WATER QUALITY

MACROINVERTEBRATE

and

FISH COMMUNITY SURVEY

of the

UPPER WHITE RIVER WATERSHED

Northwest Arkansas

West Fork, Middle Fork and Main Fork White River

Brush Creek, Richland Creek, War Eagle Creek

Kings River, Osage Creek, Long Creek, and Yocum Creek

August 1995
WQ95-08-1

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INTRODUCTION

Northwest Arkansas offers the State's citizens many natural and anthropogenic opportunities such as: Beaver Lake, the upper White River and its tributaries, the Ozark Mountains, historical monuments, rural and urban developments, industrial and agricultural development, academics, aesthetics, and fish and wildlife related activities. This portion of Arkansas is very important socially, economically, politically and environmentally.

Northwest Arkansas has experienced many changes in the past ten to twenty years. With the boom in the poultry industry, agricultural activities and other related industries in the area have increased dramatically. Additional activities include the growth of the dairy and beef cattle industry, which has accelerated land clearing to provide additional pasture land. Rural and urban development has also increased with the addition of farms and supporting businesses in the rural communities. As a result, this area has one of the highest population growth rates in the State.

The construction of Beaver Lake in the early 1960's created more recreational activities in the area and increased growth in the recreational industry. This enhanced the existing recreational uses of the upper White River and its tributaries including primary and secondary contact and other recreational activities. Tourist attractions in adjacent areas and in nearby states along with the naturally high aesthetics of the area have also increased tourism in northwest Arkansas. Increased development to support the tourism industry include the construction of roads, hotels, restaurants and other amenities.

Water quality concerns of adjacent states have directed most of the recent water quality surveys in the area to be concentrated in the westward draining watersheds in northwest Arkansas. This is primarily in the Illinois River basin. The upper White River watershed has virtually been ignored because of this. The potential for increased pollution from agricultural and other nonpoint sources in the upper White River and its tributaries prompted a survey of this drainage basin. Of special concern was the potential impact on the Kings River, an Extraordinary Resource Waterbody.

The objectives of this survey were to:

1) Determine the existing water quality in the basin;
2) Quantify pollutants in the waterways;
3) Identify sources of pollutants;
4) Characterize macroinvertebrate communities in key waters;
5) Characterize existing fish communities in key waters and compare them to historical data.

WATERSHED DESCRIPTION

Location

The upper White River watershed, which was investigated in this study, includes the West Fork, Middle Fork, and Main Fork of the White River, Brush Creek, Richland Creek, War Eagle Creek, Kings River, Osage Creek, Long Creek and Yocum Creek. This basin drains approximately 1549 mi^2 of watershed in all or part of Washington, Madison, Benton, Carroll and Boone counties, Arkansas. Most of these waterbodies arise in the Boston Mountains Ecoregion and flow in a northerly direction across the Springfield Plateau of the Ozark Highlands Ecoregion before joining either the White River, Beaver Lake, or Table Rock Lake. A small portion of the headwater streams of the White River and its forks, War Eagle Creek, and the Kings River arise in the Boston Mountains ecoregion. Individual watershed sizes taken from the furthest downstream sample station are listed below.

West Fork White River	103 mi^2
Middle Fork White River	77 mi^2
Main Fork White River	184 mi^2
Richland Creek	143 mi^2
Brush Creek	45 mi^2
War Eagle Creek	310 mi^2
Kings River	346 mi^2
Osage Creek	126 mi^2
Yocum Creek	53 mi^2
Long Creek & Dry Creek	162 mi^2
Total	1549 mi^2

Topography

The headwater streams of the upper White River forks arise in the Boston Mountains at an elevation between 2100 and 2400 feet msl. They enter the Springfield Plateau at an elevation around 1400 feet msl. Slopes in the headwaters are quite steep, but quickly change to moderate to gently sloping throughout the rivers mid and lower sections. Brush Creek and Richland Creek arise mainly on the Springfield Plateau and flow across it until they enter Beaver Lake. Generally, their slopes are characterized as being moderate to gentle, thus reflecting the uniform topography of the Plateau. War Eagle Creek slopes are similar to the White River. Headwater streams arise in the Boston Mountains with steep slopes, but quickly enter the Springfield Plateau with gentle to moderate slopes. The Kings River and Osage Creek headwaters are quite similar to the White River forks, arising in the Boston Mountains' steep slopes, then entering the Springfield Plateau. Yocum and Long Creek headwaters arise on the Springfield Plateau around 1400 feet msl and flow through the Salem Plateau only dropping approximately 400 feet before entering Table Rock Lake. These slopes are characterized as being moderate to gentle.

Soils

Soils in the headwater streams are deep to shallow, gently sloping to very steep, well drained, stony to cherty soils that formed in either residuum or colluvium of cherty limestones or shales. These soils are located in the Boston Mountains which possess low solubility characteristics, thus giving rise to very soft waters. The larger river bed soils are deep, level to moderately sloping, well drained, loamy to cobble soils that formed in alluvium derived from sandstone, limestone, and shale. Most of these areas are located within the Springfield Plateau area. As surface waters flow across this area they become harder and more alkaline. The topography of the headwater streams and the river beds are described as being karst. This topography results in many losing streams, sink holes, caves and underground drainage. Rapid recharge of unconfined aquifers can occur in this type of geologic formation and can lead to potential contamination of the areas ground water.

Land Use

Recently, the land use in the upper White River drainage basin has been estimated to be approximately 60% forest land. Forest type is dominated by oak/hickory associations. Agricultural lands comprise approximately 30% of the drainage basin and is predominantly of pasture with some crop production. Approximately 4% of the watershed is water including Beaver Reservoir and Lake Sequoyah. Less than 2% of the basin is urban.

The growth of the agricultural industry, primarily in confined animal operations, has accelerated the clearing of forest lands within the watershed for conversion to pasture lands for livestock production. These pastures are fertilized with litter and waste products from confined animal operations. Agriculture operations within the watershed produce approximately 111 million chickens, turkeys, cornish hens and 264 thousand head of livestock (beef and milk cows, pigs) each year.

CHEMICAL WATER QUALITY

Study Design

The upper White River watershed was sub-divided into nine sub-basins based on individual river systems. Forty-one synoptic water quality sampling sites were located within these nine sub-basins. In addition, data from five previously established ambient water quality monitoring stations also located within the survey area were used. Below is a list of these sub-basins and the number of synoptic sites located in each. The synoptic sites were distributed along the main stems of the larger rivers and near the mouths of the major tributaries entering these rivers.

Sub-basins	Sample Sites
West Fork White River	4
Middle Fork White River	3
Main Fork White River	4
Richland Creek	3
Brush Creek	2
War Eagle Creek	6
Clifty Creek	1
Kings River	6
Dry Fork	1
Piney Creek	1
Osage Creek	4
Long Creek	3
Dry Creek	1
Yocum Creek	2

Sample Sites

Below is a list of the synoptic water quality sample sites by sub-basin and a location description. The five ambient water quality monitoring stations are also listed. Figure 1 is a map of the study area depicting these sample sites.

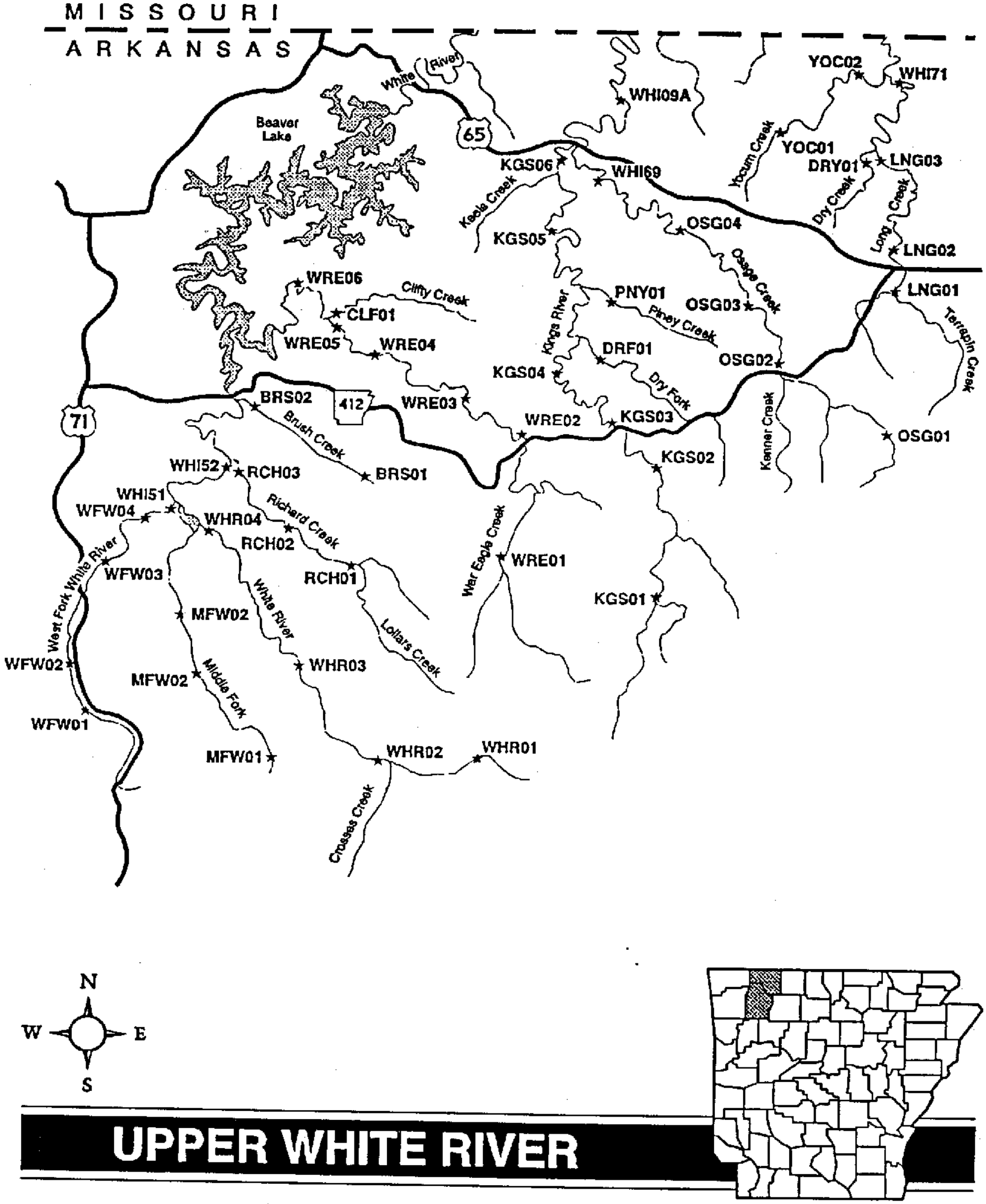

MISSOURI
ARKANSAS
Beaver Lake
White River
65
71
412
WHI09A
YOC02
WHI71
Yocum Creek
YOC01
DRY01
LNG03
KGS06
WHI69
Keels Creek
Dry Creek
Long Creek
OSG04
LNG02
KGS05
LNG01
WRE06
Clifty Creek
PNY01
OSG03
Osage Creek
CLF01
Piney Creek
Terrapin Creek
Kings River
WRE05
WRE04
DRF01
OSG02
KGS04
Dry Fork
BRS02
WRE03
KGS03
WRE02
Brush Creek
Kenner Creek
OSG01
KGS02
WHI52
RCH03
BRS01
WHI51
WFW04
WHR04
Richard Creek
RCH02
War Eagle Creek
WFW03
RCH01
WRE01
West Fork White River
KGS01
MFW02
White River
Lollars Creek
WFW02
WHR03
MFW02
Middle Fork
WFW01
MFW01
WHR02
WHR01
Crosses Creek
N
W
E
S
UPPER WHITE RIVER

FIGURE 1

West Fork White River

WFW01	Woosley Bridge off Hwy 71, 3 mi. S. of West Fork (SE¼ Sec 16, T14N, R30W) Washington County
WFW02	co. rd. 240 bridge above Dye Creek, N of West Fork (SE¼ Sec 29 , T15N, R30W) Washington County
WFW03	co. rd. bridge, ½ mi. SE of Hwy 156, SE of Fayetteville (SE¼ Sec 34, T16N, R30W) Washington County
WFW04	co. rd. 55 bridge ½ mi. S. of Hwy 16 E. of Fayetteville, (NW¼ Sec 24, T16N, R30W) Washington County
WHI51	co. rd.bridge ½ mi. N of Hwy 16, E. of Fayetteville (Sec 20, T16N, R29W)

Middle Fork White River

MFW01	co. rd. 119 bridge, 1½ mi. NW of Hazel Valley (SE¼ Sec 24, T14N, R29W) Washington County
MFW02	co. rd. 32 bridge 1 mi. S. of Sulphur City, (SE¼ Sec 21, T15N, R29W) Washington County
MFW03	co. rd. 2 mi. SW of Elkins (SE¼ Sec 33, T16N, R29W) Washington County

White River

WHR01	co. rd. bridge 0.1 mi. S. of St. Paul off Hwy 23 (NW¼ Sec 4, T13N, R26W) Madison County
WHR02	second co. rd. #328 bridge off Hwy 23 below Crosses Creek (SW¼ Sec 13, T14N R28W) Madison County
WHR03	adjacent to co. rd. 163 off Hwy 16 near Durham (SW¼ Sec 20, T15N, R28W) Washington County
WHR04	Hwy 74 bridge E. of Elkins (SE¼ Sec 26, T16N, R29W) Washington County
WHI52	Hwy 45 bridge W. of Goshen (Sec 8, T16N, R29W) Madison County

Richland Creek

RCH01	Hwy 303 bridge ¼ mi. S. of Hwy 74 SE of Wesley (SW¼ Sec 31, T16N, R27W) Madison County
RCH02	Hwy 303 bridge 1¼ mi. N. of Hwy 74 N. of Tuttle (NW¼ Sec 20, T16N, R28W) Washington County
RCH03	Hwy 45 bridge W. of Goshen (NW¼ Sec 31, T17N, R28W) Washington County

Brush Creek

BRS01	Hwy 295 bridge 2 mi. S. of Hwy 245 (SW¼ Sec 30, T17N, R27W) Madison County.
BRS02	co. rd. bridge off Hwy 303, ¼ NW of Hwy 45 near Mayfield (NE¼ Sec 22, T17N, R28W) Washington County

War Eagle Creek

WRE01	co. rd. 7 bridge, ¼ W of Hwy 23 N. of Aurora (SW¼ Sec 35, T16N, R26W) Madison County.
WRE02	Hwy 412 bridge 3 mi. E. of Huntsville (SE¼ Sec 24, T17N, R26W) Madison County.
WRE03	co. rd. bridge 1½ mi. W. of Withrow Spring St. Park (SW¼ Sec 4, T17N, R26W) Madison County.
WRE04	Hwy 45 bridge 4 mi. N. of Hindsville (NE¼ Sec 28, T18N, R27W) Madison County.
WRE05	co. rd. bridge 1½ mi. S. of Hwy 12, 1 mi. S. of Best (SW¼ Sec 18, T18N, R27W) Washington County.
CLF01	co. rd. bridge ¼ mi. SW of Hwy 12, ½ mi. W. of Best (SE¼ Sec 12, T18N, R28W) Benton County.
WRE06	at War Eagle Mill, 1¼ mi. S of Hwy 12 (SE¼ Sec 34, T19N, R28W) Benton County.

Kings River

KGS01	co. rd. crossing approx. 3 mi. S. off Hwy 74, 5 mi. S. of Kingston (SW¼ Sec 4, T15N, R24W) Madison County.
KGS02	southern most bridge on Hwy 21 N. of Kingston (SE¼ Sec 33, T17N, R24W) Madison County.
KGS03	co. rd. bridge at G&F Onion Creek access NW of Marble off Hwy 412 (SE¼ Sec 12, T17N, R25W) Madison County.
KGS04	co. rd bridge 3 mi. NE. of Alabam off Hwy 127 (SW¼ Sec 28, T18N, R25W) Madison County.
DRF01	co. rd. bridge approx. 5 mi. W. of Metalton (SW¼ Sec 23, T18N, R25W) Carroll County.
PNY01	timber access rd. approx. 4 mi. NW. of Metalton (Sec 1, T18N, R25W) Carroll County.
KGS05	Hwy 221 bridge, approx. 6 mi. SW. of Berryville (NW¼ Sec 17, T19N, R25W) Carroll County.
KGS06	co. rd. 46 bridge, approx. ½ mi. S. of Hwy 62; (NE¼ Sec 20, T20N, R25W) Carroll County.
WHI09A	Kings River at Hwy 143 bridge, 1 mi. S of Grandview (Sec 3, T25N, R20W) Carroll County

Osage Creek

OSG01	co. rd. low water crossing 5 mi. SE of Osage off Hwy 103 (NE¼ Sec 4, T17N, R22W) Carroll County.
OSG02	Hwy 412 Bridge approx 1½ mi. W. of Osage (SE¼ Sec 27, T18N, R23W) Carroll County.
OSG03	Hwy 103 bridge 5 mi NE of Metalton (NE¼ Sec 5, T18N, R23W) Carroll County.
OSG04	co. rd. bridge 1¼ mi. E of Hwy 21, 3 mi. SE of Berryville (NE¼ Sec 15, T19N, R24W) Carroll County.
WHI69	Osage Creek Below Berryville at dead-end spur off Hwy 221 (Sec 26, T20N, R25W) Carroll County

Long/Yocum Creek

LNG01	co. rd low water bridge 2. mi. S of Hwy 62 near Alpena (SW¼ Sec 26, T19N, R22W) Boone County.
LNG02	co. rd. bridge 3 mi. N of Alpena, 4½ mi. S of Denver (SE¼ Sec 35, T20N, R22W) Boone County.
LNG03	co. rd. bridge 3½ mi. E of Hwy 311 near Denver (Sec 16, T20N, R22W) Carroll County.
DRY01	co. rd. bridge 2½ E of Hwy 311, SW of Denver (SW¼ Sec 16, T20N, R22W) Carroll County.
YOC01	co. rd. low water bridge 1 mi. NW of Hwy 311, 2½ NW of Farewell (Sec 12, T20N, R23W) Carroll County.
YOC02	co. rd. bridge 1¼ mi. NW of Hwy 311, 4 mi. E. of Oak Grove (NE¼ Sec 30, T21N, R22W) Carroll County.
WHI71	Long Creek N of Denver on co. rd. bridge off Hwy 311 (Sec 34, T21N, R22W) Carroll County

Sampling Schedule

The synoptic stations were collected during two day sampling events utilizing two sampling teams. When possible, all stations located on a single river were collected on the same day. The only exception to this was the WRE01 and WRE02 sites. An attempt was made to collect the samples during the different climatic events and conditions as described below:

Summer Low-flow
Winter low-flow
Early winter (first flush) storm event
Spring storm event after litter application
Summer storm event

Seven sampling events were accomplished during this survey:

1992 May 19-20 Spring storm event
1992 Aug 17-18 Summer low flow & storm event
1992 Dec 13-14 Early winter (first flush) storm event
1993 May 17-18 Spring storm event
1993 Aug 16-17 Summer low flow
1993 Nov 29-30 Winter low flow
1994 May 11-12 Spring low flow/Spring first flush

Sampling Events

The May 19-20, 1992 sampling occurred two to three days after a storm event. Stream flows were estimated as a percentage of the channel full capacity. These ranged between 25% and 100% during the sample period. The lower flow occurred at the upper, more headwater stream stations.

Flows during the August 17-18, 1992 sample event ranged from dry to near 90% of channel full. Many of the upper stream segments of the smaller streams were dry, but some of the lower segments of the major rivers were near channel full.

The December 14-15, 1992 sample event occurred during a storm event. The storm began on the first day of sampling and continued through the night. Flows at those stations sampled on the 14^{th} were between 30% and 100% of channel full. Stations sampled on the 15^{th} were between 90% and 200% of channel capacity. The second day samples represent a major winter storm, first flush event.

The May 17-18, 1993 sample event had flows estimated between 40% and 120% of channel full. This was caused by isolated rain events and storm water runoffs.

During the August 16-17, 1993 sample event flows were between dry and 30% of channel full capacity, except at three Kings River sites where flows were approximately 50% channel full. This sample event represents a summer time, low flow situation.

Flows during the November 29-30, 1993 sampling event were estimated from 1% to approximately 25% of channel full capacity. One sample site was estimated at 50%. This sampling event represents a low flow winter event.

The final sampling event on April 11-12, 1994 had flows estimated between 10% and 25% of channel full the first day, and 30% to 100% the second day of sampling. Most of the Kings River sites were at 100%.

Sampling Procedure & QA/QC

The following equipment was used to collect water samples and take in-situ measurements:

1) YSI Model 57 portable dissolved oxygen meter
2) Orion Model 840A portable dissolved oxygen meter
3) Orion SA Model 230 portable pH meter
4) 1/2 gallon water sampling containers
5) Bacteria sampling containers
6) Winkler titration kit

Stream samples were collected, preserved, and analyzed according to the 16th Edition of Standard Methods for the Examination of Water and Wastewater. Analyses were conducted under ADPC&E's existing "Quality Assurance Plan for Ambient Water Quality and Compliance Sampling". Table 1 lists the parameters analyzed and the field data measured. The dissolved oxygen meters were calibrated daily prior to use in accordance with manufacturers guidelines or with the Winkler Titration method. The pH meter was calibrated using buffer solutions of pH 4, pH 7, and pH 10, prior to use and every four hours during use. Flow was estimated at the synoptic sites for each sampling event as a percentage of the channel full capacity of the stream at the collection site.

