

Yellow River
Rainfall Runoff and Low Flow
Water Quality Studies

No. 83-3

A REPORT FROM

*The University Hygienic
Laboratory*



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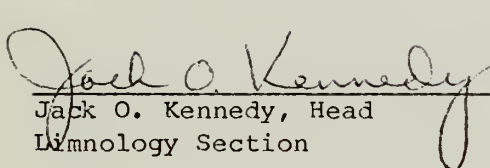
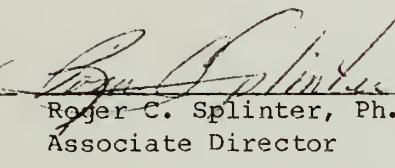
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ABSTRACT

The water quality of the Yellow River was studied during summer and fall, 1982. The primary objectives of the study were to 1) evaluate the effects of rainfall runoff during the planting season on water quality, 2) evaluate the effects of rainfall runoff on water quality during a high recreational use period, and 3) determine the effects of point source discharges on water quality during low flow summer conditions. Water samples were collected from the Yellow River on three separate occasions, twice during rainfall runoff periods and once during low flow non-runoff conditions. Flow-activated automatic samplers and flow meters located at seven sampling stations were used to monitor the runoff events. The impact of the rainfall runoff was found to be very dependent on the amount and intensity of rainfall and the quantity of runoff delivered to the receiving stream. The most notable effects of the runoff on water quality were the increases in total solids and associated parameters (organic nitrogen, total phosphate, BOD, metals, and pesticides). The impact of these solids and associated contaminants on stream biota is not known. The more water-soluble contaminants, i.e., ammonia nitrogen and soluble phosphate, experienced only minor increases in concentrations compared to the solids associated parameters, during the runoff events. Pesticide concentrations found in the Yellow River were greatest during the June event, which occurred shortly after spring planting. Four of the five pesticides reported were herbicides and included one organophosphate insecticide. The pesticide values reported were all low and much lower than presently identified acute toxic levels. Because of the short duration and localized nature of the July event, its impact on recreational activity

during the high use period was minimal. Water quality at Station 2 was the most affected of the seven stations by rainfall runoff. The highest concentrations of most parameters, including metals and pesticides, were observed at Station 2 for both runoff events. The total load values for most parameters were greatest at the most downstream stations where the highest flows occurred. Except for the poor water quality exhibited at Station 2 for both runoff events, it is not possible to make a comparison between the two runoff events because of the variation in rainfall amounts and intensities in the watershed. Results of the low flow non-runoff study demonstrated very good water quality throughout the entire Yellow River reach, with only minor changes in parameter values. Compared to the two runoff events, ammonia, total phosphorus, BOD, and solids values for the low flow study, were substantially lower and represent background conditions. The point source waste discharge from Postville had an immediate impact on Williams Creek water quality, by increasing ammonia nitrogen and BOD and decreasing dissolved oxygen. However, the effect was of relatively short duration as the water quality of Williams Creek at the mouth was similar to that of the Yellow River. Based on the benthic macroinvertebrate data obtained during the survey the water quality of the Yellow River was good. The wide species diversity with moderate numbers of individuals reflected a healthy, stable community and is comparable to previous benthic surveys.

INTRODUCTION

The Yellow River, located in extreme northeastern Iowa, originates in Winneshiek County and flows 56 kilometers (35 miles) east through southern Allamakee County joining the Mississippi River just north of Marquette, Iowa (see Figure 1). The Yellow River basin has over 241 square miles (624 square kilometers) of drainage area (1) composed primarily of agricultural land including cropland, pastureland, and woodland. The stream receives its name from the yellow colored sediment carried in suspension during high flow conditions. An indication of the rugged topography of the area is demonstrated by the river slope, which drops an average of fifteen feet per mile. In the river reach where the gradient is steep, the stream bottom is composed of rocks and gravel. Near the mouth, the gradient is reduced and, as a result, the stream bottom is mud, to a depth of several feet in places. Principal fishing in the Yellow River is provided by smallmouth bass and catfish, with the upper reaches containing some trout (2). The Yellow River has been classified as a class B warm water stream from its mouth to the Highway 51 bridge in western Allamakee County and, as a class B cold water stream from the Highway 51 bridge upstream to the confluence with the North Fork of the Yellow River. The appropriate water quality standards apply to each reach (3). In addition the Yellow River has been designated as an anti-degradation stream from its mouth upstream to the Highway 51 bridge. Iowa's anti-degradation policy was established to provide that existing high quality waters be maintained and protected at or above existing water quality. This study was performed because the Yellow River has been listed as a high quality stream and because of the interest of the Soil Conservation Service and the Iowa Department of Environmental Quality on the relationship between land use and water quality in northeast Iowa.

The primary objectives of the study were to:

- 1) evaluate the effects of rainfall runoff during the planting season (May and June) on water quality and provide data for use by the Soil Conservation Service in relating stream water quality changes to land use practices.
- 2) evaluate the effects of rainfall runoff on water quality during the high recreational use period (July and August).
- 3) determine the individual and cumulative effects of livestock operations, agricultural and point source discharges on water quality during low flow summer conditions.

SAMPLING AND ANALYTICAL METHODOLOGY

The sample collection was performed in three phases

- 1) rainfall runoff sampling conducted in June,
- 2) rainfall runoff sampling conducted in July and,
- 3) low flow sampling conducted in September.

Figure 1 is a map of the Yellow River showing the sampling locations. Table 1 lists the specific location of each station. Sampling stations 1 through 7 were used during the rainfall runoff collections while all 10 stations were sampled at low flow. Rainfall runoff samples were collected using flow activated ISCO 1680* automatic samplers. Stream stage was measured using ISCO 1870* flow meters.

Stage height was converted to flow by means of a stage discharge relationship developed for each of the seven sampling stations. Rainfall amounts and intensities were recorded by Belfort Universal* recording rain gauges located near Stations 2, 4 and 6.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the University Hygienic Laboratory.

Table 1. Yellow River Sampling Locations

Station	Location
1	Winneshiek County Road Bridge T96N, R7W, Sec 13
2	Allamakee County Road Bridge T96N, R6W, Sec 9
3	Allamakee County Road Bridge T96N, R6W, Sec 12
4	Allamakee County Road Bridge T96N, R5W, Sec 9
5	Allamakee County Road Bridge T96N, R5W, Sec 15
6 ✓	Allamakee County Road Bridge T96N, R4W, Sec 18
7 ✓	Allamakee County Road Bridge X-36 T96N, R4W, Sec 24
8	Allamakee County Road Bridge T96N, R6W, Sec 33
9	Allamakee County Road Bridge T96N, R6W, Sec 21/22
10	Allamakee County Road Bridge X-16 T96N, R5W, Sec 8

A typical sampling event scenario was as follows: Rainfall in the watershed resulted in runoff into the stream. As the stream level increased to a predetermined level it activated the automatic samplers which began sampling at regular predetermined time intervals. The flow meter sensed the change in stream stage and recorded it on a continuous recording chart (hydrograph). The samplers were programmed to take samples at 90 minute intervals with a maximum of 9 samples collected per station per event. Samples were taken to the laboratory as soon after collection as possible. Once at the laboratory a preliminary turbidity measurement was performed on each sample (see Appendices 1 and 2). Using the turbidity values and the hydrograph for each station, 5 samples were selected for routine analysis. The most turbid sample at each station was analyzed for trace metals and pesticides. As a result of equipment failure at some stations during the second runoff event, samples per station ranged from two to nine.

During the low flow study, grab samples were collected using a high density polyethylene sampling bucket and a weighted stainless steel dissolved oxygen sampler. All stream flow measurements were conducted using the U.S. Geological Survey's method of computing cross-sectional area (4). A Price AA current meter and a top-setting wading rod or weighted cable were used to measure velocity and depth.*

Procedures used in sample preservation and analysis are described in Standard Methods (5), and the Manual of Methods for Chemical Analysis of Water and Wastes (6).

Sampling, flow measuring and rainfall recording equipment were installed in the watershed during the second week of May 1982. Over the length of the study, the equipment was inspected at least weekly for operation and vandalism.

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The two rainfall runoff events occurred on 14 and 15 June and on 15 and 16 July 1982. The low flow sampling was conducted on 21 September 1982.

RUNOFF EVENT #1 - 14-15 June 1982

The first runoff event occurred during mid-June when rainfall began around 1900 hrs on the 14th and ended at approximately 0900 hrs on the 15th. The majority of the rainfall occurred during two time periods; one from 2000 hrs on the 14th to 0100 hrs on the 15th, and the other from 0400 hrs to 0700 hrs on the 15th (see Appendices 3, 4, and 5 for rain charts). Total precipitation at Station 2 was 1.55 inches while Station 4 received 1.9 inches and 1.7 inches fell at Station 6.

To determine the amount of rainfall delivered to the stream, the volume of runoff was calculated for each station. The runoff in cubic feet was determined by integrating the area under the hydrograph curve for each station for the time duration specified. The depth of the runoff was determined by dividing the runoff volume for each station by the drainage area and multiplying by 12. Runoff data for the first event are listed below.

Table 2.

YELLOW RIVER RUNOFF Event #1 - 14-15 June 1982

	<u>Drainage Area</u> <u>(sq miles)</u>	<u>Runoff</u> <u>(cubic ft)</u>	<u>Runoff</u> <u>(inches)</u>	<u>Duration of</u> <u>Runoff Measured</u> <u>(minutes)</u>
Station 1	20	1,985,760	0.0043	1140
Station 2	26	101,280	0.0002	1140
Station 3	32	3,195,960	0.0043	1140
Station 4	37	-1,395,900	-0.0016	1140
Station 5	20	2,244,700	0.0048	1140
Station 6	44	15,555,500	0.0152	1140
Station 7	42	12,516,300	0.0128	1140

The drainage area and runoff listed represent the area and runoff between stations. The quantity of rainfall runoff measured did not always increase

with increases in drainage area. This is due to the varying topography, geology, vegetative cover and land use practices between stations that affect moisture retention. The negative value for Station 4 is apparently due to an underestimated flow. The high runoff measured at Stations 6 and 7 may be due to faster runoff delivery at those stations. Also, sampling was terminated before the stream had returned to baseline flow, thereby not accounting for all the rainfall runoff.

To facilitate the evaluation of the large amount of data generated by the study, the water quality data for the first runoff event will be discussed by analytical parameter. Only summary data will be presented in the text. A complete listing of all data collected may be found in the Appendices.

Stream Flow

The hydrograph record for each sampling station may be found in Appendices 6 through 12. Flow data for the first event on the Yellow River are listed below.

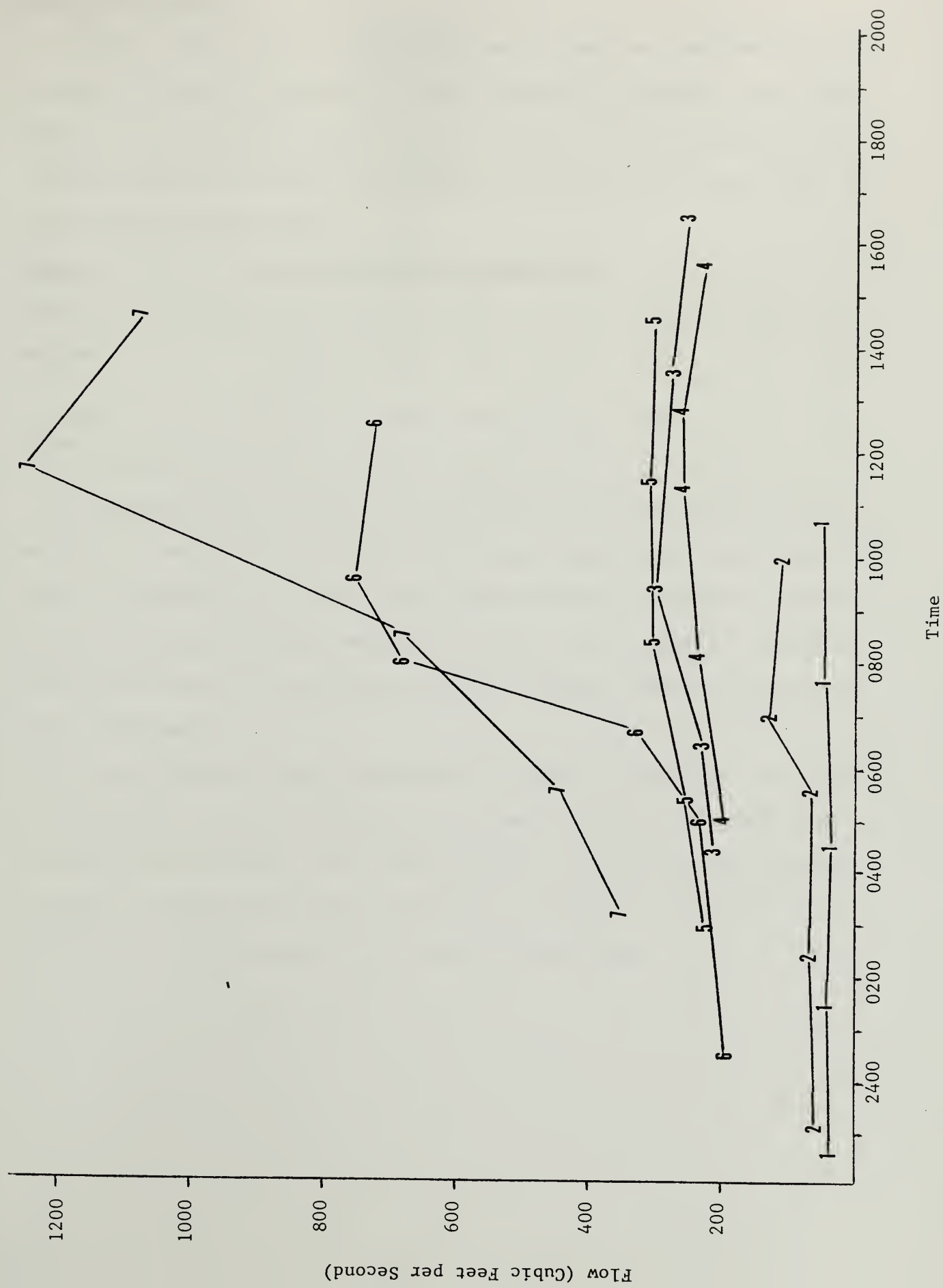
Table 3. Flow (cubic feet per second)

Station	1	2	3	4	5	6	7
Maximum	61	131	295	265	304	756	1300
Minimum	39	65	213	203	221	196	360

The stream flow ranged from a minimum of 39 cfs at Station 1 to a maximum of 1300 cfs at Station 7, generally increasing in a downstream direction. Flow at Stations 1 through 5 increased only moderately over time (Figure 2). Compared to the other stations, Stations 6 and 7 demonstrated a significant increase in flow which was related to the greater runoff that occurred at those stations.

The first three chemical parameters (specific conductance, pH and alkalinity) discussed are strongly interrelated and react similarly to external stimuli.

Figure 2. Stream Flow vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982



Specific Conductance

Specific conductance or conductivity is a numerical expression of the ability of an aqueous solution to carry an electrical current. This ability depends on the presence of ions, their total and relative concentrations, mobility, and their ionic charge. The maximum and minimum conductance values for each station are given below.

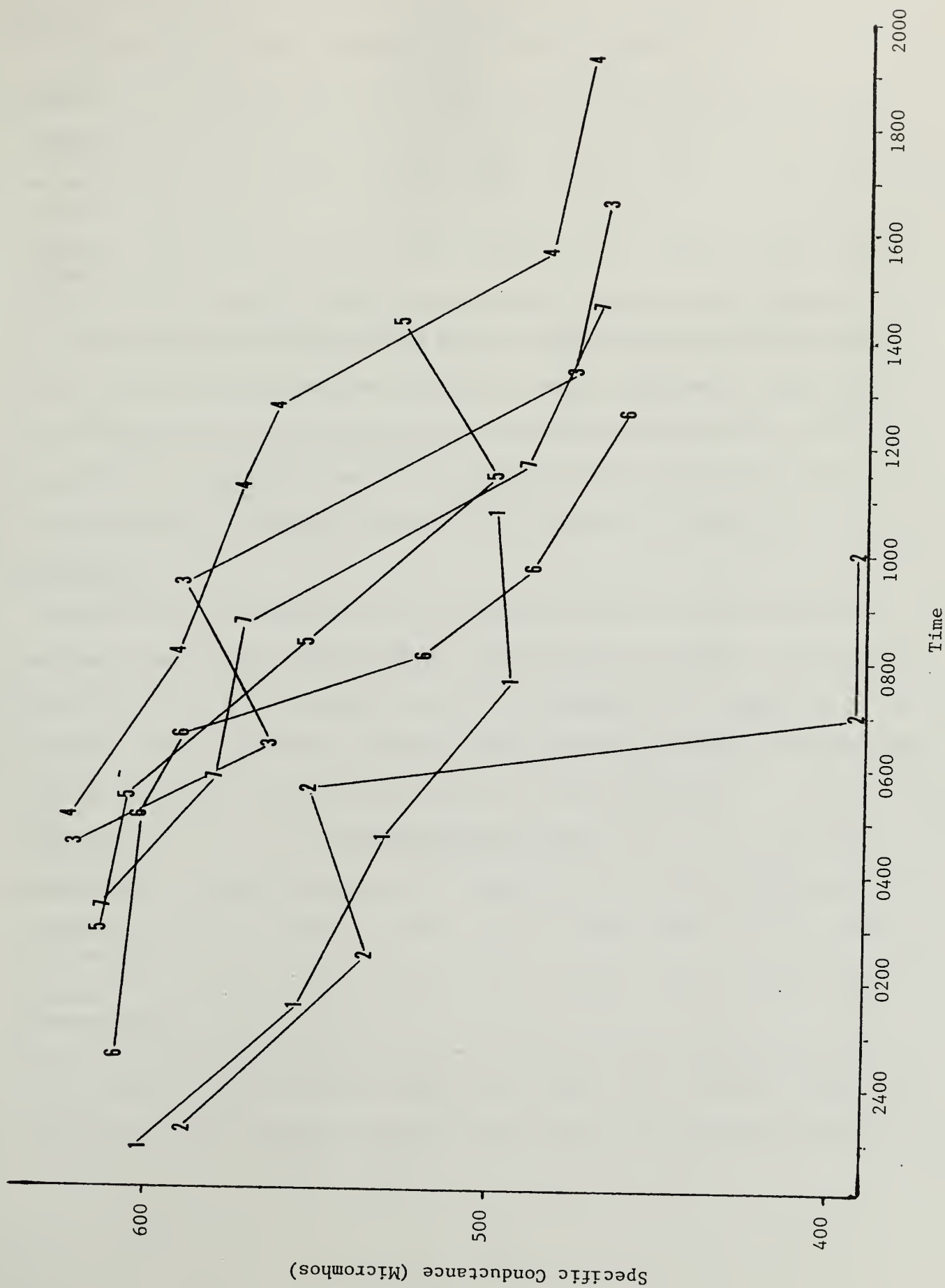
Table 4. Specific Conductance (micromhos)

Station	1	2	3	4	5	6	7
Maximum Value	600	580	630	630	610	610	610
Minimum Value	490	380	470	490	500	460	470

With the exception of Station 2, the ranges of values were similar for all stations. A comparison of specific conductance values over time is shown in Figure 3. Conductivity of the Yellow River was highest in the initial samples collected at each station and declined over time. The decline in conductivity is directly related to the dilution effect of rainwater which is usually very low in conductance.

The more pronounced drop in conductivity observed at Station 2 was caused by dilution from increased stream flow that resulted from heavy rainfall which occurred in the Station 2 area between 0430 hrs and 0600 hrs (see Appendices A3 and A7). Because of the small stream size at Station 2, the impact of this rainfall was more noticeable than at downstream stations.

Event 1 - 14 and 15 June 1982



pH

The range of pH values was relatively narrow (see below).

Table 5.

pH

Station	1	2	3	4	5	6	7
Maximum Value	8.2	8.0	8.0	8.1	8.1	8.2	8.3
Minimum Value	7.7	7.6	7.8	7.8	7.85	7.8	8.1

The pH values exhibited the same general trend as was observed with conductance, viz. values were greatest in the first sample collected at each station and declined over time. The decline in pH may also be attributed to the dilution affect of the rainfall which has a low pH (usually around 5.5 to 6.0). As with conductance, the greatest pH decline was observed at Station 2.

Alkalinity

Alkalinity is a measurement of the buffering capacity of a particular water and can be measured as phenolphthalein and/or total alkalinity. However the pH of the water has to be greater than 8.3 for phenolphthalein alkalinity to be measured. Thus only total alkalinity was measurable in this study and the maximum and minimum concentrations determined are listed below.

Table 6.

Total Alkalinity (mg/L)

Station	1	2	3	4	5	6	7
Maximum Concentration	252	253	275	274	266	269	267
Minimum Concentration	196	150	196	203	208	194	201

The range of total alkalinity values were similar with Station 2 being the exception. Total alkalinity values at each station declined over time with

the greatest decline occurring at Station 2. The drop in alkalinity was most probably caused by the dilution of river water with rainfall very low in alkalinity.

Nitrogen Series

The nitrogen series is composed of organic nitrogen, ammonia nitrogen and nitrate nitrogen. Organic nitrogen is defined as organically bound nitrogen and includes such naturally occurring substances as proteins, peptides, nucleic acids and urea. Typical organic nitrogen concentrations vary from a few hundred micrograms per liter in some lakes to more than 20 mg/L in raw sewage. The range of organic nitrogen concentrations and peak and total loads found at the seven Yellow River stations during the first event are listed below.

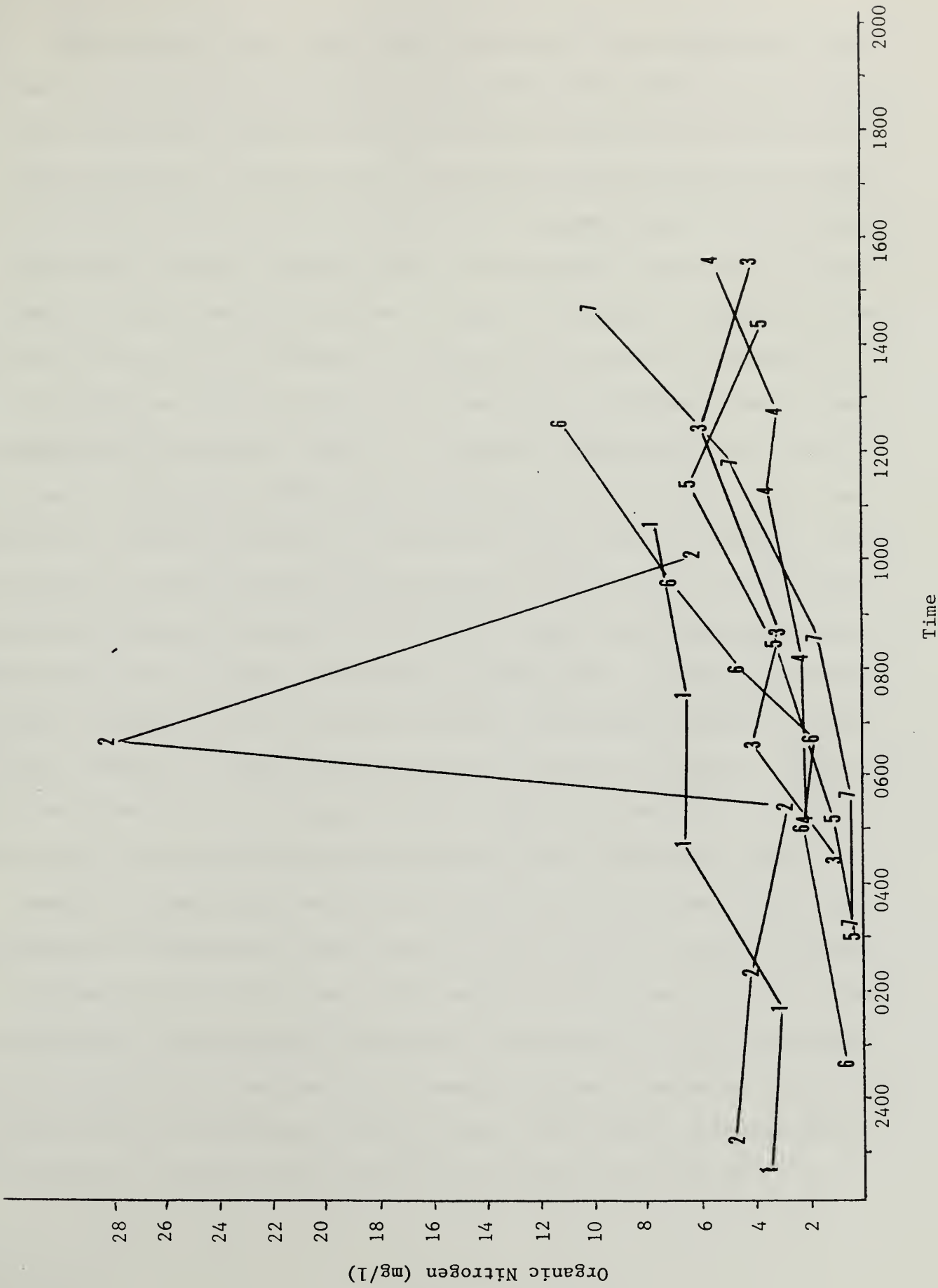
Table 7. Organic Nitrogen

Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	7.8	28	5.9	5.4	6.4	11	10
Minimum Concentration (mg/L)	2.9	2.8	1.2	1.1	0.38	0.57	0.40
Peak Load (kg/sec)	0.012	0.020	0.045	0.077	0.055	0.224	0.306
Total Load (kg/1140 min)	436	582	1,404	1,443	1,344	4,359	8,480

The range of maximum concentration values was from 5.4 to 28 mg/L. Stations 1, 3, 4 and 5 all had similar maximum values while Stations 6 and 7 were higher, and Station 2 had the highest concentration. Changes in the organic nitrogen concentration over time for each station are shown in Figure 4. As can be seen concentrations at Stations 1 through 5 had peaked and declined while concentrations at Stations 4, 6 and 7 were still increasing when the last sample was collected.

NOTE: 1 kg = 2.2 pounds

Figure 4. Organic Nitrogen Concentrations vs Time for the Seven Yellow River Sampling Stations
Event 1-14 and 15 June 1982



Instantaneous stream loadings were calculated by multiplying the stream flow at a given time by the parameter concentration measured at that time. This type of calculation determines the load a stream carried at a given time. The maximum quantity of a parameter that the stream is carrying at any given instant is defined as peak load. The total amount of a parameter that is carried over a given amount of time is the total load. Both peak and total organic nitrogen loads were calculated and are listed in Table 7. As would be expected, peak and total loads generally increased in a downstream direction with Stations 6 and 7 exhibiting the great-est load. By graphing the individual loads for each sampling time by station (Figure 5) it becomes evident that while Station 1 through 5 reached their peak loading, Stations 6 and 7 had not. Only a small portion of the high loadings at Stations 6 and 7 can be attributed to the instream load (that delivered from upstream stations). There must have been a substantial amount of material carried in the runoff from the drainage areas of Stations 6 and 7 to result in the high loads observed. The increase in stream organic nitrogen content is directly related to the rainfall runoff. As runoff occurs, sediment is washed into the stream. Attached to these soil particles are many substances, i.e. organic nitrogen, phosphates, pesticides and metals, that occur in greater concentrations when the solids content is higher.

Ammonia nitrogen occurs naturally in surface and wastewaters. Ammonia concentrations encountered in water vary from less than 10 g ammonia nitrogen/L in some natural surface and ground waters to more than 30 mg/L in some wastewaters. Because ammonia nitrogen has been shown to be toxic to fish and other aquatic life, Iowa has set an ammonia nitrogen standard of 2 mg/L in Class B warm water streams and 1 mg/L in Class B cold water streams from April 1 to October 31. Ammonia values for the first event are listed below.

