these two points consisted of an extremely turbid flow of water and extensive mud-sludge deposits along the river bank. Several dead fish were also observed at these two stations.

In addition to the relatively large DO and TSS changes observed in the Arkansas River, a slight (10%) reduction in pH also occurred in the three mile study area. This reduction is shown in Table 2 for field pH values, while for the lab pH values, a smaller decrease is noted. In general, the pH value measured in the laboratory was about 6% lower than pH values measured in the field. This difference is likely due to biological and chemical changes occurring in the sample during transportation and storage at the Laboratory.

BIOLOGICAL SURVEY

Methods

The benthic organism survey was conducted on October 10, 1972, and covered about the same stream reach as the chemical survey. However, the sample locations were displaced slightly downstream from the chemical sample stations in order to find more suitable sampling sites. A description of the biological sample stations is presented in Table 3.

An earlier benthic organism survey was undertaken on August 3, 1972, in this same stream reach. At that time high water flow precluded finding

TABLE 3

Sample Station Locations for Biological Sampling

Station Number	Description
1	Arkansas River about 50-100 yards downstream from low head dam near the Southside Water Treatment Plant.
2	Arkansas River about 300 yards downstream from Southside water reservoir discharge point.
3	Arkansas River about 100 yards downstream from Northside water reservoir discharge point.
4	Arkansas River about 50 yards downstream from lowhead dam near the 4th Street Bridge.

suitable quantitative sampling sites. Therefore, qualitative samples were collected about 30 feet downstream from both the Northside and Southside reservoir discharges. In the October survey the river flow had diminished to the extent that suitable sites for quantitative sampling were found at all stations.

One qualitative sample and two square foot Surber samples were collected at each station. Qualitative samples were collected with dip nets and by picking organisms from rocks with forceps. The samples were preserved in 10% formalin and transmitted to the EPA laboratory for processing. In the laboratory, samples were sorted and organisms classified to the lowest taxonomic level possible. These data are recorded in Table IV.

TABLE IV

Summary of Benthic Organisms Found in Arkansas River Survey Area

Organism	Station # 1	2	3	4
Plecoptera (Stoneflies)				
Neophasganophora sp.	Q			
Ephemeroptera (Mayflies)				
Baetis sp.	6	3		
Rithrogena sp.	Q	Q		
Tricorythodes sp.	1	Q		
Heptagenia sp.		Q		Q
Centroptilum sp.		Q		
Ephemerella sp.	1			
Stenonema sp.	1			
Trichoptera (Caddis flies)				
Hydropsyche sp.	99	30	2	1
Brachycentrus sp.	1	1		
Amphipoda (scuds)				
Gammarus sp.		1		
Hemiptera (water bugs)				
Ambrysus sp.	Q			Q
Decapoda (crayfish)				
Astacidae			Q	
Odonata				
Ophiogomphus sp. (dragon flies)	2	2	Q	Q
Agrionidae (damsel flies)				Q
Hetaerina sp. (damsel flies)	1	1	Q	
Diptera				
Chironomidae (midges)	65	1		1
Tipulidae (crane flies)	1	1		
Tabanidae (Horse flies)		Q		
Simulidae (Black flies)	1	Q		
Annelida				
Oligochaeta (sludge worms)		26	27	7
Total Number of Organisms/sq.ft.	179	66	29	9
Total Number of Kinds	14	15	5	7

Q - Organism not collected in quantitative sample, arbitrarily assigned a value of "1" for computing number of kinds.

Results and Discussion

Pollution sensitive organisms in this report will be defined as those which are incapable of withstanding adversely high concentrations of suspended solids in the water. Their morphological adaptations require clean, sediment-free, rocky substrate to which they can remain attached. Their gills are delicate and cannot tolerate the scouring effect of high suspended solids. Organisms of this type include Plecoptera (stone flies), Ephemeroptera (may flies), and Trichoptera (caddis flies). Pollution tolerant organisms in this context are those which can exist in heavy sediment concentrations in water and in accumulated bottom deposits. These organisms are adapted to living in sediment deposits because of their worm-like anatomy. They are capable of respiration through the body surface, and therefore do not require gills which are susceptable to abrasion by sediments. Oligochaeta (sludge worms) are the major members of this group found in the Arkansas River.

The diversity and number of organisms per square foot of substrate decreased as one progressed from the upstream control station (Sta 1) to the extreme downstream station (Sta 4). At the control station (Sta 1) the water was clear and the substrate free of any overlying sediments. Sampling in the riffle areas at this location revealed a diversity of fourteen different kinds of organisms and a total of 179 organisms per square foot. There were eight different kinds of pollution sensitive stoneflies, mayflies, and caddis flies for a total of 108 pollution sensitive forms per square foot of substrate.

Downstream from the Southside reservoir discharge (Sta 2) was a long (200 yards) shallow pool with a sediment layer approximately six to twelve inches deep covering the bottom. Sampling was conducted in a riffle area immediately downstream from this large pool. The pool area upstream of this riffle area allowed considerable settling of sediments, and the swift water flow over the riffle kept the substrate sparingly free of sediment accumulation. Even though this location was downstream from the Southside sediment discharge, the conditions created by the large pool and swift riffle made a suitable sediment-free substrate for the benthic organisms. Fifteen different kinds of organisms were found here for a total of 66 per square foot. Seven of the fifteen kinds of organisms were pollution sensitive mayflies and caddis flies. These pollution sensitive forms dropped from 108 per square foot at Sta 1 to 17 per square foot at this location (Sta 2). Thus, even though the diversities of organisms between stations 1 and 2 were similar the increased sediment load did greatly deplete the number of pollution sensitive forms per square foot of substrate. Pollution tolerant sludge worms numbered 26 per square foot at this location compared to none at Station 1.