TABLE 1

IN-SITU MEASUREMENTS	LAB ANALYSES
Temperature	Ammonia Nitrogen
pH	Nitrite + Nitrate-Nitrogen
Dissolved Oxygen	Ortho-Phosphate Phosphorus
Flow (% Channel Capacity)	Total Phosphorus
	Total Dissolved Solids
	Total Suspended Solids
	Total Hardness, Turbidity
	Chlorides, Sulfates
	Total Organic Carbon
	Fecal Coliform Bacteria
	Escherichia coli

Results

Data Evaluation

Laboratory analytical results of water samples collected during the study period are presented in Table 2. Concentrations reported as less than detection limits are designated with a "k". In order to estimate the mean concentration of a parameter at a particular site, it is assumed that concentrations less than the detection limit (k values) follow a normal distribution from zero to the detection limit. Therefore, k values were multiplied by 0.5 and used in the mean calculation (Table 3). In some cases, this will result in the mathematical mean value being lower than the minimum analytical value. The maximum, minimum and mean concentrations of selected parameters from ADPC&E ambient water quality monitoring stations in the Upper White River watershed for this time period are also included in Table 3.

Nutrients

In general, mean nutrient concentrations in the watershed were similar to ecoregion reference concentrations. However, elevated concentrations of both nitrogen and phosphorous were observed at sampling sites below point source discharges.

Ammonia-nitrogen concentrations at most sampling sites were at or below method detection limits of 0.05 milligrams per liter (mg/L). With few exceptions, when ammonia-nitrogen concentrations were elevated above 0.05 mg/L, the concentrations were less than 0.1 mg/L. Exceptions to this were observed at RCH02 in August, 1993 (0.3 mg/L), WRE06 in April, 1994 (0.97 mg/L), and OSG03 in May, 1993 (0.21 mg/L).

Nitrate+nitrite-nitrogen (which will subsequently be referred to as nitrates) concentrations in the Upper White River watershed were influenced greatly by point source discharges. Examples of this can be seen on the White River by comparing stations above the Fayetteville wastewater treatment plant (WWTP) to station WHI52 (below the discharge); on War Eagle Creek between WRE02 above the Huntsville WWTP and WRE03 below the discharge; on Osage Creek between OSG04 above the Berryville WWTP and WHI69 below the discharge; and on Long Creek between LNG03 and WHI71. Long Creek is influenced by Dry Creek which is the receiving stream for the Green Forest WWTP discharge.

Nitrate mean concentrations in the West Fork White River increased from 0.13 mg/L at WFW01 near the headwaters to 0.42 mg/L at WHI51

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
WFW01	20-May-92	17.5	8.8	6.98	0.05 k*	0.08	0.03 k	0.05	1.89	41	4.6	20.0	2	16	1.6	80	70	70
WFW01	18-Aug-92	18.0	8.2	6.67	0.05 k	0.10	0.03 k	0.05	1.96	53	2.7	26.0	2	7	8.4	30	30	35
WFW01	15-Dec-92	8.0	10.7	7.51	0.07	0.18	0.15	0.10	2.27	48	4.8	5.0 k	102	78	6.7	620	430	100
WFW01	18-May-93	16.0	9.5	7.41	0.05 k	0.13	0.03 k	0.03 k	1.59	40	4.9	16.0	1	12	1.0	150	40	70
WFW01	16-Aug-93	22.0	3.1	7.07	0.05 k	0.04	0.03 k	0.04	2.99	102	6.1		6	3	3.3	70	1 k	25
WFW01	30-Nov-93	6.1	11.6	6.67	0.05 k	0.18	0.03 k	0.03 k	1.97	39	2.2	11.5	1	10	1.1	40	30	20
WFW01	11-Apr-94	13.9	9.3	7.16	0.05 k	0.20	0.05	0.03 k	1.55	37	3.7	15.0	1	12		64	27	20
WFW02	20-May-92	18.5	8.0	7.18	0.05 k	0.39	0.04	0.03 k	2.10	104	18.2	72.0	20	25	3.1	290	200	85
WFW02	18-Aug-92	20.0	6.7	6.75	0.05 k	0.15	0.03 k	0.04	2.27	102	15.0	78.0	20	18	3.8	390	250	30
WFW02	15-Dec-92	8.5	11.5	7.42	0.05 k	0.40	0.33	0.11	2.95	70	6.3	14.0	291	155	10.1	1900	870	200
WFW02	18-May-93	17.5	8.6	7.28	0.05 k	0.28	0.03 k	0.03	1.86	71	12.2	45.1	3	7	1.3	100	80	80
WFW02	16-Aug-93	29.0	4.7	7.10	0.05 k	0.02 k	0.03 k	0.04	2.98	122	10.2		4	4	4.1	40	10	25
WFW02	30-Nov-93	5.7	11.3	6.36	0.05	0.60	0.03	0.03	2.52	84	14.5	52.0	4	16	1.2	110	40	20
WFW02	11-Apr-94	15.4	9.2	7.36	0.07	0.28	0.08	0.03 k	1.85	53	5.9	30.6	3	14		72	91	30
WFW03	20-May-92	19.5	7.8	7.61	0.05 k	0.41	0.07	0.03 k	2.5	115	18.9	84	40	37	3.8	320	340	100
WFW03	18-Aug-92	21	7.4	6.68	0.05 k	0.1	0.03	0.03	2.72	117	20.5	86	12	10	3.8	90	20	85
WFW03	15-Dec-92	8.5	11.2	7.65	0.06	0.41	0.39	0.13	3.51	83	6.3	25.1	345	170	11.2		1010	200
WFW03	18-May-93	18.3	8.2	7.02	0.05 k	0.25	0.03	0.03 k	2.04	81	15	59.2	6	7	3.2	430	330	80
WFW03	16-Aug-93	29	4.8	6.7	0.05 k	0.02 k	0.03	0.03 k	3.23	108	14.7		2	3	4.3	380	20	25
WFW03	30-Nov-93	5.2	11.2	5.98	0.05 k	0.61	0.03	0.03 k	2.73	97	16.7	63.7	1	6	1.5	10	20	20
WFW03	11-Apr-94	16.4	8.6	7.34	0.05	0.28	0.04	0.03	2.36	64	7	42.3	5	13		270	163	30
WFW04	20-May-92	20	7.7	7.29	0.05 k	0.38	0.08	0.03 k	2.73	126	20.3	84	44	45	4.8	400	290	100
WFW04	18-Aug-92	23	8.4	7.15	0.05 k	0.19	0.03 k	0.04	3.39	135	24.4	100	31	23	3.3	60	10 k	80
WFW04	15-Dec-92	8	10.6	7.5	0.09	0.38	0.48	0.15	3.59	98	8.8	31.7	452	200	13.8	3000	1730	200
WFW04	18-May-93	19.3	8.4	7.47	0.05 k	0.3	0.03 k	0.03 k	2.65	98	18.5	71.8	8	9	4.5	370	260	60
WFW04	16-Aug-93	31.5	7.1	7.53	0.05 k	0.02	0.03	0.03 k	5.13	157	32.6		22	22	6.4	10	10	25
WFW04	30-Nov-93	6.2	11.4	6.89	0.05 k	0.58	0.03 k	0.03 k	3.39	111	21.8	75.5	2	7	1.7	10	10	20
WFW04	11-Apr-94	18.2	9	7.93	0.05 k	0.26	0.03 k	0.03 k	2.73	79	11.9	55.2	10	13		172		40

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
MFW01	20-May-92	17	8.6	6.45	0.05 k	0.37	0.03 k	0.03 k	2.25	36	1.8	16	5	17	1.3	120	100	80
MFW01	18-Aug-92	17.5	8.5	6.78	0.05 k	0.43	0.03 k	0.03	2.28	37	1.8	20	5	17	1.2	120	70	60
MFW01	15-Dec-92	8.5	10.9	7.53	0.05 k	0.8	0.14	0.07	2.42	42	3.3	9.9	50	45	4.8	690	330	100
MFW01	18-May-93	14.5	10	7.15	0.06	0.42	0.03 k	0.03 k	2.1	31	4.9	18	2	9	1.3	90	50	70
MFW01	16-Aug-93	27.5	4.7	7.53	0.06	0.02	0.03 k	0.03 k	3.79	74	6.1		6	3	3.7	100	20	10
MFW01	30-Nov-93	7.7	11.2	6.93	0.05	0.98	0.03	0.03	2.07	37	2.2	18.4	1	8	1	120	60	20
MFW01	11-Apr-94	13.2	10.1	7.03	0.05 k	0.62	0.03 k	0.03 k	2.01	28	3.7	19.2	1	7		109	55	20
MFW02	20-May-92	19.5	8.3	6.78	0.05 k	0.2	0.03 k	0.03 k	2.06	66	3.3	54	6	6	1.5	170	110	95
MFW02	18-Aug-92	21	8.8	6.95	0.05 k	0.3	0.03 k	0.03	2.41	62	2.7	42	2	3	1.9	40	10	90
MFW02	15-Dec-92	9	10.8	7.54	0.06	0.54	0.17	0.11	2.27	55	3.3	14	81	60	7.5	980	470	200
MFW02	18-May-93	16.4	10	7.55	0.05 k	0.36	0.03 k	0.03 k	1.91	49	4.9	32.5	1	5	1.9	100	80	70
MFW02	16-Aug-93	31.5	7.1	7.65	0.05 k	0.02 k	0.03 k	0.03 k	3.74	91	5.1		6	3	1.8	1	1	25
MFW02	30-Nov-93	6.7	11.8	6.85	0.05 k	0.95	0.03 k	0.03 k	2.08	56	2.2	30.2	1	5	1.3	10	10	20
MFW02	11-Apr-94	15.7	9.9	7.7	0.05 k	0.45	0.03 k	0.03 k	1.99	51	3.7	34.2	2	6		36	27	40
MFW03	20-May-92	19.5	7.8	6.82	0.07	0.32	0.03 k	0.03	2.29	84	10	64	12	17	2.9	220	170	95
MFW03	18-Aug-92	21	8.2	6.95	0.05	0.21	0.03 k	0.04	2.66	75	8.2	56	4	5	2.8	40	10	70
MFW03	15-Dec-92	8	10.8	7.4	0.07	0.46	0.36	0.22	2.86	70	6.3	17.9	124	75	11	1340	990	200
MFW03	18-May-93	17.7	9.2	7.49	0.05 k	0.32	0.03 k	0.03 k	2.17	62	7.2	42.7	2	4	3	180	150	65
MFW03	16-Aug-93	31.5	6.7	7.5	0.05 k	0.02 k	0.03 k	0.03 k	3.64	90	11.2		8	6	2.4	20	1	25
MFW03	30-Nov-93	6.2	12	6.82	0.05 k	0.94	0.03 k	0.03 k	2.36	67	5.5	40.2	1	4	1.3	30	40	20
MFW03	11-Apr-94	16.8	9.7	7.66	0.05 k	0.38	0.03 k	0.03 k	2.19	62	5.9	43.8	2	7		136	90	40
WHR01	20-May-92	17.5	9.2	6.69	0.05 k	0.31	0.03	0.06	1.66	29	1	12	1	16	1	160	80	90
WHR01	18-Aug-92	19.5	8.6	6.96	0.05 k	0.35	0.03 k	0.03	1.66	25	1	10	2	4	1	10	10	40
WHR01	15-Dec-92	9	10.5	7.5	0.06	0.28	0.24	0.11	1.96	39	4.8	5 k	173	120	4.9	540	490	100
WHR01	18-May-93	15.4	9.5	7.14	0.05 k	0.24	0.03 k	0.03 k	1.38	23	2.5	11.6	1	8	1	180	80	50
WHR01	16-Aug-93	28.5	5.8	7.2	0.05 k	0.47	0.03 k	0.03 k	2.15	33	2.6		1	4	1	20	1	25
WHR01	30-Nov-93	6.2	11.6	7.2	0.05 k	0.52	0.03 k	0.03 k	1.43	30	1	9	1	9	1.2	20	10	15
WHR01	11-Apr-94	14.1	10.1	6.96	0.05 k	0.2	0.03 k	0.03 k	1.55	13	2.5	15	1	8		240	100	20

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
WHR02	20-May-92	18.5	8.5	6.29	0.05 k	0.18	0.03	0.05	1.51	28	1	14	2	15	1.4	100	30	100
WHR02	18-Aug-92	20.5	7.8	6.92	0.05 k	0.17	0.03 k	0.03	1.54	28	1	14	8	8	1.1	250	100	80
WHR02	15-Dec-92	9	10.6	7.37	0.06	0.38	0.18	0.08	2.11	37	4.8	5 k	93	75	5	630	310	200
WHR02	18-May-93	15.7	9.3	6.91	0.05 k	0.18	0.03 k	0.03 k	1.26	27	3.7	6.1	4	8	1	150	70	70
WHR02	16-Aug-93	31	6.9	7.34	0.11	0.02 k	0.03 k	0.03 k	3.23	38	2.6		4	3	1.8	60	20	25
WHR02	30-Nov-93	7.1	11.1	6.82	0.05 k	0.47	0.03 k	0.03 k	1.38	33	1	5 k	1	9	1.2	10	10	20
WHR02	11-Apr-94	14.4	9.1	6.83	0.05 k	0.21	0.03 k	0.03 k	1.51	27	2.5	10.5	1	8		64	18	40
WHR03	20-May-92	19	8.3	6.98	0.05 k	0.19	0.03	0.03 k	1.56	33	1.8	24	2	16	1.3	200	60	100
WHR03	18-Aug-92	21	8.2	6.9	0.05 k	0.18	0.03 k	0.03	1.7	38	1	24	4	6	1.4	30	10	50
WHR03	15-Dec-92	9	10.6	7.37	0.07	0.27	0.25	0.11	2.24	47	4.8	5.5	174	110	6.6	1180	610	200
WHR03	18-May-93	16.9	9.3	7.12	0.05 k	0.19	0.03 k	0.03 k	1.33	28	3.7	13.9	2	7	1	200	100	70
WHR03	16-Aug-93	29	5.7	7.34	0.05	0.02 k	0.03 k	0.03 k	2.5	52	6.1		3	2	2.1	50	40	25
WHR03	30-Nov-93	6.8	11.4	6.75	0.05 k	0.57	0.03 k	0.03 k	1.73	40	2.2	11.5	1	8	1.1	50	10	20
WHR03	11-Apr-94	15.8	9.2	7.13	0.05 k	0.26	0.03 k	0.03 k	6.8	34	3.7	17.1	1	8		109	45	40
WHR04	20-May-92	19.5	7.7	6.58	0.05 k	0.21	0.04	0.03 k	1.72	42	3.3	22	8	20	1.9	220	120	100
WHR04	18-Aug-92	21.5	7.4	6.95	0.05 k	0.2	0.03 k	0.03 k	1.87	47	2.7	30	6	7	1.7	10	10	90
WHR04	15-Dec-92	9	10.3	7.61	0.07	0.28	0.3	0.12	2.48	57	4.8	7.8	195	120	8.1	1600	700	200
WHR04	18-May-93	17.7	8.4	7.33	0.05 k	0.22	0.03 k	0.03 k	1.53	36	4.9	19.9	2	7	1.6	130	60	70
WHR04	16-Aug-93	30.5	6.7	7.5	0.05 k	0.02 k	0.03 k	0.03 k	2.7	76	8.3		4	3	3.6	30	1	25
WHR04	30-Nov-93	6.8	11.3	7	0.05 k	0.64	0.03 k	0.03 k	1.76	50	2.2	18.4	1	8	1.2	30	10	20
WHR04	11-Apr-94	16.3	9.1	7.36	0.05	0.27	0.03 k	0.03 k	1.53	42	4.8	23.1	3	9		72	63	50
RCH01	20-May-92	19.5	9	7.25	0.05 k	0.18	0.03	0.03 k	2.41	51	4.6	24	2	17	1.9	150	60	25
RCH01	18-Aug-92	23.3	10.6	8.14	0.09	0.23	0.03 k	0.05	3.91	63	8.2	34	3	3	1.3	30	10	20
RCH01	15-Dec-92	8.5	11.2	7.25	0.05	0.32	0.15	0.1	2.69	52	4.8	17.9	52	53	7.2	1190	630	100
RCH01	18-May-93	17.2	9.6	7.59	0.06	0.18	0.03 k	0.03 k	2.4	40	7.2	18	1 k	8	1.1	200	100	70
RCH01	16-Aug-93																	
RCH01	30-Nov-93	6.9	10.3	7.63	0.05 k	0.73	0.03 k	0.03 k	3.13	48	3.9	18.4	1 k	7	1.4	130	60	25
RCH01	11-Apr-94	15.6	10.1	7.73	0.05 k	0.28	0.03 k	0.03 k	2.68	41	5.9	34.2	1	8		64	72	25

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
RCH02	20-May-92	18.5	8.3	7.35	0.06	0.56	0.08	0.05	2.89	98	10.9	72	17	25	3.9	410	220	100
RCH02	18-Aug-92	19.9	8.7	7.7	0.06	0.67	0.03 k	0.05	4.06	127	11.2	82	4	4	2.8	10	10	40
RCH02	15-Dec-92	8.5	11	7.48	0.06	0.59	0.26	0.15	3.33	79	7.6	28.5	76	61	10	1650	1300	100
RCH02	18-May-93	16.6	8.9	7.45	0.05 k	0.64	0.03 k	0.03 k	2.82	77	9.3	56.1	2	5	2.9	80	60	80
RCH02	16-Aug-93	28.5	5.5	7.62	0.3	0.02	0.33	0.07	6.11	163	9.2	113	139	52	12.5	220	70	10
RCH02	30-Nov-93	10	10	7.6	0.05 k	1.47	0.03 k	0.03 k	4.24	102	14.5	64.8	1	5	1.4	60	30	50
RCH02	11-Apr-94	14.6	9	7.88	0.05 k	0.53	0.03 k	0.03 k	3.01	72	10	49.8	3	9		164	100	30
RCH03	20-May-92	18.5	8.5	7.35	0.05 k	0.41	0.05	0.03 k	2.91	94	11.8	62	4	17	4	380	210	100
RCH03	18-Aug-92	22.3	14.4	8.6	0.05 k	0.47	0.03 k	0.03	4.17	139	11.2	116	2	2	3.1	80	10	20
RCH03	15-Dec-92	8.5	11	7.49	0.05 k	0.46	0.29	0.15	3.48	77	7.6	25.1	150	60	10	2600	1330	100
RCH03	18-May-93	17.1	9.4	7.6	0.05 k	0.57	0.03 k	0.03 k	2.73	88	10.3	64.2	2	5	2.6	280	140	90
RCH03	16-Aug-93	30.5	7.9	7.56	0.06	0.06	0.04	0.04	4.75	153	9.2	116	14	9	4.2	80	30	10
RCH03	30-Nov-93	9.2	10.4	7.78	0.05 k	1.16	0.03 k	0.03 k	3.76	99	12.2	67.3	1	4	1.6	30	20	25
RCH03	11-Apr-94	16.3	9.6	7.95	0.05 k	0.44	0.03 k	0.03 k	3.08	80	10.9	55.2	4	9		220	118	30
BRS01	20-May-92	18.5	8.6	7.3	0.05 k	0.43	0.05	0.03 k	3.24	114	14.3	82	1	7	3.9	460	250	55
BRS01	18-Aug-92																	
BRS01	15-Dec-92	8.5	11.2	7.63	0.1	0.56	0.25	0.15	3.44	89	7.6	36.4	78	64	11.1	3000	2400	90
BRS01	18-May-93	17	10.1	7.38	0.05 k	0.88	0.03 k	0.03 k	4.69	146	19.3	114	1	3	3.3	630	510	75
BRS01	16-Aug-93																	
BRS01	30-Nov-93	4.3	11.7	7.83	0.05 k	1.63	0.03 k	0.03 k	8.43	208	18.8	164	2	2	2.2	80	50	<1
BRS01	11-Apr-94	17.2	10.5	8.37	0.05 k	0.32	0.03 k	0.03 k	3.95	120	18	87.9	1	8		250	173	25
BRS02	20-May-92	17.5	8.9	7.6	0.05 k	0.62	0.06	0.03 k	3.61	150	14.3	112	9	18	4.5	430	300	40
BRS02	18-Aug-92	17.9	8	7.95	0.13	0.85	0.03 k	0.05	7.46	200	18.4	170	3	3	5.9	500	310	20
BRS02	15-Dec-92	9	11	7.66	0.06	0.75	0.28	0.15	3.99	105	7.6	47.9	170	89	11.5	3100	1480	90
BRS02	18-May-93	15.9	10	7.43	0.05 k	1.32	0.03 k	0.03 k	5.05	169	15	139	1	2	2.3	420	230	80
BRS02	16-Aug-93	26.5	6.7	7.58	0.05 k	0.93	0.03 k	0.04	9.07	216	10.2	172	2	2	3.2	230	60	10
BRS02	30-Nov-93	8.5	10.5	7.55	0.05 k	1.89	0.03 k	0.03 k	6.47	195	18.8	160	1	2	2.1	40	10	25
BRS02	11-Apr-94	15.5	10.3	8.34	0.08	0.95	0.03 k	0.03 k	4.7	155	16.3	123	2	5		280	200	25