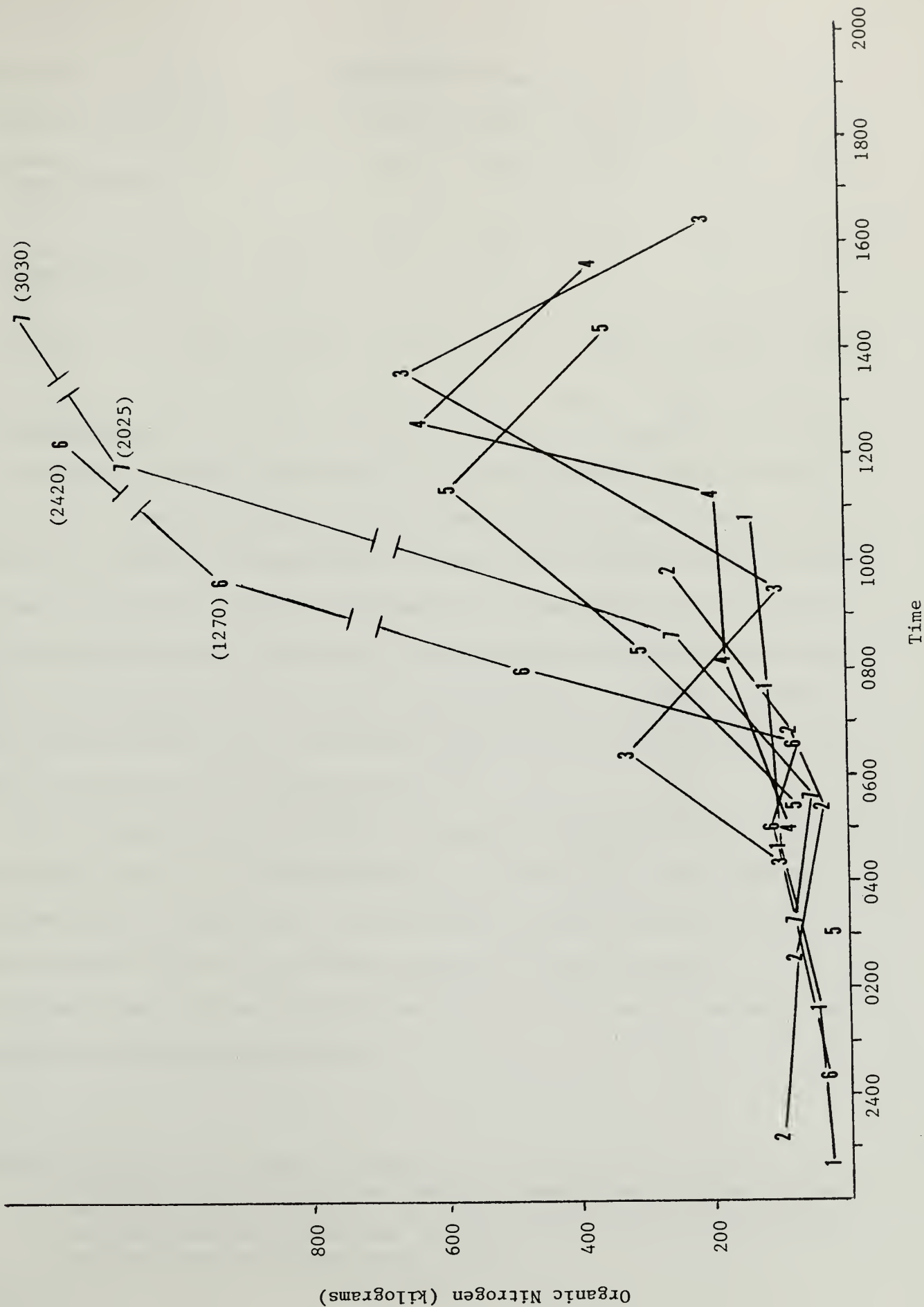


Table 8.

Ammonia Nitrogen

Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	1.3	1.3	0.88	0.69	0.58	0.87	0.22
Minimum Concentration (mg/L)	0.17	0.35	0.29	0.41	0.25	0.24	0.68
Peak Load (kg/sec)	0.002	0.012	0.007	0.004	0.005	0.018	0.021
Total Load (kg/1140 min)	67	101	224	190	169	383	491

The ammonia nitrogen values fell within a relatively small range (0.17 mg/L to 1.3 mg/L). Ammonia nitrogen concentrations by station over time have been plotted in Figure 6. Comparatively, Stations 1 and 2 had the highest ammonia values early in the sampling. The remaining stations showed a gradual increase in concentrations over time and most did not reach a peak concentration before the end of sampling. The 1.3 mg/L value measured at Station 2 exceeded the Iowa Water Quality Class B cold water standard of 1 mg/L, but was technically not in violation of the standard (see note).

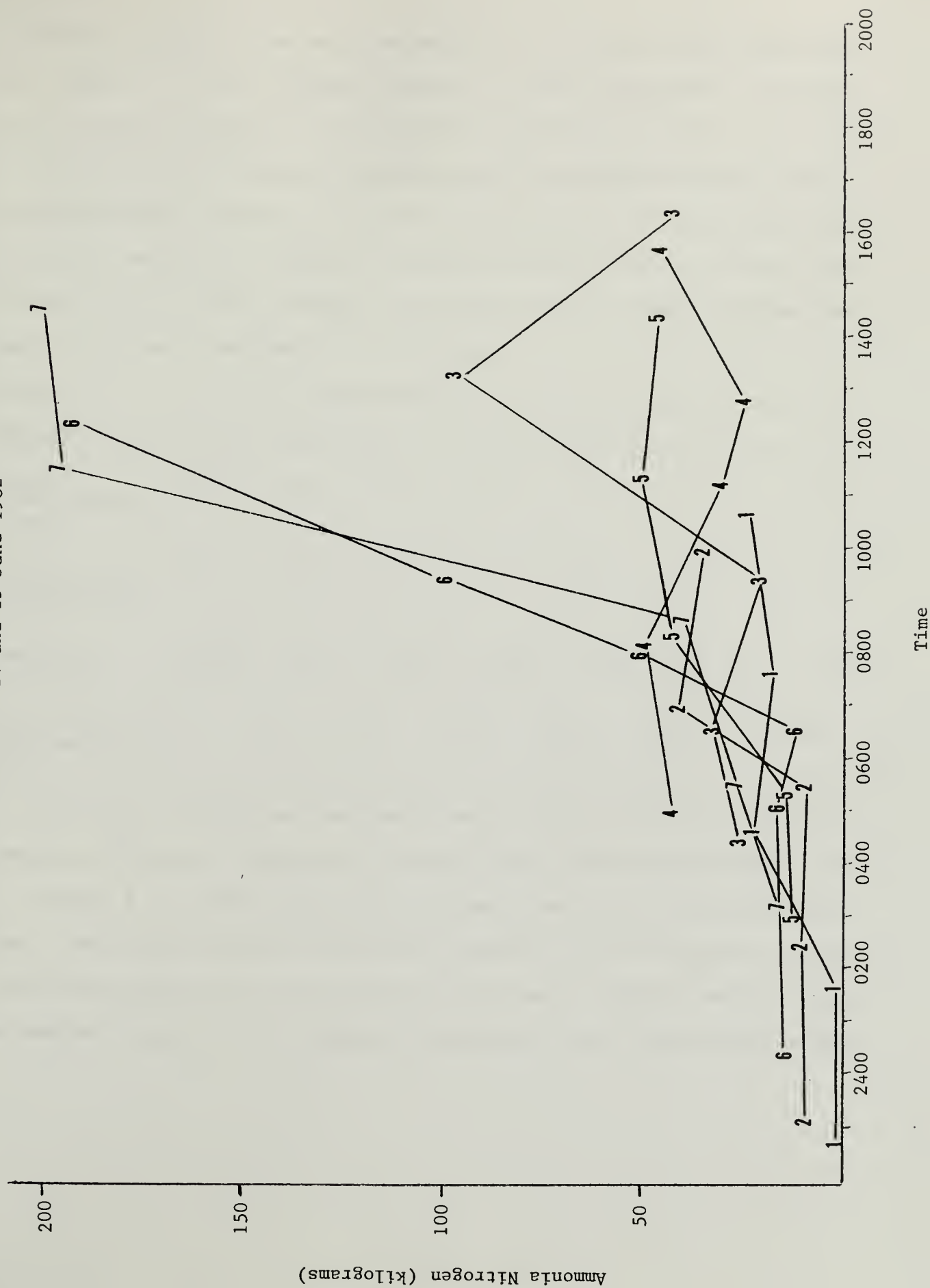
Peak and total loads for ammonia nitrogen demonstrate the general trend of increased loading in a downstream direction with Stations 6 and 7 having the highest peak and total load. By plotting each individual sample load over for each station (Figure 7) it becomes apparent that while Stations 1, 2, 3 and 5 reached a peak load and declined, Stations 4, 6 and 7 had not reached a peak load before sampling was terminated.

NOTE: The Iowa Water Quality Standards state "the levels set shall not be exceeded at any time the flow equals or exceeds the seven-day, ten-year low flow unless the material is from uncontrollable nonpoint sources." The assumption being made that the source of the elevated ammonia value was from uncontrollable nonpoint sources.

Event 1 - 14 and 15 June 1982



Figure 7. Ammonia Nitrogen Loads vs Time for the Seven Yellow River Sampling Stations
 Event 1 - 14 and 15 June 1982



Nitrate nitrogen is the most oxidized state of nitrogen and therefore the most stable. It is an essential nutrient for many photosynthetic autotrophs and in some cases may be a growth-limiting nutrient. A limit of 10 mg/L nitrate nitrogen has been set on drinking water to prevent an illness known as methemoglobinemia in infants. All tables except those in the appendices refer to nitrate expressed as nitrogen (nitrate-N) nitrogen only. To convert from nitrate (N) to nitrate, multiply the value by 4.43. Values obtained from Event 1 for the Yellow River are listed below.

Table 9.		Nitrate (N)					
Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	5.8	5.8	6.5	6.9	6.1	5.9	4.9
Minimum Concentration (mg/L)	4.2	3.5	5.0	5.2	5.3	5.0	4.8
Peak Load (kg/sec)	0.008	0.014	0.039	0.047	0.053	0.112	0.180
Total Load (kg/1140 min)	385	629	2,210	2,075	2,300	3,310	5,550

The range of values was relatively narrow (3.5 to 6.9 mg/L) with the greatest difference in concentration occurring at the upstream stations (1 and 2). Figure 8 is a graph representing nitrate concentration by station versus time. The graph indicates some dilution effect from the rainwater as most values drop slightly over time and then increase again. Nitrate concentrations at Station 7 appear to be completely unaffected by the runoff and remained

Figure 8. Nitrate Nitrogen Concentrations vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982

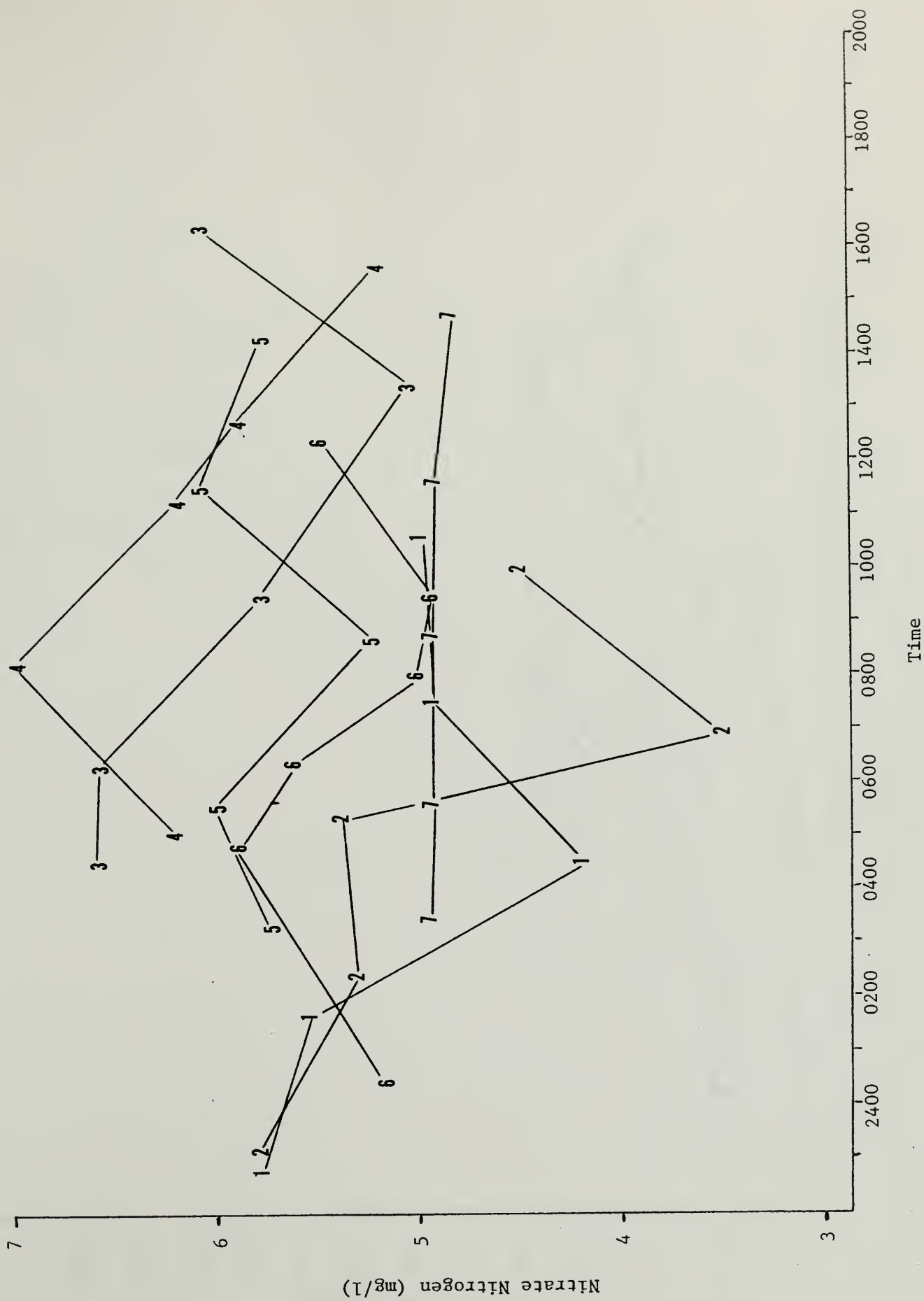
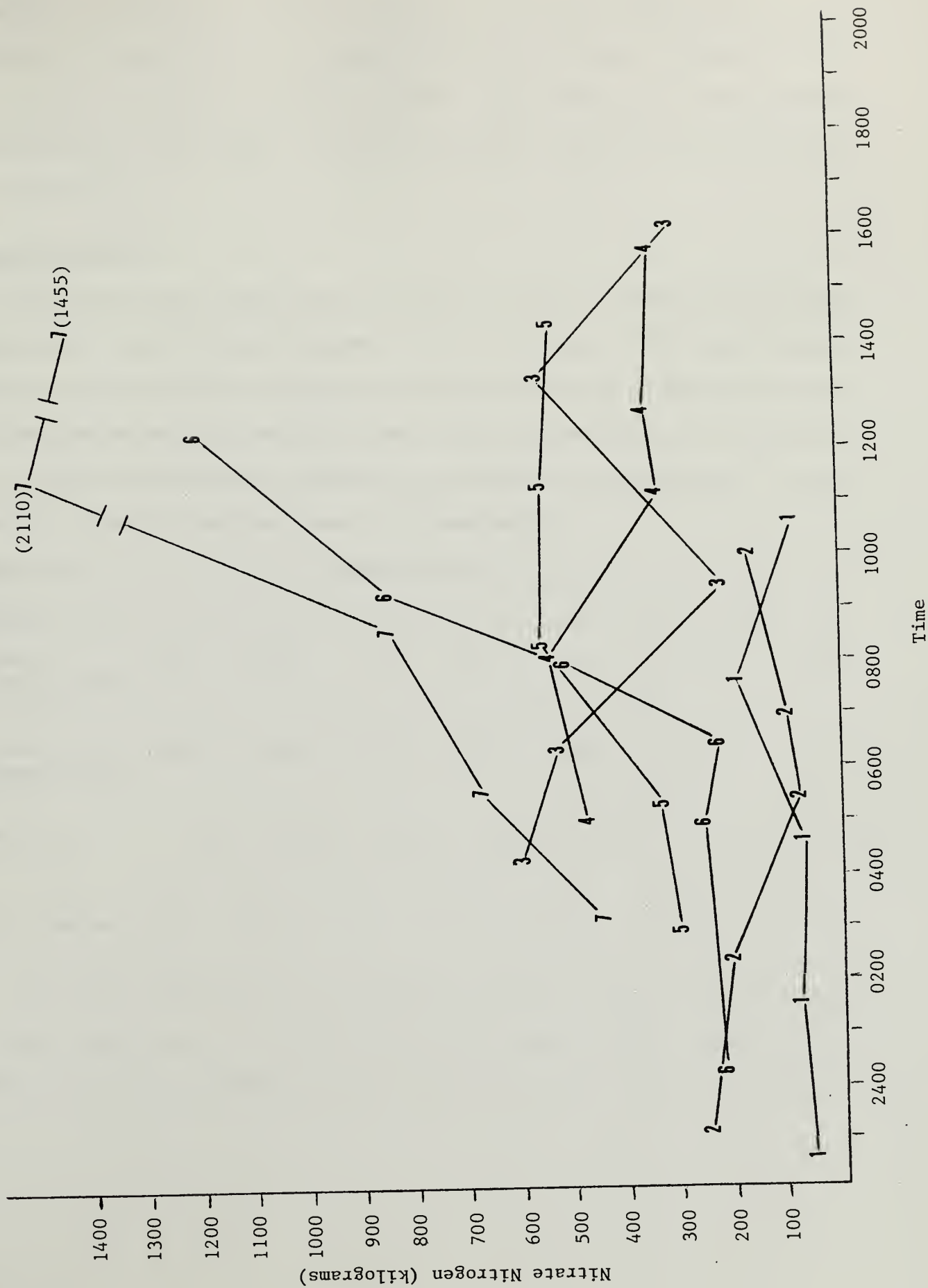


Figure 9. Nitrate Nitrogen Loads vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982



constant throughout the sampling period. The loading graph (Figure 9) for nitrate (N) demonstrates how increased flow affects loading. Although the concentration at Station 7 remained constant, the nitrate (N) load increased substantially. The increase was due to the greater amount of flow that occurred at Station 7.

Residue Series

The residue series (also known as solids series) is composed of filtrable (dissolved), nonfiltrable (suspended) and total residue. The term "residue" refers to solid material suspended or dissolved in water. Because the concentrations demonstrated parallel trends, only total residue will be discussed. All residue determinations conducted are listed in the appendices. Total residue values for the first event are listed below.

Table 10.

Total Residue

Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	2,000	15,000	1,700	1,400	1,600	3,100	2,400
- Minimum Concentration (mg/L)	850	740	600	880	390	560	610
Peak Load (kg/sec)	3.45	58.25	10.78	8.19	13.77	63.12	73.63
Total Load (kg/1140 min)	15,400	605,850	441,100	367,550	429,000	1,398,000	1,885,904

The maximum residue value was measured at Station 2 and was approximately 5 times greater than the values for the next highest station. With the exception of Station 2, maximum residue values ranged from 1,400 to 3,100 mg/L, a

relatively narrow range. The minimum concentration values occurred most often in the first sample and increased thereafter (Figure 10).

The extremely high concentration found at Station 2 appears to represent a very high, short term loading to the stream. Many other parameter values for that particular sample at Station 2 were also elevated and are directly related to the high residue content. The high residue concentration found at Station 2 also resulted in higher peak and total loads at Station 2 as compared to Stations 1, 3 and 4 (Figure 11). The residue loading graph is very similar to previous loading graphs in that Stations 1 through 5 have load values that are relatively similar. The higher residue loads at Station 6 and 7 continue to demonstrate the increased loading occurring at those stations. Peak load did not appear to have occurred at Station 6 but did occur at Station 7. As stated previously the major cause for the high loads at Stations 6 and 7 was the much higher flows measured at those stations.

Phosphorus

In aquatic systems the element phosphorus is usually found in the oxidized form of phosphate (PO_4). Phosphorus is a necessary compound essential for the growth of organisms (particularly algae) and is a nutrient that frequently limits the growth of the primary producers in an aquatic system. It should be noted that the values are given as elemental phosphorus (P) not as phosphate (PO_4). To obtain the phosphate concentration multiply the concentrations of P by 3.06. The filterable phosphorus is basically the soluble portion of phosphorus that is in a form readily available to the primary producers. The total phosphorus represents this soluble form and phosphorus that is organically bound and not currently available to the primary producers. The maximum and minimum filtrable phosphorus values from the Yellow River for Event 1 are listed in Table 11.

Figure 10. Total Solids Concentration vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982

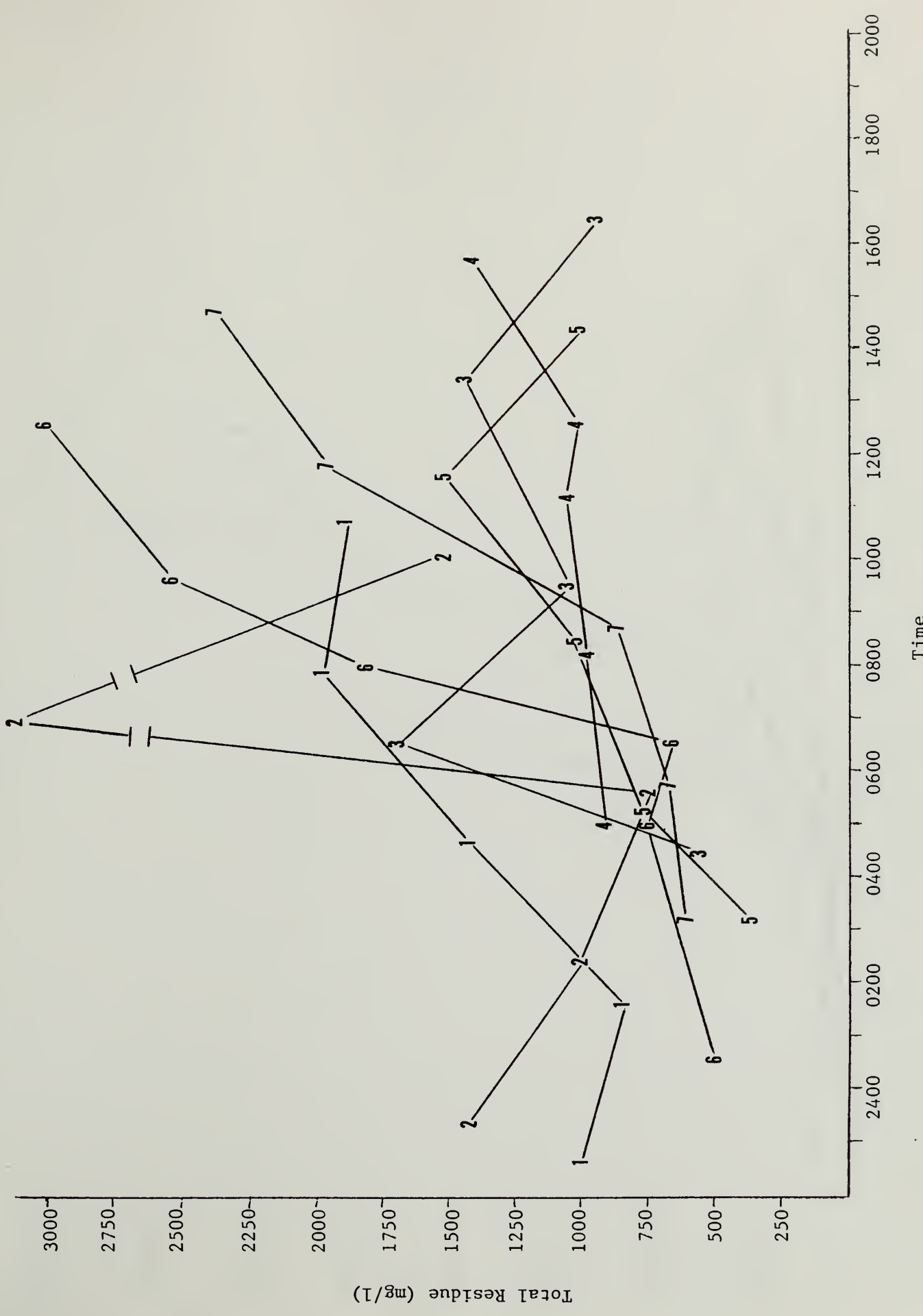


Figure 11. Total Residue Loads vs Time for the Seven Yellow River Sampling Stations
 Event 1 - 14 and 15 June 1982

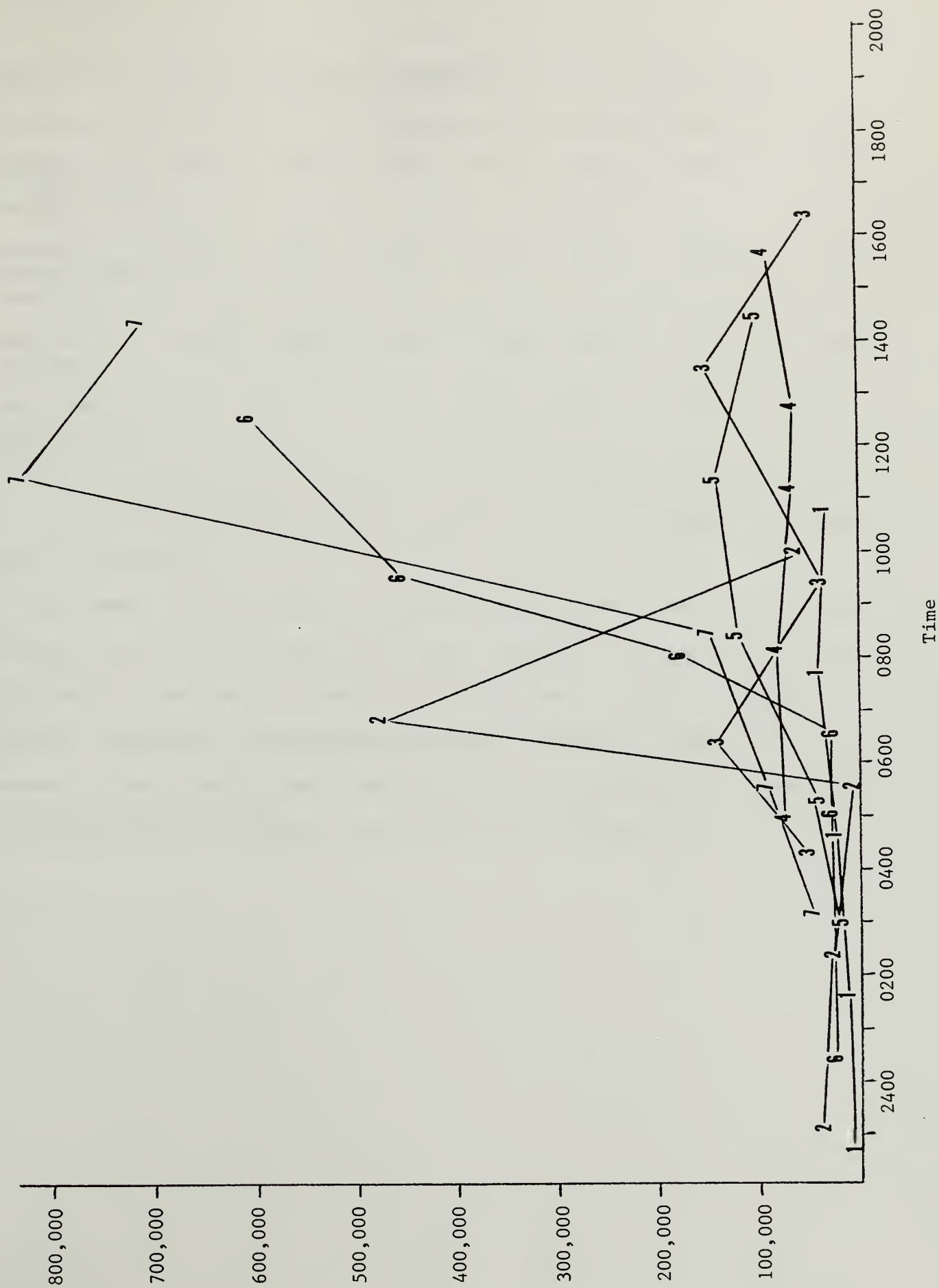


Table 11. Filtrable Phosphorus

Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	0.46	0.60	0.38	0.33	0.39	0.29	0.24
Minimum Concentration (mg/L)	0.15	0.21	0.13	0.09	0.12	0.06	0.05
Peak Load (kg/sec)	0.001	0.002	0.003	0.002	0.003	0.006	0.007
Total Load (kg/1140 min)	26	55	94	66	97	143	185

In general the filtrable phosphorus values were low and reflect only minor input to the stream.

The highest concentrations were measured at Stations 1 and 2 and may be related to runoff from cropland in that area. Maximum concentrations of filtrable phosphorus decrease in a downstream direction most probably as a result of dilution. Although the concentration decreased, the overall loadings increased because of the increased flow. Concentrations at each station increased over time and the overall loadings increased because of increased flow.

Values for total phosphorus from the Yellow River Event 1 are listed below.

Table 12.		Total Phosphorus					
Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	3.0	11	2.2	2.2	1.9	3.3	2.8
Minimum Concentration (mg/L)	0.97	1.1	0.56	0.51	0.20	0.21	0.22
Peak Load (kg/sec)	0.005	0.009	0.011	0.013	0.016	0.067	0.086
Total Load (kg/1140 min)	158	240	286	378	447	1,349	1,739

Maximum total phosphorus concentrations were relatively consistent with the exception of Station 2. The high phosphorus value at Station 2 occurred at the same time as the very high residue at that station and may be attributed to the organically bound phosphorus residue. Except for Stations 1 and 2, most values for total phosphorus were low on the initial sample and increased over time. The higher values at 1 and 2 may be due to the first flush effect of the runoff with little dilution. A graph of total phosphorus over time (Figure 12) shows Stations 2, 3 and 5 reaching peak concentrations and declining while Stations 1, 4, 6 and 7 did not. The loading graph for total phosphorus (Figure 13) also demonstrates that peak loading had not occurred at all stations especially Stations 6 and 7, during the sampling period.