For a distance of 50 yards downstream of the Northside reservoir discharge (Sta 3) sediments covered the river bottom to a depth of about six to twelve inches. Sampling was conducted approximately 100 yards downstream from this discharge to insure thorough sediment mixing with the river water. The water at this location was very turbid (high in TSS as shown in Table 1 in the Appendix), and the substrate had a sediment overlay approximately ¼ inch in depth. Kinds of organisms dropped to five with a total of 29 organisms per square foot of substrate being recorded. In the five kinds of organisms present only two pollution sensitive caddis flies were present, numbering two per square foot. The other 27 organisms per square foot were pollution tolerant sludge worms. This indicates further depletion of organisms from Station 2 due to the sediment load.

Downstream from the low head dam near the 4th Street bridge (Sta 4) the turbidity of the water had greatly decreased from Station 3 (see TSS values in Table 1 in the Appendix). Substrate consisted of large pieces of shale (three by four feet) with some rocky areas in a small side channel of the river. The number of kinds of organisms recorded here was seven, with a total number of nine organisms per square foot. This decline in number of organisms from the previous upstream station is somewhat misleading. In looking at Table IV it can be seen that at Station 3, 27 of the 29 organisms per square foot of substrate were sludge worms. At Station 4 sludge worms were also present at a density of seven per square foot. However, the substrate was not sedimented over to the same extent as that at Station 3, which offered a less favorable habitat for this particular organism. Even though there was a decrease in number of organisms per square foot, there was a slight increase in diversity of organisms from Station 3 to Station 4. This diversity numbered seven different kinds of organisms at Station 4 compared to five at Station 3. Two of this number were pollution sensitive mayflies and caddis flies. This would tend to indicate some recovery from the sediment load being discharged upstream. The recovery is likely due to the settling out of some of the suspended solids upstream from the low head dam at Station 4.

CONCLUSIONS AND RECOMMENDATIONS

The data from this three-day survey provides documentation from which recommendations concerning the two Pueblo water treatment plant discharges can be made. The conclusions and recommendations related to the survey are presented below.

1. The discharge of pond sediments from the Northside and Southside water treatment plants causes a sevenfold increase in total suspended solids in the Arkansas River. As a result of these discharges extensive sludge deposits have built up along the river banks immediately downstream from the discharges. This condition violates the narrative standards of the Colorado Water Quality Standards.

2. Dissolved oxygen (DO) values decreased by over 20% in the affected stream reach near the discharges. However, no existing water quality standards are violated, since the DO remains above 7 mg/l.

3. The heavy sediment discharges have a detrimental impact on the benthic invertebrate organisms for at least two and a half stream miles. Both the number of organisms per square foot and the diversity of organisms (with the exception of Station 3) declined from the upstream control station to the stations downstream from the discharges.

4. It is recommended that the practice of flushing pond sediments from the Pueblo Northside and Southside Water Treatment Plants into the Arkansas River be discontinued. An alternative sludge disposal system must be devised by the city and put into operation. Such a system could include sludge drying beds similar to those used for sewage sludge drying.

REFERENCES

1. Colorado Water Quality Standards Summary, Water Pollution Control Commission, Colorado Department of Health, May 1, 1972.

APPENDIX

TABLE 1

Summary of Chemical Data for Arkansas River Survey

October 10-12, 1972

Station	Date	Time	Temp °C	pH Field	pH Lab	DO, mg/l Field Probe	DO, mg/l Lab Winkler	Conductivity µmhos/cm	TDS mg/l	TSS mg/l	VSS mg/l
	10/10	1040	15.0	8.50	8.2	-	8.9	795	532	20.5	0.5
AR-1	10/11	1212	15.0	8.65	8.3	6.9	9.4	770	506	16.8	1.2
	10/12	1020	13.0	8.40	8.0	-	9.2	805	526	24.8	4.0
	10/10	1330	18.5	7.30	8.1	-	7.5	860	568	168	18
AR-2	10/11	1002	14.0	7.85	7.9	-	7.2	740	548	158	14
	10/12	1230	15.0	7.90	7.8	-	6.8	860	562	124	13
	10/10	1235	17.0	8.45	7.5	-	Too Muddy	815	550	8240	520
AR-3	10/11	1102	15.0	7.65	7.3	2.3	Too Muddy	805	526	17000	1120
	10/12	1200	15.0	8.35	7.9	-	8.6	830	532	319	12
	10/10	1125	15.0	9.00	8.1	-	8.8	850	566	1630	126
AR-4	10/11	1150	15.5	8.10	7.9	7.2	8.8	840	558	418	34
	10/12	1100	14.0	8.45	8.0	-	8.8	850	562	228	20
	10/10	1110	15.5	8.90	7.5	-	Too Muddy	890	566	15600	1200
SSP-1	10/11	1136	15.5	8.10	7.6	6.0	≈ 5.7	850	580	1950	180
	10/12	1045	14.5	8.25	7.9	-	8.0	870	570	153	10
	10/10	1245	17.0	8.65	7.2	-	Too Muddy	635	542	73400	5520
NSP-1	10/11	1050	15.0	7.6	7.1	0.3	Too Muddy	805	496	35000	2400
	10/12	1140	15.0	7.9	7.7	-	7.2	820	530	640	24