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
WRE01	19-May-92	18.5	9.3	7.25	0.05 k	0.12	0.06	0.06	1.75	49	3.3	22	3	19	2.2	320	200	100
WRE01	17-Aug-92	22	8.8	7.18	0.05 k	0.1	0.03 k	0.04	1.88	56	1	44	1	2	1.6	180	10	25
WRE01	14-Dec-92	10	11.2	7.7	0.05 k	0.29	0.03 k	0.03 k	2.19	38	3.3	26.7	2	8	1.1	50	30	30
WRE01	17-May-93	17.5	9.7	7.85	0.05 k	0.17	0.03	0.03 k	1.9	40	4.9	25	1	6	11.1	140	40	80
WRE01	17-Aug-93	26	5.3	6.95	0.05 k	0.04	0.03	0.04	2.99	97	6.1	61.8	2	2	3.1	20	50	10
WRE01	29-Nov-93	6.8	11	7.83	0.05 k	0.38	0.03 k	0.03 k	2.64	51	3.9	22.7	1	7	1.4	30	10	15
WRE01	12-Apr-94	13.6	11.1	7.66	0.05 k	0.13	0.05	0.03 k	1.71	48	3.7	21.3	2	18		220	90	95
WRE02	20-May-92	19.5	7.9	7.25	0.05 k	0.17	0.05	0.03 k	2.11	62	5.8	40	10	21	2.8	360	280	90
WRE02	17-Aug-92	22	7.2	6.43	0.05 k	0.18	0.03 k	0.03 k	2.23	72	2.7	54	4	4	3.4	30	10	20
WRE02	14-Dec-92	8.5	11.1	7.9	0.05 k	0.55	0.03 k	0.05	2.87	64	7.6	40.9	4	11	1.2	170	30	60
WRE02	18-May-93	15.5	9	7.14	0.05 k	1.47	0.04	0.03 k	3.39	159	9.3	129	4	8	3.6	1800	690	90
WRE02	17-Aug-93	27.5	4.8	7.51	0.05 k	0.21	0.03	0.03 k	3.83	105	7.3	75.5	4	3	4.6	40	10	25
WRE02	29-Nov-93	4.9	11.3	7.23	0.05 k	0.58	0.03 k	0.03 k	3.04	74	6.9	44.9	1	7	1.4	10	40	20
WRE02	12-Apr-94	15	9.6	7.66	0.05	0.32	0.08	0.03	2.79	78	7	37.5	25	50		5000	2700	100
WRE03	20-May-92	18.5	7.8	7.15	0.05 k	0.43	0.1	0.03 k	2.65	74	5.8	20	22	26	3.3	430	320	95
WRE03	18-Aug-92	20.2	8.7	7.8	0.13	1.26	0.24	0.2	13.7	136	8.2	98	6	5	3.2	75	60	30
WRE03	14-Dec-92	9	10.9	7.63	0.06	0.57	0.24	0.1	3.58	79	6.3	36.4	144	58	6.8	1700	930	100
WRE03	18-May-93	17.1	8.5	7.16	0.05 k	0.73	0.06	0.03 k	2.95	88	9.3	66.1	11	15	4.9	830	650	100
WRE03	16-Aug-93	26.5	7.5	7.55	0.05 k	2.39	0.16	0.08	15.8	186	9.2	132	9	6	3.4	20	40	15
WRE03	30-Nov-93	5.5	9.8	7.51	0.05 k	1.13	0.03 k	0.03 k	5.88	96	6.9	69.7	1	6	1.8	50	40	25
WRE03	11-Apr-94	15.3	8.7	7.61	0.06	0.59	0.05	0.03 k	3.18	72	7	62.1	6	8		136	109	50
WRE04	20-May-92	19	7.8	6.95	0.05 k	0.61	0.06	0.03 k	2.75	84	5.8	56	27	27	3.3	500	290	90
WRE04	18-Aug-92	19.8	8.6	7.87	0.05 k	1.31	0.06	0.06	6.09	144	4.8	116	7	4	4.6	50	10	30
WRE04	14-Dec-92	9.5	10.4	7.74	0.05 k	1.34	0.1	0.05	3.71	93	6.3	62.1	44	21	3.4	800	370	100
WRE04	18-May-93	15.9	8.8	7.11	0.05 k	1.06	0.09	0.03 k	2.78	99	8.3	69	21	21	5.8	3600	2000	100
WRE04	16-Aug-93	26.2	6.7	7.43	0.05 k	1.36	0.03	0.03 k	9.91	167	5.9	123	8	5	2.1	70	20	30
WRE04	30-Nov-93	5.7	10.6	7.48	0.05 k	1.4	0.03 k	0.03 k	5.11	108	5.5	77.7	1	5	1.6	170	90	25
WRE04	11-Apr-94	14.9	8.9	7.8	0.05 k	0.91	0.04	0.03 k	3.35	84	5.9	66	7	7		118	191	50

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
WRE05	20-May-92	19	7.8	7.05	0.05 k	0.63	0.07	0.03 k	2.85	87	5.8	62	26	28	3.4	550	340	90
WRE05	18-Aug-92	19.9	7.7	7.85	0.05 k	1.2	0.04	0.05	5.94	144	4.8	118	7	4	3.2	70	40	30
WRE05	14-Dec-92	9.5	10.6	7.86	0.05 k	1.21	0.09	0.06	3.78	91	6.3	62.1	24	15	3.5	1250	700	100
WRE05	18-May-93	15.7	8.7	6.91	0.05 k	1.09	0.1	0.03	2.86	104	7.2	70.8	20	28	6.5	3400	2900	100
WRE05	16-Aug-93	26.8	6.8	7.4	0.05 k	1.19	0.03	0.03 k	9.58	164	5.9	124	8	5	5	40	40	45
WRE05	30-Nov-93	5.9	10.8	7.89	0.05 k	1.47	0.03 k	0.03 k	4.87	110	5.5	80	1	4	1.7	20	30	25
WRE05	11-Apr-94	14.8	8.7	7.83	0.05 k	1.54	0.04	0.03 k	3.37	90	5.9	68.4	7	8		490	260	50
CLF01	20-May-92	14	8.4	7	0.05 k	1.55	0.03 k	0.07	5.93	162	3.3	136	1	1	2.8	50	50	100
CLF01	18-Aug-92	16	7.8	7.46	0.05 k	1.58	0.03	0.04	6.36	191	2.7	160	1 k	1	2.6	10	10	40
CLF01	14-Dec-92	11.5	10	7.47	0.06	1.56	0.14	0.07	4.62	136	6.3	85.8	174	64	6.5	2000	1000	100
CLF01	18-May-93	13.3	9	6.59	0.05 k	1.44	0.03 k	0.03 k	4.12	138	6.1	115	4	3	3.3	570	530	100
CLF01	16-Aug-93	16	6.9	6.92	0.05 k	1.47	0.03 k	0.03 k	7.3	184	3.5	146	1 k	1	2.9	1	1	50
CLF01	30-Nov-93	13.2	9.2	7.54	0.05 k	1.99	0.03 k	0.03 k	5.07	171	2.2	138	1 k	1	1.4	10	20	25
CLF01	11-Apr-94	12.4	8.8	7.71	0.05 k	1.69	0.03 k	0.03 k	4.84	142	5.9	115	1	1		9	18	30
WRE06	20-May-92	18	8	6.95	0.05 k	0.64	0.07	0.03 k	2.92	92	5.8	62	34	30	4.5	410	360	95
WRE06	18-Aug-92	19.9	9.5	7.98	0.08	1.13	0.04	0.04	5.82	153	2.7	130	7	4	4.9	90	90	20
WRE06	14-Dec-92	9.5	10.7	7.95	0.05 k	1.07	0.08	0.05	3.34	92	6.3	64.5	22	17	4.1	530	290	100
WRE06	18-May-93	15.7	8.9	6.63	0.05 k	1.13	0.09	0.03 k	3	107	7.2	77.3	28	26	4.5	2800	2100	100
WRE06	16-Aug-93	26.7	7.4	6.69	0.05 k	1	0.03	0.03 k	7.58	160	3.5	128	11	7	4.4	90	50	50
WRE06	30-Nov-93	6	11	8.05	0.05 k	1.48	0.03 k	0.03 k	4.59	117	3.9	86.5	2	4	1.6	20	10	25
WRE06	11-Apr-94	14.7	9.2	7.67	0.97	1.02	0.03 k	0.03 k	3.32	94	4.8	73.2	9	7		45	36	50
KGS01	19-May-92	17	9.1	6.9	0.05 k	0.15	0.03 k	0.03 k	1.53	38	1.8	16	4	10	1.8	200	145	100
KGS01	17-Aug-92	20.5	6.2	6.73	0.05 k	0.12	0.03 k	0.04	2.01	51	1	36	1 k	1	1.8	10	10	20
KGS01	14-Dec-92	9	11.4	7.63	0.05 k	0.23	0.03 k	0.04	1.84	30	1.7	17.9	1 k	6	1.2	10	10	50
KGS01	17-May-93	15.9	9.8	7.58	0.05 k	0.11	0.03 k	0.03 k	1.67	30	3.8	21.6	1 k	4	1	80	20	70
KGS01	17-Aug-93	27	3	7.16	0.05 k	0.02 k	0.03 k	0.03 k	1.91	64	38.7	49.5	1 k	1	1.4	150	10	10
KGS01	29-Nov-93	5.7	11.4	8.06	0.05 k	0.28	0.03 k	0.03 k	2.05	42	2.2	26.6	1 k	5	1.1	20	10	15
KGS01	12-Apr-94	13.1	10.8	7.39	0.05 k	0.12	0.03 k	0.03 k	1.68	43	2.5	28.8	3	26		350	200	100

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
KGS02	19-May-92	17.5	9.1	7.17	0.05 k	0.16	0.04	0.03 k	1.67	57	3.3	32	14	21	3.2	590	470	100
KGS02	17-Aug-92	20.5	7.4	6.86	0.05 k	0.14	0.03 k	0.03 k	2.72	118	6.6	102	1	3	3.2		10	90
KGS02	14-Dec-92	10	10.8	8.1	0.05 k	0.25	0.03 k	0.03 k	2.16	51	4.8	31.7	4	7	1.7	60	10	60
KGS02	17-May-93	16.4	8.5	7.66	0.05	0.22	0.04	0.03 k	2.1	64	6.1	45.1	8	20	4	4800	2700	100
KGS02	17-Aug-93	29	6.4	7.53	0.05 k	0.04	0.03	0.03 k	3.23	143	7.3	107	2	2	3.9	550	150	20
KGS02	29-Nov-93	7.4	11	7.84	0.05 k	0.41	0.03 k	0.03 k	2.44	76	5.5	52	1 k	5	1.3	10	10	15
KGS02	12-Apr-94	13.9	10.5	7.74	0.05 k	0.11	0.03 k	0.03 k	2	54	3.7	34.2	4	12		350	200	100
KGS03	19-May-92	17	9	7.15	0.05 k	0.18	0.05	0.03 k	1.74	70	3.3	52	16	26	4.7	1005	510	100
KGS03	17-Aug-92	20	7.7	6.9	0.07	0.18	0.03 k	0.03 k	3.37	135	4.8	114	1 k	2	4	70	10	50
KGS03	14-Dec-92	9.5	10.8	7.83	0.05 k	0.35	0.03 k	0.03 k	2.44	70	6.3	47.9	3	7	2.3	30	10	60
KGS03	17-May-93	16	8.3	7.6	0.06	0.41	0.19	0.05	2.39	91	7.2	60.2	106	57	9.6	7700	6200	105
KGS03	17-Aug-93	27.5	6.1	7.57	0.05 k	0.21	0.03 k	0.04	3.36	159	6.1	126	2	2	3.9	40	30	25
KGS03	29-Nov-93	6.9	10.9	7.75	0.05 k	0.6	0.03 k	0.03 k	2.8	100	5.5	74.3	1 k	4	1.3	30	40	15
KGS03	12-Apr-94	14.5	10	7.85	0.05 k	0.21	0.03 k	0.03 k	2.41	78	4.8	55.2	5	8		590	370	100
KGS04	19-May-92	17.5	8.4	7.29	0.05 k	0.23	0.08	0.03 k	1.87	75	4.6	42	34	40	6	2500	2200	100
KGS04	17-Aug-92	20.5	8.1	6.9	0.11	0.24	0.03 k	0.03 k	3.53	136	4.8	116	6	4	2.7	10	10	80
KGS04	14-Dec-92	8.5	10.8	8.14	0.05 k	0.56	0.03 k	0.03 k	2.59	81	4.8	59.6	4	7	3	50	10	50
KGS04	17-May-93	17	8.1	7.69	0.06	0.45	0.06	0.03 k	2.43	86	4.9	67.1	15	11	3.5	1000	780	110
KGS04	17-Aug-93	27.5	6.4	7.78	0.05 k	0.31	0.03 k	0.03 k	3.35	150	2.6	123	7	3	2.4	50	1	25
KGS04	29-Nov-93	5.9	10.9	6.9	0.05 k	0.89	0.03 k	0.03 k	2.76	109	3.9	86.5	1	3	1.4	10	10	15
KGS04	12-Apr-94	14.9	9.8	7.9	0.05 k	0.56	0.03 k	0.03 k	2.41	92	4.8	72	4	6		330	200	100
DRF01	19-May-92	16	9.5	7.28	0.05 k	0.25	0.03	0.04	2.17	98	4.6	72	8	16	4.9	520	300	100
DRF01	17-Aug-92	19.5	9	7.17	0.05 k	0.29	0.03 k	0.03	3.24	148	2.7	126	1 k	1 k	3.7	20	10	80
DRF01	14-Dec-92	10.5	11	8.15	0.05 k	0.61	0.03 k	0.05	3.57	119	7.6	91.1	1 k	1	1	30	30	50
DRF01	17-May-93	14.5	8.8	7.6	0.09	0.42	0.07	0.03 k	1.89	101	4.9	71.8	38	21	6.2	6000	8900	100
DRF01	17-Aug-93	25	8	7.8	0.05 k	0.38	0.03 k	0.03 k	3.33	149	3.9	122	1 k	1 k	1.4	110	100	25
DRF01	29-Nov-93	6.7	11.5	6.79	0.05 k	0.85	0.03 k	0.03 k	3.08	129	3.9	110	1 k	1	1.3	30	20	15
DRF01	12-Apr-94	12.6	11	8.17	0.05 k	0.45	0.03 k	0.03 k	2.33	106	4.8	90.3	1	2		81	36	95

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
PNY01	19-May-92	16.5	9.2	7.85	0.05 k	0.84	0.03 k	0.03	2.27	126	3.3	112	2	2	2.6	110	50	100
PNY01	17-Aug-92	20.5	8.7	6.75	0.05 k	0.81	0.03 k	0.03	3.32	171	2.7	154	1 k	1 k	2.6	200	70	70
PNY01	14-Dec-92	10.5	10.8	8.04	0.05 k	1.57	0.03 k	0.03	3.54	141	6.3	126	1 k	1 k	1.1	10	30	50
PNY01	17-May-93	14.6	8.8	8.08	0.09	0.73	0.37	0.04	2.66	134	6.1	90.6	438	145	17.5	6400	4800	120
PNY01	17-Aug-93	25.5	8	7.5	0.05 k	0.9	0.03 k	0.03 k	3.74	177	3.9	150	1 k	1	1	10	1	25
PNY01	29-Nov-93	6.9	10.9	7.75	0.05 k	2.11	0.03 k	0.05	3.71	161	2.2	142	1 k	0.3	1.4	20	10	15
PNY01	12-Apr-94	11.8	10.9	8.09	0.05	1	0.03 k	0.03 k	2.48	125	4.8	96.6	2	3		200	127	100
KGS05	19-May-92	17.5	8.4	7.49	0.05 k	0.29	0.08	0.03 k	2.01	101	4.6	80	44	33	5.1	1600	630	100
KGS05	17-Aug-92	20.5	7.6	6.95	0.05 k	0.15	0.03 k	0.03 k	2.83	141	2.7	152	1 k	1	4.3	10	10	25
KGS05	14-Dec-92	9	10.8	8.04	0.05 k	0.61	0.03 k	0.03 k	2.54	105	4.8	88	2	4	3.8	210	90	30
KGS05	17-May-93	16.7	8.5	7.81	0.05 k	0.38	0.03	0.03 k	2.15	99	4.9	84.5	18	7	2.8	170	60	80
KGS05	17-Aug-93	28.5	6.2	7.62	0.05 k	0.1	0.03 k	0.03 k	3.12	146	3.9	124	2	1	1.5	50	1	25
KGS05	29-Nov-93	5.4	11.1	6.68	0.05 k	0.97	0.03 k	0.03 k	2.74	124	3.9	106	1	1	1.3	10	10	15
KGS05	12-Apr-94	12.9	9.5	7.88	0.05 k	0.34	0.03 k	0.03 k	1.82	105	3.7	85.8	8	7		709	480	100
KGS06	19-May-92	17.5	8.6	7.78	0.06	0.3	0.11	0.05	1.95	109	4.6	88	83	36	4.8	735	660	100
KGS06	17-Aug-92	19.4	7.4	6.7	0.05 k	0.11	0.03 k	0.03 k	2.56	153	2.7	146	2	2	6.3	30	10	90
KGS06	14-Dec-92	8.5	11.1	8.04	0.05 k	0.57	0.03 k	0.03	2.39	114	4.8	101	1	3	3.3	130	100	40
KGS06	17-May-93	16.7	8.1	7.63	0.05 k	0.37	0.03 k	0.03 k	2.1	100	4.9	93.1	8	6	4.3	4700	1400	90
KGS06	17-Aug-93	29.5	9	8.02	0.05 k	0.06	0.03 k	0.03 k	3.18	149	3.9	129	2	1	2.7	40	20	25
KGS06	29-Nov-93	5.6	11.7	6.64	0.05 k	0.91	0.03 k	0.03 k	2.64	129	3.9	113	1 k	1	1.4	30	50	20
KGS06	12-Apr-94	12.9	9.5	7.92	0.05 k	0.35	0.04	0.03 k	1.77	119	3.7	97.5	20	12		1027	2100	100
OSG01	19-May-92	17.5	8.8	7.15	0.05 k	0.05	0.03	0.03 k	1.97	46	4.6	22	6	16	2.6	105	135	100
OSG01	17-Aug-92	20.5	8.2	7.76	0.05 k	0.06	0.03 k	0.05	2.97	52	4.8	34	1 k	2	1.6	10	10	10
OSG01	14-Dec-92	8	11.8	7.5	0.05 k	0.07	0.03	0.03	2.76	32	4.8	25.1	3	1	1.9	10	10	100
OSG01	17-May-93	14.7	9.1	7.53	0.07	0.18	0.43	0.18	2.48	85	8.2	25	424	185	16.7	5000	4300	100
OSG01	17-Aug-93	26.5	4.1	7.07	0.05	0.02 k	0.03 k	0.05	2.48	79	14.7	45.4		2	2.3	30	10	5
OSG01	29-Nov-93	4.9	10.8	7.12	0.05 k	0.04	0.03 k	0.03 k	2.6	42	2.2	14	1 k	5	1.4	10	10	25
OSG01	11-Apr-94	12.1	9.5	7.25	0.05 k	0.11	0.03 k	0.03 k	2.28	42	2.5	25.2	3	14		250	145	80

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
OSG02	19-May-92	17	9.4	7.2	0.05 k	0.11	0.04	0.03 k	1.79	74	5.8	46	8	27	4.1	490	220	100
OSG02	17-Aug-92	22.2	9.8	7.55	0.05 k	0.24	0.03 k	0.04	2.2	117	4.8	100	1	2	3.6	10	10	10
OSG02	14-Dec-92	12	10.6	7.4	0.05 k	0.15	0.03 k	0.03	2.5	58	6.3	39.4	1	6	1.9	20	10	100
OSG02	17-May-93	15.3	8.8	7.43	0.1	0.23	0.66	0.11	3.09	108	9.3	32.5	744	290	20.1	8900	7300	100
OSG02	17-Aug-93	23	6.7	7.09	0.05 k	0.25	0.03 k	0.03	2.38	133	9.3	101		2	2.9	40	60	10
OSG02	29-Nov-93	9.3	10	7.29	0.05 k	0.19	0.03 k	0.03 k	2.54	74	5.5	44.9	1 k	6	1.4	10	10	25
OSG02	11-Apr-94	13.1	9.7	7.45	0.05 k	0.12	0.03 k	0.03 k	1.9	55	4.8	35.7	4	17		460	320	80
OSG03	19-May-92	17.5	8.7	7.2	0.05 k	0.15	0.1	0.03 k	1.82	77	5.8	48	47	34	4.7	2600	1100	100
OSG03	17-Aug-92	20.8	8.4	7.87	0.05 k	0.28	0.04	0.05	2.84	129	4.8	108	10	6	3.3	590	200	20
OSG03	14-Dec-92	10	10.8	7.6	0.05 k	0.34	0.03	0.04	2.89	79	6.3	58.4	2	7	2.6	670	350	100
OSG03	17-May-93	15.4	8.1	7.23	0.21	0.43	1.35	0.39	3.51	110	7.2	61.2	662	150	14.8	6000	6000	100
OSG03	17-Aug-93	28.1	5.6	7.45	0.05 k	0.19	0.11	0.03 k	3.42	142	7.3	114		5	4.8	3900	2900	10
OSG03	29-Nov-93	8.3	9.9	7.48	0.05 k	0.49	0.03 k	0.03 k	2.79	97	3.9	68.5	1 k	5	1.7	590	270	25
OSG03	11-Apr-94	13.4	9.3	7.57	0.05 k	0.21	0.04	0.03 k	2.04	72	4.8	45.3	9	18		645	460	90
OSG04	19-May-92	17.5	8.4	7.1	0.05 k	0.19	0.13	0.03 k	1.96	90	5.8	60	67	37	6.4	2000	1300	100
OSG04	17-Aug-92	21.4	8.8	8.1	0.05 k	0.32	0.34	0.05	3.12	144	4.8	128	8	6	3.8	130	10	20
OSG04	14-Dec-92	9.5	11	7.57	0.05 k	0.47	0.04	0.03 k	2.98	98	6.3	80.5	4	7	2.8	350	100	100
OSG04	17-May-93	16.1	8.6	7.32	0.09	0.41	0.49	0.17	2.36	121	6.1	76.5	388	120	15.9	13200	10200	100
OSG04	17-Aug-93	29.3	6.5	7.61	0.05 k	0.06	0.03	0.03 k	3.74	162	6.1	136		4	5.5	170	80	10
OSG04	29-Nov-93	7	9.8	7.58	0.05 k	0.73	0.03 k	0.03 k	3.28	121	5.5	95.7	1	4	1.9	150	70	25
OSG04	11-Apr-94	14.2	9.1	7.73	0.05 k	0.31	0.05	0.03 k	2.19	89	4.8	64.5	16	16		1036	1300	100
LNG01	19-May-92	17	9	7.15	0.05 k	0.13	0.06	0.03 k	2.11	95	9	72	8	29	5.3	570	400	95
LNG01	17-Aug-92	19.5	7.8	7.52	0.05 k	0.4	0.03 k	0.03 k	3.84	174	9.8	148	8	7	4.3	90	10	30
LNG01	14-Dec-92	9.5	10.6	7.32	0.05 k	0.51	0.03	0.03 k	3.59	116	14.5	89.1	4	8	3.3	40	20	100
LNG01	17-May-93	15	8.6	6.68	0.08	0.34	0.09	0.03 k	2.74	105	9.3	78.2	36	36	2.8	2000	1800	100
LNG01	17-Aug-93	26.4	6.7	7.3	0.05 k	0.24	0.03 k	0.03 k	4.8	186	12.1	152		6	4.1	1	1	10
LNG01	29-Nov-93	8.6	10	7.27	0.05 k	0.81	0.03 k	0.03 k	4.01	142	12.2	111	1 k	5	1.6	50	40	25
LNG01	11-Apr-94	12.3	9.7	7.85	0.05 k	0.17	0.04	0.03 k	2.22	90	8	59.4	5	26		645	430	90