Figure 12. Total Phosphorus Concentrations vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982

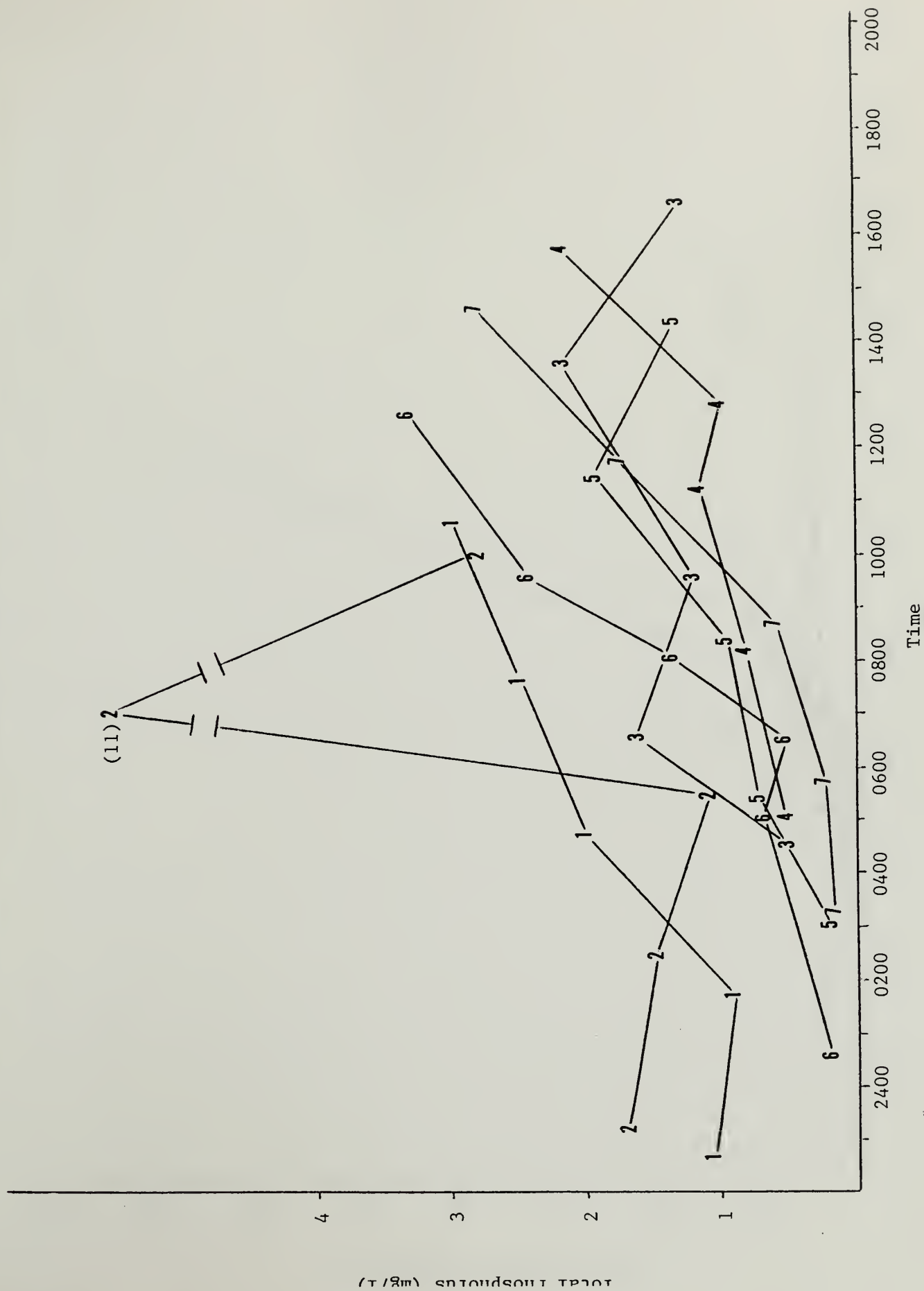
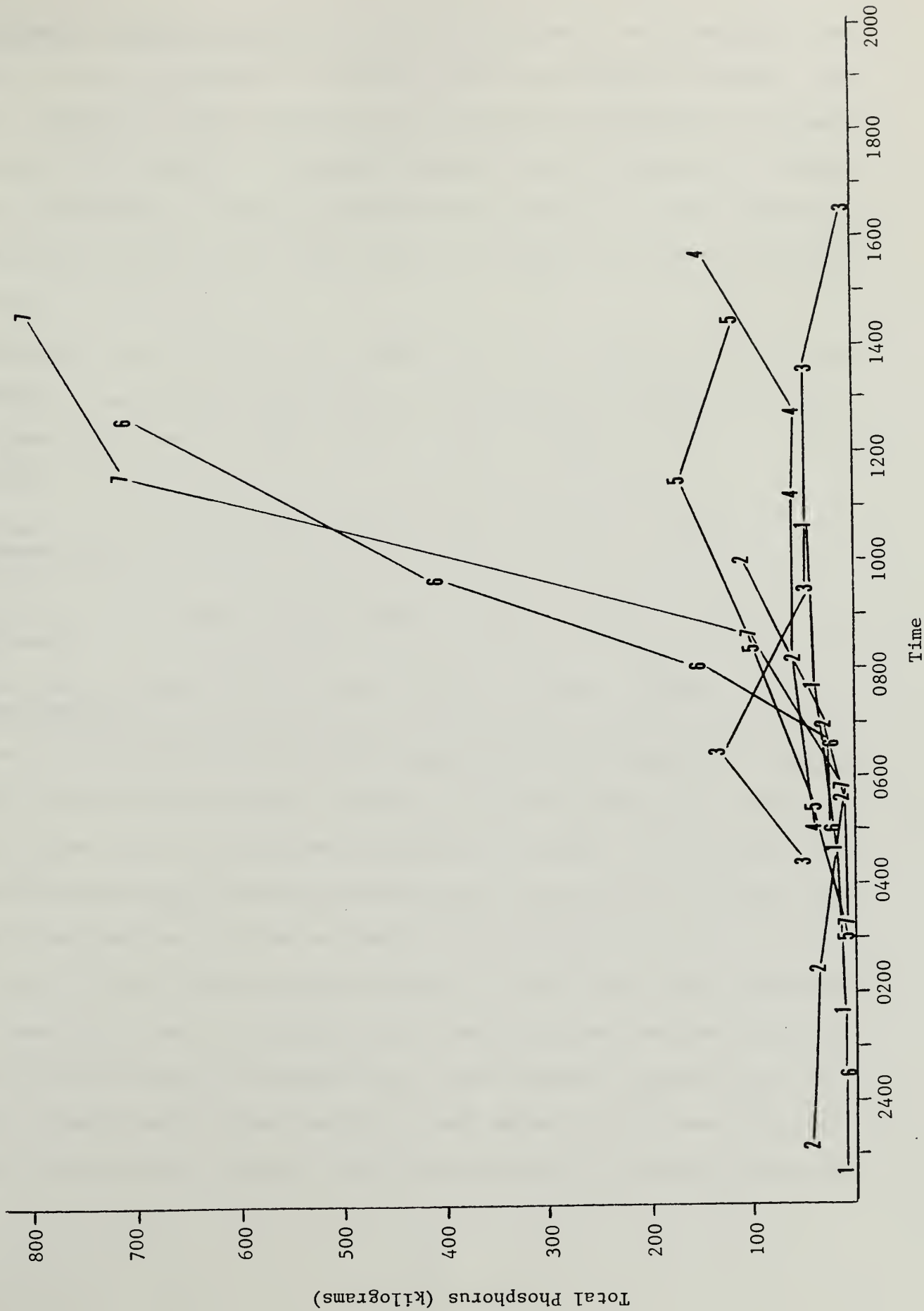


Figure 13. Total Phosphorus Loads vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982

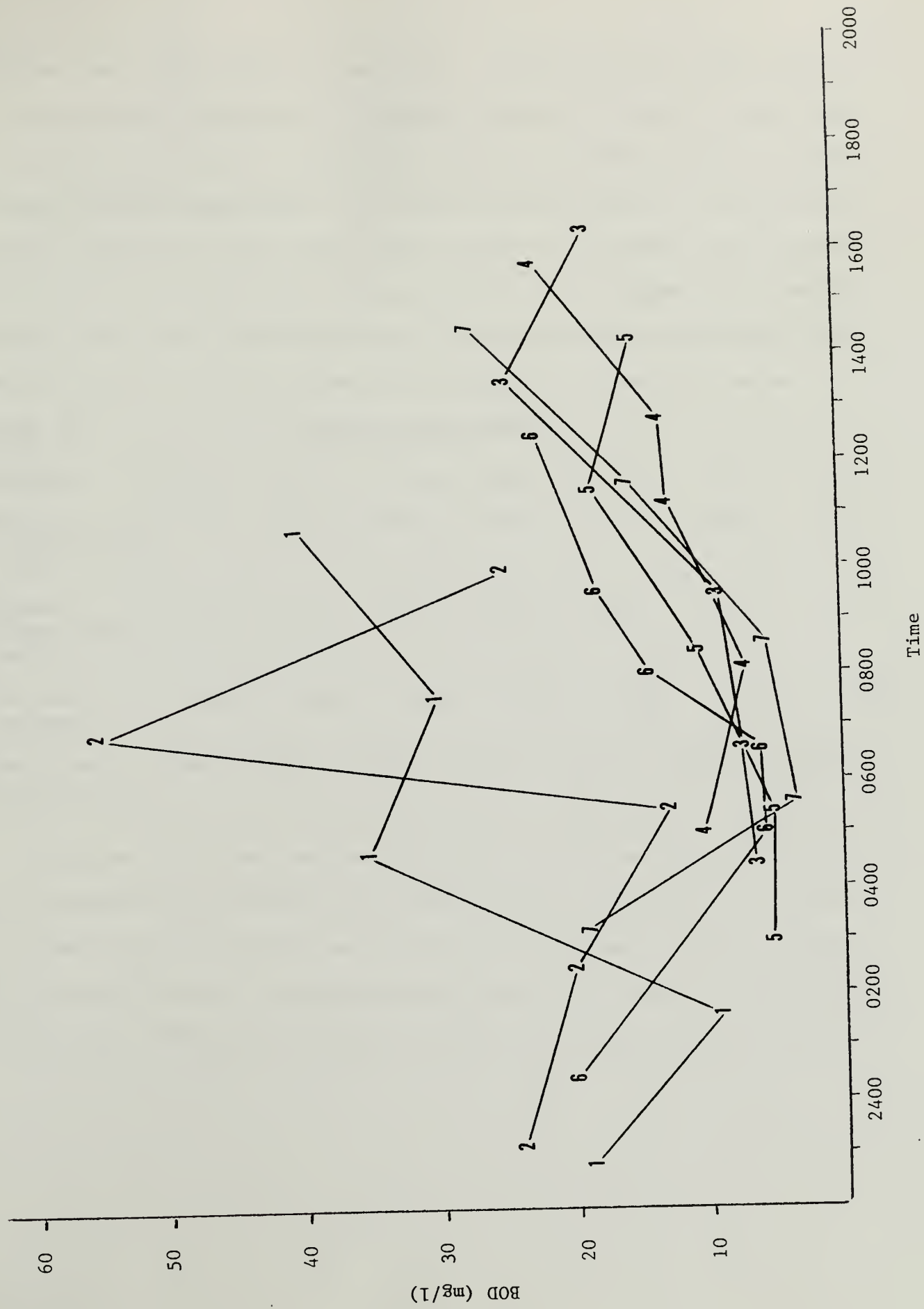


Biochemical Oxygen Demand (BOD) - The BOD determination is an empirical test which is used to determine the relative oxygen requirements of waters. The test measures the oxygen required for the biochemical degradation of organic material, the oxidation of inorganic material and the oxidation of reduced forms of nitrogen. Typical stream BOD values during non-runoff conditions are usually 5 mg/L or less. BOD values for the first runoff event are listed below.

Table 13.		BOD					
Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	40	55	24	22	18	22	27
Minimum Concentration (mg/L)	9	13	6	7	5	6	4
Peak Load (kg/sec)	0.063	0.204	0.098	0.129	0.155	0.448	0.826
Total Load (kg/1140 min)	2,144	3,716	5,030	4,320	4,765	10,880	18,415

As can be seen from the table, BOD ranges were quite variable with Stations 1 and 2 having the widest range. By plotting the BOD values for each station by time (Figure 14), data trends become apparent. Stations 1 and 2 start out with high BOD values decline and then increase again. This follows the rainfall pattern (see appendices) with BOD responding to the times of heavy rain at Stations 1 and 2. Initial BOD values for Stations 3, 4 and 5 were lower and slowly increased over time with all but Station 4 reaching a peak and then declining. The first BOD values for Stations 6 and 7 were elevated, declined with time, then increased again without reaching a peak before sampling was terminated. The trend observed at Stations 6 and 7 also follows the rainfall pattern and

Figure 14. BOD Concentrations vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982



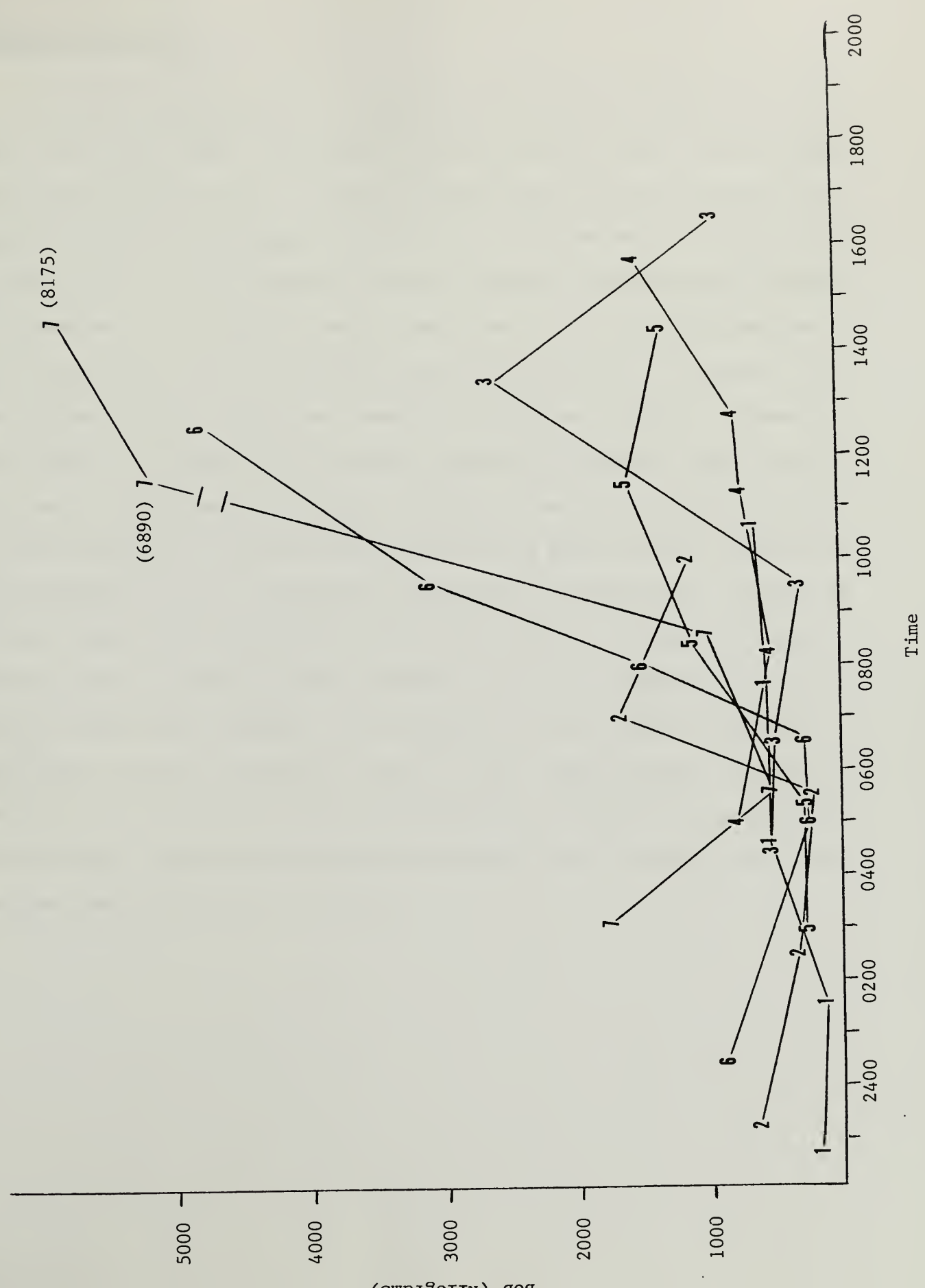
reflects the runoff loading to the stream. The peak and total loads generally show an increase proceeding in a downstream direction (Figure 15). Peak loads were not established for Stations 6 and 7 before the last sample was collected.

Chemical Oxygen Demand (COD) - The chemical oxygen demand is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For samples from a specific source, COD can be related empirically to BOD and Total Organic Carbon (TOC). The COD values for the first event on the Yellow River are listed below.

Table 14.		Chemical Oxygen Demand					
Station	1	2	3	4	5	6	7
Maximum Concentration (mg/L)	195	722	162	139	151	258	199
Minimum Concentration (mg/L)	75	77	44	50	29	50	29
Peak Load (kg/sec)	0.311	2.68	0.666	0.813	1.30	5.25	6.09
Total Load (kg/1140 min)	11,600	35,800	38,500	28,400	36,300	106,500	129,900

The maximum COD values occurred at Station 2 and may be associated with the high residue that was present at the same time. The COD values for other stations were relatively similar and increased with increased residues. Peak and total loads increased in a downstream direction as flow increased, with Stations 6 and 7 again exhibiting the greatest loads but not attaining peak loading.

Figure 15. BOD Loads vs Time for the Seven Yellow River Sampling Stations
Event 1 - 14 and 15 June 1982



Summary of Event #1

Rainfall of approximately 1.5 inches fell throughout the Yellow River basin on 14 and 15 June 1982. The amount of runoff delivered to the river was greatest at the Stations 6 and 7. Parameter concentrations such as conductivity, pH, alkalinity and nitrate decreased over time. These decreases were due to the dilution effect of the rainwater. Several parameter concentrations increased (nitrogen series, phosphorus, metals, pesticides) and were directly related to their association with the residue (solids) concentration. Increases in the more water-soluble contaminants (ammonia nitrogen and filterable phosphorus) were minimal. Although three parameters (ammonia nitrogen-one sample, barium-one sample, and copper-five samples) exceeded the Iowa Water Quality Standards, it was assumed they originated from uncontrollable point sources and therefore the standards were not applicable. The parameter concentrations observed at Station 2 were much greater than at any other station and indicate an atypical drainage area. Because of the increase in flow in a downstream direction, loading values also increased. The greatest flow and loading values for all parameters occurred at Stations 6 and 7. Peak loading values could not be determined at at Stations 6 and 7 because sampling was completed before the end of the event. The total load values therefore do not adequately reflect the maximum total load for those stations.

RUNOFF EVENT #2 - 15 AND 16 JULY 1982

Upon completion of the first event, the sampling equipment was inactivated. The intent being to collect the recreational season runoff event later in the summer. The sampling equipment was reactivated early in July. The second runoff event occurred as a result of rain that fell on 15 July 1982. The rain was of relatively short duration, beginning about 1745 hrs and ending around 2000 hrs on the 15th. Total rainfall at Station 2 was 0.9 inches and 0.45 inches at Station 6 (see Appendices 20 and 21). The rainfall intensity guage at Station 4 was destroyed by vandals prior to the event so rainfall intensity data is not available. Rainfall runoff values for the second event are listed below. The wide variation in rainfall between Stations 2 and 6 was reflected in the runoff delivered to the stream.

Table 18.

YELLOW RIVER RUNOFF Event #2 - 15-16 July 1982

	Drainage Area (sq. miles)	Runoff (cubic ft.)	Runoff (inches)	Duration of Runoff Measured (minutes)
Station 1	20	1,679,400	0.0036	810
Station 2	26	345,600	0.0006	810
Station 5	20	8,278,200	0.0178	1,260
Station 6	44	3,251,700	0.0032	1,110
Station 7	42	-5,112,900	-0.0052	930

Because of equipment malfunctions, runoff was measured and samples collected only at 5 stations. The runoff was quite variable ranging from 0.0178 inches at Station 5 to a -0.0052 inches at Station 7. The higher value at Station 5 may be due to the longer time duration measured and may be more representative of the total runoff. The negative value at Station 7 may be a result of more rainfall occurring at upstream station than at Station 7. Because of the shorter time duration of measurement it might not account for all the rainfall runoff. As with the first event the results will be discussed by parameters. All data collected may be found in the appendices.

Stream Flow

The hydrographs for the second event may found in Appendices 22 through 26. Figure 16 is a graphical representation of the streamflow for the 5 stations on the Yellow River during the second event. Stations 1 and 2 showed a modest rise in flow and a slow decline over time. The flow at Station 5 increased sharply between 2230 and 2400 hrs most probably as a result of upstream flow reaching that station. Between 0100 and 0200 hrs a dramatic increase in flow was observed at Station 6 and may have been caused by the same surge in flow as that which occurred at Station 5. Flow at Station 7 was generally a steady moderate rise over a period of several hours. Figure 16 also demonstrates the affects of accumulative drainage area on river flow. Stations 1 and 2 located in the head waters had only minor increases in flow whereas the lower stations with much more drainage area had a greater change in flows.

Specific Conductance

The range of values for specific conductance at all stations sampled are tabled below.

Table 19. Specific Conductance (micromhos)

Station	1	2	5	6*	7
Maximum Concentration	630	410	620	490	610
Minimum Concentration	370	290	420	470	550

*only two samples collected

As discussed previously rainfall over the basin was not equally distributed and therefore runoff delivered to the stream was not uniform. This caused parameter values between stations to be highly variable. For example, conductivity at Stations 1 and 5 declined over time (Figure 17) while Station 2 initially declined and then increased to pre-runoff values.

Figure 16. Stream Flow vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982

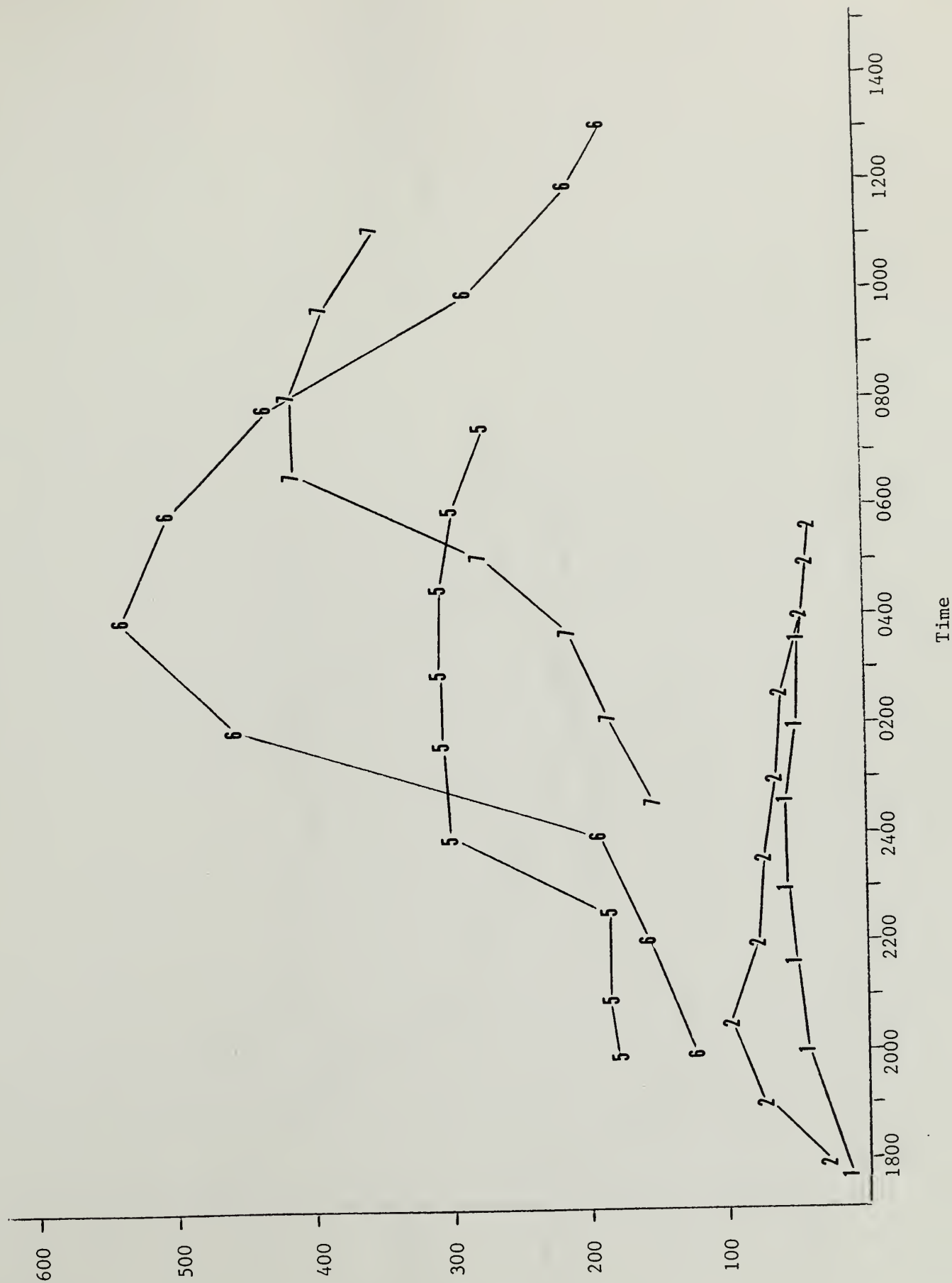
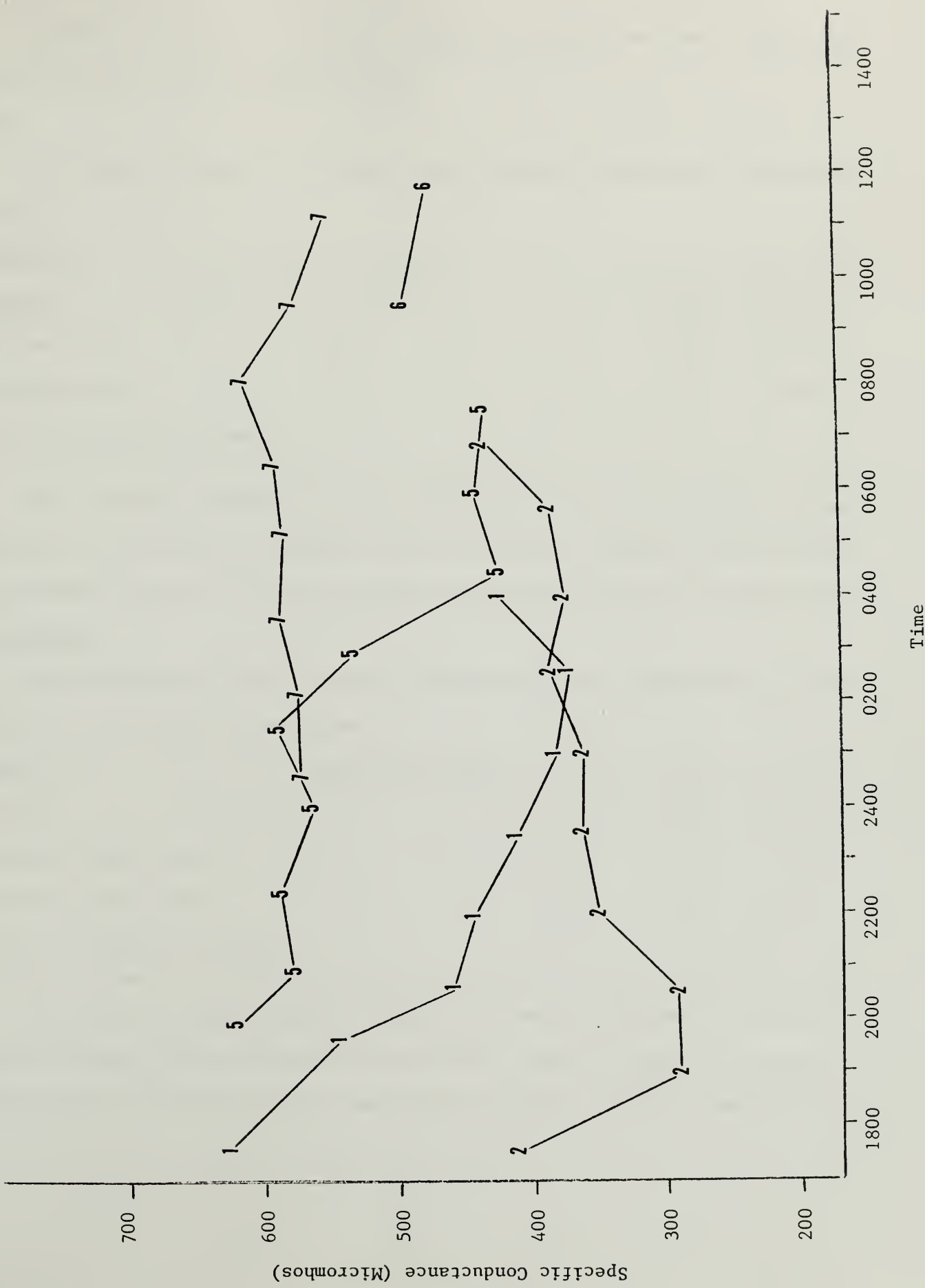


Figure 17. Specific Conductance vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



Conductivity values for Station 7 did not fluctuate very much indicating little effect from the rainfall runoff.

pH

The range of values for pH at the five Yellow River Stations are tabulated below.

Table 20.		pH				
Station	1	2	5	6*	7	
Maximum Value	8.2	7.9	8.3	7.8	7.9	
Minimum Value	7.7	7.6	7.7	7.7	7.8	

*only two samples collected

The greatest difference in pH values again occurring at the upstream stations. Very little difference in pH was noted at Station 7 and reflects the stream's ability to assimilate change over distance and with increased flow.

Alkalinity

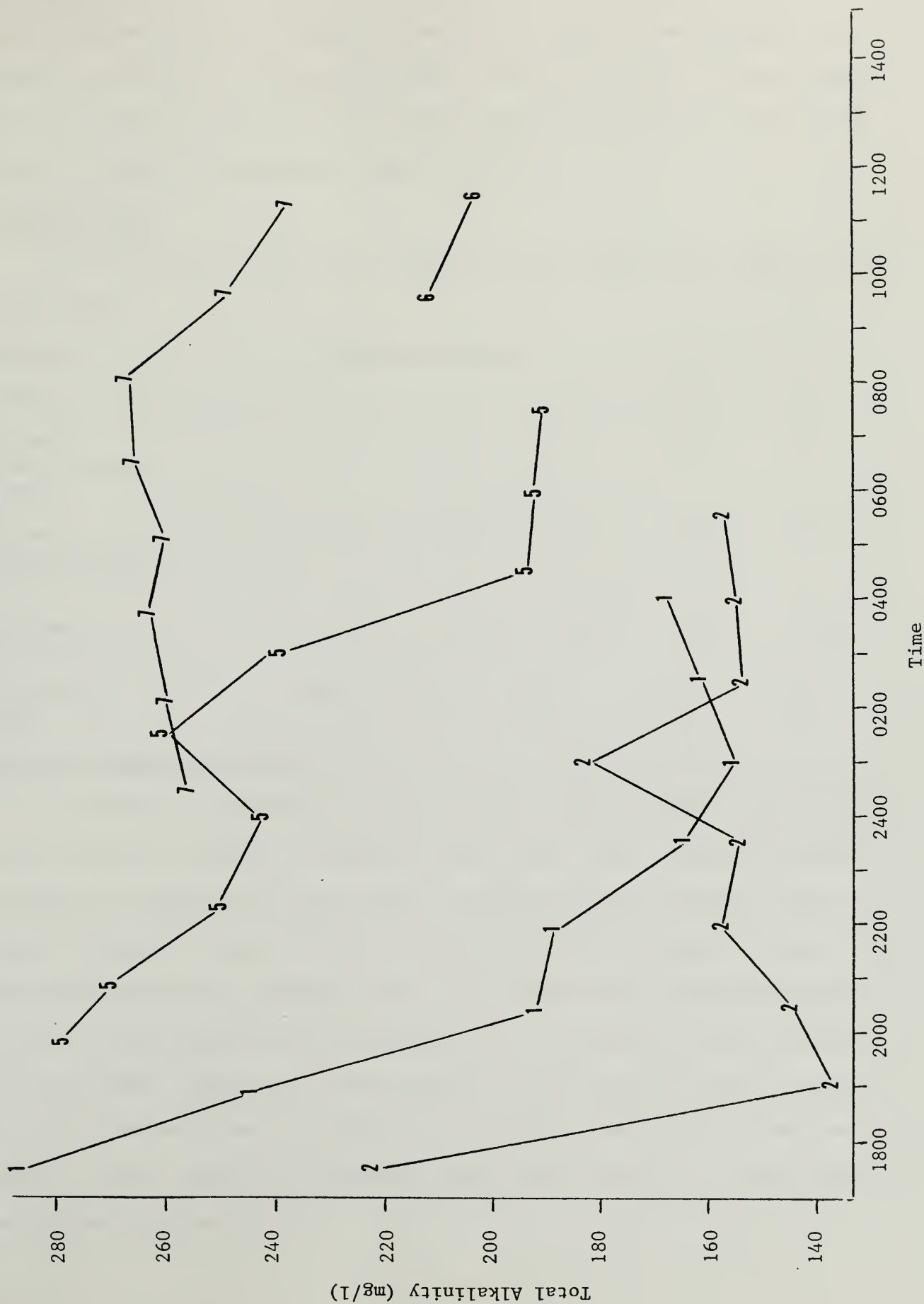
No phenolphthalein alkalinity was measured during the second event. Total alkalinity values are listed below.

Table 21.	Alkalinity (mg/L)				
Station	1	2	5	6*	7
Maximum Concentration	277	224	278	214	268
Minimum Concentration	156	138	192	205	238

*only two samples collected

The graph for total alkalinity (Figure 18) demonstrates how the impact of rainfall runoff affects the different stations. Stations 1 and 2 had a significant decline in alkalinity over time while the decline at Station 5 was moderate

Figure 18. Total Alkalinity vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



and the change in values at Station 7 was minor. The upstream changes in alkalinity are the result of rainfall runoff's ability to impact a stream segment with relatively low background flow. The absence of impact on the downstream segment was due to insufficient rainfall runoff.

Nitrogen Series

The concentrations of organic nitrogen at each station for Event 2 are listed below.

Table 22.		Organic Nitrogen				
Station	1	2	5	6*	7	
Maximum Concentration (mg/L)	14	24	10	7.0	2.9	
Minimum Concentration (mg/L)	1.3	9.2	1.2	5.9	0.82	
Peak Load (kg/sec)	0.023	0.057	0.087	0.057	0.028	
Total Load (kg)	549	1,265	2,014	*	639	

*only two samples collected

In reviewing the graph for organic nitrogen (Figure 19) Stations 1 and 5 show a definite increase in organic nitrogen over time. The first samples collected at Station 2 were very high in organic nitrogen and even though the values declined over time, the lowest values at Station 2 were about equal to the peak values seen at Stations 1 and 5. Concentrations of organic nitrogen at Station 7 had a relatively narrow range (0.82 - 2.9 mg/L) and increased minimally over time. The loading curves (Figure 20) for organic nitrogen indicates that all stations except for Station 7 reached a peak load and declined. Station 7 values reflect an increased loading which was still increasing when sampling was terminated.

Figure 19. Organic Nitrogen Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982

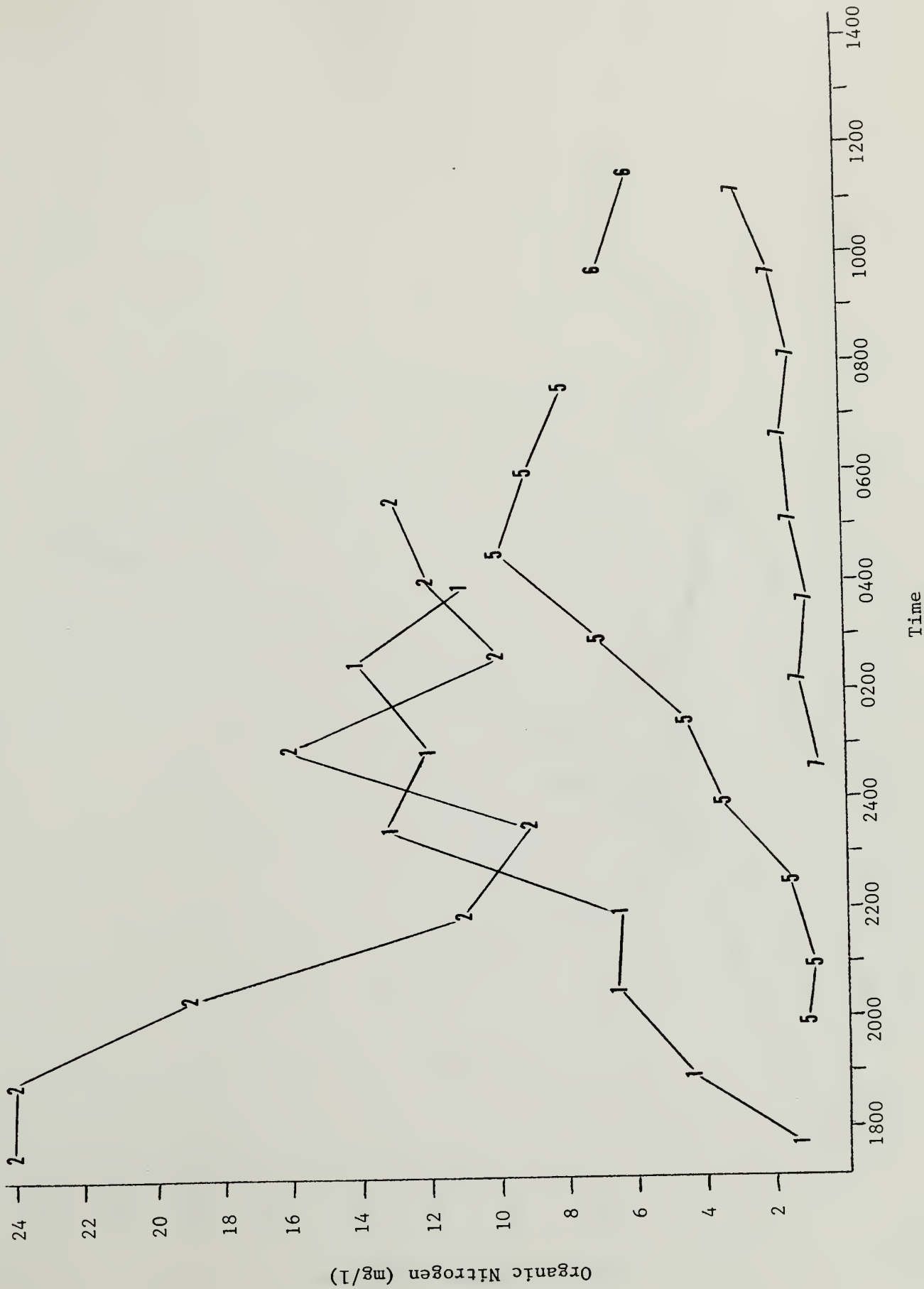
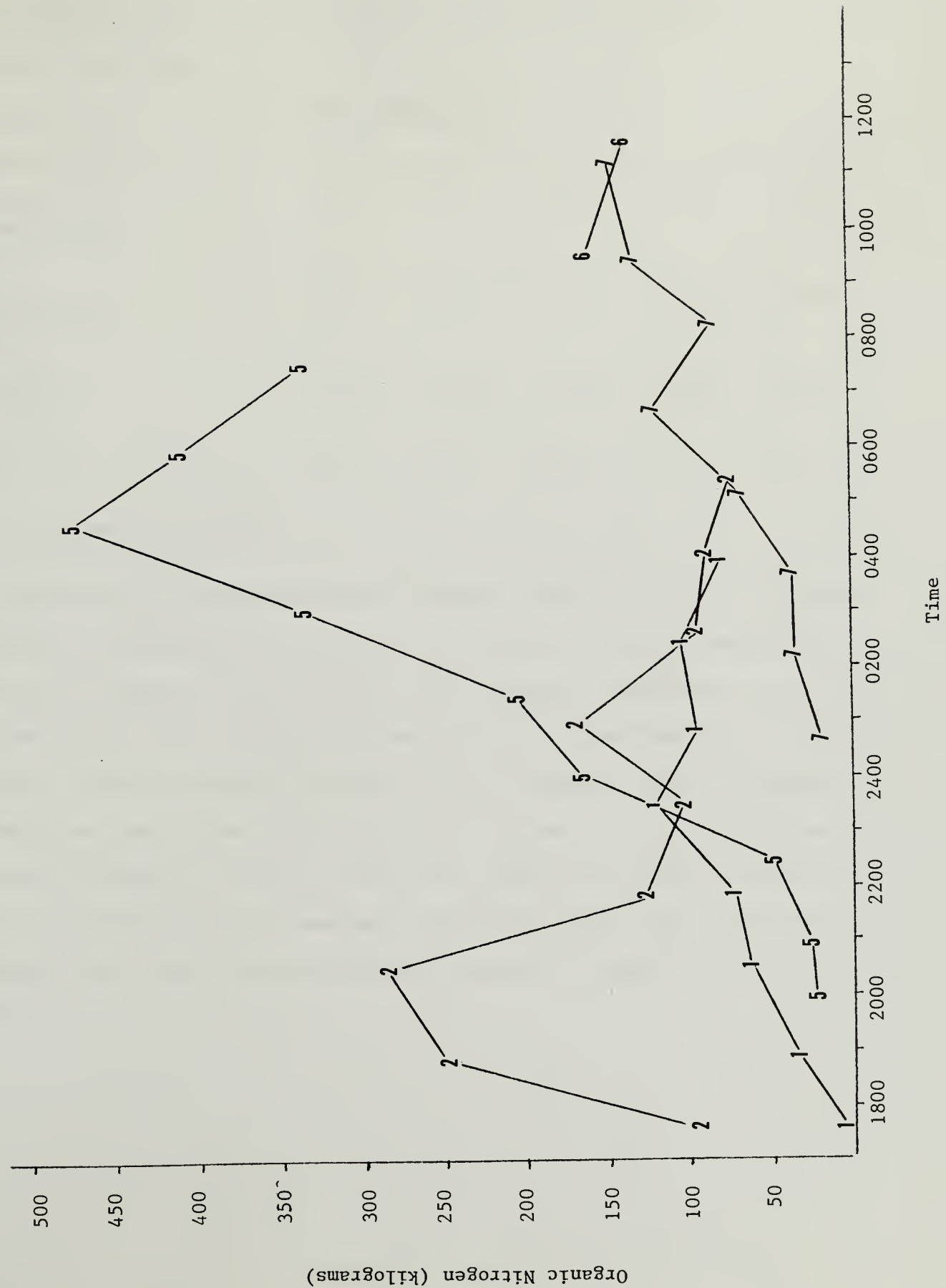


Figure 20. Organic Nitrogen Loads vs Time for the Five Yellow River Sampling Stations
Event 2 -15 and 16 July 1982



Ammonia Nitrogen - The ammonia nitrogen concentration and loadings for each station are listed below.

Table 23. Ammonia Nitrogen

Station	1	2	5	6*	7
Maximum Concentration (mg/L)	1.1	1.5	0.21	0.15	0.07
Minimum Concentration (mg/L)	0.06	0.25	0.04	0.13	0.06
Peak Load (kg/sec)	0.002	0.003	0.002	0.001	0.001
Total Load (kg)	33.4	50.4	40.6	--	23.8

*only two samples collected

Maximum ammonia concentrations were highest at Stations 1 and 2 with maximum concentrations decreasing in a downstream direction. The initial sample concentrations at Station 1 were relatively low, increased dramatically, and then declined (Figure 21). Station 2 showed a similar trend, but with a higher maximum. The time difference between peaks at Stations 1 and 2 most probably reflects the travel time between stations. Station 5 had only a very small increase in ammonia. Station 7 values were constant throughout the sampling period. Individual ammonia loads were plotted for each station (Figure 22). Peak and total loading values for ammonia nitrogen were greatest at Stations 1 and 2.

Figure 21. Ammonia Nitrogen Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982

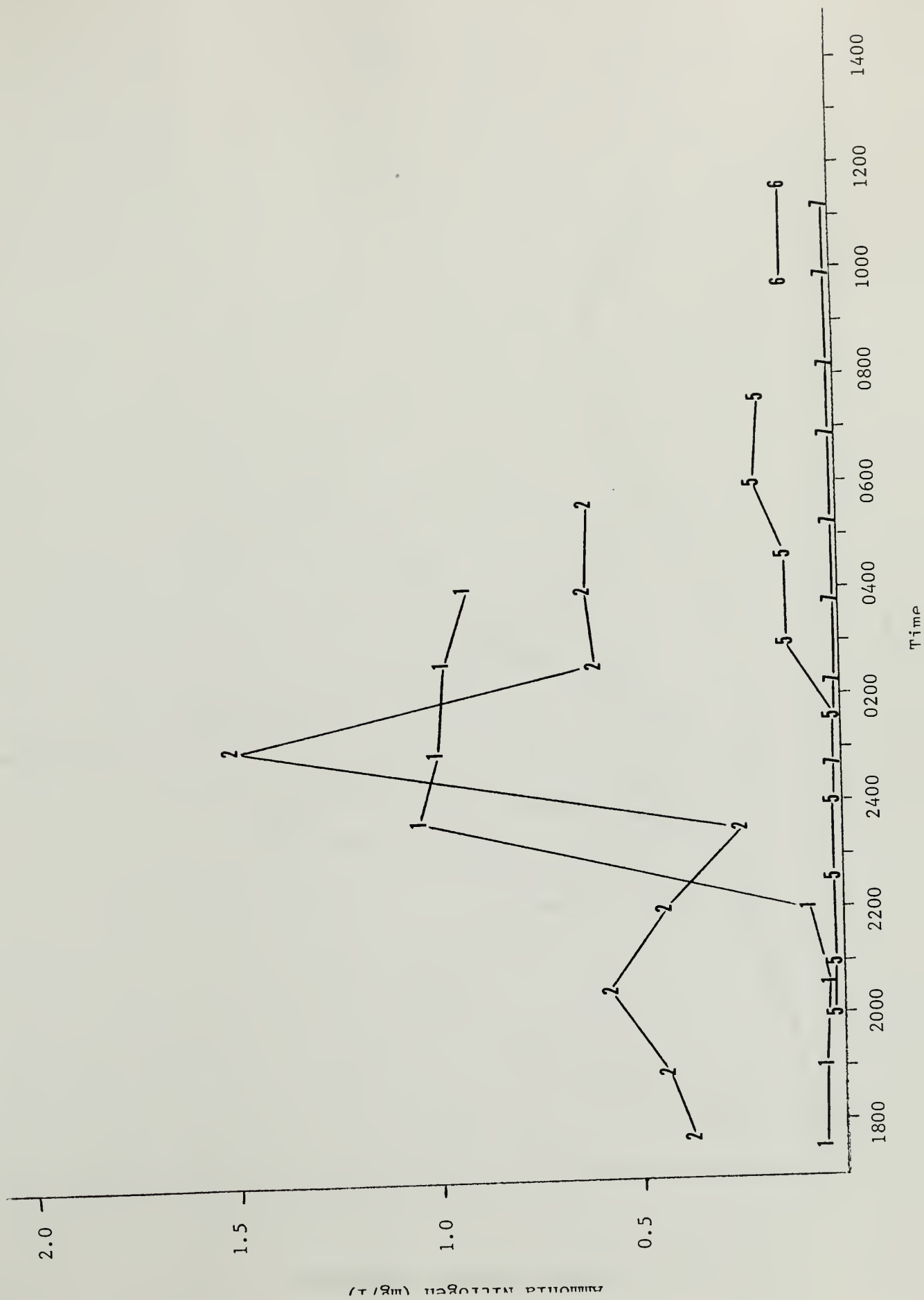
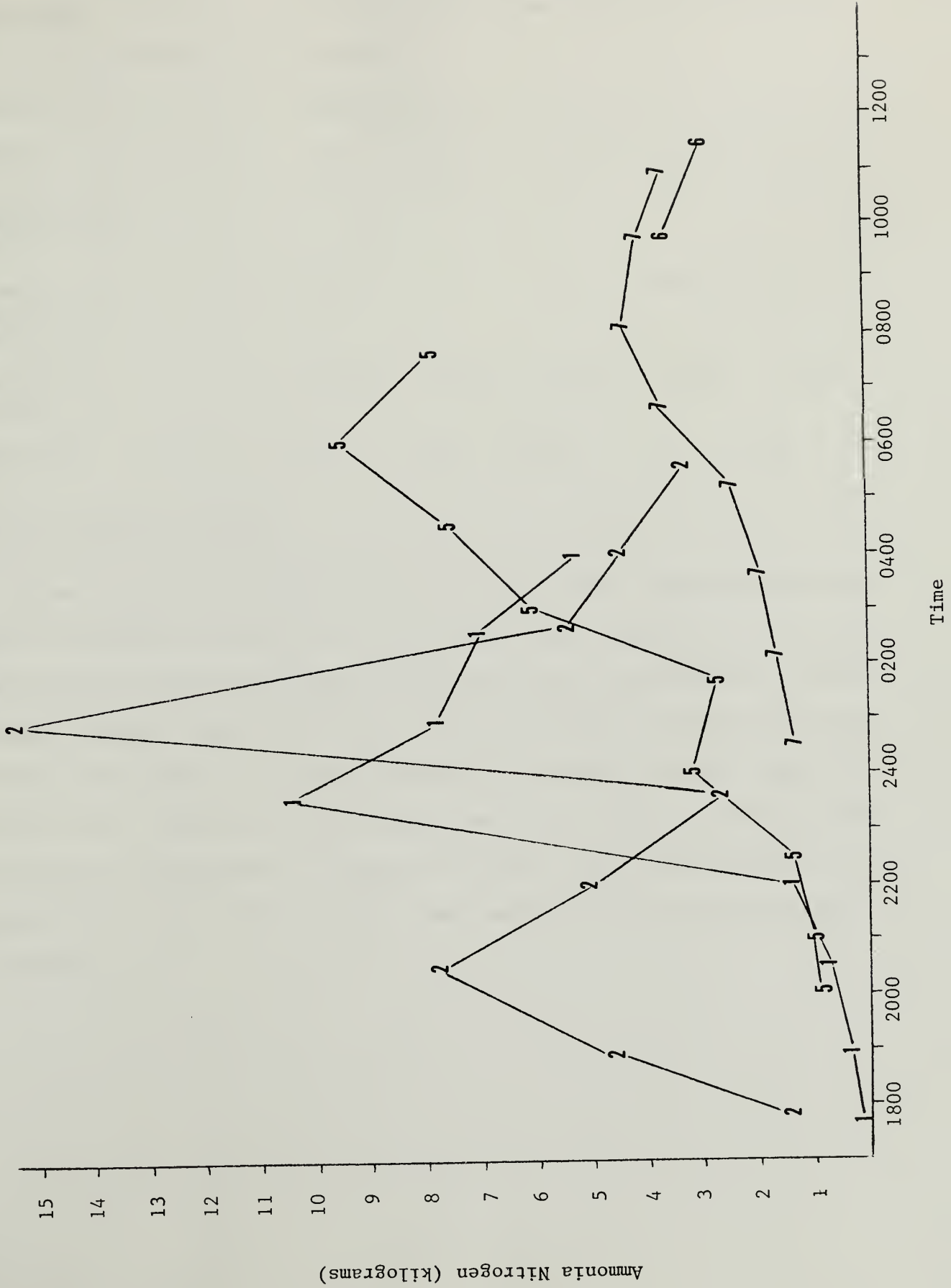


Figure 22. Ammonia Nitrogen Loads vs Time for the Five Yellow River Sampling Stations
 Event 2 - 15 and 16 July 1982



Nitrate (N) - The maximum and minimum concentrations with peak and total loads for nitrate nitrogen are listed below.

Table 24. Nitrate (N)

Station	1	2	5	6*	7
Maximum Concentration (mg/L)	6.1	4.6	5.4	4.4	4.6
Minimum Concentration (mg/L)	3.0	1.9	4.3	4.3	4.0
Peak Load (kg/sec)	0.009	0.010	0.048	0.036	0.054
Total Load (kg)	251	292	1,685	--	1,609

*only two samples collected

Maximum nitrate levels were found at Stations 1 and 5. The minimum nitrate value was measured at Station 2. Plotting the nitrate values by station over time (Figure 23) demonstrates the inconsistency of the nitrate levels. Station 1 values initially drop then recover, Station 2 values start out lower than Station 1, and except for one value continue to increase. Nitrate values for Stations 5 and 7 showed very little change over time. Figure 24 represents the nitrate (N) load versus time. Loadings at Stations 1 and 2 were relatively low compared to Stations 5 and 7 loadings. Peak loading were apparently reached at all stations.

Figure 23. Nitrate Nitrogen Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982

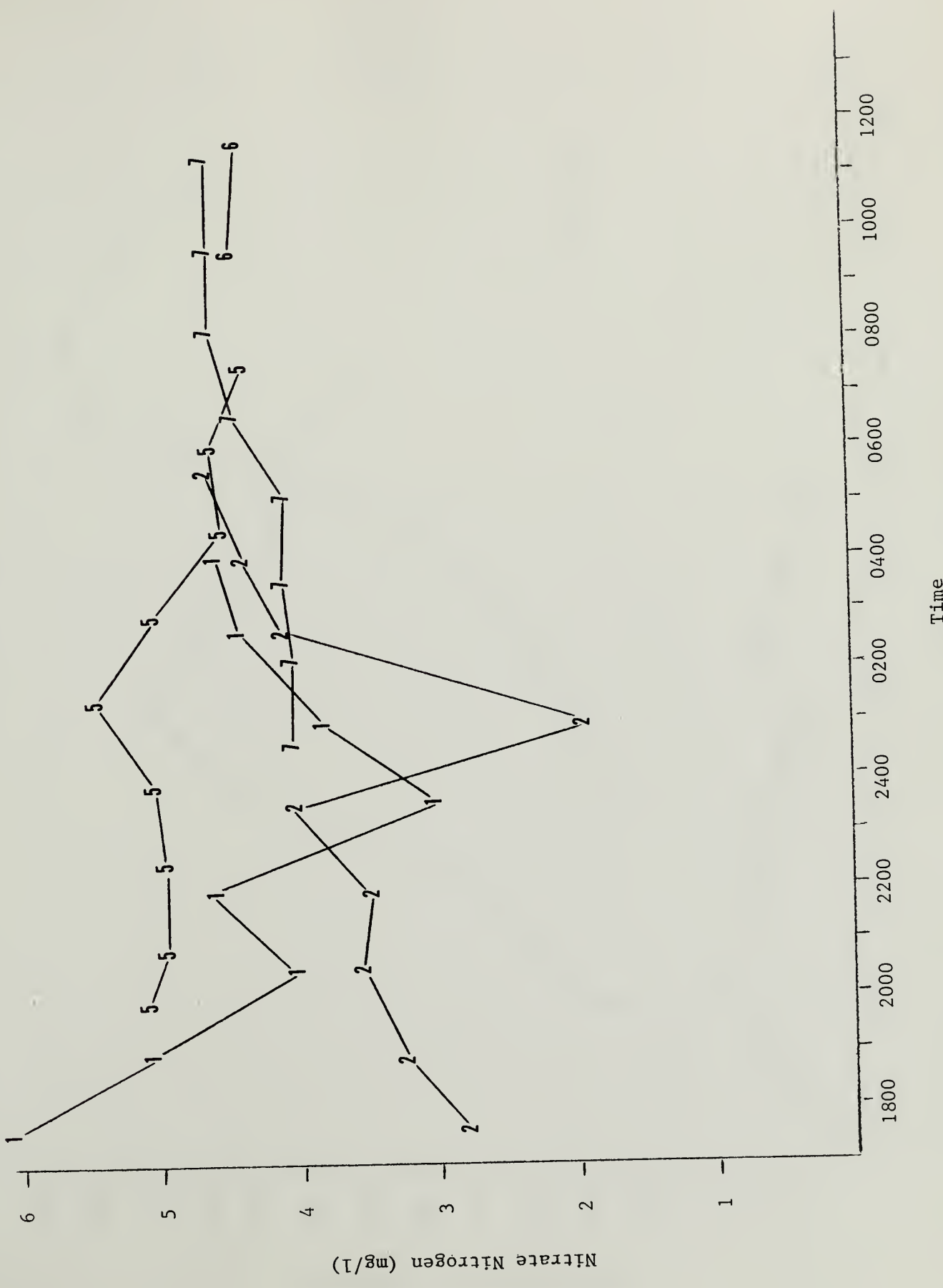
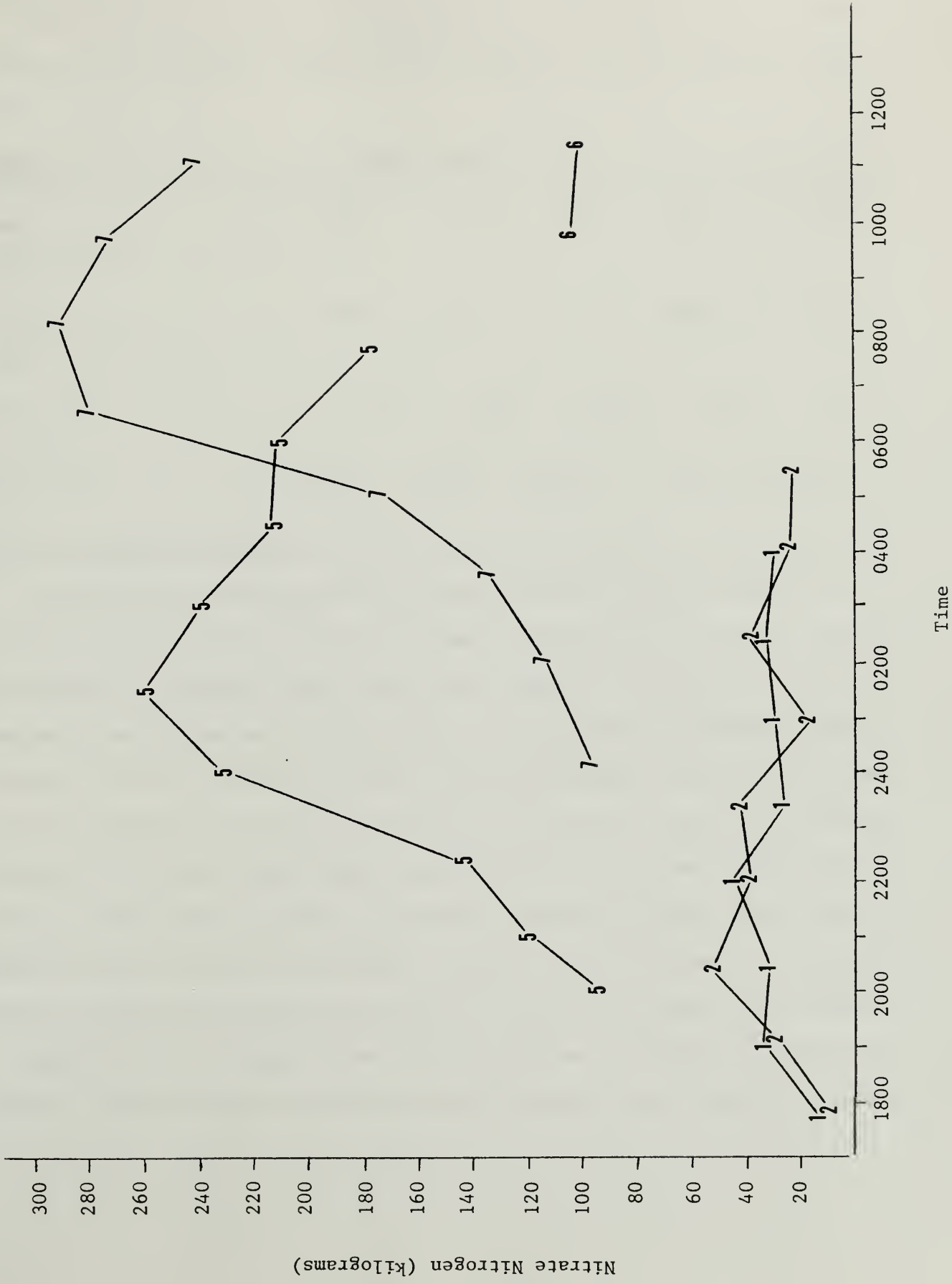


Figure 24. Nitrate Nitrogen Loads vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



Residue Series

As was done with Event 1, total residue will be the only portion of the residue series discussed. Range and load values for total residue are given below.