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
LNG02	19-May-92	17.5	8.7	7.11	0.05 k	0.21	0.09	0.03 k	2.25	106	9	64	34	40	7	1265	650	95
LNG02	17-Aug-92	19.6	9.2	7.92	0.05 k	0.69	0.03 k	0.04	4.6	176	6.6	148	3	4	6.1	110	10	30
LNG02	14-Dec-92	9	11	7.78	0.05 k	0.62	0.03	0.04	3.8	125	12.3	99.2	2	8	3.6	60	20	30
LNG02	17-May-93	15.7	8.5	6.94	0.05 k	0.54	0.03 k	0.03 k	2.94	122	8.3	100	3	4	4.3	580	390	85
LNG02	17-Aug-93	26.2	7.4	7.42	0.05 k	1.08	0.03	0.03 k	6.85	199	8.3	161		4	4.1	160	90	10
LNG02	29-Nov-93	7.2	10.4	7.82	0.05 k	0.92	0.03 k	0.03 k	3.86	154	8.4	126	1 k	4	1.4	50	90	25
LNG02	11-Apr-94	13.4	9.1	7.8	0.05 k	0.38	0.05	0.03 k	2.49	105	8	74.4	17	30		1100	590	85
LNG03	19-May-92	17.5	8.2	7.1	0.05 k	0.28	0.11	0.03	2.46	117	79	72	44	46	8	970	760	50
LNG03	17-Aug-92	18.8	8.8	7.67	0.05 k	1.05	0.03 k	0.05	5.08	195	4.8	166	5	3	3.7	200	40	20
LNG03	14-Dec-92	9.5	10.6	7.61	0.05 k	0.92	0.04	0.04	4.03	149	11.2	123	5	7	4.1	90	110	30
LNG03	17-May-93	15.8	8.2	6.61	0.05 k	0.69	0.03 k	0.03 k	3.09	140	8.3	121	4	4	4.7	550	450	70
LNG03	17-Aug-93	24.5	8.2	7.26	0.05 k	1.6	0.05	0.03 k	7.86	208	7.3	170		3	4.9	460	190	10
LNG03	29-Nov-93	7.7	10.5	7.79	0.05 k	1.14	0.03 k	0.03 k	3.96	174	6.9	149	1 k	2	1.4	60	40	25
LNG03	11-Apr-94	13.7	9.5	8.12	0.05 k	0.49	0.07	0.03 k	2.57	116	8	91.2	17	20		691	590	75
DRY01	19-May-92	18.5	9.1	7.3	0.09	1.49	0.45	0.34	12	173	17.4	110	10	23	5.1	600	250	20
DRY01	17-Aug-92	18.8	10	7.59	0.05 k	2.26	0.12	0.13	17.5	138	15	170	2	3	6	220	50	15
DRY01	14-Dec-92	9.5	11.2	7.65	0.05 k	4.25	0.34	0.31	14.3	206	20.3	146	1	1 k	2	90	20	40
DRY01	17-May-93	15.7	8.2	7.08	0.05 k	2.28	0.21	0.15	6.71	175	13.2	141	4	3	2.4	460	290	40
DRY01	17-Aug-93																	
DRY01	29-Nov-93	7.2	11.2	7.81	0.05 k	4.04	0.29	0.26	11.1	223	15.6	167	1 k	2	2	10	40	25
DRY01	11-Apr-94	13.1	9.5	8.1	0.05 k	1.98	0.33	0.26	5.77	163	13.7	115	18	28		7100	5300	70
YOC01	19-May-92	16.5	8.7	7	0.05 k	2.56	0.12	0.05	5.33	182	8	144	4	5	4.8	600	600	30
YOC01	17-Aug-92	18.3	9.6	7.79	0.05 k	2.71	0.03 k	0.07	6.74	209	2.7	174	1 k	1 k	6.1	120	10	30
YOC01	14-Dec-92	11.5	10.2	7.45	0.05 k	2.87	0.07	0.07	7.25	180	7.6	146	2	1 k	3.3	30	70	30
YOC01	17-May-93	14.8	8.3	6.67	0.05 k	2.91	0.07	0.04	5.85	180	6.1	156	3	2	1.3		570	70
YOC01	17-Aug-93	24.3	8.7	7.5	0.06	2.45	0.05	0.05	8.19	208	5.1	169		1 k	4.4	60	60	10
YOC01	29-Nov-93	9.8	10.8	7.56	0.05 k	3.54	0.03 k	0.04	6.73	202	5.5	168	1 k	1	1.3	20	40	25
YOC01	11-Apr-94	12.7	10.1	8	0.05 k	2.62	0.14	0.11	5.46	174	5.9	134	4	6		3000	3700	75

TABLE 2
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA

STATION	DATE	TEMP deg C	DO mg/L	pH S.U.	NH3 mg/L	NO3 mg/L	TPHOS mg/L	OPHOS mg/L	CL mg/L	TDS mg/L	SO4 mg/L	THARD mg/L	TSS mg/L	TURB ntu	TOC mg/L	FECAL #/100 ml	ECOLI #/100 ml	FLOW % bank
YOC02	19-May-92	17	8.2	6.9	0.05	2.28	0.09	0.07	4.91	183	6.1	148	3	4	2.5	600	870	85
YOC02	17-Aug-92	19.3	7.6	7.72	0.05 k	2.48	0.03 k	0.07	5.87	208	2.7	176	1 k	1	5.7	80	10	30
YOC02	14-Dec-92	10	10.7	7.6	0.05 k	2.59	0.05	0.05	6.48	180	6.3	155	1	1	4.3	40	45	30
YOC02	17-May-93	15.3	8.3	6.59	0.05 k	2.5	0.03	0.03 k	5.25	179	6.1	161	1 k	1	3.1	100	130	80
YOC02	17-Aug-93	25	5.5	7.44	0.05 k	2.12	0.05	0.05	6.85	206	5.1	168		2	4.4	140	20	10
YOC02	29-Nov-93	8.5	10	8	0.05 k	3.24	0.03 k	0.03 k	5.86	202	3.9	167	1 k	1	1.3	60	10	25
YOC02	11-Apr-94	12.6	9.5	8.05	0.06	2.35	0.14	0.11	5.32	171	5.9	120	5	7		5600	5100	75

* k = less than method detection limit

TABLE 3
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA
(MAX,MIN, MEAN)

STATION	NH3			NO3			TPHOS			OPHOS			TDS			THARD			TSS			TURB		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
WFW01	0.07	0.05	0.04	0.2	0.04	0.13	0.15	0.03	0.04	0.1	0.03	0.04	102	37	51	26	5	15	102	1	16.43	78	7	20
WFW02	0.07	0.05	0.04	0.6	0.02	0.30	0.33	0.03	0.08	0.11	0.03	0.04	122	53	87	78	14	49	291	3	49.29	155	4.2	34
WFW03	0.06	0.05	0.03	0.61	0.02	0.30	0.39	0.03	0.09	0.13	0.03	0.04	117	64	95	86	25.1	60	345	1	58.71	170	3	35
WFW04	0.09	0.05	0.03	0.58	0.02	0.30	0.48	0.03	0.10	0.15	0.03	0.04	157	79	115	100	31.7	70	452	2	81.29	200	6.8	46
WHI51	0.14	0.03	0.05	0.5	0.09	0.42	0.17	0.02	0.11	0.09	0.015	0.05	183	78	135	124	45	89	361	2	56.44	270	4	46
MFW01	0.06	0.05	0.04	0.98	0.02	0.46	0.14	0.03	0.04	0.07	0.03	0.03	74	28	41	20	9.9	17	50	1	10.00	45	2.8	15
MFW02	0.06	0.05	0.03	0.95	0.02	0.40	0.17	0.03	0.04	0.11	0.03	0.03	91	49	61	54	14	34	81	1	14.14	60	3	13
MFW03	0.07	0.05	0.05	0.94	0.02	0.38	0.36	0.03	0.07	0.22	0.03	0.05	90	62	73	64	17.9	44	124	1	21.86	75	4	17
WHR01	0.06	0.05	0.07	0.52	0.2	0.34	0.24	0.03	0.05	0.11	0.03	0.04	39	13	27	15	5	10	173	1	25.71	120	3.9	24
WHR02	0.11	0.05	0.05	0.47	0.02	0.23	0.18	0.03	0.04	0.08	0.03	0.03	38	27	31	14	5	8	93	1	16.14	75	2.9	18
WHR03	0.07	0.05	0.04	0.57	0.02	0.24	0.25	0.03	0.05	0.11	0.03	0.03	52	28	39	24	5.5	16	174	1	26.71	110	2	22
WHR04	0.07	0.05	0.04	0.64	0.02	0.26	0.3	0.03	0.06	0.12	0.03	0.07	76	36	50	7.8	30	20	195	1	31.29	120	3.2	25
WHI52	0.17	0.03	0.05	1.63	0.01	0.59	0.16	0.03	0.09	0.1	0.015	0.04	201	66	102	117	30	68	30	1	18.35	52	5.5	22
RCH01	0.09	0.05	0.05	0.73	0.18	0.32	0.15	0.03	0.04	0.1	0.03	0.04	63	40	49	34.2	17.9	24	52	1	9.83	53	3	16
RCH02	0.3	0.06	0.08	1.47	0.02	0.64	0.33	0.03	0.11	0.15	0.03	0.05	163	72	103	113	28.5	67	139	1	34.57	61	4	23
RCH03	0.06	0.05	0.03	1.16	0.06	0.51	0.29	0.03	0.07	0.15	0.03	0.04	153	77	104	116	25.1	72	150	1	25.29	60	2	15
BRS01	0.1	0.05	0.05	1.63	0.32	0.76	0.25	0.03	0.07	0.15	0.03	0.05	208	89	135	164	36.4	97	78	1	18.40	78	1	17
BRS02	0.13	0.05	0.05	1.89	0.62	1.04	0.28	0.03	0.06	0.15	0.03	0.05	216	105	170	172	47.9	132	170	1	26.86	89	1.8	17
WRE01	0.05	0.05	0.03	0.38	0.04	0.18	0.06	0.03	0.03	0.06	0.03	0.03	97	38	54	61.8	21.3	32	3	1	1.71	19	1.6	9
WRE02	0.05	0.05	0.03	1.47	0.17	0.50	0.08	0.03	0.04	0.05	0.03	0.02	159	62	88	129	40	60	25	1	7.43	50	3.2	15
WRE03	0.13	0.05	0.05	2.39	0.43	1.01	0.24	0.03	0.12	0.2	0.03	0.07	186	72	104	132	20	69	144	1	28.43	58	5	18
WRE04	0.05	0.05	0.03	1.4	0.61	1.14	0.1	0.03	0.06	0.06	0.03	0.03	167	84	111	123	56	81	44	1	16.43	27	4	13
WRE05	0.05	0.05	0.03	1.54	0.63	1.19	0.1	0.03	0.06	0.06	0.03	0.03	164	87	113	124	62	84	26	1	13.29	28	4	13
WRE06	0.97	0.05	0.17	1.48	0.64	1.07	0.09	0.03	0.05	0.05	0.03	0.03	160	92	116	130	62	89	34	2	16.14	30	4	14

TABLE 3
UPPER WHITE RIVER
WATER QUALITY SURVEY DATA
(MAX,MIN, MEAN)

STATION	NH3			NO3			TPHOS			OPHOS			TDS			THARD			TSS			TURB		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
KGS01	0.05	0.05	0.03	0.28	0.02	0.15	0.03	0.03	0.02	0.04	0.03	0.03	64	30	43	49.5	16	28	4	1	1.36	26	1	8
KGS02	0.05	0.05	0.03	0.41	0.04	0.19	0.04	0.03	0.03	0.03	0.03	0.02	143	51	80	107	31.7	58	14	1	4.79	21	2	10
KGS03	0.07	0.05	0.04	0.6	0.18	0.31	0.19	0.03	0.05	0.05	0.03	0.03	159	70	100	126	47.9	76	106	1	19.00	57	2	15
KGS04	0.11	0.05	0.05	0.89	0.23	0.46	0.08	0.03	0.03	0.03	0.03	0.02	150	75	104	123	42	81	34	1	10.14	40	3	11
KGS05	0.05	0.05	0.03	0.97	0.1	0.41	0.08	0.03	0.03	0.03	0.03	0.02	146	99	117	152	80	103	44	1	10.79	33	1	8
KGS06	0.06	0.05	0.03	0.91	0.06	0.38	0.11	0.03	0.03	0.05	0.03	0.02	153	100	125	146	88	110	83	1	16.64	36	1	9
WHI09A	0.16	0.05	0.09	0.99	0.14	0.44	0.77	0.03	0.17	0.47	0.03	0.11	192	100	154	164	72	127	390	0.5	27.94	180	0.7	15
OSG01	0.07	0.05	0.04	0.18	0.02	0.07	0.43	0.03	0.08	0.18	0.03	0.05	85	32	54	45.4	14	27	424	1	72.83	185	1	32
OSG02	0.1	0.05	0.04	0.25	0.11	0.18	0.66	0.03	0.11	0.11	0.03	0.04	133	55	88	101	32.5	57	744	1	126.42	290	2	50
OSG03	0.21	0.05	0.06	0.49	0.15	0.30	1.35	0.03	0.24	0.39	0.03	0.08	142	72	101	114	45.3	72	662	1	121.75	150	5	32
OSG04	0.09	0.05	0.04	0.73	0.06	0.36	0.49	0.03	0.16	0.17	0.03	0.04	162	89	118	136	60	92	388	1	80.67	120	4	28
WHI69	0.49	0.03	0.08	1.38	0.37	0.81	1.89	0.02	0.493	1.68	0.015	0.40	280	107	194	193	76	141	309	1	28.13	105	1	13
LNG01	0.08	0.05	0.04	0.81	0.13	0.37	0.09	0.03	0.04	0.03	0.03	0.04	186	90	130	152	59.4	101	36	1	10.25	36	5	17
LNG02	0.05	0.05	0.03	1.08	0.21	0.63	0.09	0.03	0.04	0.04	0.03	0.02	199	105	141	161	64	110	34	1	9.92	40	4	13
LNG03	0.05	0.05	0.03	1.6	0.49	0.88	0.07	0.03	0.05	0.05	0.03	0.03	208	116	157	170	91.2	127	17	1	12.58	20	2	12
WHI71	0.34	0.03	0.06	2.26	0.91	1.53	0.11	0.02	0.06	0.99	0.015	0.11	218	134	187	179	74	148	1074	0.5	66.88	440	1.1	30
CLF01	0.06	0.05	0.03	1.99	1.44	1.61	0.14	0.03	0.04	0.07	0.03	0.04	191	136	161	160	85.8	128	174	1	25.93	64	1	10
DRF01	0.09	0.05	0.04	0.85	0.25	0.46	0.07	0.03	0.03	0.05	0.03	0.03	149	98	121	126	71.8	98	38	1	7.00	21	1	6
PNY01	0.09	0.05	0.04	2.11	0.73	1.14	0.37	0.03	0.07	0.05	0.03	0.03	177	125	148	154	90.6	124	438	1	63.43	145	0.3	22
DRY01	0.09	0.05	0.04	4.25	1.49	2.72	0.45	0.12	0.29	0.34	0.13	0.24	223	138	180	170	110	142	18	1	5.92	28	1	10
YOC01	0.06	0.05	0.03	3.54	2.45	2.81	0.14	0.03	0.07	0.11	0.04	0.06	209	174	191	174	134	156	4	1	2.33	6	1	2
YOC02	0.06	0.03	0.03	3.24	2.12	2.51	0.14	0.03	0.06	0.11	0.03	0.05	208	171	190	176	120	156	5	1	1.75	7	1	2

which was the furthest downstream sampling point on West Fork White River (Figure WQ-1). Concentrations in Middle Fork were very consistent between the three sampling sites and mean concentrations were around 0.4 mg/L (Figure WQ-2). On the main fork of the White River, nitrates were consistently low at all stations above WHI52 (Figure WQ-3). It is noted, however, that the furthest upstream station had noticeably higher mean and minimum nitrate values. This indicates a constant, although relatively low input of nitrates. This station is located in the community of St. Paul. Station WHI52 is located downstream of Lake Sequoyah, the confluence of West Fork White River and the City of Fayetteville WWTP. Figure WQ-4 compares this station to the last station on West Fork (WHI51), the last station on the Middle Fork (MFW03) and, the last station on the main fork of the White River (WHR04). It is apparent from this comparison that the source of elevated nitrates is the Fayetteville WWTP, although average values were just above 0.5 mg/L.

Both Richland and Brush Creeks had consistently higher nitrate values than the three upstream forks of the White River (Figure WQ-5). Since no point source discharges occur in these creeks, the source was non-point. The elevated average and, in some cases, minimum nitrate values indicate a rather constant nitrate input. Both creeks have substantial groundwater influences. This is more significant in Brush Creek than in Richland Creek, and is reflected by the higher nitrates in Brush Creek. It is therefore likely that the elevated nitrates are from groundwater sources.

Nitrate data from War Eagle Creek also demonstrated the effects of a point source discharge (Figure WQ-6). Upstream of the discharge from the City of Huntsville WWTP (WRE02), nitrate mean concentrations were less than 0.5 mg/L. Below the discharge (WRE03), concentrations had increased substantially. Maximum nitrate values recorded at WRE03 were the highest recorded on War Eagle Creek. Previous investigations of the discharge from Huntsville indicated periodic, very high concentrations of nitrates entering Holman Creek which flows into War Eagle Creek approximately 2.5 miles above station WRE03. Average and minimum nitrate values at this station also show substantial increases over the next upstream station. These values continue to increase slightly at subsequent downstream stations, but maximum values, although somewhat elevated, remain well below the peak value at WRE03. It is not likely that the point source discharge continues to impact the creek at the lower stations since dilution flows increase substantially. It is therefore most likely that non-point sources maintain the elevated nitrates downstream.