Table 25.		Total Residue				
Station		1	2	5	6*	7
Maximum Concentration (mg/L)		2,800	7,100	2,400	1,600	950
Minimum Concentration (mg/L)		580	2,100	520	1,000	540
Peak Load (kg/sec)		5.15	14.01	23.55	12.96	9.28
Total Load (kg)		133,715	281,060	590,245	75,365	269,300

*only two samples collected

The difference between stations in maximum residue concentrations was considerable, with Station 2 having the highest and Station 7 the lowest. Except for Station 2, minimum residue values were similar for Stations 1, 5 and 7. Residue values plotted versus time (Figure 25) demonstrate the variation between stations. Station 1 started out with low residue values, increased with time and then declined. The first 3 samples at Station 2 were high, probably reacting to the first flash effect, and declined over time eventually becoming stable. The values at Station 5 gradually increased from the first sample, peaked and then started to decrease. Residue values for Station 7 remained within a relatively narrow range and did not exhibit any significant changes.

The individual residue loads for each station are shown in Figure 26. Station 5 had the highest residue load, with Station 2 next highest. The peak

Figure 25. Total Residue Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982

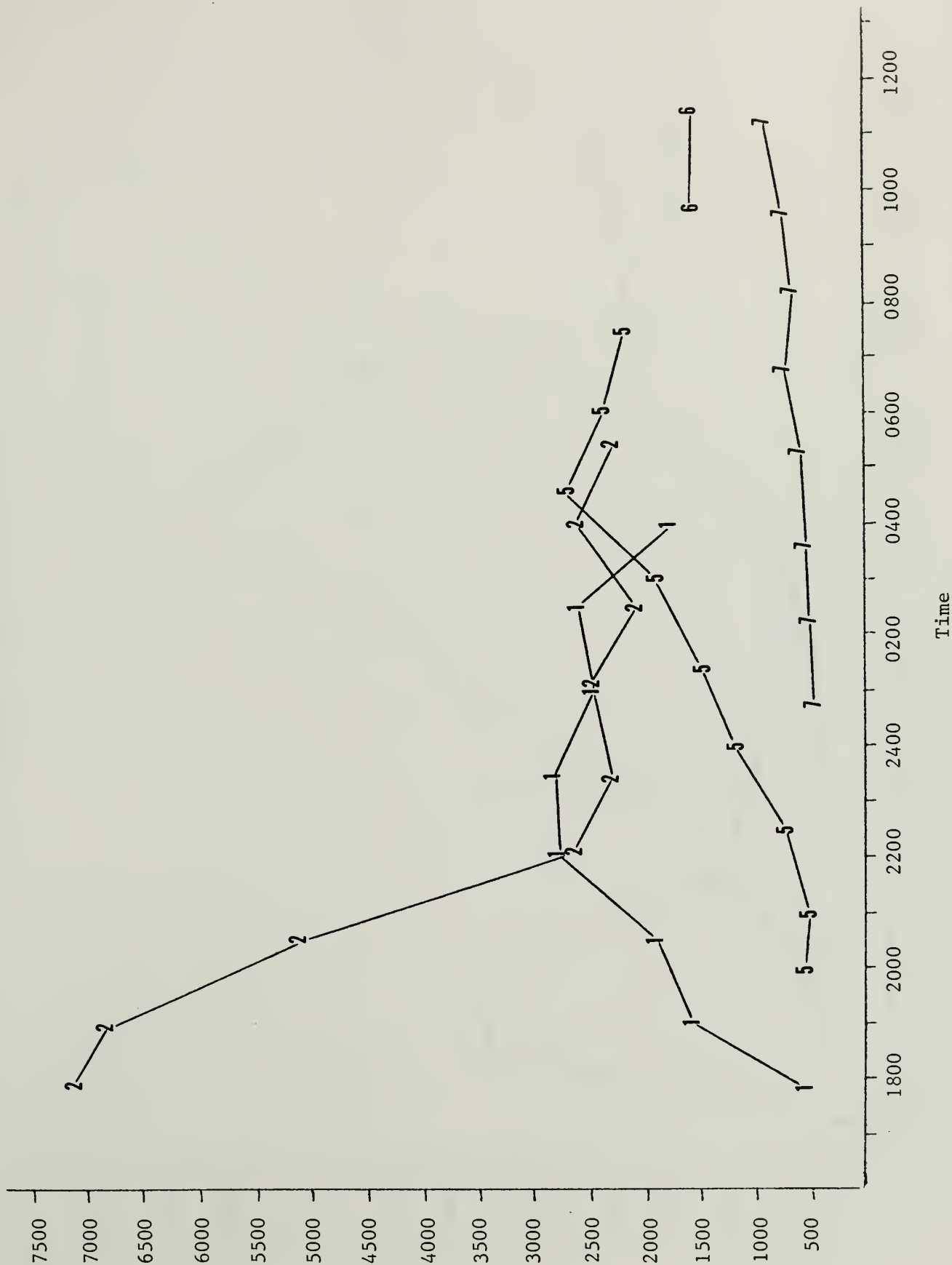
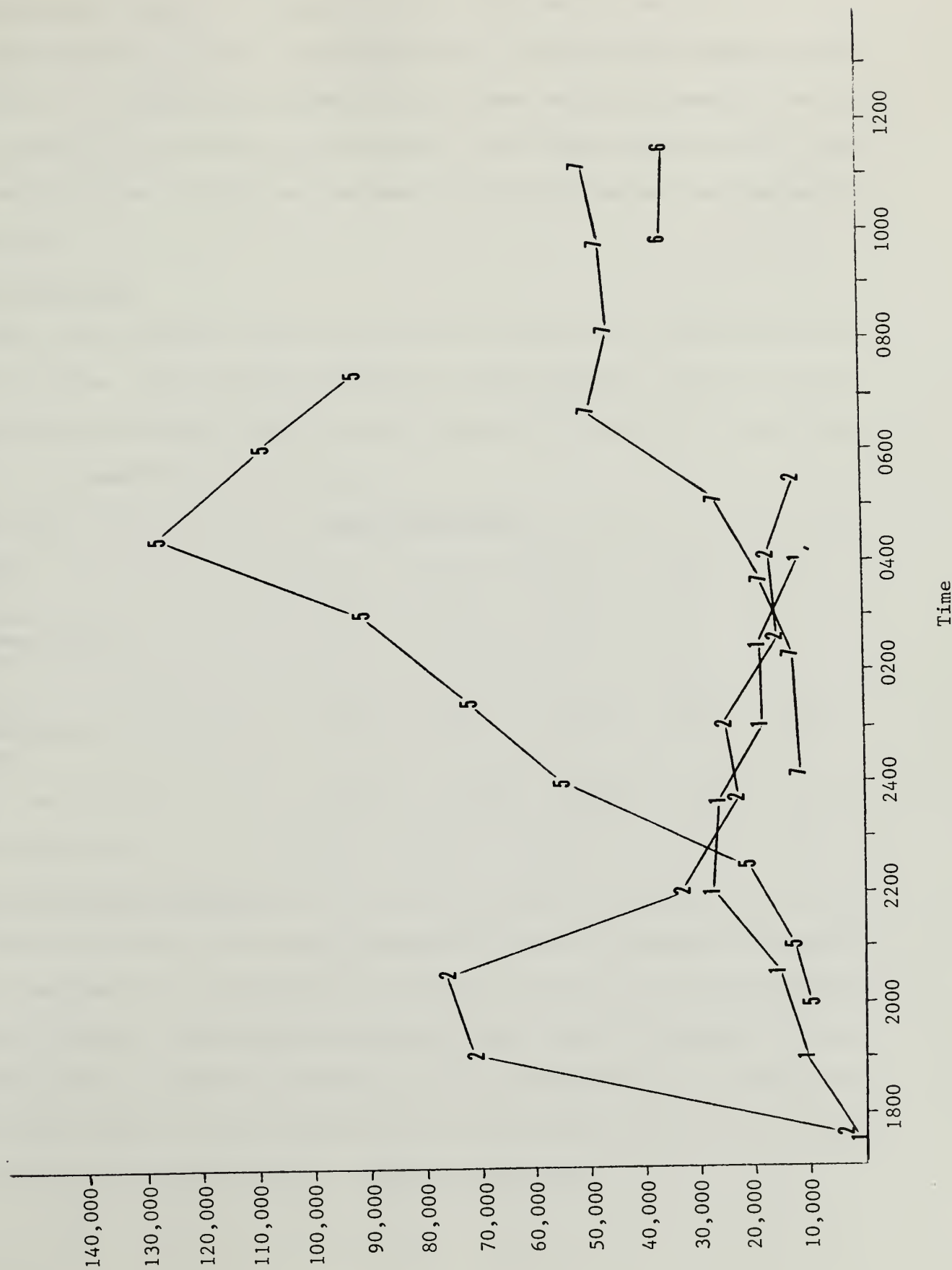


Figure 26. Total Residue Loads vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



residue at Station 7 occurred about 2 hours after the peak at Station 5. The two peaks may reflect the "slug" of residue moving downstream with the 2 hours representing time of travel between stations. Although residue concentrations at Station 7 increased only slightly, total residue loading increased reflecting the increase in stream flow at that station. The residue load at Station 7 was not declining when sampling was concluded and therefore may have not reached its peak load.

Total Phosphorus

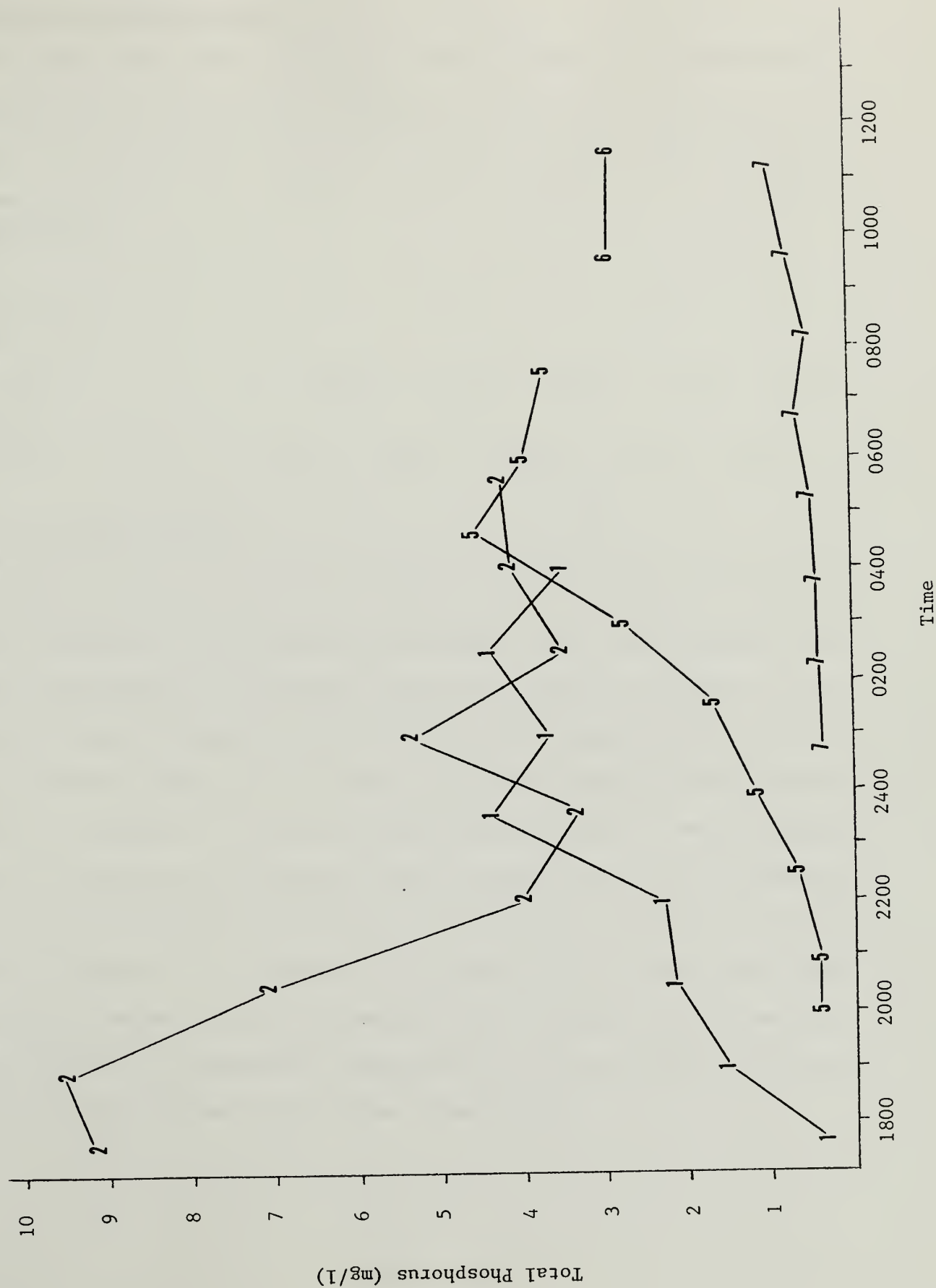
The total phosphorus value trends are very similar to those observed for total residue. The individual phosphorus values plotted in Figure 27 yields almost the same curves as those of total residue. The concentration load values for total phosphorus are listed below.

Table 26.	Total Phosphorus				
Station	1	2	5	6*	7
Maximum Concentration (mg/L)	4.4	9.5	4.6	2.9	1.0
Minimum Concentration (mg/L)	0.41	3.3	0.46	2.9	0.47
Peak Load (kg/sec)	0.007	0.020	0.040	0.024	0.010
Total Load (kg)	155	460	863	137	260

*only two samples collected

As seen in many of the previous parameters, the total phosphorus concentrations for Station 1 and Station 5 are similar while Station 2 is much higher and Station 7 lower. The correlation between solids and total phosphate is very apparent and was caused by the association of total phosphorus on soil particles. The loading curves for total phosphorus were also similar to the residue loading curves with all stations except 7 reaching a peak load.

Figure 27. Total Phosphorus Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



Biochemical Oxygen Demand (BOD)

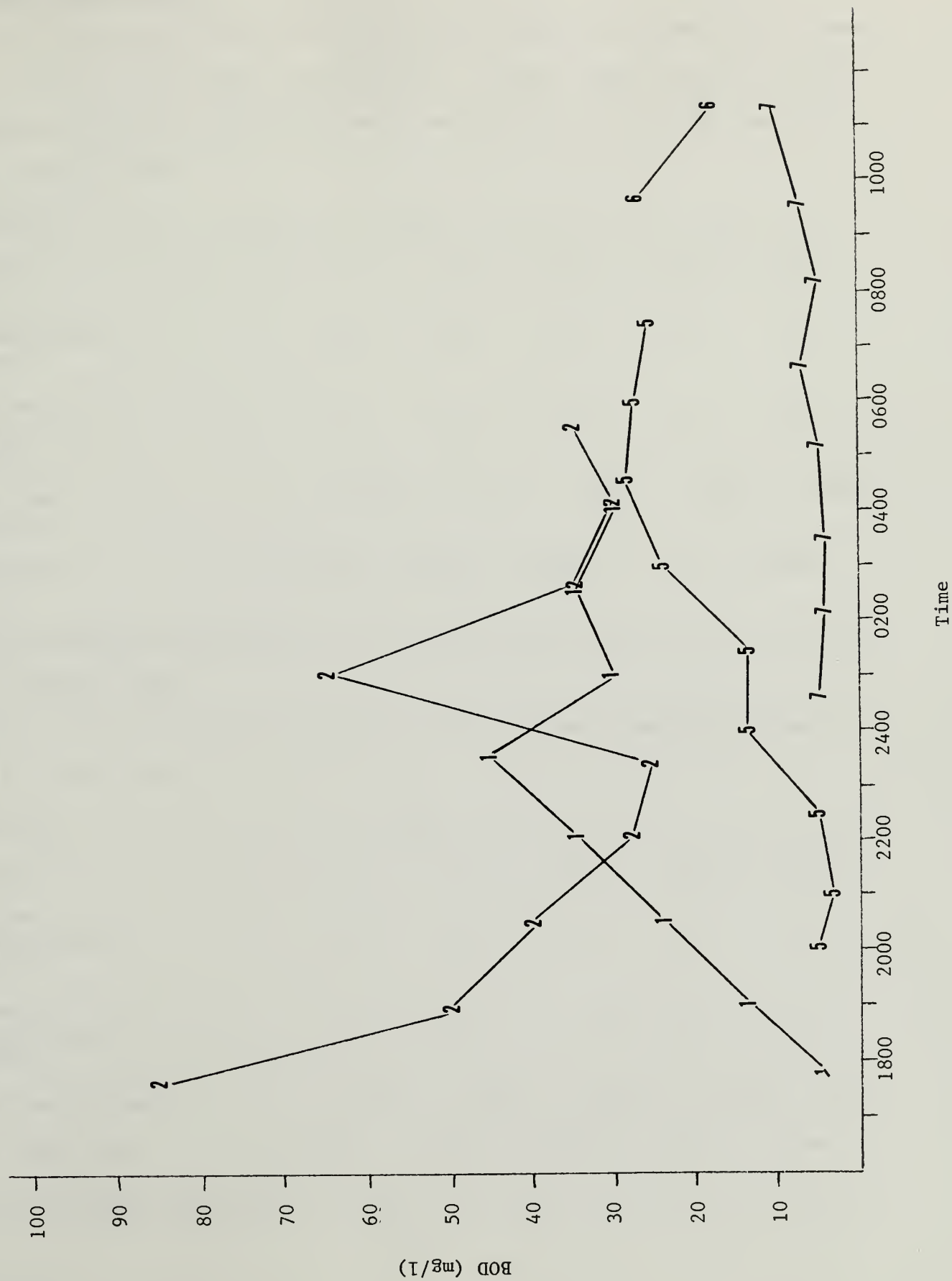
The range of BOD concentrations and loads for Event 2 are listed below.

Table 27.		BOD				
Station		1	2	5	6*	7
Maximum Concentration (mg/L)		45	85	29	27	10
Minimum Concentration (mg/L)		5	26	4	18	5
Peak Load (kg/sec)		0.079	0.123	0.253	0.219	0.098
Total Load (kg)		1,779	3,445	6,560	1,065	2,477

*only two samples collected

Maximum BOD values ranged from a low of 10 mg/L at Station 7 to a high of 85 mg/L at Station 2. BOD concentrations increased over time at Stations 1 and 5 while little change in concentration was seen at Station 7 (Figure 28). The highest BOD value at Station 2 occurred in the first sample and then decreased for the next four samples, then increased again for one sample and then remained steady for 3 samples. The range of BOD values at Station 7 was relatively narrow (5-10 mg/L) and only showed a slight increase over time. Although BOD concentrations were greater at Station 1 and 2 the highest peak and total loads occurred at Station 5 as a result of the increased flow at that station. The concentration graphs for total residue and total phosphate already discussed, are quite similar to that for BOD. Generally during runoff conditions the BOD value is directly related to the residue concentration.

Figure 28. BOD Concentrations vs Time for the Five Yellow River Sampling Stations
Event 2 - 15 and 16 July 1982



Chemical Oxygen Demand

The COD values for Event 2 are listed below; and for all practical purposes they follow the same general trends as BOD. Station 2 again had the highest maximum and minimum concentration while Station 5 had the greatest peak and total load for COD.

Table 28.

COD

Station	1	2	5	6*	7
Maximum Concentration (mg/L)	295	598	241	160	70
Minimum Concentration (mg/L)	33	200	30	151	30
Peak Load (kg/sec)	0.518	1.16	2.10	1.30	0.684
Total Load (kg)	11,690	37,725	47,200	--	16,840

*only two samples collected

Total Organic Carbon

The concentration range and loads for TOC have been tabulated for Event 2 and are listed below.

Table 29.

TOC

Station	1	2	5	6*	7
Maximum Concentration (mg/L)	110	210	75	49	19
Minimum Concentration (mg/L)	14	62	7.5	47	10
Peak Load (kg/sec)	0.172	0.412	0.654	0.397	0.186
Total Load (kg)	4,180	9,275	15,030	2,260	4,750

*only two samples collected

Trends in TOC data parallel the same general relationships as observed between residue, BOD, and COD. Concentrations were greatest at Station 2 and lowest at Station 7. Peak and total loads were greatest at Station 5 and were not that large at Station 7 where the greatest flow occurred.

Trace Metals

Seven samples from Event 2 were analyzed for trace metals. Because of the equipment failures, metals samples were collected from only 4 stations. Analytical results for those samples may be found in Table 29. Low level amounts of arsenic were found in all samples with Station 2 values being the highest. Barium and zinc, which are commonly found in Iowa surface waters, had reportable values at all stations which were slightly higher in concentration than those values found during Event 1.

Although values for chromium and nickel were measured at several stations, the values are low and are just at the limits of detection. Copper and lead values were reported in all samples except for lead at Station 7. Although the Iowa Water Quality Standards do not apply, copper was the only metal to exceed its standard of 0.02 mg/L (six samples). The highest concentrations of all metals measured occurred at Station 2.

Pesticides

Only 3 samples were analyzed for pesticides from the second event. Several additional samples were collected but the sample containers were broken in transit. No chlorinated hydrocarbons were found in any of the samples and the number and quantities of herbicides measured were less than found in Event 1 (Table 30). Because herbicides are generally short-lived in the environment, a decline in herbicide concentrations from June to July was anticipated.

Table 30. YELLOW RIVER TRACE METALS DATA

Event #2 - 15-16 July 1982

(all values in mg/L)

Parameter	<u>Sampling Stations - Time</u>						
	<u>1-0230</u>	<u>1-0400</u>	<u>2-1745</u>	<u>2-1900</u>	<u>5-0430</u>	<u>5-0600</u>	<u>7-1110</u>
Arsenic	0.02	0.02	0.04	0.03	0.02	0.02	0.01
Barium	0.6	0.8	1.3	1.3	0.6	0.8	0.3
Chromium	<0.01	0.01	0.01	0.02	0.01	<0.01	<0.01
Copper	0.05	0.10	0.16	0.14	0.06	0.04	0.01
Lead	0.03	0.04	0.05	0.05	0.03	0.03	<0.01
Nickel	<0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1
Zinc	0.16	0.28	0.50	0.42	0.20	0.20	0.04

Table 31. YELLOW RIVER PESTICIDE DATA

Event #2 - 15-16 July 1982

(all values in micrograms/liter)

<u>Parameter</u>	<u>Sampling Stations - Time</u>		
	<u>2 - 1745</u>	<u>5 - 0430</u>	<u>7 - 1110</u>
Chlorinated Hydrocarbons	ND*	ND	ND
Atrazine	2.1	3.0	2.1
Bladex	20	4.3	0.71
Lasso	3.2	1.0	0.29
Dual	ND	ND	ND
Dyfonate	ND	ND	ND
Furadan	ND	ND	ND
Treflan	ND	ND	ND

*ND = Not Detected

The highest values for two of the three herbicides reported were from Station 2. Overall the herbicide values are very low and much lower than those found in runoff studies from other areas of Iowa.

Summary of Event 2

Scattered rainfall created a second rainfall runoff event in the Yellow River on 15 and 16 July 1982. Precipitation was greatest in the area of Stations 1 and 2 (approximately 0.9 inches) and less at the downstream stations (0.45 inches near Station 6). Compared to the first event parameter concentrations were much more variable between stations. This variation was a direct result of the precipitation pattern. A direct correlation was observed between residue (solids) concentrations and organic nitrogen, total phosphorus and metals. Peak concentrations of almost all parameters occurred at Station 2 and must be related to the land use and/or geology of the area between Stations 1 and 2. Peak and total loadings occurred most frequently at Station 5 and may be related to the increased flow at that station. The water quality at Station 7 experienced only minor changes through the course of the sampling period. The lack of impact seen at Station 7 may be due to: 1) not enough rainfall in the area to affect the stream; 2) dilution and assimilation capacity of the stream prevented major changes; or, 3) sampling was terminated before the "slug" from Station 5 had a chance to affect Station 7. Because of the short duration and localized nature of the second runoff event any effect rainfall runoff had on water quality as it pertains to recreational activity was minimal.

LOW FLOW STUDY - 21 SEPTEMBER 1982

A water quality evaluation of the Yellow River was conducted during non-runoff conditions. The study was to be performed during late summer when stream flow is usually lowest. Because of time and flow constraints the survey was completed during the week of 19 September 1982 when the flow measured at Station 7 was 114 cfs. The seven-day ten-year low flow value calculated for Station 7 is 19 cfs (9). The main objective of the low flow study was to determine cumulative and individual effects of agricultural and point source discharges on water quality during low flow and to determine the differences between low flow and high flow water quality. Because of the rugged topography, the Yellow River Basin is sparsely populated, resulting in few point source waste dischargers. The town of Postville (1970 pop. 1,546) and its associated turkey and beef packing plants represent the major point-source waste dischargers to the Yellow River.

The seven runoff sampling stations along with two additional sampling sites on Williams Creek that were added to better define the impact of these discharges on Yellow River water quality were sampled on 21 September 1982. Williams Creek is an unclassified stream and therefore only the general water quality criteria apply. Methods used for sample collection and flow measurements have been previously discussed. Single grab samples were collected at each of the 10 sampling locations. The results of the analyses on those samples may be found in Table 32.

Stream Flow

Stream flow as expected increased in a downstream direction. Flow at Station 1 was 7.8 cfs and increased to 114 cfs by Station 7. Williams Creek

Table 32

YELLOW RIVER LOW FLOW STUDY

21 September 1982

(all values in mg/L unless designated otherwise)

Sampling Stations

Parameter	1	2	3	4	5	6	7
Specific Conductance ¹	660	690	700	660	660	650	620
pH ²	8.3	8.4	8.3	8.35	8.3	8.3	8.4
p Alkalinity ³	3.8	3.8	3.6	5.4	4.0	4.4	5.6
Total Alkalinity	308	312	317	305	311	303	292
Organic Nitrogen	0.40	0.46	0.73	0.25	0.17	0.10	0.09
Ammonia Nitrogen	0.01	0.01	<0.01	<0.01	0.01	0.02	<0.01
Nitrate -(N)	6.2	6.3	6.3	5.3	5.1	4.7	4.0
Nitrate (NO ₃)	27	28	28	23	22	21	18
Filtrable Residue	400	390	410	390	400	390	360
Nonfiltrable Residue	32	36	12	8	6	6	14
Total Residue	450	460	440	420	420	400	390
Filtrable Phosphate	0.08	0.09	0.14	0.12	0.12	0.10	0.07
Total Phosphate	0.14	0.17	0.20	0.16	0.16	0.15	0.12
BOD	1	1	1	1	<1	<1	<1
Phenol	2	3	2	<2	<2	2	<2
DO	11.4	11.3	11.1	13.0	12.9	12.8	13.0
TOC	5.5	3.8	3.3	4.1	4.1	4.1	8.4
Turbidity ⁴	16	16	5.5	3.4	4.1	3.6	3.4
Fecal Coliform	3,000*	2,700*	570	210	270	100	80
Temperature °C ⁵	9°	9.5°	10.5°	14.5°	13°	13°	14°
Flow ⁶	7.8	14.5	45	52	76	80	114

*exceed the Iowa Water Quality Standard of 2,000 organisms/100 mL

¹Micromhos²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

Table 32 (continued)

YELLOW RIVER LOW FLOW STUDY

21 September 1982

(all values in mg/L unless designated otherwise)

Parameter	Sampling Stations				Iowa Turkey Lagoon Final Eff.
	8	Postville WWTP Final Eff.	9	10	
Specific Conductance ¹	760	1,300	870	700	
pH ²	7.9	7.9	7.8	8.4	7.4
p Alkalinity ³	--	--	--	7.6	
Total Alkalinity	323	347	322	312	
Organic Nitrogen	0.55	3.2	0.60	0.24	
Ammonia Nitrogen	0.11	15	2.5	0.02	8.8
Nitrate -(N)	2.5	3.5	5.8	5.4	
Nitrate (NO ₃)	11	15.5	26	24	
Filtrable Residue	430	670	500	400	
Nonfiltrable Residue	60	26	10	14	23
Total Residue	540	730	520	440	
Filtrable Phosphate	0.28	2.7	1.4	0.21	
Total Phosphate	0.61	3.8	1.6	0.26	
BOD	2	25	7	2	5
Phenol	2	8	2	3	
DO	7.9	7.0	5.0	11.8	8.3
TOC	8.8	22	8.1	3.8	
Turbidity ⁴	28	8.3	4.8	2.3	
Fecal Coliform	640	410,000	2,400	2,200	
Temperature °C ⁵	11	14.5	10.5	11.5	
Flow ⁶	0.1		1.0	3.0	

¹Micromhos²pH Units³phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

discharge (3 cfs at Station 10) was very small, compared to the Yellow River (52 cfs at Station 4).