Figure WQ-1
Nitrate+Nitrite-N
West Fork White River

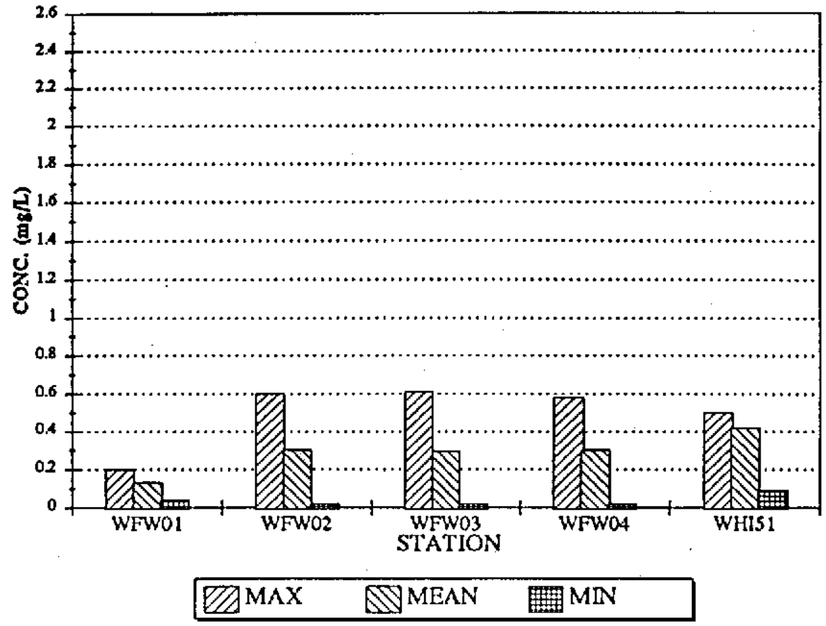


Figure WQ-2
Nitrate+Nitrite-N
Middle Fork White River

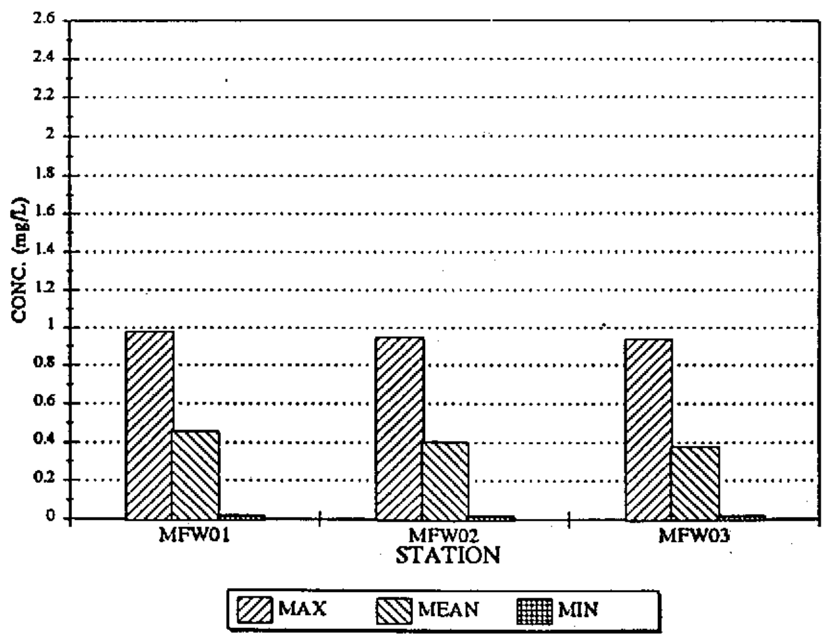


Figure WQ-3
Nitrate+Nitrite-N
Main Fork White River

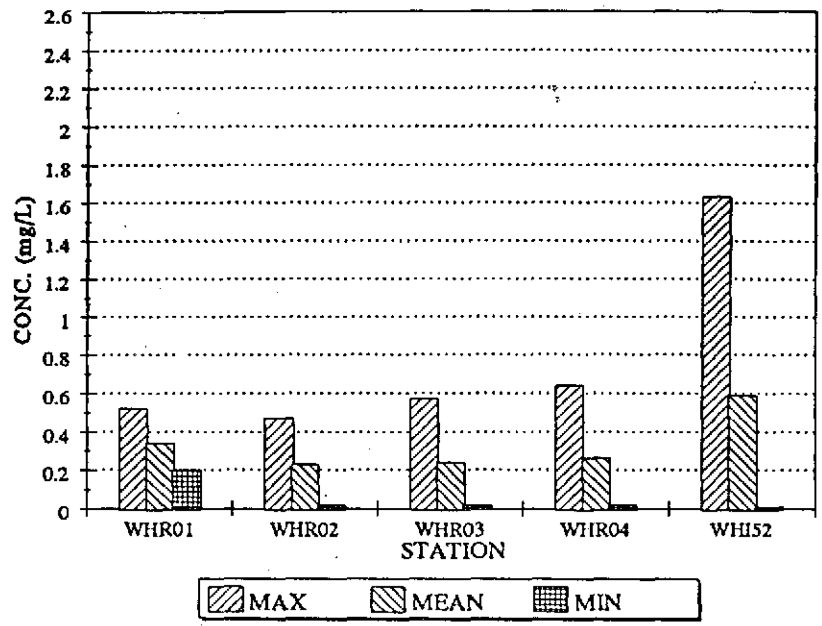


Figure WQ-4
Nitrate+Nitrite-N
Comparison of Stations Above
and Below Fayetteville WWTP

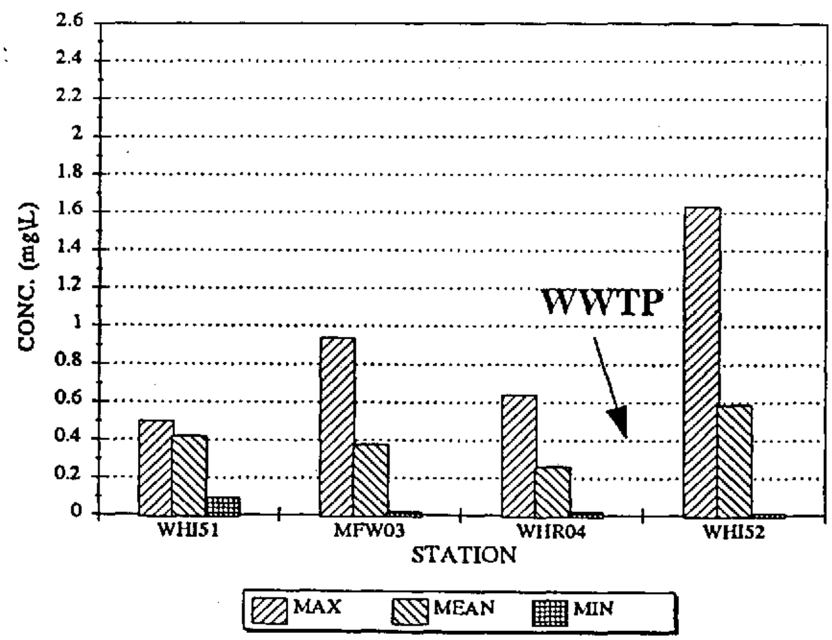


Figure WQ-5
Nitrate+Nitrite-N
Richland & Brush Creeks

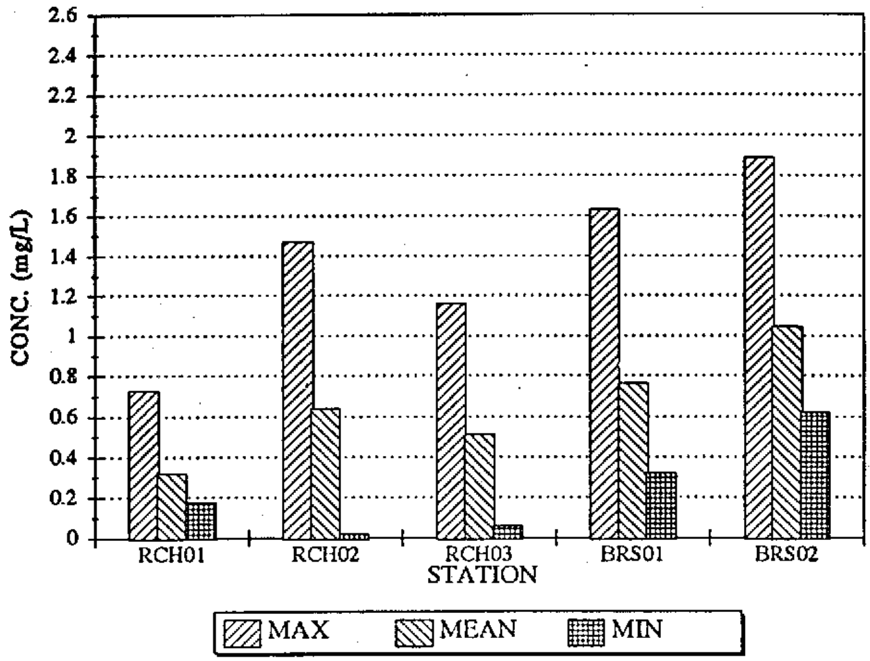
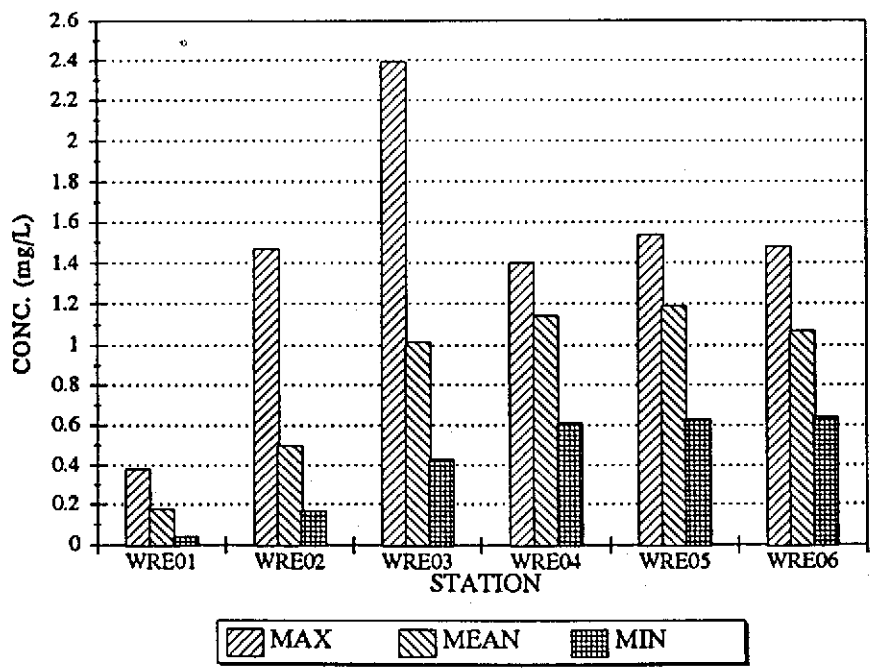


Figure WQ-6
Nitrate+Nitrite-N
War Eagle Creek



Kings River nitrate levels show a general trend of gradually increasing downstream (Figure WQ-7). Slightly higher average and minimum values were noted at station KGS04. This station is just downstream from the small community of Marble. All values, however, are relatively low with the average values for all stations not exceeding 0.5 mg/L.

Similarly, nitrate concentrations in Osage Creek showed relatively low values which slightly increased in a downstream direction, except at station WHI69 which is below Freeman Branch, the primary receiving stream for the City of Berryville WWTP. At this station, maximum and average concentrations are twice that of the next upstream station (Figure WQ-8).

The nitrate concentrations in Long Creek are similar to those in Kings River and Osage Creek, except maximum and average values are substantially higher in Long Creek (Figure WQ-9). The farthest downstream station in Long Creek (WHI71) showed even higher nitrate concentrations, particularly the average and minimum values. These consistently high values were most likely from the city of Green Forest WWTP which discharges into Dry Creek which flows into Long Creek about three miles above station WHI71.

Nitrate values for several of the tributary streams sampled in the study are displayed in Figure WQ-10. Clifty Creek (CLF) discharges into the lower section of War Eagle Creek. Dry Fork Creek (DRF) and Piney Creek (PNY) both flow into Kings River between stations KGS04 and KGS05. Dry Creek (DRY) discharges into Long Creek upstream from station WHI71. These tributary streams, all of which have significant groundwater contributions to their base flow, had the highest nitrate values of any water sampled during the study. As discussed earlier, Dry Creek receives the WWTP discharge from the City of Green Forest. This results in elevated nitrates at the sample station and produced the highest nitrate value recorded in the study. Yocum Creek does not receive point source discharges but it does have a significant groundwater inflow and the watershed of the stream has an exceptionally large area in poultry production. In this stream, minimum and average concentrations were the highest of any stream sampled during this study. Clifty Creek also has consistently high nitrate values although substantially lower than Yocum Creek. Clifty has a relatively small watershed but its flow is dominated by groundwater. Piney Creek appears to be slightly more groundwater flow influenced than Dry Fork Creek; as a result, nitrate values in Piney are noticeably greater.

Generally, phosphorous concentrations, both ortho-phosphate ("reactive")and total, in the Upper White River Watershed average less than the 0.1 mg/L guideline level for streams. Elevated

Figure WQ-7
Nitrate+Nitrite-N
Kings River

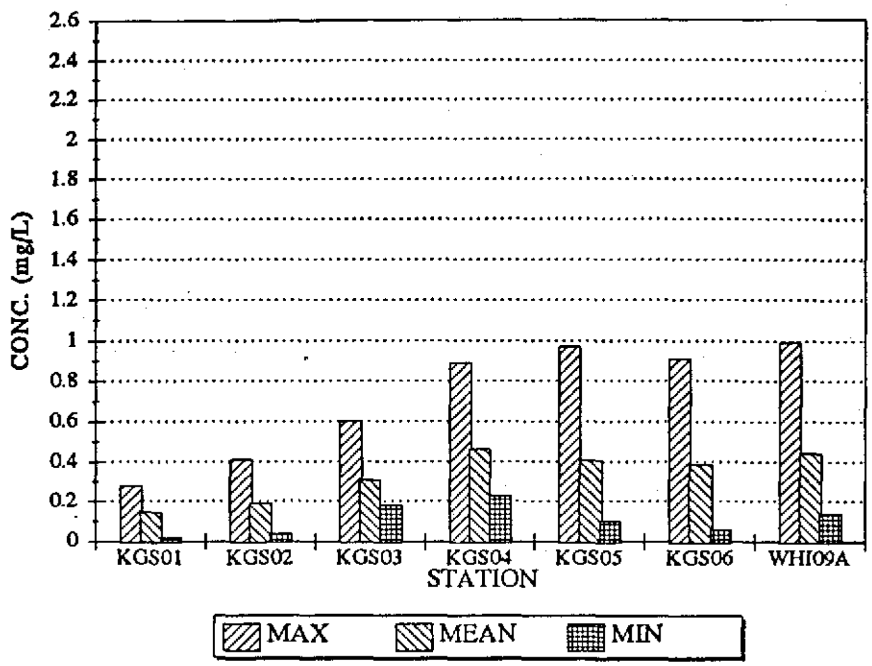


Figure WQ-8
Nitrate+Nitrite-N
Osage Creek

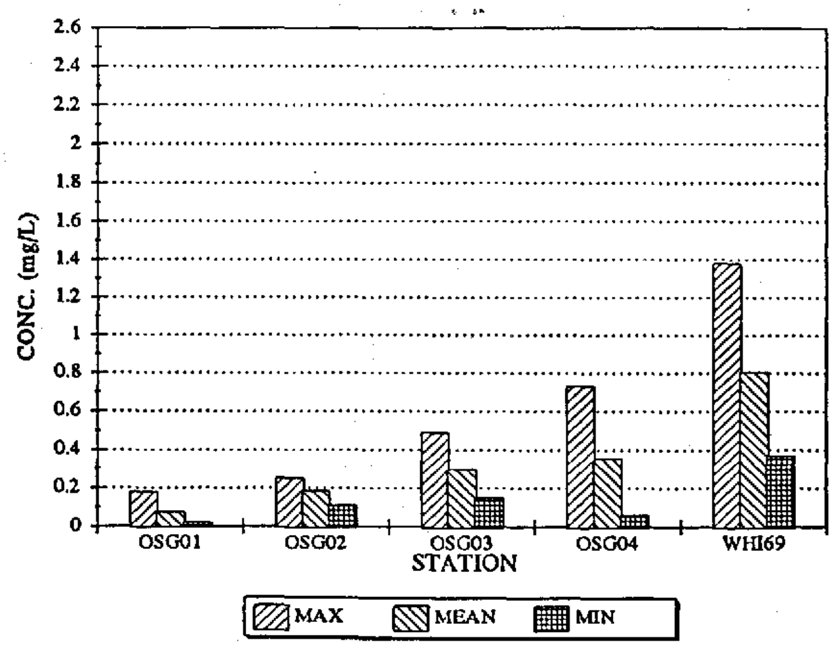


Figure WQ-9
Nitrate+Nitrite-N
Long Creek

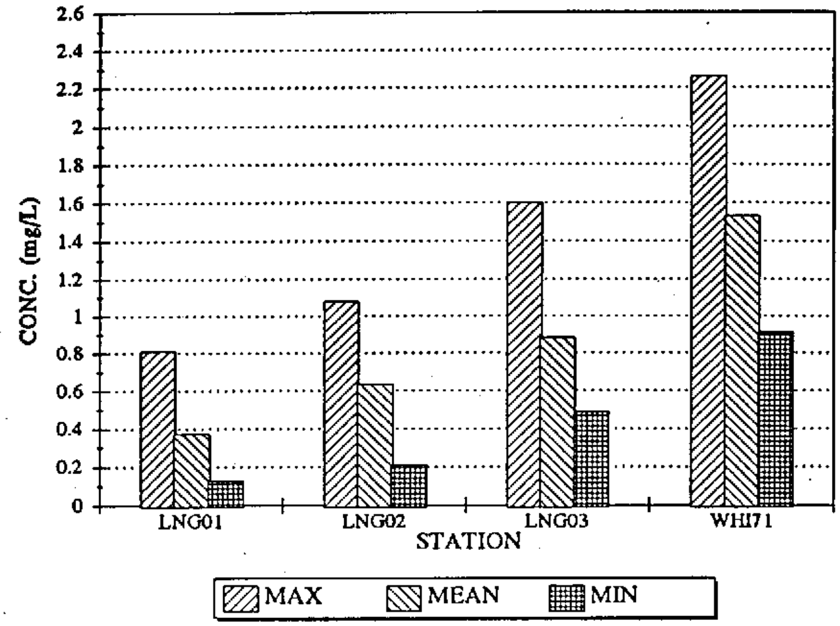
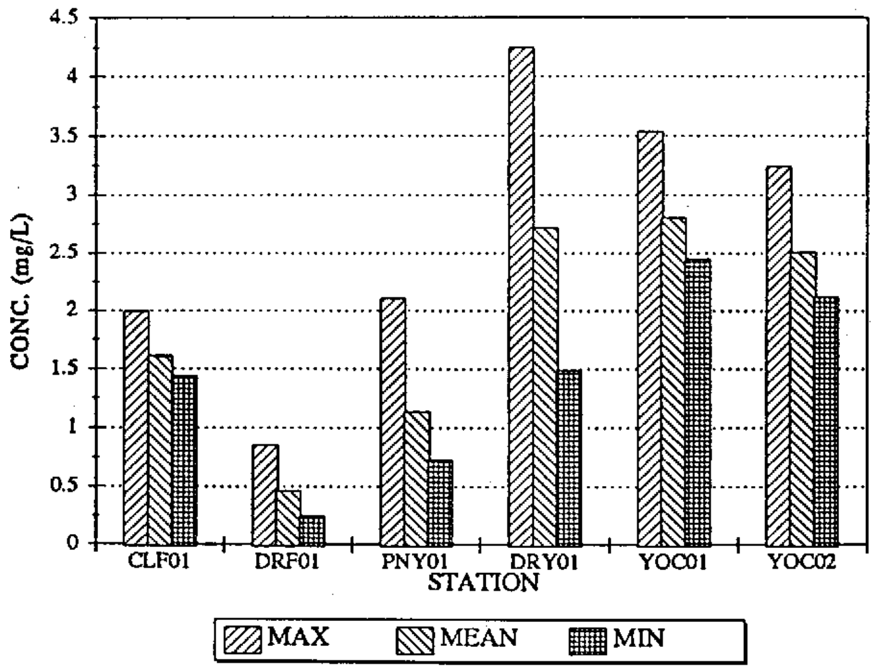


Figure WQ-10
Nitrate+Nitrite-N
Tributary Creeks
(note scale change)



Figures WQ-11 through WQ-14 demonstrate the total phosphorous concentration in the main forks of the upper White River and in the Richland and Brush Creek tributaries. Average concentrations for all stations are below the phosphorous guideline value; however, maximum concentrations, particularly in West Fork White River, are very high. All of the maximum values for all stations shown in these figures occurred on December 15, 1992 during a major storm event where stream flows were out-of-bank. Plots of Richland and Brush Creek data shows a nearly identical pattern. In Figure WQ-11, the data from the most downstream station on West Fork (WHI51) seems to be inconsistent with the other stations. WHI51 is monitored monthly as a part of the routine ambient monitoring network; it was not sampled during the December 15 flood event. Similarly, in Figure WQ13, the WHI52 station is sampled monthly but was not sampled on December 15, 1992, and therefore does not reflect the maximum phosphorous concentrations found on that date.

War Eagle Creek total phosphorous values are shown in Figure WQ-15. The pattern of phosphorous levels in this stream were much different than in the White River forks. All maximum phosphorous values except one, in War Eagle Creek were below the guideline level, and the large peaks of phosphorous input were not demonstrated at these stations. These stations were sampled on December 14, 1992, before the major storm event which caused the much higher maximum values in the White River forks which were sampled on December 15, 1992. In contrast, WRE03 shows noticeably elevated maximum and average total phosphorus values. The source of these elevated levels is probably the Huntsville WTP discharge. Ortho-phosphate phosphorus was also elevated at this site which further supports the probability that the source is from a sewage treatment plant.

The Kings River phosphorus levels (Figure WQ-16) were very similar to that found in War Eagle Creek, with maximum values generally below 0.1 mg/L (with one noticeable exception) and average values below 0.05 mg/l. Also, as with War Eagle samples, the Kings River samples in December were taken the day before the major storm event. Station WHI09A on Kings River shows distinctly elevated phosphorus levels. This station is downstream from the confluence of Osage Creek. Figure WQ-17 shows phosphorus levels in Osage Creek and it is noted that the station just above the confluence with Kings River (WHI69) has substantially elevated maximum and average total phosphorus concentrations. This is also the first station below the City of Berryville WTP discharge and is likely the source of the elevated phosphorus levels in the Kings River. However, it is most likely that these elevated levels occurred during very low flows in both streams. The elevated maximum and average phosphorus values at OSG03 are suspected to be from a dairy operation on an upstream tributary. Consistently elevated fecal

Figure WQ-11
Total Phosphorus
West Fork White River

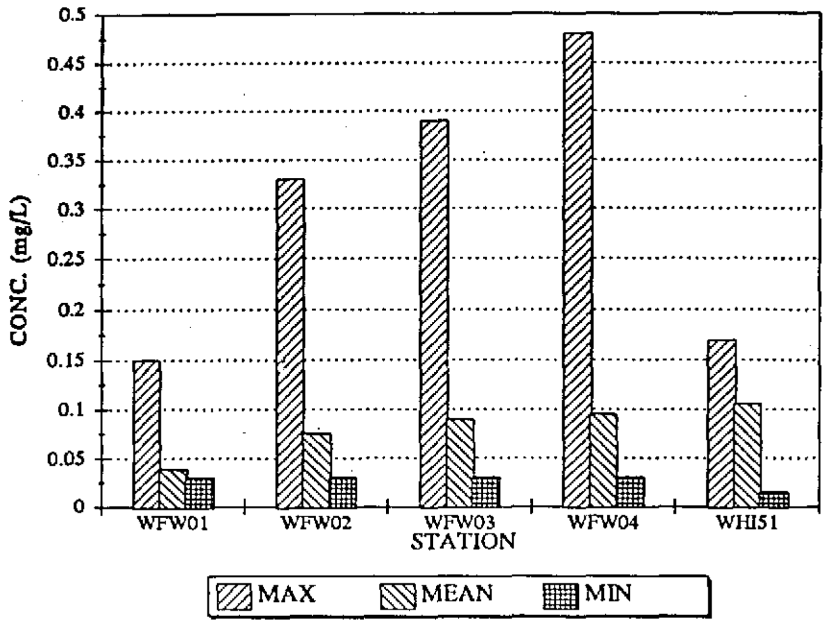


Figure WQ-12
Total Phosphorus
Middle Fork White River

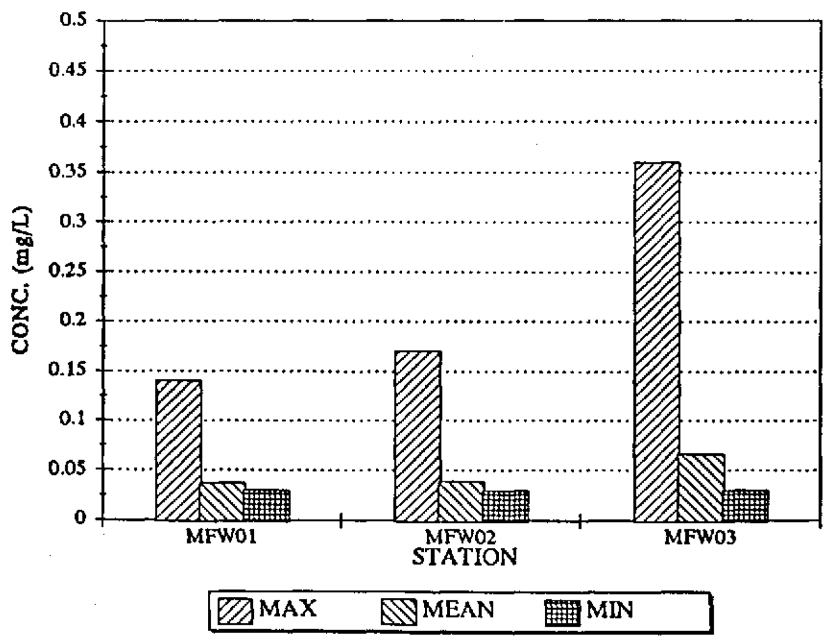


Figure WQ-13
Total Phosphorus
Main Fork White River

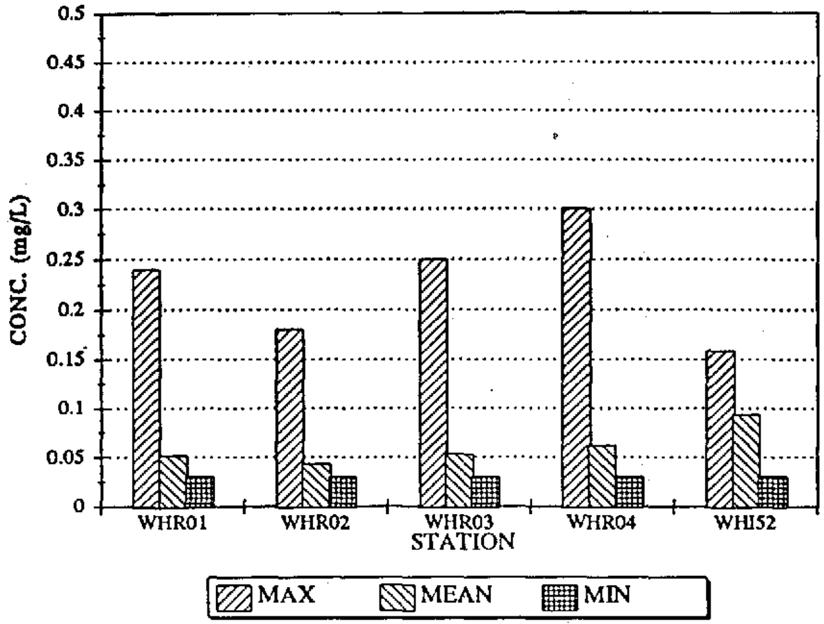


Figure WQ-14
Total Phosphorus
Richland & Brush Creeks

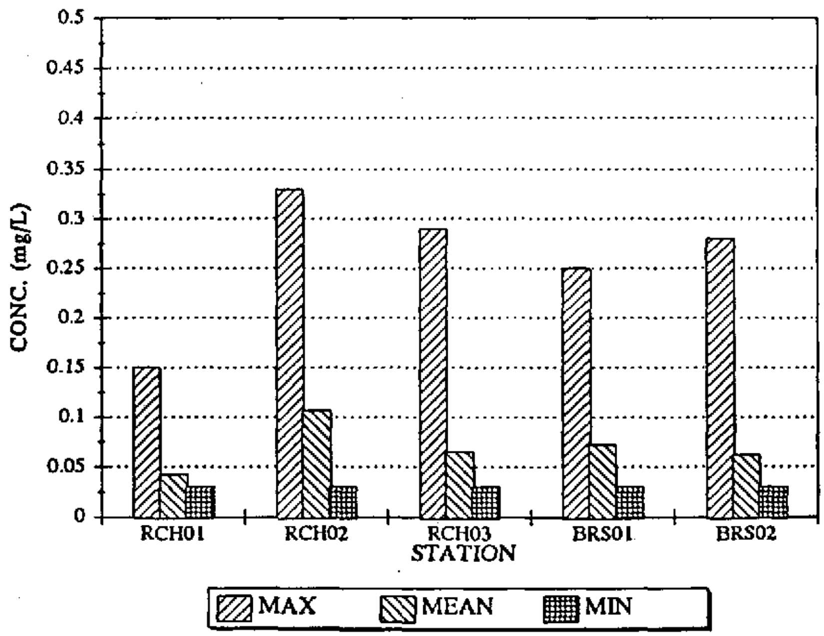


Figure WQ-15
Total Phosphorus
War Eagle Creek

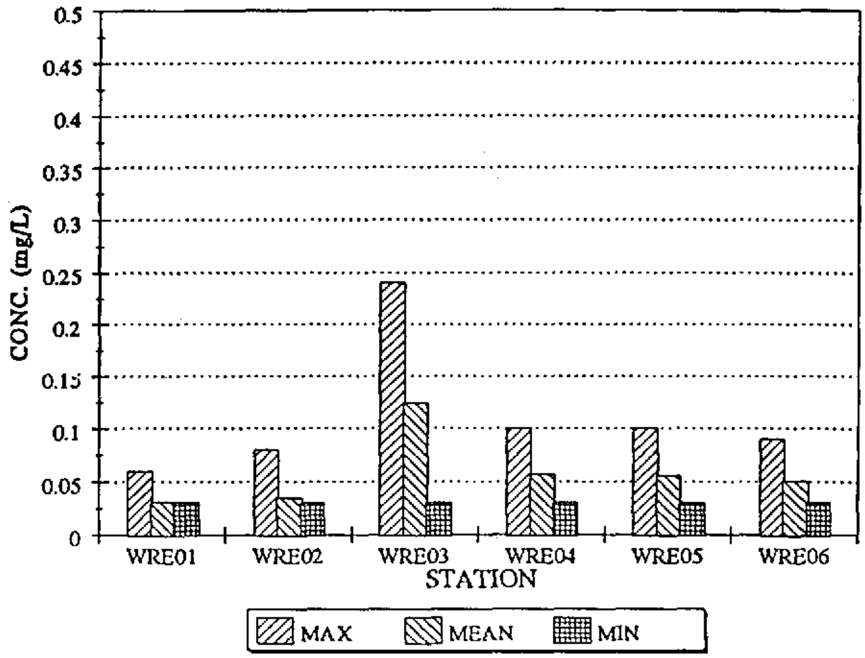


Figure WQ-16
Total Phosphorus
Kings River
(note scale change)

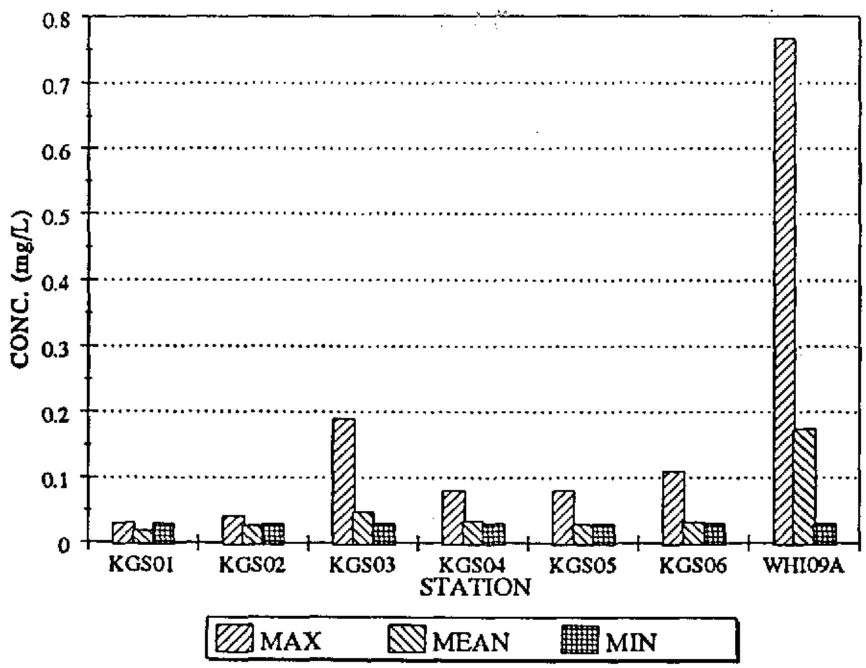


Figure WQ-17
Total Phosphorus
Osage Creek
(note scale change)

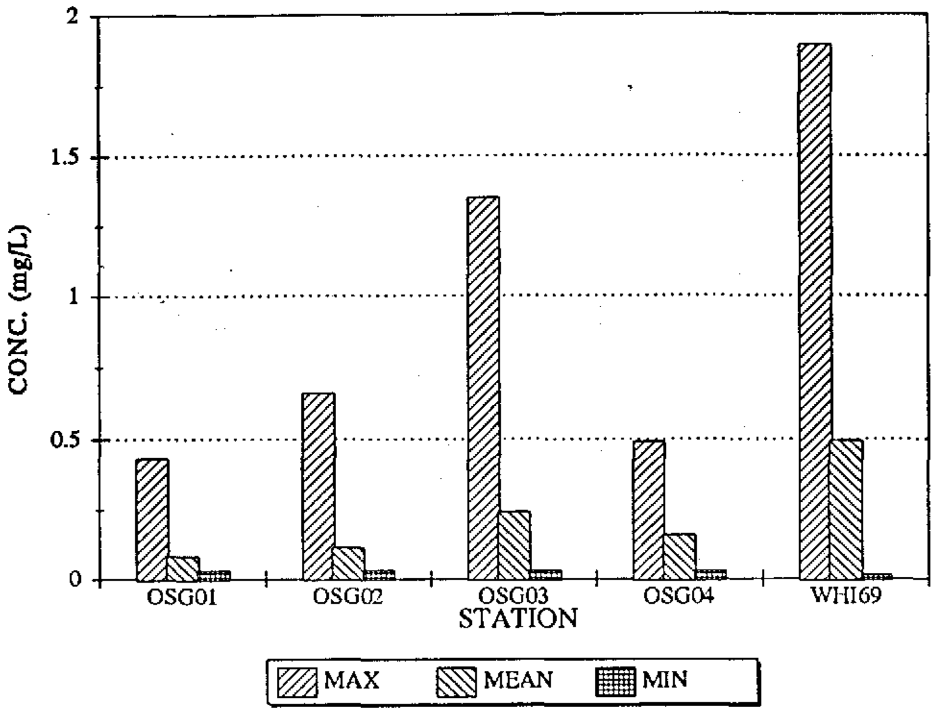
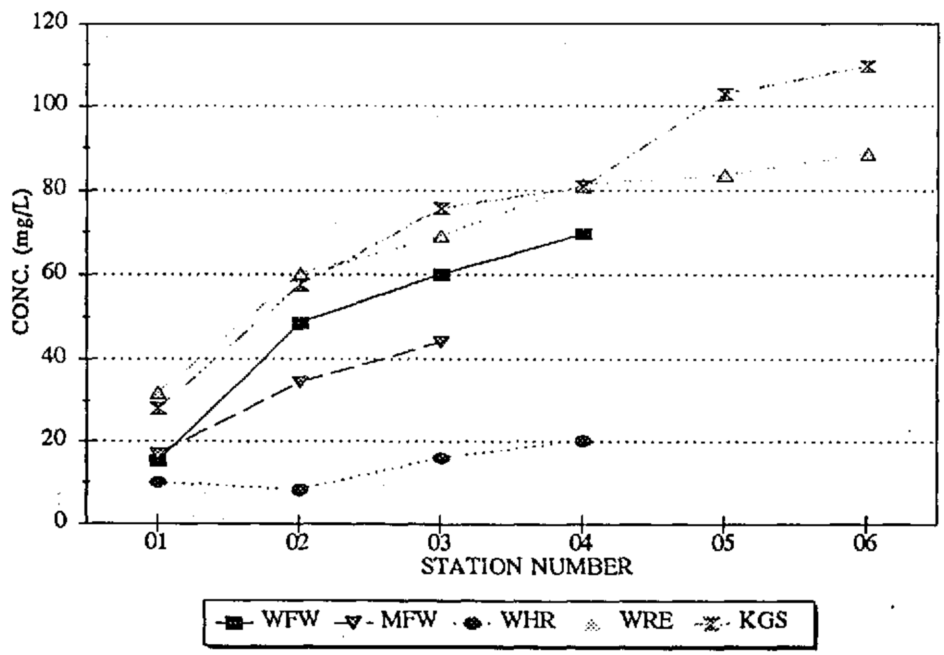


Figure WQ-17 shows phosphorus levels in Osage Creek. Note that the station just above the confluence with Kings River (WHI69) has substantially elevated maximum and average total phosphorus concentrations. This is also the first station below the City of Berryville WWTP discharge, which is the likely source of the elevated mean phosphorus levels in the Kings River at WHI09A. However, these elevated levels probably occurred during very low flows in both streams. The elevated maximum and average phosphorus values at OSG03 are probably from a dairy operation on an upstream tributary. Consistently elevated fecal coliform bacteria were also found at this site which further supports this supposition.

Total Dissolved Solids and Hardness

Differences in total dissolved solids (TDS) and total hardness concentrations at sampling sites in the Boston Mountains Ecoregion and sites in the Ozark Highlands Ecoregion were very distinct. The headwaters of the West, Middle and Main Forks of the White River, War Eagle Creek, and Kings River are located in the Boston Mountains Ecoregion. Total hardness concentrations are typically around 20 mg/L in this ecoregion. In the Ozark Highlands Ecoregion total hardness values are generally greater than 100 mg/L. Figure WQ-18 demonstrates the ecoregion influences on the total hardness values in the streams that originate in the Boston Mountains Ecoregion, flow through the Ozark Highlands Ecoregion, and have large transition zones.

Figure WQ-18
Mean Hardness
Upper White River Watershed



Turbidity and Total Suspended Solids

Turbidity and total suspended solids (TSS) concentrations varied greatly and were primarily influenced by stream flow rates. The highest values of these parameters were recorded after rain events when channel full estimates were 100 percent or greater. The highest turbidity and TSS concentrations were recorded in West Fork and Osage Creek. High values in West Fork were most likely due to runoff from construction of Highway 71 between Alma and Fayetteville.

Figures WQ-19 through WQ-22 display the maximum, average, and minimum turbidity values recorded in the three forks of the White River and in Richland and Brush Creeks. In all of these waters, the average turbidity values exceeded the water quality standards. In the West Fork White River these values exceeded the standard by two to four times. In the main fork of White River the exceedance was normally about double the standard. In the Middle Fork, Richland Creek and Brush Creek the average values exceeded the standard by almost 5 NTU. Even though these average values are influenced by the very high maximum turbidity values recorded, it is apparent that these waters are significantly impacted by silt laden turbidity, particularly during high flow events. During the study, maximum turbidity values ranged from 45 NTU at the headwater station on Middle Fork to 200 NTU at the lower station on West Fork (WFW04). All of these maximum values were recorded during the December 15, 1992 flood event, with the exception of the WHI51 turbidity value of 270 NTU, collected on November 11, 1992.

The Kings River turbidity values (Figure WQ-23) indicate that average values generally meet the water quality standard of 10 NTU. This stream was not sampled during the December 15 flood event and the maximum values occurred during a localized storm event on either the May 1992 or May 1993 sample run. Neither of these events occurred basin wide. The very high turbidity level shown at station WHI09A was likely caused by a localized storm event that occurred only in the Osage River basin and flowed into Kings River or it was a result of the extensive instream gravel mining activities just upstream from this station on the Kings River.

In Osage Creek, turbidity problems appear to be more severe in the upper segments (Figures WQ-24) with average values significantly exceeding the standard. Maximum turbidity values from 120 NTU to 290 NTU were recorded at the four study-project sites on Osage Creek on May 17, 1993. These high values were caused by a localized storm event that occurred east of Kings River and primarily in the upper Osage Creek watershed. A regularly-graded