Specific Conductance

Specific conductance values for the Yellow River ranged from 700 at Station 3 to 620 micromhos at Station 7. Compared to Station 1, conductivity increased at Stations 2 and 3, most probably a result of groundwater recharge to the stream. Groundwaters are usually higher in conductance than surface waters. The conductivity on Williams Creek (Stations 8, 9 and 10) increased sharply as a result of the Postville discharge but had declined to background levels by Station 10 at the mouth.

pH

The Yellow River pH values were very similar throughout the entire reach ranging from 8.3 to 8.4. The pH of Williams Creek was lower than the Yellow River at Stations 8 and 9 but by Station 10 had increased to Yellow River levels.

Alkalinity

Both phenolphthalein and total alkalinity were consistent throughout the 7 sampling stations. Because of the pH, no phenolphthalein alkalinity was measured at Stations 8 and 9 on Williams Creek. Station 10 values on Williams Creek were similar to those reported for the Yellow River.

Nitrogen Series

Organic nitrogen was relatively low, ranging from 0.09 mg/L at Station 7 to 0.73 mg/L at Station 3. Ammonia nitrogen in the Yellow River was very low (<0.01 to 0.02 mg/L). An increase in ammonia was observed at Station 9, downstream of the Postville wastewater treatment plant discharge, which was responsible for that increase. The ammonia value of 2.5 mg/L was not in violation of the Iowa Water Quality Standards because Williams Creek is not a classi-

fied stream. The ammonia was rapidly assimilated and by Station 10 had decreased to Yellow River values. Nitrate levels in the Yellow River declined in a downstream direction (6.2 mg/L at Station 1 to 4.0 mg/L at Station 7). The nitrate decline may be attributed to dilution and nitrate utilization by aquatic plant life.

Residue Series

Values for the residue series during the low flow study were much different than measured during the runoff event. During the runoff studies the majority of the residue was composed of nonfiltrable residue (suspended solids). The majority of residue during the low flow study was filtrable residue (dissolved solids). Total residue levels decreased (400 mg/L at Station 1 to 360 mg/L at Station 7) in a downstream direction most probably as a result of dilution. Residues for Williams Creek were not much different than those found in the Yellow River.

Phosphorus

Filtrable and total phosphorus values for the Yellow River ranged from 0.07 to 0.14 mg/L and 0.12 to 0.20 mg/L respectively. These values are in expected ranges for non-runoff conditions and indicate that point source waste discharges are not a problem in the Yellow River. Phosphorus levels on Williams Creek did increase downstream from the Postville WWTP as a result of that discharge. Although the increase was significant, phosphorus levels had declined by Station 10 and no increase in concentration was observed in the Yellow River downstream from Williams Creek.

BOD and TOC

Parameters indicating organic oxygen demand (BOD and TOC) had very low values for the Yellow River. All BOD values were 1 mg/L or less and TOC concentrations were 8.4 mg/L or less. The low values for these parameters indicate

very low levels of organic compounds and oxygen demanding wastes occurring during low flow periods. The slightly higher BODs and TOC measured on Williams Creek are related to the Postville WWTP discharge. Again, no effect was observed in BOD and TOC in the Yellow River as a result of Williams Creek discharge.

Dissolved Oxygen

Dissolved oxygen concentrations ranged from 11.1 mg/L to 13.0 mg/L in the Yellow River and from 5.0 mg/L to 11.8 mg/L in Williams Creek. Except for Station 9 on Williams Creek these values all represent approximately 100% dissolved oxygen saturation and are adequate levels to sustain fish and aquatic life. Although the 5.0 mg/L DO at Station 9 is not in violation of the Iowa Water Quality Standards, it indicates a potential stressful environment for fish and aquatic life.

Turbidity

Turbidity values were also very low on both Williams Creek and the Yellow River, an indication of good water clarity during non-runoff conditions.

Fecal Coliform

Fecal coliform values exceeded the Iowa Water Quality Standard of 2,000 organisms/100 mL at Stations 1 and 2 on the Yellow River. Considerable cattle pasturing occurs in the areas of Stations 1 and 2, and cattle were frequently seen in the stream which may account for the higher fecal coliform seen at these stations. The high fecal coliform value at Station 9 on Williams Creek is a direct result of the Postville WWTP discharge.

Pesticides

Grab samples for pesticide analysis were also collected from the seven Yellow River stations during the low flow study. The only pesticide found was the herbicide atrazine (see Table 33). The atrazine values for the low flow

Table 33

YELLOW RIVER PESTICIDE DATA

Low Flow Study

21 September 1982

(all values in micrograms/L)

Parameter	<u>Sampling Stations</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Chlorinated hydrocarbons	ND	ND	ND	ND	ND	ND	ND
Atrazine	0.15	0.15	0.20	0.18	0.17	0.19	0.20
Bladex	ND	ND	ND	ND	ND	ND	ND
Lasso	ND	ND	ND	ND	ND	ND	ND
Dual	ND	ND	ND	ND	ND	ND	ND
Dyfonate	ND	ND	ND	ND	ND	ND	ND
Furadan	ND	ND	ND	ND	ND	ND	ND
Treflan	ND	ND	ND	ND	ND	ND	ND

* ND = Not Detected

study were approximately 100 times less than those of the first runoff event and 10 times less than those of the second event. Atrazine is one of the most widely used herbicides in Iowa and is known for its carryover (persistence). Although atrazine was found at all stations, the concentrations were very low and reflects usage throughout the basin.

Biological Sampling

Sampling for benthic macroinvertebrates was performed in conjunction with the low flow study on 21 and 22 September 1982. Samples were collected on the mainstem of the Yellow River at Stations 1-7 and on Williams Creek at Stations 8 and 10. Two samples at each location were obtained using a Surber sampler which provides a quantitative method of determining density by sampling a known area (1 square foot). All of the samples were preserved with 70% ethanol and returned to the laboratory where they were identified to the lowest practical taxa. All of the data collected can be found in Table 34.

The density of the macroinvertebrates on the mainstem of the Yellow River ranged from 1,601 organisms per square meter at Station 1 to 8,482 organisms per square meter at Station 5. The total density generally increased from Station 1 to Station 5 and then declined slightly at Stations 6 and 7. The number of taxa at each station (on the Yellow River mainstem) ranged from 10 (Station 3) to 18 (Station 5). The percent composition of the major taxa for each sampling station are found in Table 35.

Table 34. Benthic organisms collected from the Yellow River, September 1982

	organisms per square meter									
	1	2	3	Station No.		6	7	8	10	
				4	5					
ANNELIDA										
Oligochaeta										
Tubificidae								296		
Hirudinea										
Erpobdellidae				5		11	11		5	
MOLLUSCA										
Gastropoda										
Physidae										
<u>Physa</u> sp.	5							253	11	
ARTHROPODA										
Crustacea										
Decapoda										
Astacidae										
<u>Orconectes virilis</u>	5									
Insecta										
Ephemeroptera										
Baetidae										
<u>Baetis brunneicolor</u>				5	5	5			11	
<u>B. flavistriga</u>	43	16	18	199	242	70	11	5	102	
<u>Pseudocloeon dubium</u>	156									
Caenidae										
<u>Caenis</u> sp.									11	
Heptageniidae										
<u>Stenonema mediopunctatum</u>	11	75	11	38	199	48	495		54	
<u>S. terminatum</u>					11	5				
<u>S. vicarium</u>					5					
Siphonuridae										
<u>Isonychia</u> sp.	16			11	11		64			
Odonata (Zygoptera)										
Coenagrionidae										
<u>Anomalagrion/ischnura</u> sp.	5									
Trichoptera										
Hydropsychidae										
<u>Cheumatopsyche</u> sp.	317	97	414	1,522	2,577	990	915		167	
<u>Hydropsyche bettini</u>	75	86	11		5	5				
<u>Symphitopsyche bifida</u>	565	506	118	1,775	1990	1,377	1,592		11	
<u>S. riola</u>	75		86	264	726	183	75		124	
<u>S. slossonae</u>	48	1,162	1,022	242	441	22			506	
<u>S. sparna</u>	108		172	699	898	134	54		5	
<u>S. Alhedra</u>			75	59	194	11	11		32	
<u>S. morosa</u>					27	48				
Coleoptera										
Elmidae										
<u>Stenelmis</u> sp.	5	22		16	22	38	54			
Diptera										
Chironomidae (larvae)	124	231	1,060	672	898	269	694	22	2,636	
Chironomidae (pupae)	11			16			27	5		
Rhagionidae										
<u>Atherix variegata</u>	32	91	167	97	32	43	5		11	
Simuliidae			5						11	
Tipulidae										
<u>Antocha</u> sp.		75	38	16	199	48	360			
Total Density	1,601	2,361	3,111	5,636	8,482	3,307	4,368	581	3,702	
Number of Taxa	17	10	13	16	18	17	14	5	15	

Table 35. Yellow River Low Flow Study
Percent Composition of Major Macroinvertebrate Taxa
September 1982

<u>Taxa</u>	Station								
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>10</u>
Trichoptera (Caddisflies)	74	78	60	80	80	83	60	0	23
Ephemeroptera (Mayflies)	14	3	1	5	6	4	13	1	5
Dipterans	10	17	38	14	13	11	25	5	71
Mollusks	<1	0	0	0	0	0	0	44	<1
Tubificids (Sludgeworms)	0	0	0	0	0	0	0	50	<1
Others	1	2	1	1	1	2	2	0	1

As illustrated by Table 35, the three taxa most commonly found at Stations 1-7 were caddisflies (Trichoptera), dipterans and mayflies (Ephemeroptera). The caddisflies were found most frequently, comprising between 60% (Stations 3 and 7) to 83% (Station 6) of the total organisms. Dipterans percentages ranged from 11% (Station 6) to 38% (Station 3) and mayflies from 1% (Station 3) to 14% (Station 1). The density of the macroinvertebrates on Williams Creek was 581 organisms per square meter (representing 4 taxa) at Station 8 and 3,702 organisms per square meter (representing 15 taxa) at Station 10. The major taxa found at Station 8 were sludgeworms (Tubificids) comprising 50% of the total organisms and mollusks (*Physa* sp.) at 44%. Dipterans were the dominant organisms (71%) and caddisflies the next most prevalent (23%) at Station 10 (located near the mouth of Williams Creek).

Many types of mayflies and caddisflies that are considered indicators of good water quality (10 and 11) were common in the Yellow River collections.

They include the mayfly species Baetis flavistriga, Stenonema mediopunctatum and Isonychia sp., and the caddisfly species, Cheumatopsyche sp., Hydropsyche bettini, Symphitopsyche bifida, S. riola, S. slossonae and S. sparna.

Station 8, located on Williams Creek upstream from the Postville wastewater treatment plant discharge, had both a low density of organisms (581 organisms per square meter) and a low number of taxa (4 taxa). The dominant organisms, sludgeworms (Tubificids) and mollusks (Physa sp.) are generally considered pollution tolerant. Although the chemical data (Table 32) does not indicate poor water quality, the macroinvertebrate data reflects poor quality. A possible reason for this discrepancy is that Williams Creek in the area of Station 8 is quite small and shallow with very little flow. The physical conditions are not suitable for a large, diverse community structure at Station 8. Biological data at Station 10, located near the mouth of Williams Creek, reflects much better water quality than at Station 8 with a large number of taxa (15) and a population density of 3,702 organisms per square meter. Dipterans (71% occurrence) were the dominant organisms found at Station 10, followed by caddisflies (23% occurrence).

Compared to two previous macroinvertebrate studies (7,12) of the Yellow River many of the same mayflies, caddisflies and mollusks were collected. A notable difference in the data obtained during this study compared to the previous two was the greater total density. The 1978 study reported 300 organisms per square meter per station while the 1981 and 1982 studies reported 1,100 organisms per square meter and 4,000 organisms per square meter per station respectively. The difference in density may be attributed to the seasonal

variation in macrobenthic populations. Although the total numbers varied between surveys the same types of organisms were found during all three surveys.

Based on the benthic macroinvertebrate data obtained during the survey the water quality of the Yellow River was good. The wide species diversity with moderate numbers of individuals reflected a healthy, stable community.

Summary of Low Flow Study

Water quality sampling of the Yellow River and Williams Creek was performed during relatively low flow non-runoff conditions. Results of the chemical sampling indicated very good water quality throughout the entire Yellow River reach, with only minor changes in parameter values. The point source waste discharge from Postville did have an immediate impact on Williams Creek water quality, i.e. increased ammonia nitrogen, BOD and decreased dissolved oxygen. However, the affect was of relatively short duration as the water quality of Williams Creek at Station 10 was of similar quality as the Yellow River. Overall the water quality of the Yellow River was very good during the survey and should be typical of non-runoff conditions.

The results of the benthic macroinvertebrate data demonstrated good, long term water quality in the Yellow River. A diverse community consisting of species representative of good water quality were collected. Macroinvertebrate diversity was similar to previous studies, while Caddisfly density was greater and may be related to seasonal variation.

SUMMARY AND CONCLUSIONS

Water samples were collected from the Yellow River on three separate occasions, twice during rainfall runoff periods and once during low flow non-runoff conditions. Flow activated automatic samplers and flow meters located at seven sampling stations were used to monitor the runoff events. The impact of the rainfall runoff was very dependent on amount and intensity of rainfall and runoff delivered to the receiving stream. The most notable effects of the runoff on water quality were the increases in total solids and associated parameters (organic nitrogen, total phosphate, BOD, metals, and pesticides). The impact of these solids and associated contaminants on stream biota is not known. The more water soluble parameters, i.e., ammonia nitrogen and soluble phosphate, demonstrated only minor increases in concentrations compared to the solids associated parameters, during the runoff events. Pesticide concentrations found in the Yellow River were greatest during the June event, which occurred shortly after spring planting. Four of the five pesticides reported were herbicides and included one organophosphate insecticide. The pesticide values reported were all low and much lower than presently identified acute toxic levels. Because of the short duration and localized nature of the July event, its impact on recreational activity during the high use period was minimal. Water quality at Station 2 was the most affected of the seven stations by rainfall runoff. Peak concentrations of most parameters, including metals and pesticides, were observed at Station 2 for both runoff events. The total load values for most parameters were greatest at the most downstream stations where the highest flows

occurred. Except for the poor water quality exhibited at Station 2 for both runoff events, it is not possible to make a comparison between the two runoff events because of the variation in rainfall amounts and intensities in the watershed. Results of the low flow non-runoff study demonstrated very good water quality throughout the entire Yellow River reach, with only minor changes in parameter values. Compared to the two runoff events, ammonia, total phosphorus, BOD, and solids values for the low flow study were substantially lower and represent background conditions. The point source waste discharge from Postville had an immediate impact on Williams Creek water quality, by increasing ammonia nitrogen and BOD and decreasing dissolved oxygen. However, the effect was of relatively short duration as the water quality of Williams Creek at the mouth was of similar quality as the Yellow River. Based on the benthic macroinvertebrate data obtained during the survey the water quality of the Yellow River was good. The wide species diversity with moderate numbers of individuals reflected a healthy, stable community and is comparable to previous benthic surveys.

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APPENDICES

PRELIMINARY TURBIDITY VALUES

YELLOW RIVER RUNOFF

Event #1 - 14-15 June 1982

(all values in NTUs)

Sample Number	<u>Stations</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	80*	160*	50*	30*	<50*	25*	20*
2	95	170	80	20	50	30	30
3	80*	180	210*	40	80*	55	55*
4	120	125*	110	100*	65	95	75
5	125*	110	120*	140	150*	75*	90*
6	140	95*	175	160*	190	210*	200
7	150*	>1,000*	185*	125*	200*	195*	215*
8	150	160	170	200	175	140	210
9	150*	175*	140*	180*	150*	150*	195*

* Indicates samples selected for further analysis.

PRELIMINARY TURBIDITY VALUES

YELLOW RIVER RUNOFF

Event #2 15-16 July 1982

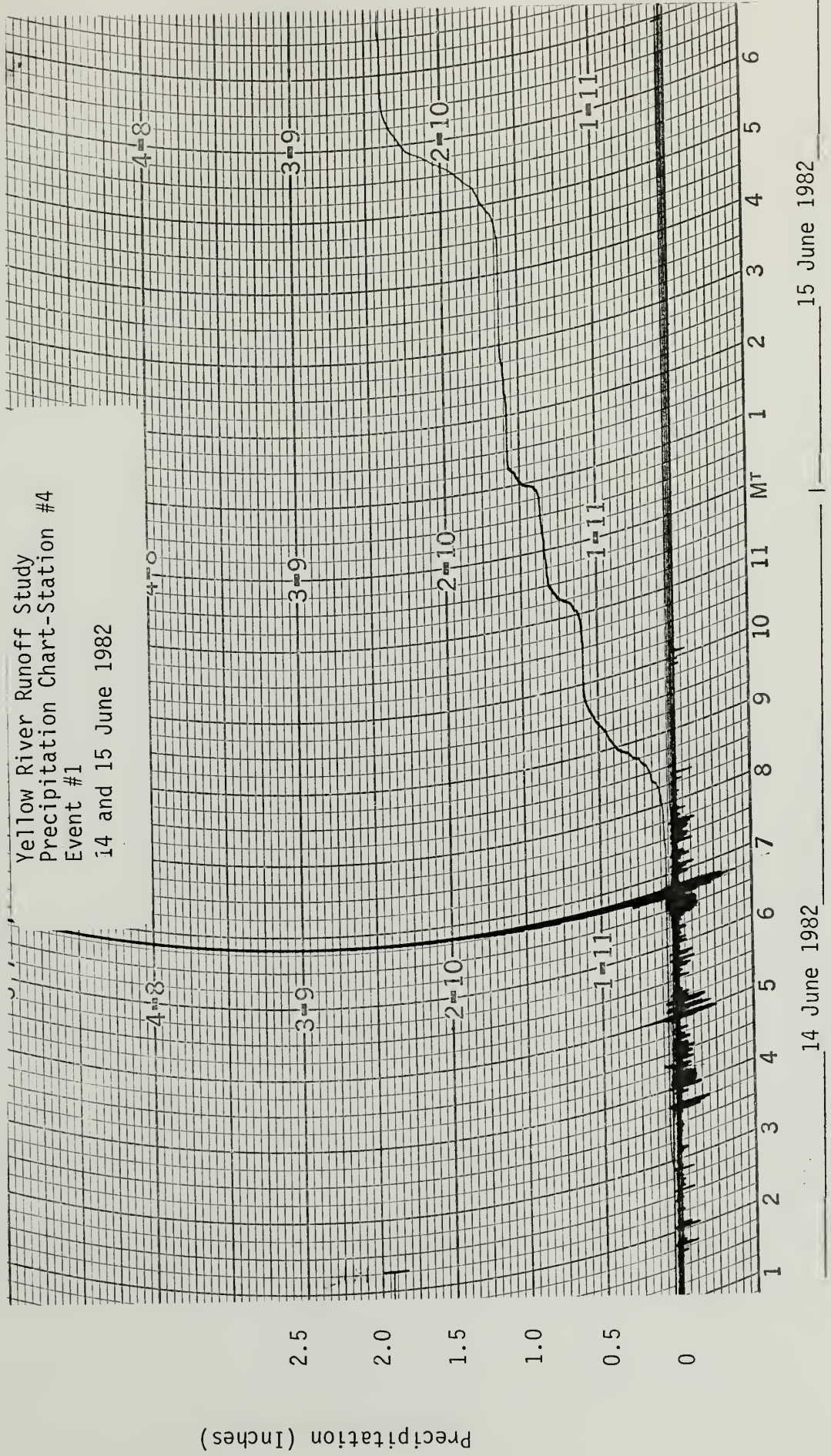
(all values in NTUs)

Sample Number	<u>Stations</u>				
	<u>1</u>	<u>2</u>	<u>5</u>	<u>6</u>	<u>7</u>
1	76	2,440*	75*	54	38
2	60*	2,200*	55*	42	58*
3	290*	1,600*	98*	460*	67*
4	490*	1,000*	268*	560*	62*
5	680*	840*	320*	500	69*
6	840*	860*	620*	-	96*
7	860*	760*	1,040*	-	96*
8	1,200*	1,000*	860*	-	132*
9	760*	800*	680*	-	176*

* Indicates samples selected for further analysis.

A-4

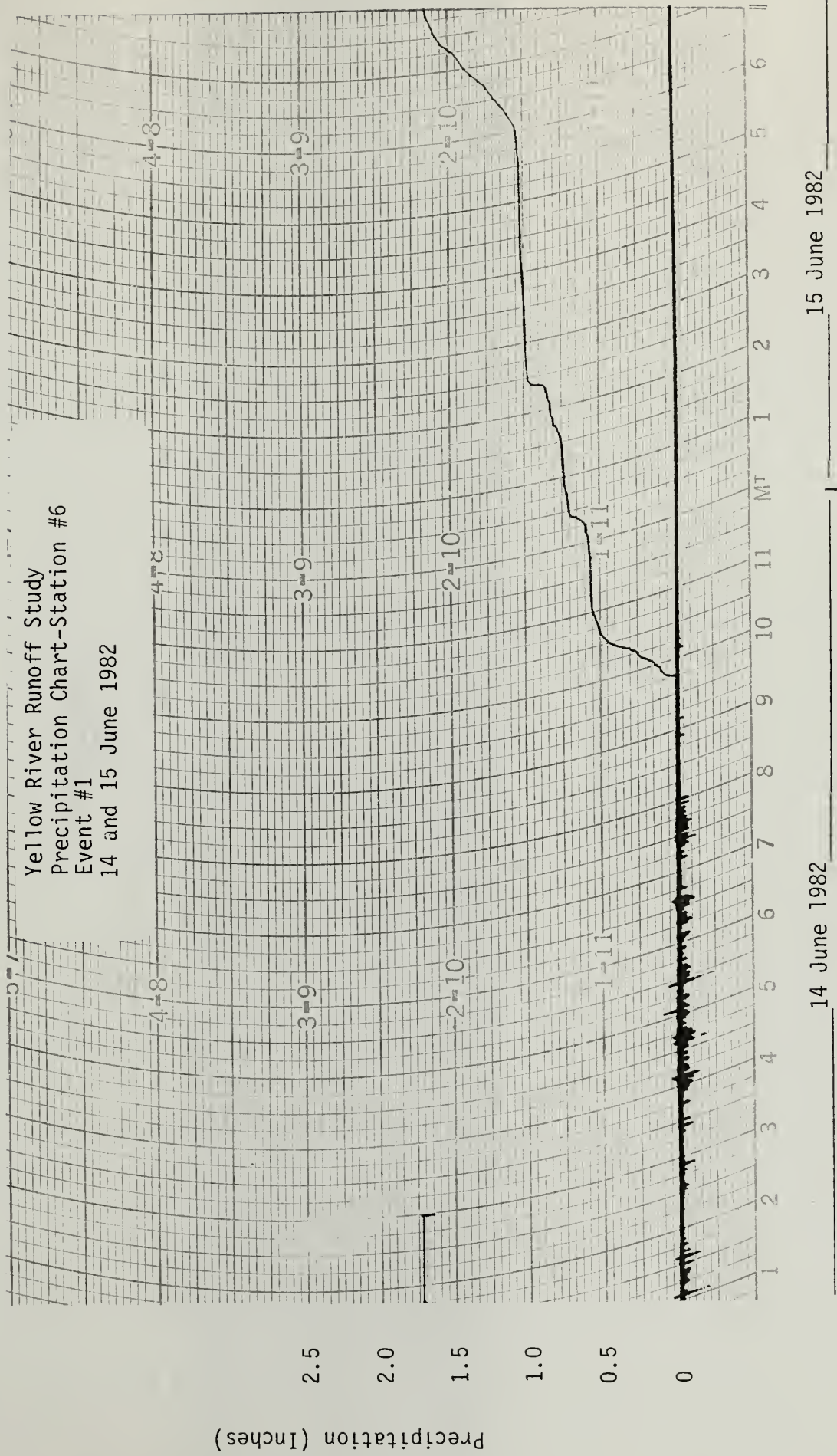
Yellow River Runoff Study
Precipitation Chart-Station #4
Event #1
14 and 15 June 1982



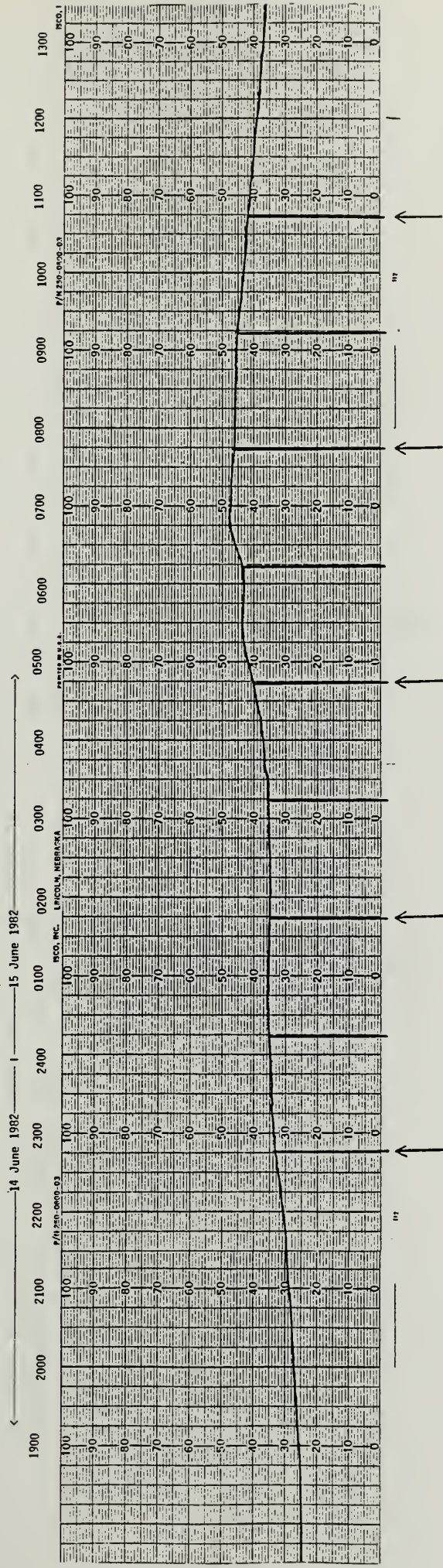
Time (Hours)

A-5

Yellow River Runoff Study
Precipitation Chart-Station #6
Event #1
14 and 15 June 1982

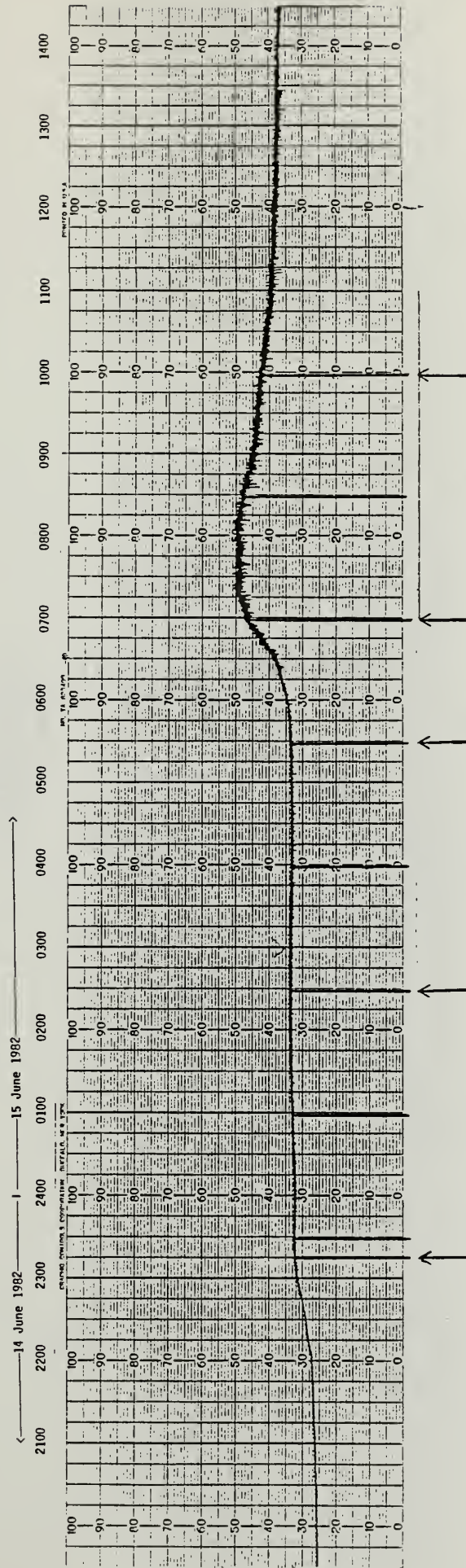


A-6
 Yellow River Runoff Study
 Hydrograph for Station #1
 Event 1
 14 and 15 June 1982