Figure WQ-19
Turbidity
West Fork White River

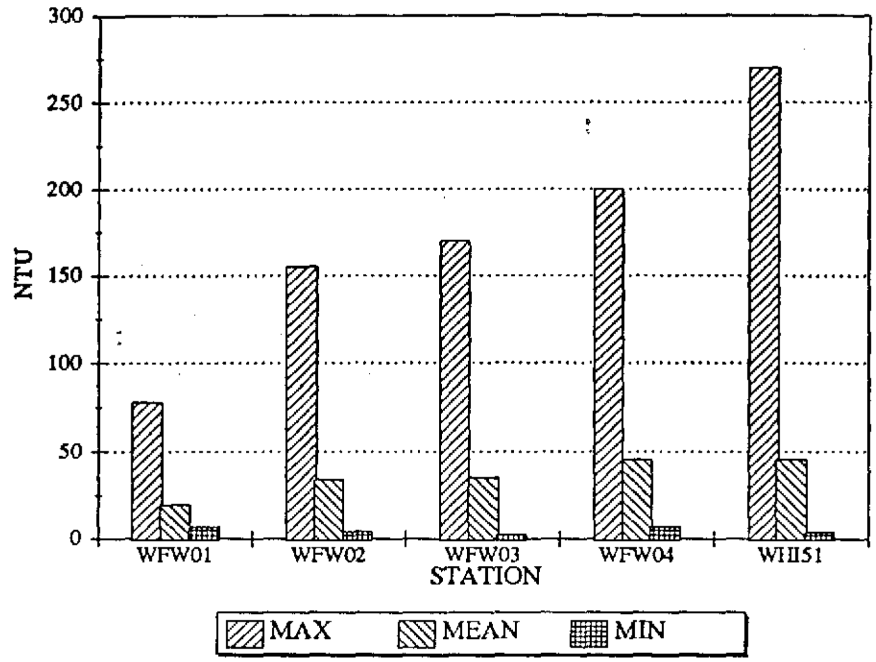


Figure WQ-20
Turbidity
Middle Fork White River

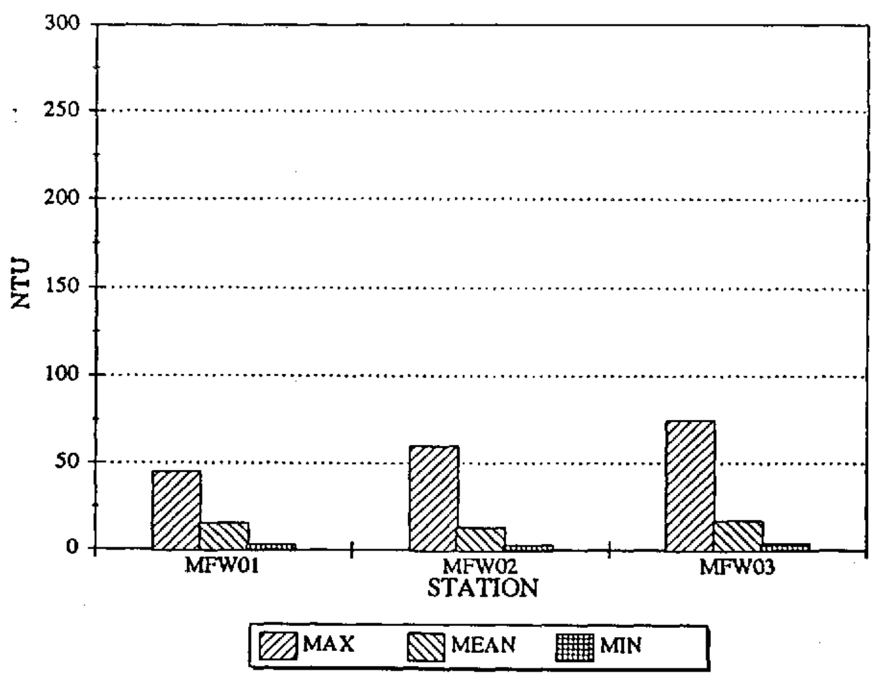


Figure WQ-21
Turbidity
Main Fork White River

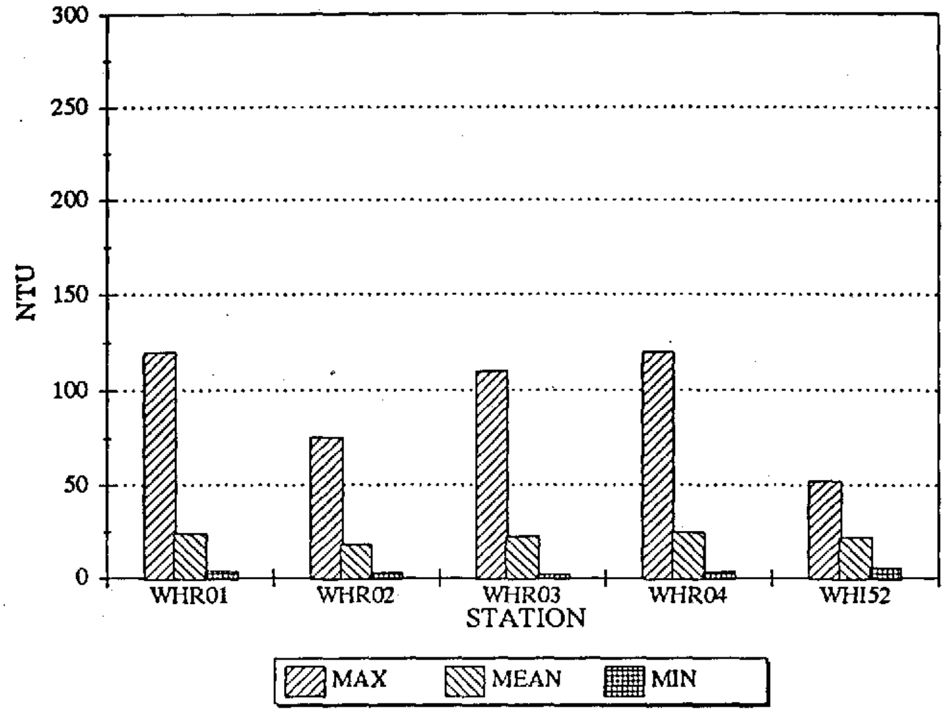


Figure WQ-22
Turbidity
Richland & Brush Creeks

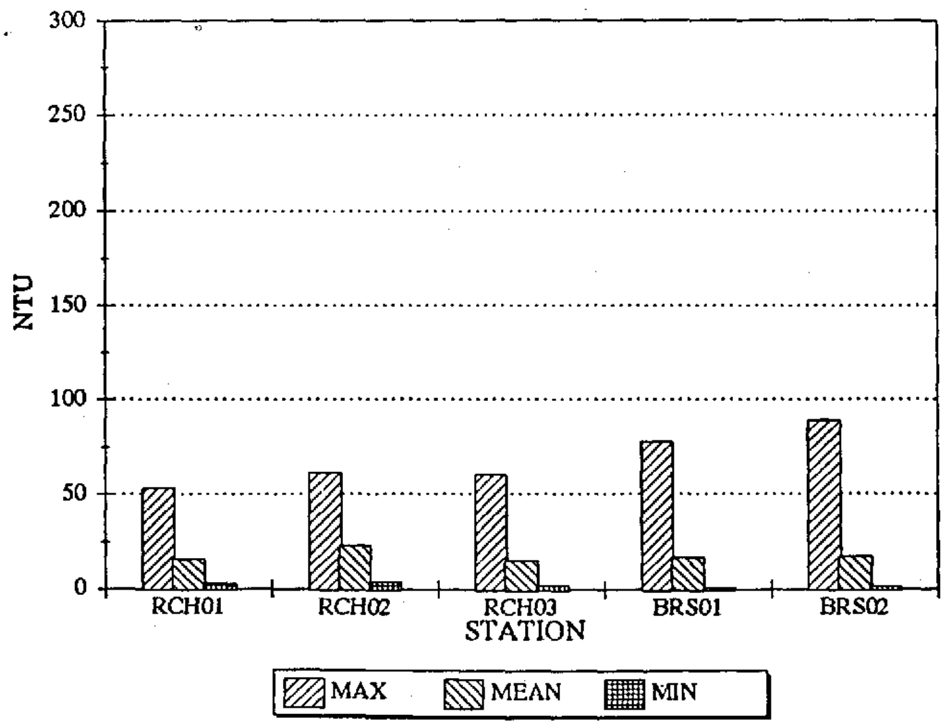


Figure WQ-23
Turbidity
Kings River

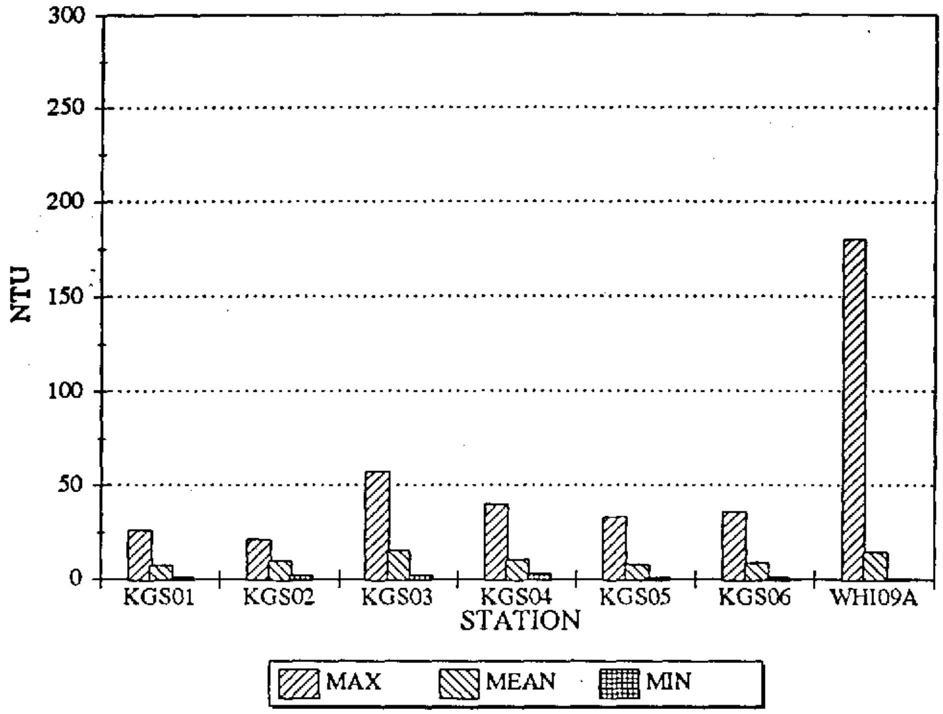
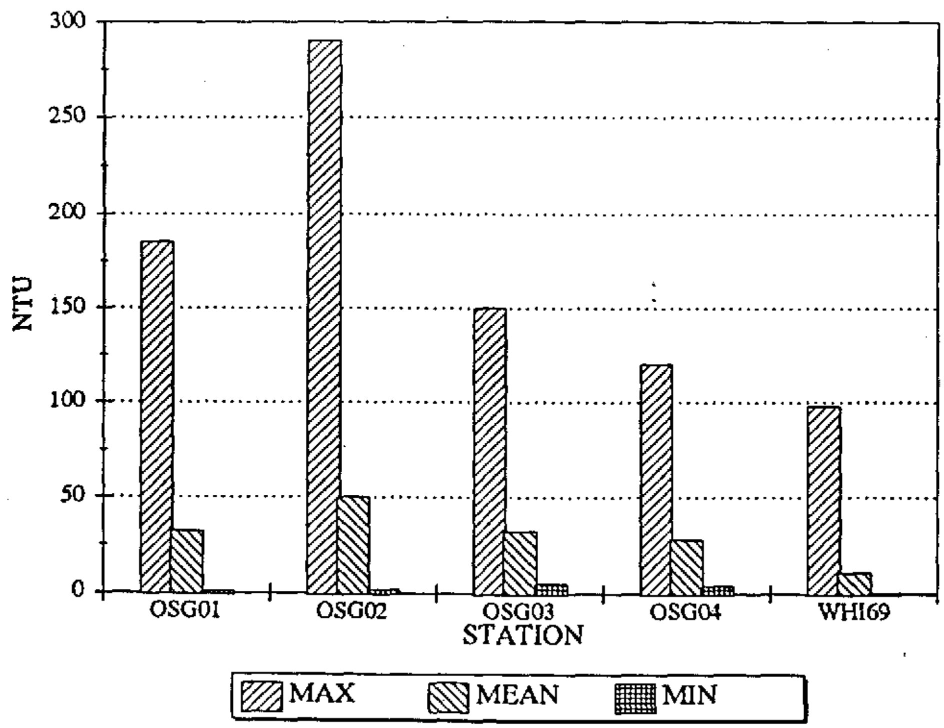
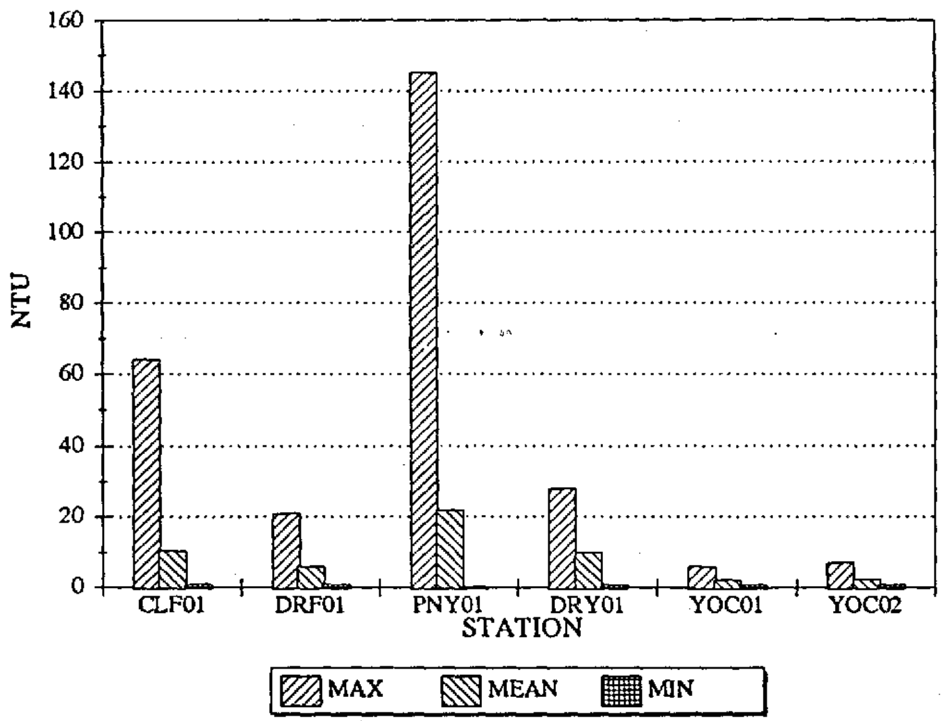


Figure WQ-24
Turbidity
Osage Creek



gravel road parallels and frequently crosses Osage Creek throughout much of its upper segment. The tributary creeks have very low turbidity values and generally average below the water quality standard. Figure WQ-25 shows an unusually high turbidity maximum in Piney Creek (PNY01). This occurred during the May 17, 1993 storm event that affected Osage Creek; however, the adjacent watershed to Piney Creek, which is Dry Fork Creek, showed only minimum impact from this event. During the study period, active land clearing was observed in the Piney Creek watershed.

Figure WQ-25
Turbidity
Tributary Creeks



Total Organic Carbon

Total organic carbon (TOC) concentrations ranged from a low of 1 mg/L to over 20 mg/L from all sites within the study project; however, most values were less than 5 mg/L. TOC generally followed a similar pattern as turbidity and suspended solids which were primarily flow related. Levels of TOC generally increased in a downstream direction and increased substantially during the December 15, 1992 and the May 17, 1993 storm events. Osage Creek had the highest values of any of the waters sampled. The single-station, maximum value occurred during the May 1993 storm event. Piney Creek had the second highest value (17.5 mg/L) of any station, which also occurred during the May 1993 storm.

Bacteria

All samples collected were analyzed for both fecal coliform and E. coli bacteria. In general, the E. coli bacteria accounted for over one half of the total fecal coliform bacteria. As expected, bacteria counts increased with flow rates. Counts of over 1,000 colonies per 100 ml were regularly seen in samples during high flow situations. This can be attributed to runoff from contaminated areas of the landscape.

Geometric and arithmetic means of fecal coliform counts were calculated for each sampling site. Because of occasional very high bacteria counts during heavy runoff, the arithmetic mean is substantially affected by one or two high values. In contrast, the geometric mean value minimizes the influence of a very high value. If all values at the same site are similar (not a large range of variations), the geometric mean and the arithmetic mean will be similar. However, if there are one or two very high values, and the remainder of the values are low, the geometric mean will be much less than the arithmetic mean. The lowest geometric means were found in the Middle Fork and the main fork of the White River. The highest geometric means were found in the Osage Creek watershed.

Figures WQ-26 through WQ-28 display the geometric mean and the arithmetic means of fecal coliform bacteria for the stations on West Fork, Middle Fork, and the main fork of the White River (scale may differ on all graphs). The bacteria counts are relatively low in these waters. The West Fork station WFW03 seems to have constant bacteria levels that are slightly higher than the other stations in this stream. This station is downstream of the City of West Fork WWTP discharge. Station WFW04 appears to be only occasionally impacted by elevated levels of bacteria. The Middle Fork values are generally low with no distinct pattern of

Figure WQ-26
Fecal Coliform
West Fork White River

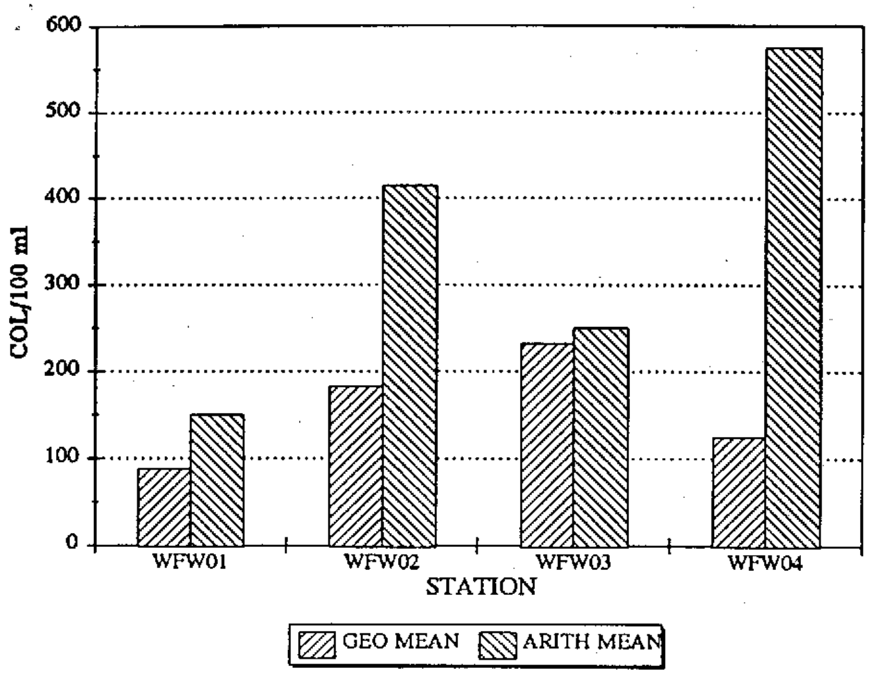


Figure WQ-27
Fecal Coliform
Middle Fork White River

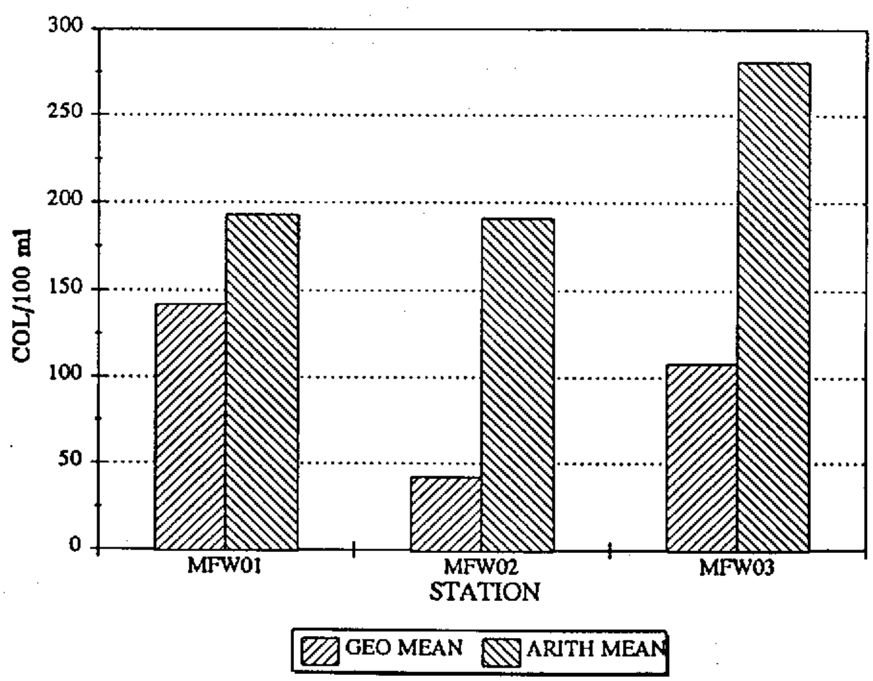
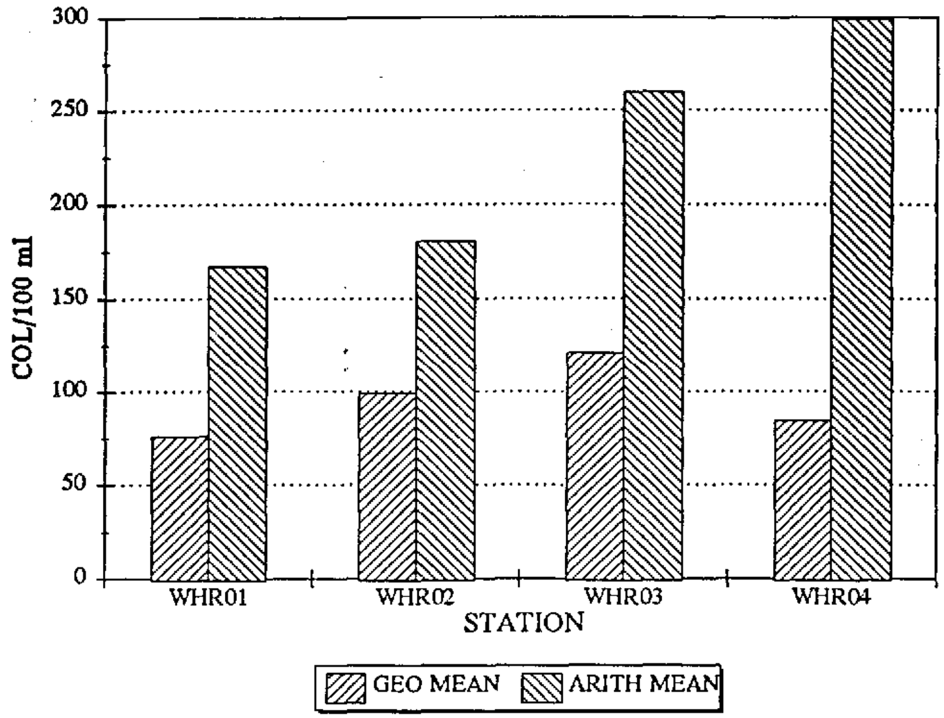


Figure WQ-28
Fecal Coliform
Main Fork White River



contamination. The main fork of the White River has low values also, but with slightly increasing levels downstream.

The geometric mean values in War Eagle Creek were within an acceptable range, although they were subject to sharply increased levels during heavy runoff. This seems to be most evident at station WRE02 (Figure WQ-29).

Fecal coliform levels in Kings River (Figure WQ-30) were quite low at the headwaters station, but they increased sharply downstream at station KGS02 and KGS03. These sites produced very high bacteria counts after storm events. Downstream, at site KGS05 the bacteria counts were substantially lower. For several miles above this site the Kings River watershed on the west side of the river is included in the Madison County Wildlife Management area.

Osage Creek fecal coliform levels were the highest in the study area. The upper two stations, OSG01 and OSG02, produced high values only during high flow events; however, OSG03 had consistently elevated bacteria levels as indicated by the geometric mean (Figure WQ-31, note scale). These levels moderated somewhat downstream at OSG04, but at high flows, values remained excessively elevated. A dairy operation just upstream from OSG03 is suspected as the source of these high values.