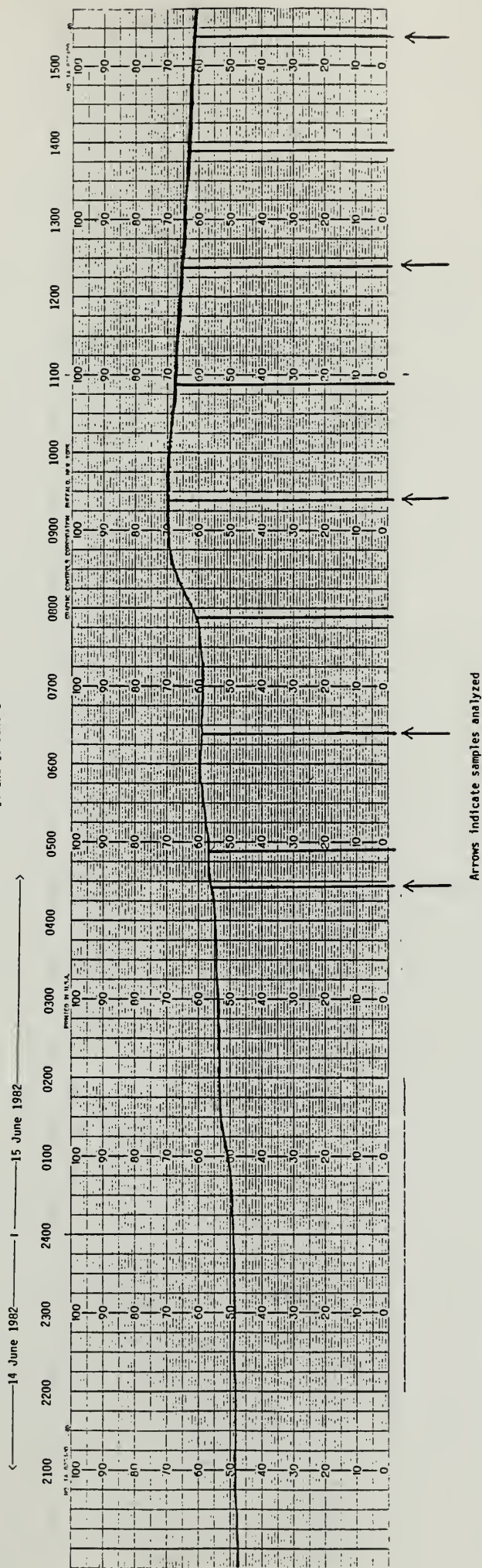
Arrows indicate samples analyzed

A-7
Yellow River Runoff Study
Hydrograph for Station #2
Event 1
14 and 15 June 1982



Arrows indicate samples analyzed

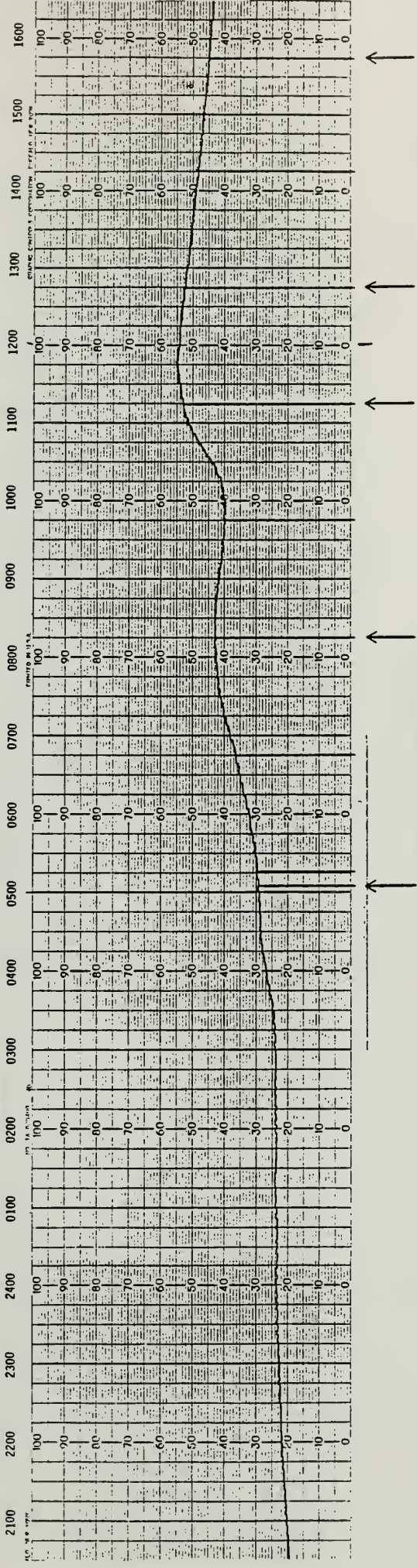
A-8
Yellow River Runoff Study
Hydrograph for Station #3
Event 1
14 and 15 June 1982



Arrows indicate samples analyzed

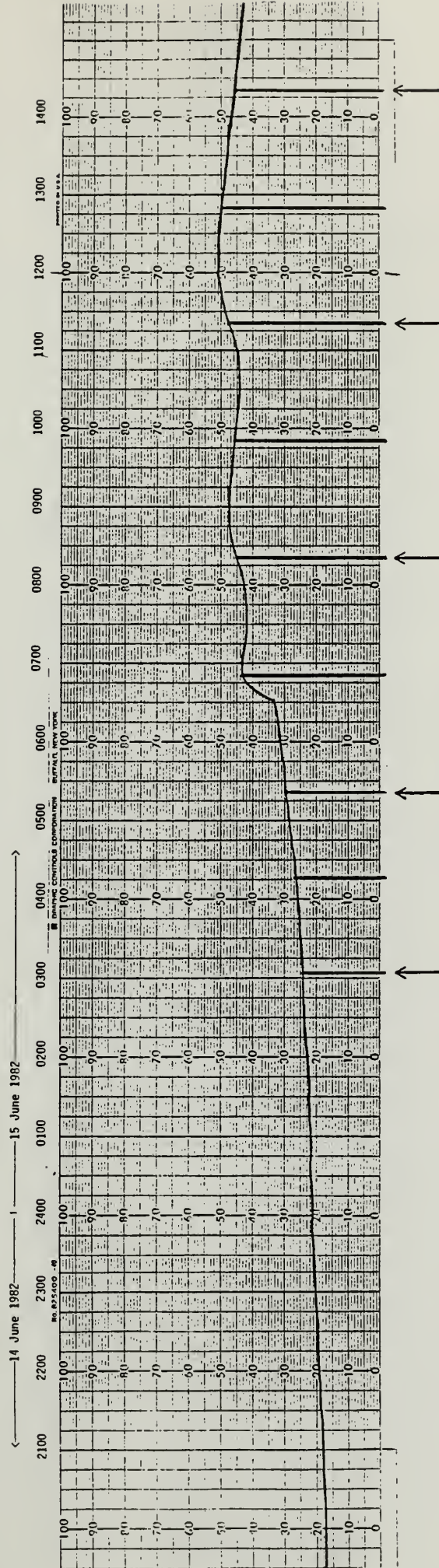
A-9
 Yellow River Runoff Study
 Hydrograph for Station #4
 Event 1
 14 and 15 June 1982

14 June 1982 15 June 1982



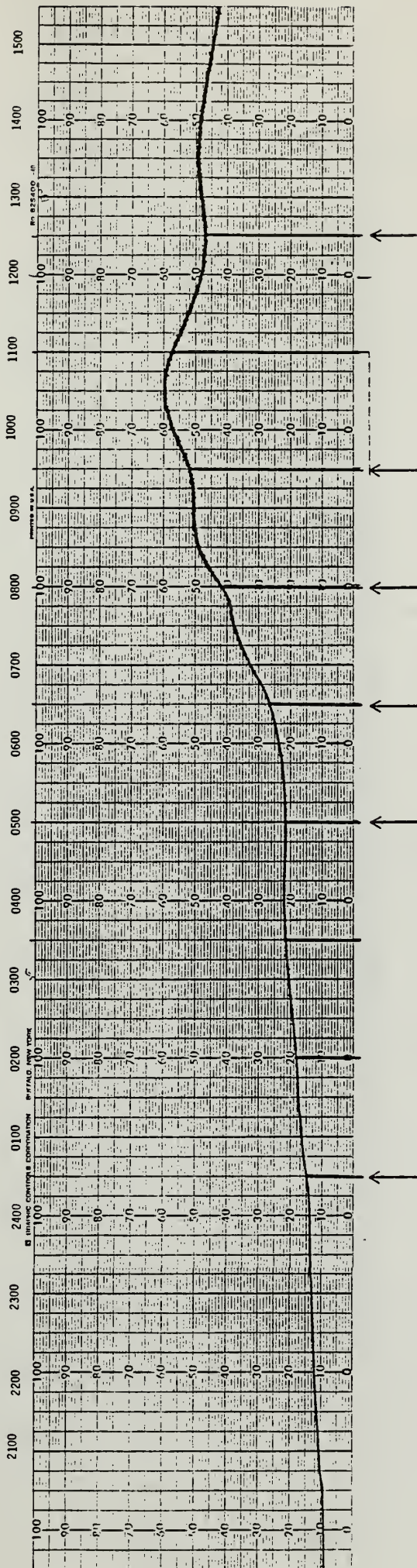
Arrows indicate samples analyzed

A-10
 Yellow River Runoff Study
 Hydrograph for Station #5
 Event 1
 14 and 15 June 1982



A-11
 Yellow River Runoff Study
 Hydrograph for Station #6
 Event 1
 14 and 15 June 1982

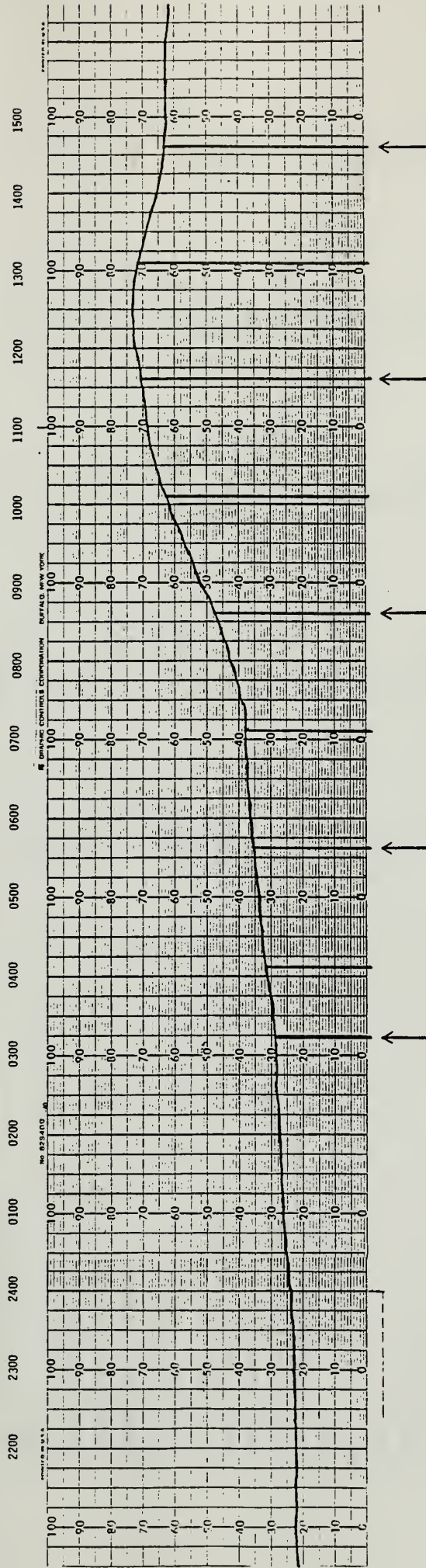
← 14 June 1982 | 15 June 1982 →



Arrows indicate samples analyzed

A-12
Yellow River Runoff Study
Hydrograph for Station #7
Event 1
14 and 15 June 1982

← 14 June 1982 | 15 June 1982 →



Arrows indicate samples analyzed

YELLOW RIVER RUNOFF STUDY

Station 1

Event #1 - 14-15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection				
	2245	0145	0445	0745	1045
Specific Conductance ¹	600	560	530	490	500
pH ²	8.1	8.0	7.7	7.9	7.7
p ³ Alkalinity	0	0	0	0	0
Total Alkalinity	252	232	212	191	196
Organic Nitrogen	3.5	2.9	6.4	6.3	7.8
Ammonia Nitrogen	0.17	0.31	1.3	0.91	1.3
Nitrate Nitrogen	5.8	5.5	4.2	4.9	5.0
Nitrate	25.7	24.4	18.6	21.7	22.2
Filtrable Residue	390	320	300	280	300
Nonfiltrable Residue	600	500	920	1,400	1,300
Total Residue	1,000	850	1,400	2,000	1,900
Filtrable Phosphate	0.15	0.17	0.42	0.36	0.46
Total Phosphate	1.1	0.97	2.1	2.5	3.0
BOD	19	9	35	30	40
COD	99	75	180	173	196
TOC	34	26	57	61	70
Turbidity ⁴	120	130	220	310	360
Temperature ⁵	17.5	17.5	17.5	17.5	17.5
Flow ⁶	39	48	54	61	56

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 2

Event #1 14-15 June 1982

(all values in mg/L unless designated otherwise)

Time of Collection

<u>Parameter</u>	<u>2315</u>	<u>0230</u>	<u>0530</u>	<u>0700</u>	<u>1000</u>
Specific Conductance ¹	580	530	550	380	380
pH ²	8.0	8.0	8.1	7.6	7.7
p ³ Alkalinity	0	0	0	0	0
Total Alkalinity	253	223	224	165	150
Organic Nitrogen	4.4	4.0	2.8	28	6.3
Ammonia Nitrogen	0.35	0.52	0.61	1.3	0.80
Nitrate Nitrogen	5.8	5.3	5.4	3.5	4.4
Nitrate	25.7	23.5	23.9	15.5	19.5
Filtrable Residue	300	300	290	430	220
Nonfiltrable Residue	960	620	360	10,300	1,200
Total Residue	1,400	1,000	740	15,700	1,600
Filtrable Phosphate	0.21	0.29	0.34	0.60	0.50
Total Phosphate	1.7	1.5	1.1	11	2.8
BOD	24	20	13	55	25
COD	128	115	77	722	177
TOC	44	41	30	240	63
Turbidity ⁴	260	180	120	2,600	360
Temperature ⁵	18	18	18	18	18
Flow ⁶	65	67	67	131	114

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 3

Event #1 - 15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection			
	0425	0625	0925	1325
Specific Conductance ¹	630	560	580	480
pH ²	8.0	8.0	7.9	7.8
p ³ Alkalinity	0	0	0	0
Total Alkalinity	275	239	243	196
Organic Nitrogen	1.2	4.0	2.9	5.9
Ammonia Nitrogen	0.29	0.42	0.55	0.88
Nitrate Nitrogen	6.5	6.5	5.8	5.0
Nitrate	28.8	28.9	25.7	22.2
Filtrable Residue	330	300	340	270
Nonfiltrable Residue	210	1,200	730	1,100
Total Residue	600	1,700	1,100	1,400
Filtrable Phosphate	0.13	0.19	0.23	0.38
Total Phosphate	0.56	1.6	1.2	2.2
BOD	6	7	9	24
COD	44	100	91	162
TOC	15	37	32	56
Turbidity ⁴	55	350	160	400
Temperature ⁵	16	16	16	16
Flow ⁶	213	231	295	272
				1625
				470
				7.8
				0
				222
				4.0
				0.88
				6.0
				26.6
				310
				610
				980
				0.31
				1.3
				18
				96
				37
				210
				16
				245

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 4

Event #1 - 15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection				
	0505	0815	1115	1245	1545
Specific Conductance ¹	630	590	570	560	490
pH ²	8.1	7.8	7.9	8.0	8.0
p ³ Alkalinity	0	0	0	0	0
Total Alkalinity	274	243	237	243	203
Organic Nitrogen	1.1	2.2	3.6	3.2	5.4
Ammonia Nitrogen	0.52	0.61	0.54	0.41	0.69
Nitrate Nitrogen	6.2	6.9	6.2	5.9	5.2
Nitrate	27.5	30.6	27.5	26.1	23.0
Filtrable Residue	340	310	280	280	270
Nonfiltrable Residue	360	540	920	740	1,100
Total Residue	880	990	1,200	1,000	1,400
Filtrable Phosphate	0.09	0.14	0.21	0.23	0.33
Total Phosphate	0.51	0.79	1.2	1.0	2.2
BOD	10	7	13	13	22
COD	50	63	95	81	139
TOC	17	22	31	27	34
Turbidity ⁴	70	130	250	190	380
Temperature ⁵	16	16	16	16	16
Flow ⁶	203	238	265	264	244

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 5

Event #1 - 15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection				
	0305	0520	0820	1120	1420
Specific Conductance ¹					
pH ²	610	600	550	500	530
p ³ Alkalinity	8.1	8.1	8.0	7.85	8.0
Total Alkalinity	0	0	0	0	0
Organic Nitrogen	266	260	238	208	219
Ammonia Nitrogen	0.38	1.3	2.9	6.4	3.8
Nitrate Nitrogen	0.25	0.28	0.37	0.58	0.51
Nitrate	5.7	6.0	5.3	6.1	5.8
Filtrable Residue	52.2	26.6	23.5	27.0	25.7
Nonfiltrable Residue	240	310	310	240	240
Total Residue	150	300	670	1,300	820
Filtrable Phosphate	390	750	1,100	1,600	1,100
Total Phosphate	0.12	0.14	0.21	0.39	0.27
BOD	0.20	0.71	0.95	1.9	1.3
COD	5	5	11	18	15
TOC	29	47	85	151	99
Turbidity ⁴	7.6	12	24	48	32
Temperature ⁵	27	100	200	400	250
Flow ⁶	16.5	16.5	16.5	16.5	16.5
	221	253	297	304	301

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 6

Event #1 - 15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection					
	0030	0500	0630	0800	0930	1230
Specific Conductance ¹	610	600	580	510	480	460
pH ²	8.1	8.2	8.2	8.0	7.9	7.8
p ³ Alkalinity	0	0	0	0	0	0
Total Alkalinity	269	262	251	223	211	194
Organic Nitrogen	0.57	2.1	1.8	4.6	7.3	11
Ammonia Nitrogen	0.24	0.32	0.31	0.51	0.58	0.87
Nitrate Nitrogen	5.2	5.9	5.6	5.0	4.9	5.5
Nitrate	23.0	26.1	24.8	22.2	21.7	24.4
Filtrable Residue	260	310	290	270	260	280
Nonfiltrable Residue	210	450	350	1,300	2,000	2,500
Total Residue	560	770	680	1,700	2,600	3,100
Filtrable Phosphate	0.06	0.13	0.13	0.18	0.27	0.29
Total Phosphate	0.21	0.67	0.53	1.4	2.4	3.3
BOD	20	6	7	14	18	22
COD	52	66	50	109	179	258
TOC	18	22	18	40	63	81
Turbidity ⁴	32	120	90	360	600	750
Temperature ⁵	16	16	16	16	16	16
Flow ⁶	196	221	328			

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 7

Event #1 - 15 June 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection				
	0315	0540	0840	1140	1440
Specific Conductance ¹					
pH ²	610	570	560	490	470
p ³ Alkalinity	8.2	8.3	8.2	8.1	8.1
Total Alkalinity	0	0	0	0	0
Organic Nitrogen	267	259	248	220	201
Ammonia Nitrogen	0.89	0.40	1.5	4.7	10
Nitrate Nitrogen	0.22	0.20	0.22	0.46	0.68
Nitrate	4.9	4.9	4.9	4.9	4.8
Filtrable Residue	21.7	21.7	21.7	21.7	21.3
Nonfiltrable Residue	340	300	290	280	270
Total Residue	190	210	400	1,400	1,900
Filtrable Phosphate	610	680	840	2,000	2,400
Total Phosphate	0.05	0.06	0.11	0.19	0.24
BOD	0.22	0.24	0.60	1.7	2.8
COD	19	4	6	16	27
TOC	47	29	45	124	199
Turbidity ⁴	18	9.5	15	40	73
Temperature ⁵	27	55	100	450	650
Flow ⁶	16	16	16	16	16
	360	454	688	1,300	1,080

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

PEAK LOADING FOR ALL PARAMETERS

YELLOW RIVER RUNOFF STUDY

Event #1 - 14-15 June 1982

(all values in kilograms unless designated otherwise)

Parameter	<u>Sampling Stations</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Total Alkalinity	0.330(0745) *	0.484(1000)	1.66 (0425)	1.58 (0505) *	2.00 (0820) *	3.95 (1230) *	8.77 (1140) *
Organic Nitrogen	0.012(1045)	0.020(1000)	0.045(1325)	0.077(1245)	0.055(1120)	0.224(1230)	0.306(1440)
Ammonia Nitrogen	0.002(1045)	0.012(0700)	0.007(1325)	0.004(0815)	0.005(1120)	0.018(1230)	0.021(1440)
Nitrate Nitrogen	0.008(0745)	0.014(1000)	0.039(0425)	0.047(0815)	0.053(1120)	0.112(1230)	0.180(1140)
Nitrate	0.035(0745)	0.062(1000)	0.173(0425)	0.208(0815)	0.235(1120)	0.496(1230)	0.797(1140)
Filtrable Residue	0.484(0745)	1.59 (0700)	1.99 (0425)	1.95 (0505)	2.607(0820)	5.701(1230)	10.31 (1140)
Nonfiltrable Residue	2.418(0745)	38.21 (0700)	7.85 (0625)	6.43 (1545)	11.19 (1120)	50.90 (1230)	51.54 (1140)
Total Residue	3.455(1045)	58.25 (0700)	10.78 (1325)	8.19 (1545)	13.77 (1120)	63.12 (1230)	73.63 (1140)
Filtrable Phosphate	0.001(1045)	0.002(1000)	0.003(1325)	0.002(1545)	0.003(1120)	0.006(1230)	0.007(1140)
Total Phosphate	0.005(1045)	0.009(1000)	0.011(0625)	0.013(1545)	0.016(1120)	0.067(1230)	0.086(1440)
BOD	0.063(1045)	0.204(0700)	0.099(1325)	0.129(1545)	0.155(1120)	0.448(1230)	0.826(1440)
COD	0.311(1045)	2.68 (0700)	0.666(1325)	0.813(1545)	1.30 (1120)	5.25 (1230)	6.09 (1440)
TOC	0.111(1045)	0.890(0700)	0.431(1325)	0.199(1545)	0.413(1120)	1.65 (1230)	2.23 (1440)

* values in parantheses are times of sample collection

TOTAL LOADING FOR ALL PARAMETERS

YELLOW RIVER RUNOFF STUDY

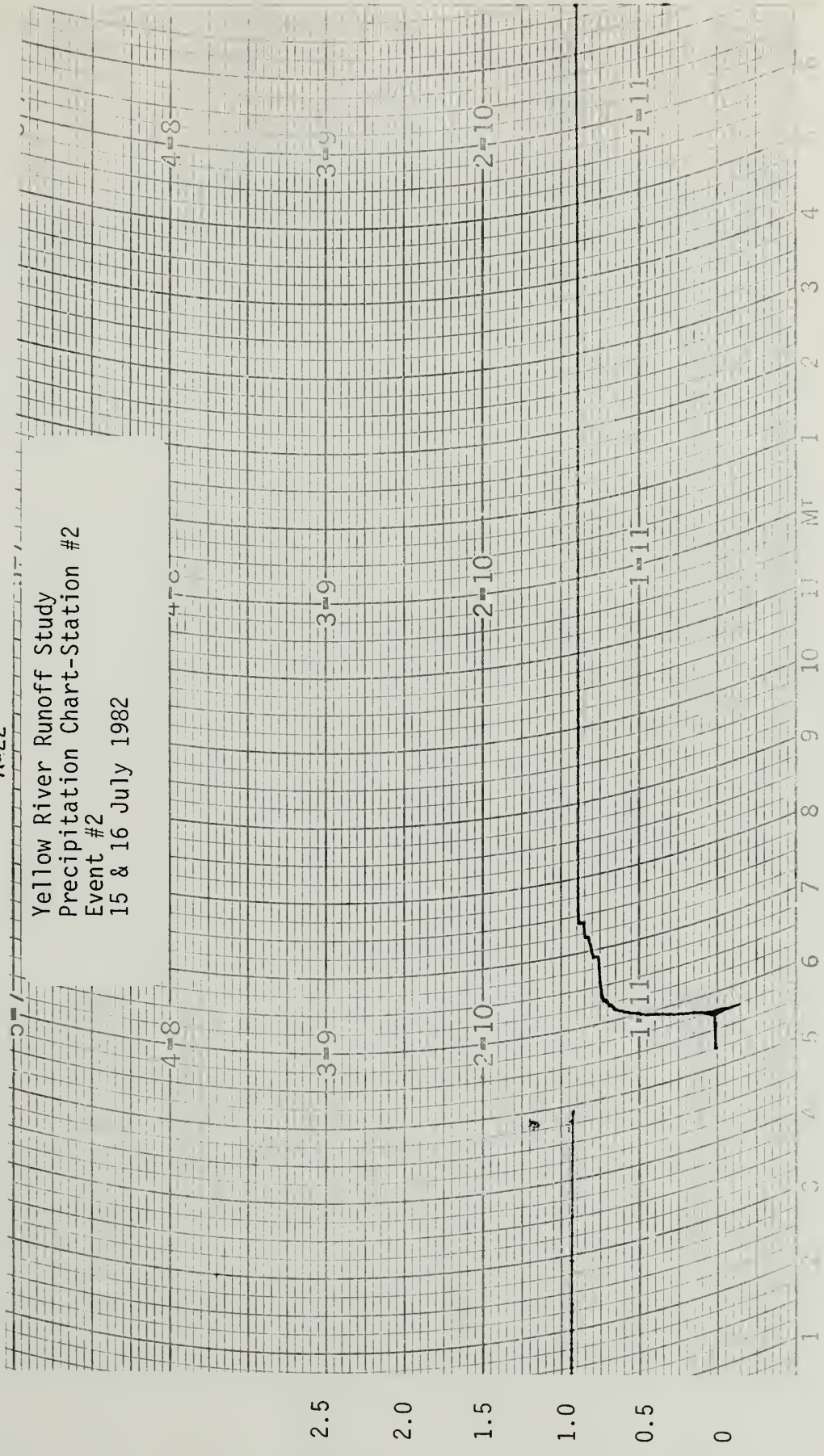
Event #1 - 14-15 June 1982

(all values in kilograms unless designated otherwise)

<u>Parameter</u>	<u>Sampling Stations</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Total Alkalinity	16,300	25,779	87,047	81,836	93,239	136,837	259,578
Organic Nitrogen	436	582	1,404	1,443	1,344	4,359	8,480
Ammonia Nitrogen	67	101	224	190	169	383	491
Nitrate Nitrogen	385	629	2,209	2,073	2,298	3,313	5,553
Nitrate	1,700						
Filtrable Residue	23,892	40,428	113,402	101,393	101,617	172,523	326,073
Nonfiltrable Residue	76,886	402,019	188,414	240,301	292,023	1,076,155	1,295,098
Total Residue	15,399	605,853	441,107	367,543	429,033	1,397,000	1,885,904
Filtrable Phosphate	26	55	94	66	97	143	185
Total Phosphate	158	240	286	378	447	1,349	1,739
BOD	2,144	3,716	5,030	4,322	4,763	10,878	18,417
COD	11,643	35,829	38,491	28,395	36,314	106,516	129,901
OOC	3,998	12,242	13,697	8,690	11,022	35,450	44,936

A-22

Yellow River Runoff Study
Precipitation Chart-Station #2
Event #2
15 & 16 July 1982

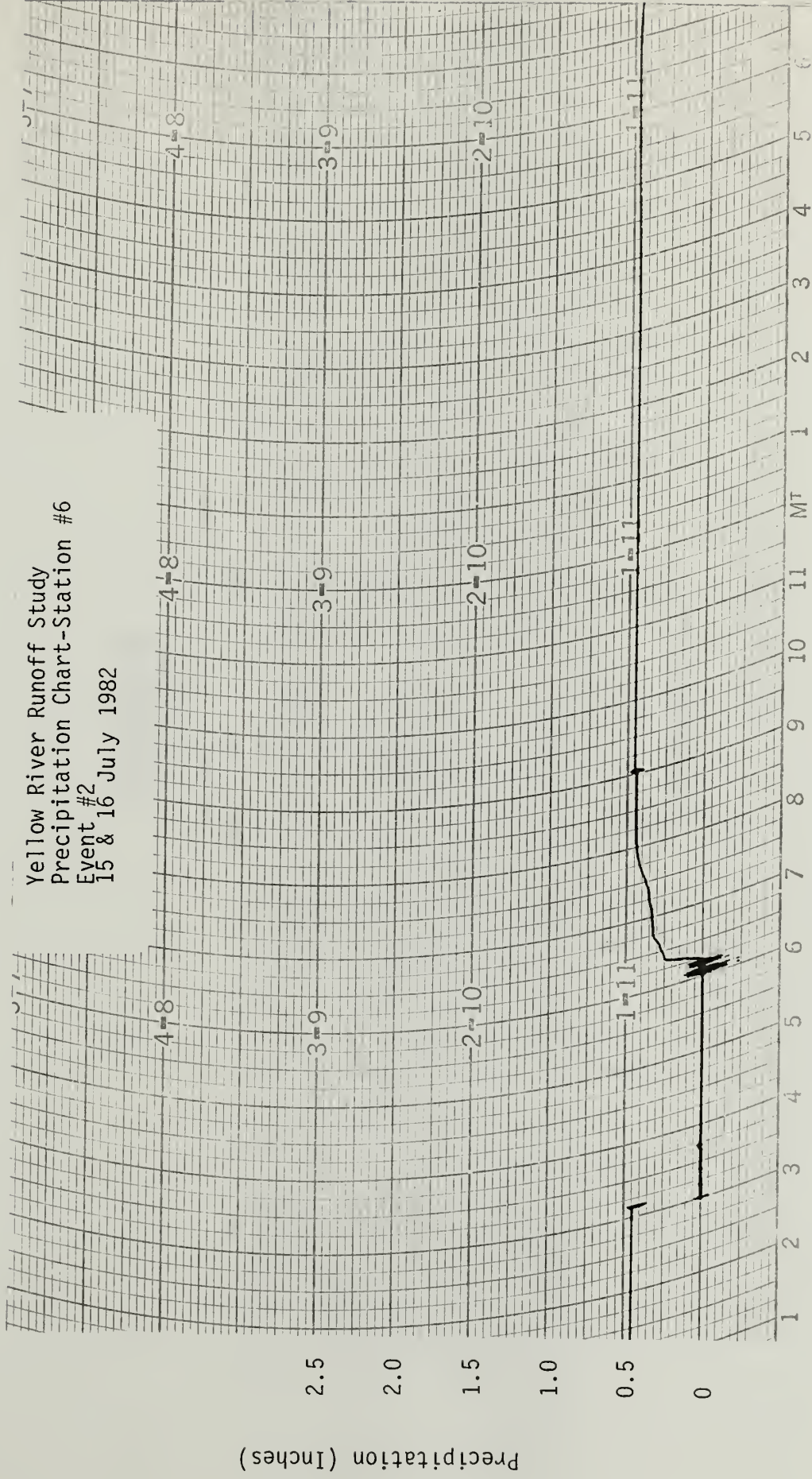


15 July 1982 | 16 July 1982

Time (Hours)

A-23

Yellow River Runoff Study
Precipitation Chart-Station #6
Event #2
15 & 16 July 1982

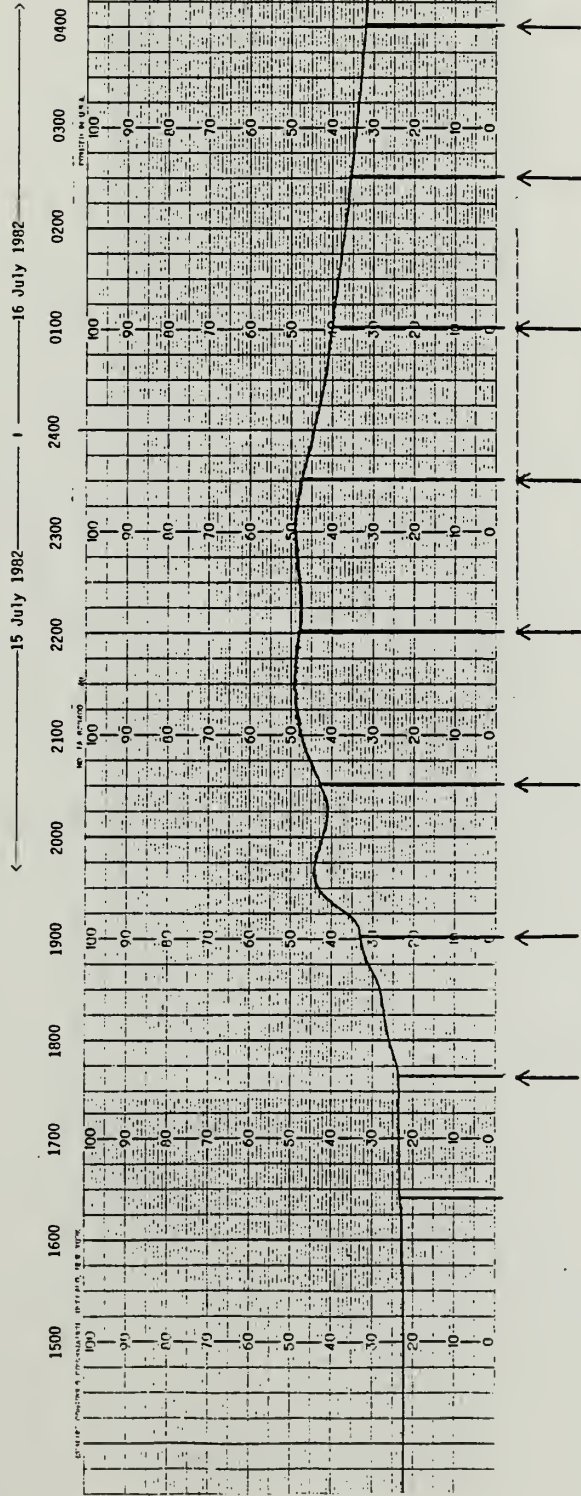


15 July 1982

16 July 1982

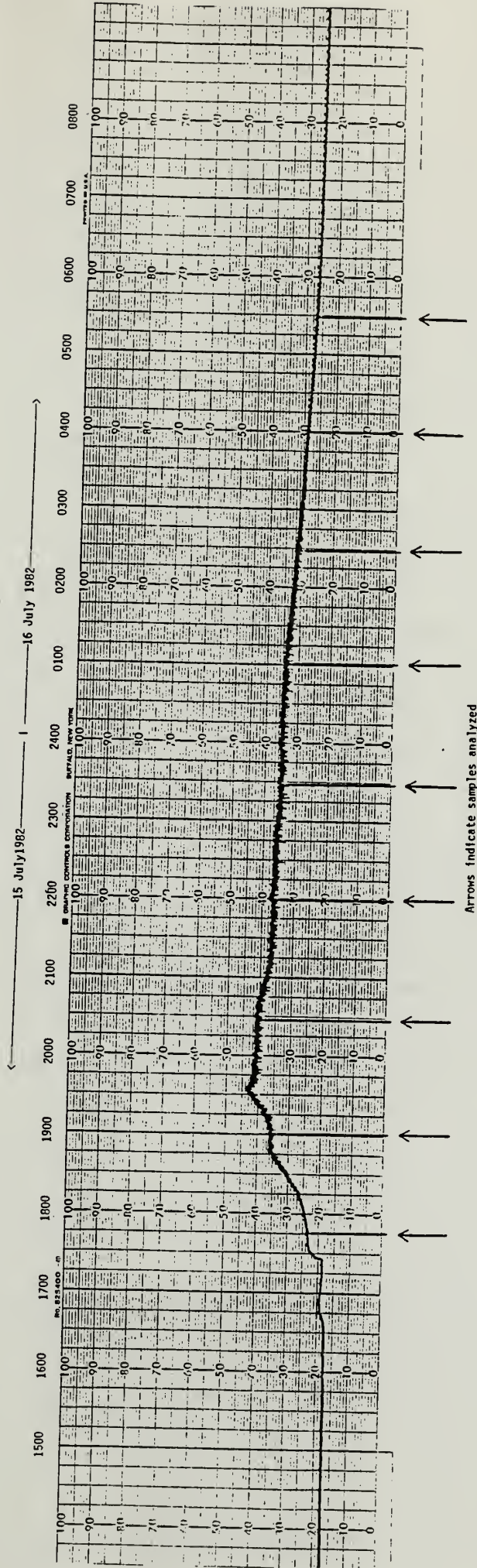
Time (Hours)

A-24
Yellow River Runoff Study
Hydrograph for Station #1
Event 2
15 and 16 July 1982

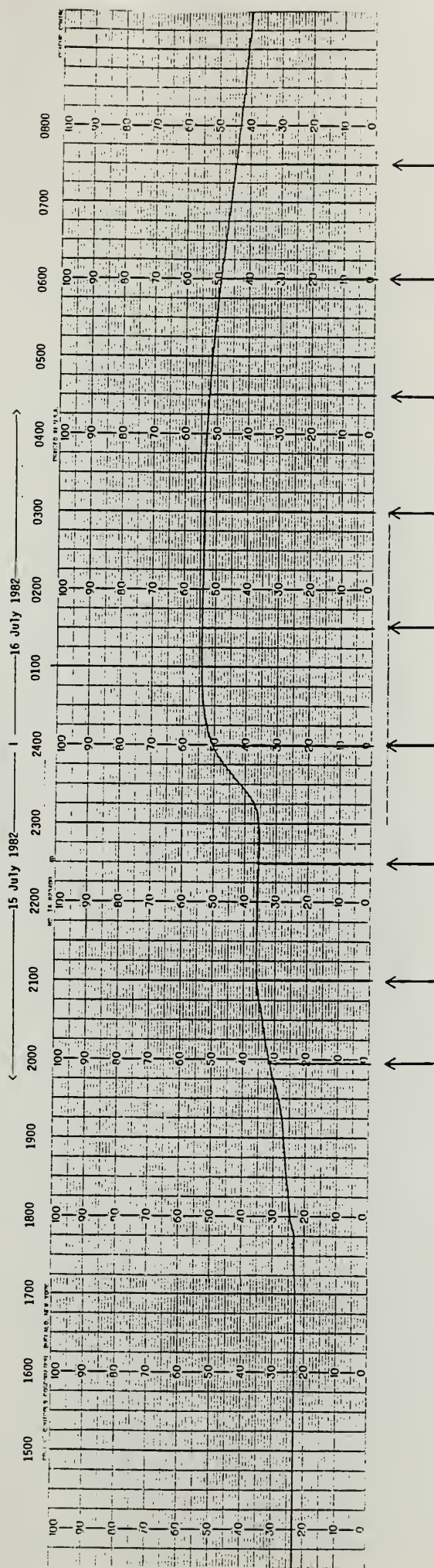


Arrows indicate samples analyzed

A-25
 Yellow River Runoff Study
 Hydrograph for Station #2
 Event 2
 15 and 16 July 1982

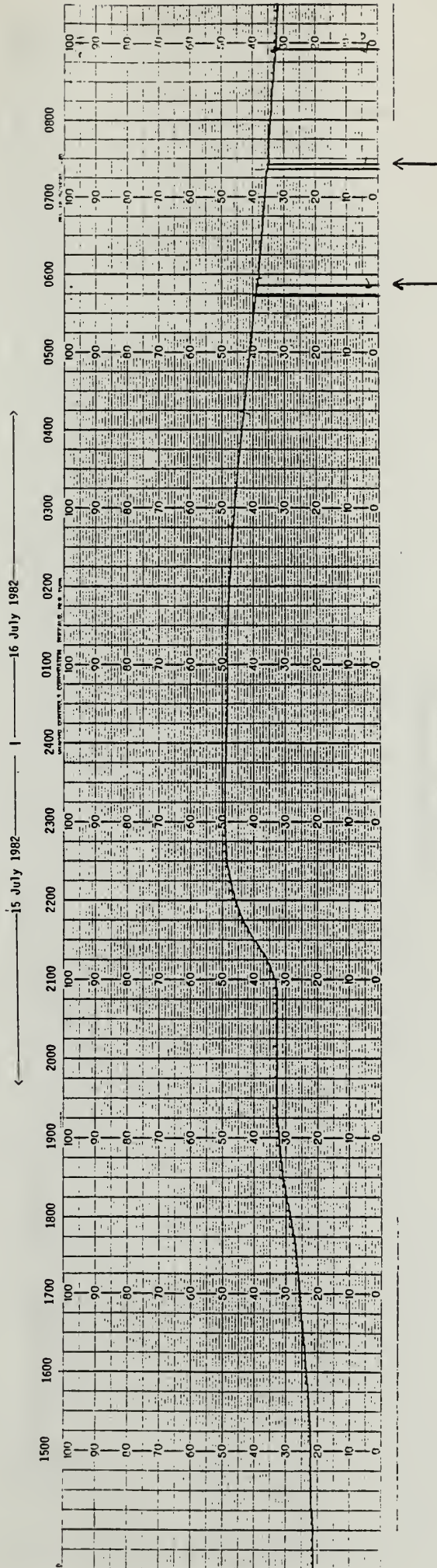


A-26
 Yellow River Runoff Study
 Hydrograph for Station #5
 Event 2
 15 and 16 July 1982



Arrows indicate samples analyzed

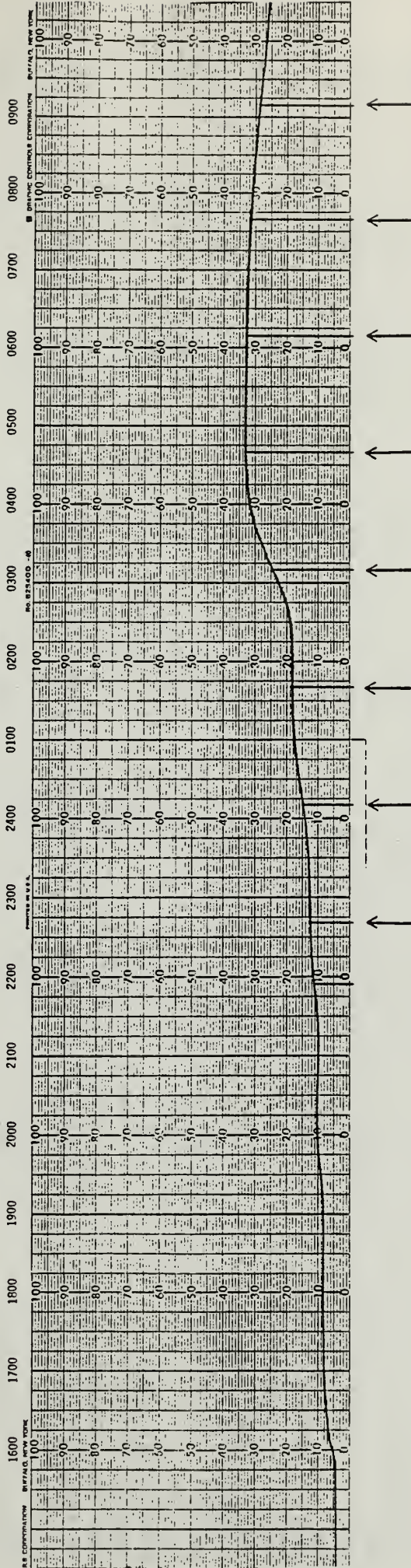
A-27
 Yellow River Runoff Study
 Hydrograph for Station #6
 Event 2
 15 and 16 July 1982



Arrows indicate samples analyzed

A-28
Yellow River Runoff Study
Hydrograph for Station #7
Event 2
15 and 16 July 1982

15 July 1982 | 16 July 1982



Arrows indicate samples analyzed

YELLOW RIVER RUNOFF STUDY

Station 1

Event #2 - 15-16 July 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection							
	1740	1900	2030	2200	2330	0100	0230	0400
Specific Conductance ¹	630	540	460	440	410	380	370	420
pH ²	8.2	8.2	8.0	7.9	7.7	7.8	7.8	7.7
p ³ Alkalinity	0	0	0	0	0	0	0	0
Total Alkalinity	277	246	192	188	164	156	162	168
Organic Nitrogen	1.3	4.5	6.5	6.6	13	12	14	11
Ammonia Nitrogen	0.09	0.06	0.09	0.15	1.1	1.0	0.95	0.81
Nitrate Nitrogen	6.1	5.1	4.0	4.6	3.0	3.8	4.4	4.6
Nitrate	27.0	22.6	17.7	20.4	13.3	16.8	19.5	20.4
Filtrable Residue	450	370	380	380	340	360	370	370
Nonfiltrable Residue	120	1,200	1,500	2,300	2,300	2,200	2,300	1,400
Total Residue	580	1,600	1,900	2,800	2,800	2,500	2,600	1,800
Filtrable Phosphate	0.13	0.19	0.24	0.35	0.59	0.47	0.51	0.63
Total Phosphate	0.41	1.6	2.2	2.3	4.4	3.7	4.4	3.5
BOD	5	14	24	35	45	30	35	30
COD	33	100	145	140	295	236	295	223
TOC	14	45	47	55	98	87	110	71
Turbidity ⁴	55	310	500	650	750	800	1,100	650
Temperature ⁵	21	21	21	21	21	21	21	21
Flow ⁶	15	45	57	65	62	51	48	43

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 2

Event #2 - 15-16 July 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection								
	1745	1900	2030	2200	2330	0100	0230	0400	0530
Specific Conductance ¹	410	290	290	350	360	360	380	370	390
pH ²	7.6	7.7	7.7	7.8	7.8	7.6	7.9	7.9	7.9
p ³ Alkalinity	0	0	0	0	0	0	0	0	0
Total Alkalinity	224	138	146	158	154	184	154	156	158
Organic Nitrogen	24	24	19	11	9.2	16	10	12	13
Ammonia Nitrogen	0.37	0.45	0.53	0.43	0.25	1.5	0.60	0.64	0.61
Nitrate Nitrogen	2.8	3.2	3.6	3.4	4.0	1.9	4.1	4.3	4.6
Nitrate	12.4	14.2	15.9	15.1	17.7	8.4	18.2	19.0	20.3
Filtrable Residue	370	300	300	320	310	410	470	440	480
Nonfiltrable Residue	6,600	6,400	4,700	2,300	1,900	2,000	1,700	2,000	1,900
Total Residue	7,100	6,900	5,100	2,700	2,300	2,500	2,100	2,600	2,300
Filtrable Phosphate	0.37	0.77	0.63	0.52	0.40	0.75	0.51	0.43	0.51
Total Phosphate	9.1	9.5	7.1	4.0	3.3	5.3	3.5	4.1	4.2
BOD	85	50	40	28	26	65	35	30	35
COD	598	500	422	229	200	390	213	255	246
TOC	210	170	150	90	62	72	100	94	78
Turbidity ⁴	2,200	2,200	1,800	950	750	900	1,400	1,100	950
Temperature ⁵	21	21	21	21	21	21	21	21	21
Flow ⁶	31	72	97	77	70	67	59	45	37

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 5

Event #2 - 15-16 July 1982

(all values in mg/L unless designated otherwise)

Time of Collection

<u>Parameter</u>	<u>2000</u>	<u>2100</u>	<u>2230</u>	<u>2400</u>	<u>0130</u>	<u>0300</u>	<u>0430</u>	<u>0600</u>	<u>0730</u>
Specific Conductance ¹	620	580	590	560	590	530	420	440	430
pH ²	8.3	8.3	8.2	7.6	7.9	7.9	7.6	7.7	7.7
p ³ Alkalinity	0	0	0	0	0	0	0	0	0
Total Alkalinity	278	269	252	244	262	240	194	194	192
Organic Nitrogen	1.2	0.97	1.7	3.5	4.3	7.0	10	9.0	8.1
Ammonia Nitrogen	0.05	0.04	0.05	0.07	0.06	0.13	0.16	0.21	0.19
Nitrate Nitrogen	5.1	4.9	4.9	5.0	5.4	5.0	4.5	4.6	4.3
Nitrate	22.6	21.7	21.7	22.2	23.9	22.2	19.9	20.4	19.0
Filtrable Residue	300	460	440	340	360	320	260	250	290
Nonfiltrable Residue	200	78	250	860	1,100	1,500	2,400	2,100	1,900
Total Residue	570	530	730	1,200	1,500	1,900	2,700	2,400	2,200
Filtrable Phosphate	1.4	0.16	0.18	0.27	0.27	0.29	0.39	0.40	0.34
Total Phosphate	0.46	0.46	0.73	1.2	1.7	2.8	4.6	4.0	3.7
BOD	6	4	6	14	14	24	29	28	26
COD	30	30	51	79	94	150	241	210	198
TOC	13	7.6	12	28	31	46	75	68	64
Turbidity ⁴	55	50	120	280	320	550	1,000	850	800
Temperature ⁵	19	19	19	19	19	19	19	19	19
Flow ⁶	182	193	191	302	313	311	308	298	271

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 6

Event #2 - 16 July 1982

(all values in mg/L unless designated otherwise)

Parameter	Time of Collection	
	0945	1125
Specific Conductance ¹	490	470
pH ²	7.7	7.8
p ³ Alkalinity	0	0
Total Alkalinity	214	205
Organic Nitrogen	7.0	5.9
Ammonia Nitrogen	0.15	0.13
Nitrate Nitrogen	4.4	4.3
Nitrate	19.5	19.0
Filtrable Residue	300	240
Nonfiltrable Residue	1,300	1,300
Total Residue	1,600	1,600
Filtrable Phosphate	0.25	0.25
Total Phosphate	2.9	2.9
BOD	27	18
COD	160	151
TOC	49	47
Turbidity ⁴	550	600
Temperature ⁵	19	19
Flow ⁶	286	211

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

YELLOW RIVER RUNOFF STUDY

Station 7

Event #2 - 16 July 1982

(all values in mg/L unless designated otherwise)

Time of Collection

<u>Parameter</u>	<u>0040</u>	<u>0210</u>	<u>0340</u>	<u>0510</u>	<u>0640</u>	<u>0810</u>	<u>0940</u>	<u>1110</u>
Specific Conductance ¹	570	570	590	580	590	610	570	550
pH ²	7.8	7.9	7.9	7.9	7.8	7.9	7.8	7.8
p ³ Alkalinity	0	0	0	0	0	0	0	0
Total Alkalinity	258	261	264	261	266	268	250	238
Organic Nitrogen	0.82	1.2	1.1	1.6	1.9	1.4	2.0	2.9
Ammonia Nitrogen	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
Nitrate Nitrogen	4.0	4.0	4.1	4.1	4.4	4.6	4.6	4.6
Nitrate	17.7	17.7	18.2	18.2	19.5	20.4	20.4	20.4
Filtrable Residue	320	300	310	300	320	330	320	300
Nonfiltrable Residue	200	210	220	250	420	330	410	650
Total Residue	540	560	580	620	790	730	810	950
Filtrable Phosphate	0.11	0.11	0.11	0.11	0.14	0.12	0.15	0.18
Total Phosphate	0.47	0.51	0.53	0.59	0.77	0.66	0.80	1.0
BOD	6	5	5	6	7	6	7	10
COD	30	34	33	38	49	41	51	70
TOC	11	12	10	12	13	12	12	19
Turbidity ⁴	60	70	65	70	110	90	120	180
Temperature ⁵	19	19	19	19	19	19	19	19
Flow ⁶	158	187	218	279	414	412	390	345

¹Micromhos per cm @ 25°C²pH Units³Phenolphthalein⁴Nephelometric Turbidity Units⁵Degrees Centigrade⁶Cubic Feet per Second

PEAK LOADING FOR ALL PARAMETERS

YELLOW RIVER RUNOFF STUDY

Event #2 - 15-16 July 1982

(all values in kilograms unless designated otherwise)

<u>Parameter</u>	<u>Stations</u>						
	<u>1</u>	<u>2</u>	<u>5</u>	<u>6</u>	<u>7</u>		
Total Alkalinity	0.346 (2200)	0.401 (2030)	2.32 (0130)	1.73 (0945)	3.13 (0810)	*	
Organic Nitrogen	0.023 (2330)	0.052 (2030)	0.087 (0430)	0.057 (0945)	0.028 (1110)		
Ammonia Nitrogen	0.002 (2330)	0.003 (0100)	0.002 (0600)	0.001 (0945)	0.001 (0810)		
Nitrate Nitrogen	0.009 (2200)	0.010 (2030)	0.048 (0130)	0.036 (0945)	0.054 (0810)		
Nitrate	0.039 (2200)	0.088 (2030)	0.212 (0130)	0.159 (0945)	0.478 (0810)		
Filtrable Residue	0.699 (2200)	0.824 (2030)	0.212 (0130)	2.43 (0945)	3.85 (0810)		
Nonfiltrable Residue	4.23 (2200)	12.91 (2030)	3.19 (0130)	10.53 (0945)	6.35 (1110)		
Total Residue	5.15 (2200)	14.01 (2030)	23.55 (0430)	12.96 (0945)	9.28 (1110)		
Filtrable Phosphate	0.001 (2330)	0.002 (2030)	0.003 (0430)	0.002 (0945)	0.002 (1110)		
Total Phosphate	0.007 (2330)	0.020 (2030)	0.040 (0430)	0.024 (0945)	0.010 (1110)		
BOD	0.079 (2330)	0.123 (0100)	0.253 (0430)	0.219 (0945)	0.098 (1110)		
COD	0.518 (2330)	1.16 (2030)	2.10 (0430)	1.30 (0945)	0.684 (1110)		
TOC	0.172 (2330)	0.412 (2030)	0.654 (0430)	0.397 (0945)	0.186 (1110)		

* values in parentheses are times of sample collection

TOTAL LOADING FOR ALL PARAMETERS

YELLOW RIVER RUNOFF STUDY

Event #2 - 15-16 July 1982

(all values in kilograms unless designated otherwise)

Parameter	<u>Stations</u>						
	<u>1</u>	<u>2</u>	<u>5</u>	<u>6</u>	<u>7</u>		
Total Alkalinity	10,937	13,236	80,295	15,975	94,829		
Organic Nitrogen	549	1,265	2,014	496	639		
Ammonia Nitrogen	33.4	50.4	40.6	10.75	23.8		
Nitrate Nitrogen	251	292	1,685	331	1,609		
Nitrate							
Filtrable Residue	21,848	30,294	7,466	21,196	115,411		
Nonfiltrable Residue	109,525	270,115	113,545	98,807	134,968		
Total Residue	133,714	281,057	590,246	121,608	269,296		
Filtrable Phosphate	24.3	47.4	122	19.0	49.0		
Total Phosphate	155	460	863	221	260		
BOD	1,779	3,443	6,561	1,762	2,477		
COD	11,689	37,724	47,194	11,870	16,838		
TOC	4,180	17,575	15,027	3,660	4,751		
Time interval used for calculations (minutes)	810	810	1,260	1,110	930		

Daily Precipitation in Inches Record for Yellow River
May, June, and July 1982
Gauge Site #2

Day	May	June	July
1	--	0.00	0.00
2	--	0.00	0.15
3	--	0.00	0.20
4	--	0.00	0.00
5	--	0.00	0.00
6	--	0.00	0.00
7	--	0.60	0.30
8	--	0.00	0.00
9	--	0.00	0.00
10	0.00	0.00	0.00
11	0.15	0.00	0.15
12	0.00	0.05	0.00
13	0.10	0.00	0.10
14	0.10	0.05	0.00
15	0.05	1.55	0.90
16	0.00	0.00	--
17	0.50	0.05	--
18	0.15	0.05	--
19	0.55	0.00	--
20	0.10	0.00	--
21	1.45	0.00	--
22	0.00	0.10	--
23	0.00	0.00	--
24	0.00	0.00	--
25	0.00	0.15	--
26	0.00	0.25	--
27	0.20	0.00	--
28	0.00	0.00	--
29	0.00	0.45	--
30	0.00	0.00	--
31	0.00	--	--

Daily Precipitation in Inches Record for Yellow River
May, June, and July 1982
Gauge Site #4

Day	May	June	July
1	--	0.00	0.00
2	--	0.00	0.00
3	--	0.00	0.00
4	--	0.00	0.00
5	--	0.00	0.00
6	--	0.00	0.00
7	--	0.45	0.00
8	--	0.00	0.00
9	--	0.00	0.00
10	0.00	0.00	0.00
11	0.20	0.00	0.00
12	0.15	0.00	0.00
13	0.10	0.00	0.00
14	0.10	0.05	0.00
15	0.20	1.90	0.00
16	0.00	0.00	0.00
17	0.45	0.05	--
18	0.00	0.05	--
19	0.20	0.00	--
20	0.00	0.00	--
21	0.60	0.00	--
22	0.70	0.10	--
23	0.00	0.00	--
24	0.00	Rain gauge	--
25	0.00	Missing	--
26	0.00	"	--
27	0.35	"	--
28	0.10	"	--
29	0.00	"	--
30	0.00	"	--
31	0.00	"	--

Daily Precipitation in Inches Record for Yellow River
May, June, and July 1982
Gauge Site #6

Day	May	June	July
1	--	0.00	0.00
2	--	0.00	0.15
3	--	0.00	0.20
4	--	0.00	0.00
5	--	0.00	0.00
6	--	0.00	0.00
7	--	0.42	0.30
8	--	0.00	0.00
9	--	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.15
12	0.00	0.00	0.00
13	0.10	0.00	0.00
14	0.00	0.05	0.00
15	0.00	1.70	0.45
16	0.00	0.00	--
17	0.10	0.05	--
18	0.00	0.05	--
19	0.00	0.00	--
20	0.00	0.00	--
21	0.85	0.00	--
22	0.00	0.10	--
23	0.00	0.00	--
24	0.00	0.00	--
25	0.00	0.15	--
26	0.00	0.25	--
27	0.10	0.00	--
28	0.00	0.00	--
29	0.00	0.40	--
30	0.00	0.00	--
31	0.00	--	--