Figure WQ-29
Fecal Coliform
War Eagle Creek

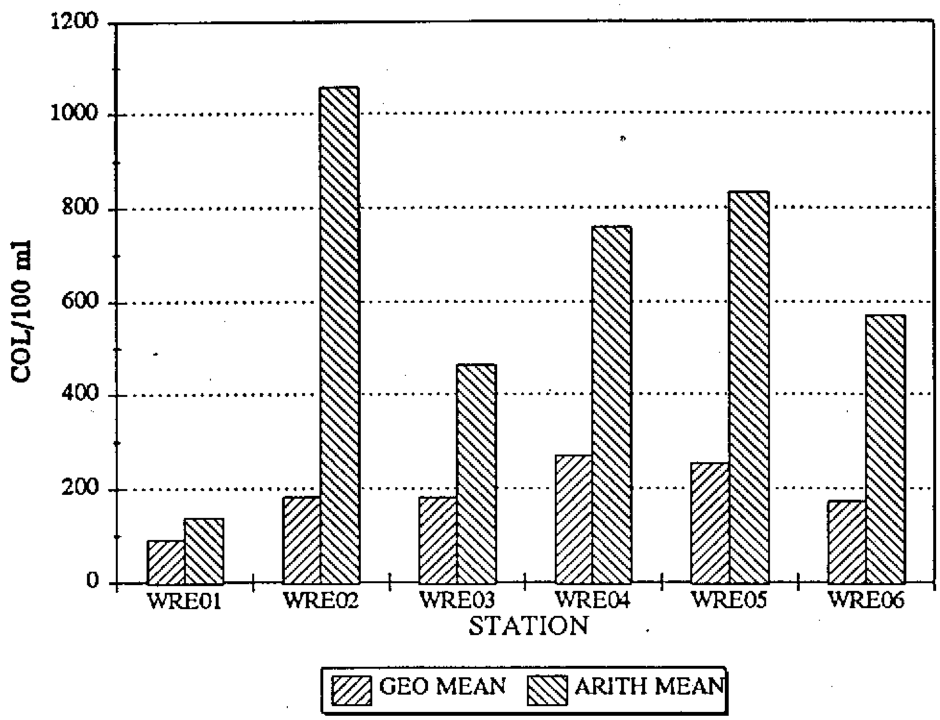


Figure WQ-30
Fecal Coliform
Kings River

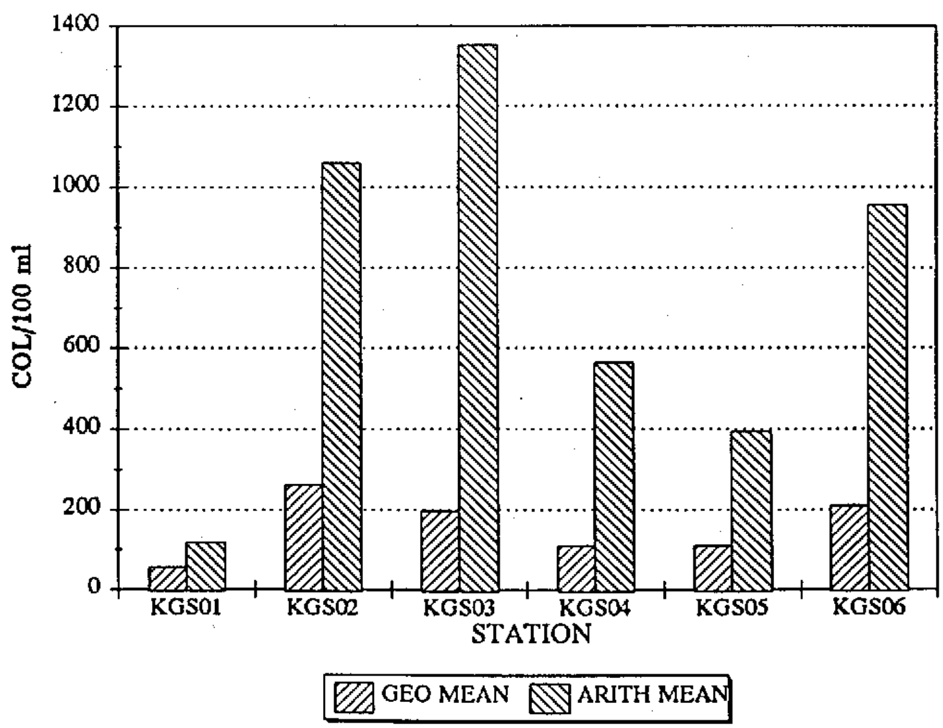


Figure WQ-31
Fecal Coliform
Osage Creek

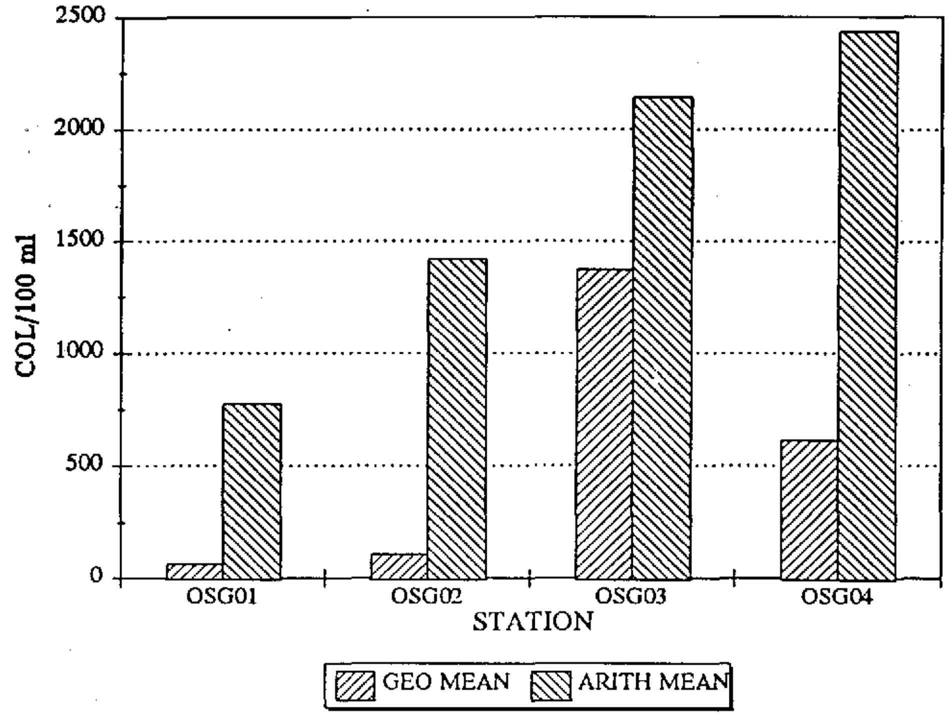
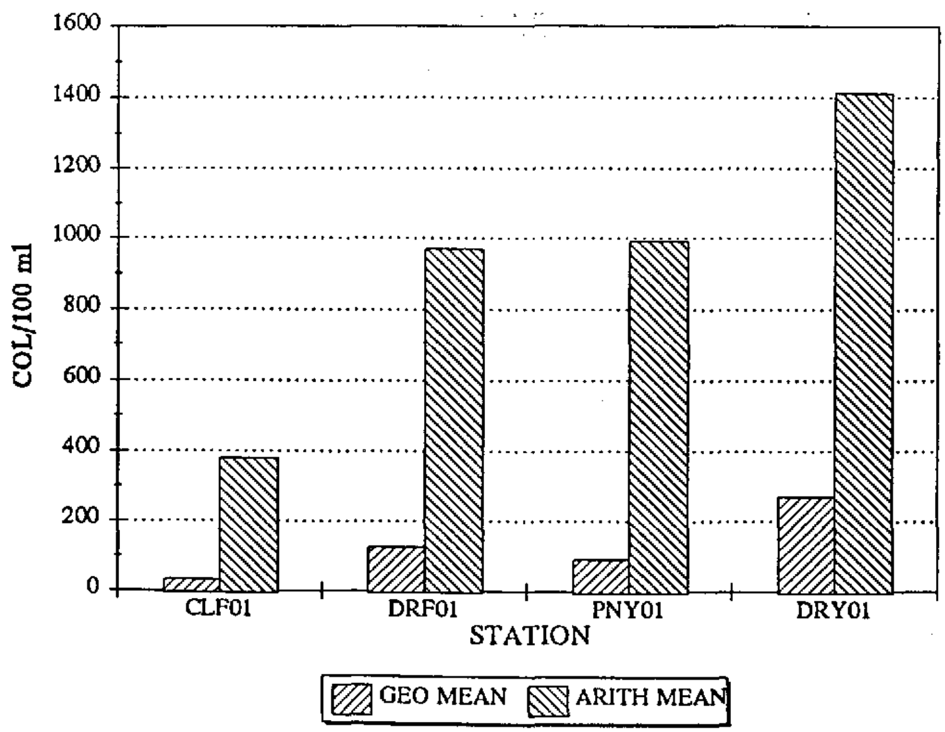
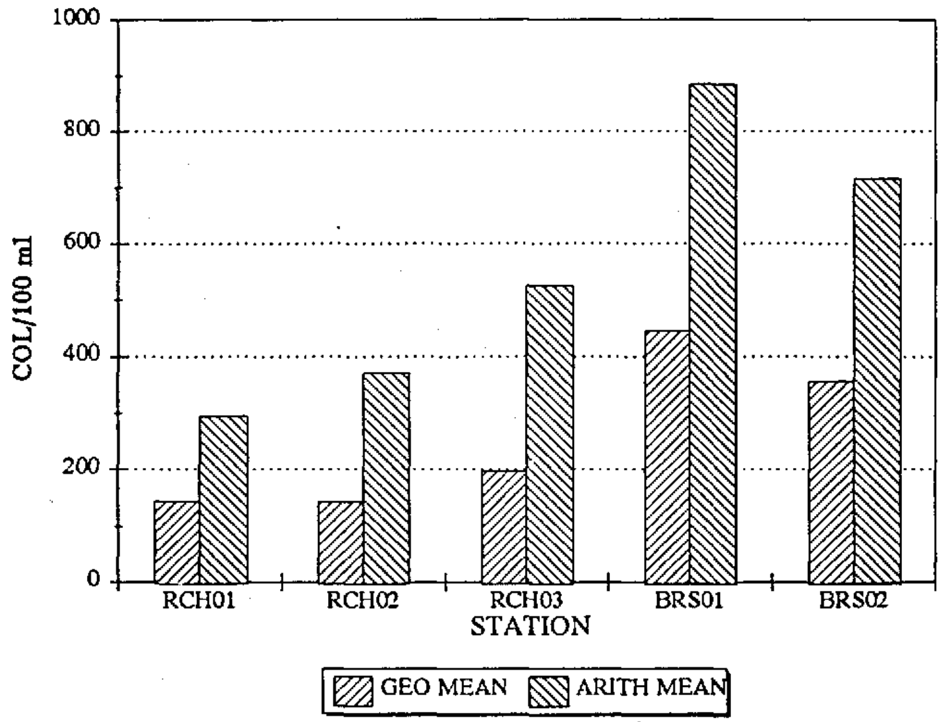


Figure WQ-32
Fecal Coliform
Tributary Creeks



The tributary streams, Clifty, Dry Fork, Piney, and Dry Creeks, generally maintained low bacteria levels, although all had fecal coliform counts above 2000 colonies/100 ml during heavy runoff events (Figure WQ-32). Also, the Richland Creek and Brush Creek fecal coliform data indicates slightly increasing levels downstream on Richland Creek and notably higher levels in Brush Creek (Figure WQ-33). The Brush Creek values were also consistently elevated.

Figure WQ-33
Fecal Coliform
Richland & Brush Creeks



MACROINVERTEBRATE COMMUNITIES

Materials and Methods

Macroinvertebrate community analyses were conducted at 26 of the 41 water quality monitoring sites (Table M-1). One additional site was selected for monitoring on the Kings River near Berryville. This site (WHI0077) was selected to measure impacts from instream gravel removal. Sites were selected based on the ability to apply the rapid bioassessment (RBA) protocols. These techniques usually work best in streams with a cobble or smaller particle size substrate and with riffle environments that are no more than one-half meter deep. The macroinvertebrate community analysis consisted of a one-time sampling event during the critical season.

The actual sampling event followed EPA protocols as outlined by (Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. EPA/440/4-89-001. U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, Washington, D.C.). A one meter square net was placed in the riffle perpendicular to the flow. A person dislodged the organisms from the substrate upstream of the net by agitating the bottom with their boots. Macroinvertebrates from larger cobbles and small boulders immediately above the net were hand picked and the rock was removed from the sampling area. An area of approximately one square meter was sampled. The net was visually examined to decide if enough organisms were present to select a subsample. If not, additional sampling was done.

Organisms were washed and picked from the net into a five-gallon bucket. All big rocks, leaves, roots and sticks were removed from the bucket and examined for organisms. Organisms picked from the extraneous material or rinsed from the net were placed in the bucket. The bucket material was then sieved through a U.S. Standard No. 30 plastic sieve. Sieved material was placed into a white enamel pan and any organisms remaining in the sieve were picked and put into the pan. Enough water was introduced into the pan to float the organisms.

Approximately 100 organisms were picked randomly from the pan. The organisms were preserved in 70% ethanol and placed in jars labeled with the date, time, sampling station and collectors. Organisms were identified to the lowest possible taxonomic classification as feasible in the field and recorded on field sheets. This identification was not relied upon for the final analysis. It was used to simplify laboratory identification. Macroinvertebrates often lose vital, taxonomic features due to preservation, agitation, or by larger organisms that are slow to die. Samples were transported to the laboratory for positive identification.

A field habitat assessment was also done. The purpose of the habitat evaluation was to ensure that differences in habitat were taken into consideration in any station comparisons. The assessment included measurement of the predominant substrate types. In-stream vegetation and fish cover were estimated by visual observation. Dissolved oxygen, pH and temperature were taken during the sampling event. Stream flow was measured. The riparian area was evaluated as to vegetative type and bank stability. Surrounding land uses were categorized. Any remarkable features of the site were noted on the habitat evaluation form. Any other observations pertinent to the analysis or deviations from the sampling plan were noted on the habitat evaluation form.

In the laboratory, organisms were identified to the lowest necessary taxonomic classification, usually genus, to identify water quality impacts. Organisms were identified using keys from various authors. All taxonomic determinations were made by one person to avoid differences in identifications and corresponding differences in data analysis. Field identification forms were corrected as necessary during the laboratory identification. Upon completion of the identification, data was entered into the computer database for storage and analysis.

Data Analyses

Macroinvertebrate data from the rapid bioassessment sampling was analyzed using metrics listed in Plafkin et al.(1989). The metrics included taxa richness, the Hilsenhoff biotic index, the scraper/filterer-collector (SC/FC) functional feeding group ratio, percent dominant contribution, Ephemeroptera-Plecoptera-Trichoptera (EPT) index and the community loss index. These indices require comparison to a reference station. The station on Piney Creek (PNY01) exhibited the qualities of a least disturbed stream in water quality, macroinvertebrate community and habitat evaluation; therefore, it was selected as the reference site. The above metrics were used to establish the RBA scoring criteria.

The RBA scoring indicates if the aquatic community at a selected site is impaired and the severity of that impairment. The endpoints of the RBA scores are: not significantly impaired(0.83 - 1.00), slightly impaired (0.54 - 0.79), moderately impaired (0.21 - 0.50) and extremely impaired (<0.17). Numeric values are determined by comparing the site with a reference site. It is up to the investigator to decide the impairment of sites that fall between categories. The "not significantly impaired" category is usually called not impaired or nonimpaired. This study was structured to look, primarily, at nonpoint source impacts, and RBA studies are not as sensitive to these types of impacts. A stream could be slightly influenced by nutrient enrichment without being detectable by the RBA process. Thus, the category name change was necessary to reflect this possibility.

The RBA scores were divided into the habitat correlation coefficient "r" to provide a numerical score that was influenced by the habitit coefficient. These data provided another scoring scheme to remove the variations in the communities that might be attributed to the habitat. This data showed definite patterns that were considered categories of impairment. The final determination was made by averaging the impairment status as shown by the RBA score with the status of impairment as suggested after adjustment with the habitat correlation coefficient. Figure M-1 shows the relationship of the RBA score to habitat quality. The figure shows that all of the stations should at least partially support a fauna similar to that of the reference site.

Results

The RBA analysis identified 14 stations in the upper White River watersheds with degraded aquatic life use. Seven of these showed only slight impairment from various sources. Moderate-to-slight impairment was indicated at four sites, and three sites showed moderate impairment. One site (CLF01) showed extreme impairment, but this was not due to anthropogenic causes. Overall, all of the major watersheds showed some degree of impairment. Table M-1 lists all of the sites, the RBA scores, habitat correlation coefficients and severity of impairment. Also included is a discussion of the macroinvertebrate community and possible explanations of the impairment status. Appendix A contains a complete list of macroinvertebrates collected at each site, in order of dominant taxa, the RBA score and diversity index.

Seven RBA sites were located on the Kings River. The upper sites, KGS02, KGS03 and KGS05 showed no significant impairment. The KGS06 site showed impairment in the slight-to-moderate range with no explanations suggested by the assessment. KGS07, the site in the gravel removal area, showed some impact from gravel removal. Piney Creek (PNY01) served as the reference site for this study. Dry Fork (DRF01) showed slight impairment, possibly due to nutrient enrichment. Only two sites were sampled on Osage Creek, a tributary to the Kings River. No significant impairment was indicated at the OSG03 site, but OSG04 showed some impairment. The primary reason for the impairment shown may be the habitat, since

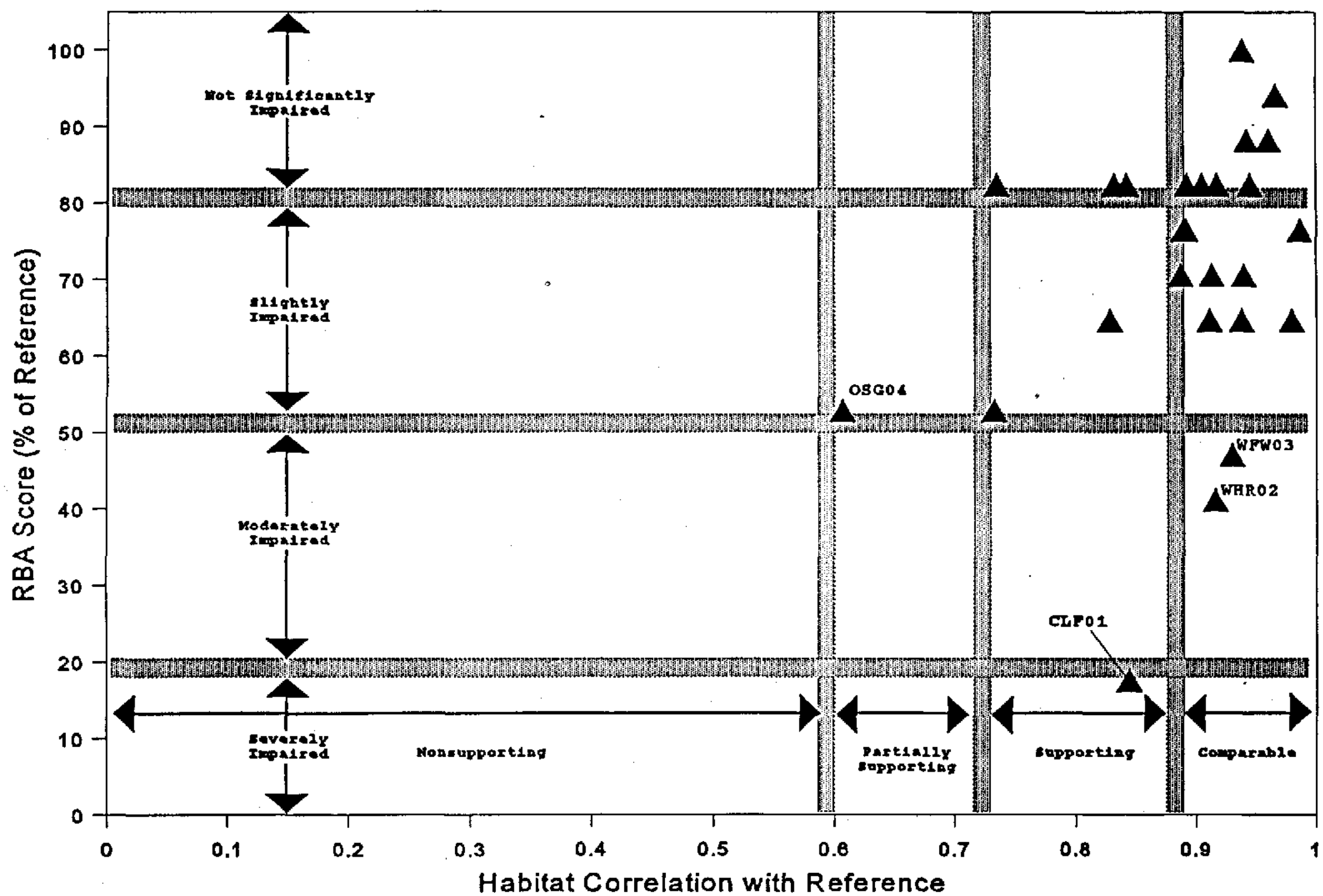


Figure M1. Habitat Quality versus RBA Score from Upper White River Stations (Original graph without data from Plafkin, et al. (1989)). Outliers are identified.

the habitat correlation between OSG04 and the reference site was the lowest for the study.

The War Eagle Creek watershed showed some impairment in the upper end of the sampled area (WRE02). The WRE03 site showed no impairment but WRE04 showed moderate impairment in the RBA. WRE05 continued to show some impairment, possibly from nutrient enrichment. WRE06 showed slight impairment with no reason for impairment indicated by the assessment. Clifty Creek showed significant impairment as indicated by the RBA, but all impairment could be attributed to the cold water influence of the stream's springflow origins.

Long Creek showed no significant impairment at sites LNG02 and LNG03. The RBA at Dry Creek (DRY01) showed slight impairment. A habitat analysis indicated some periphyton growth, which may be induced by nutrient enrichment. Yocum Creek showed a degradation from YOC01 (no significant impairment) to YOC02 (slight impairment). Again, some periphyton growth was noted in the habitat analysis suggesting nutrient enrichment.

Three sampling sites were located on the White River. The uppermost site at St. Paul (WHR01) was impacted by channel alteration through gravel removal. WHR02 exhibited moderate impairment with no direct indication of the cause. Some channel separation was evident, but there were no indications of recent gravel removal. No significant impairment was noted at the WHR03 site, despite some indications of recent gravel removal. It appeared that most of the removal had come from the dry stream bed.

The Middle Fork and West Fork of the White River both showed moderate impairment. Impairment at the Middle Fork site may be influenced by habitat differences with the reference site. The West Fork site showed good habitat correlation. Therefore, any degradation at this site is directly related to water quality or watershed activities. Richland Creek (RCH03) and Brush Creek (BRS02) sites showed no significant impairment.

The macroinvertebrate data is presented in this report with the following caveats:

1. The macroinvertebrate data are from a one-time sampling event - more sampling events could prove or refute any impairment status. This was not intended to be an exhaustive study. It was only designed to take a quick look at current conditions. The sites deemed to be impaired could be resampled in the future, if it is deemed necessary.

2. The RBA sampling technique is a useful tool in identifying water quality impairments. It <u>may</u> not identify streams influenced by small amounts of nutrients. In those streams, the carrying capacity of the stream may be augmented without the stream exhibiting the detrimental effects of excess nutrients.

Table M-1. Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA

Station ID	RBA Score	Habitat "r"	Habitat/RBA "r"	Impairment Status
WFW03	0.4706	0.9310	1.9783	Moderately Impaired
	Significant diversity reduction was exhibited at this station. Only 11 taxa were collected. The impairment status may be a result of excessive siltation from road construction and gravel mining activities located in the watershed.			
MFW03	0.5294	0.7328	1.3842	Moderately Impaired
	The ratio of scrapers to filterer-collectors is affecting the RBA score. The five dominant taxa, all from the EPT complex, comprise a large portion of the total macroinvertebrate fauna. Two of these five taxa are considered more pollution tolerant. The RBA score is perhaps influenced by some differences in habitat, but impairment is still indicated.			
WHR01	0.6471	0.9117	1.4089	Slightly to Moderately Impaired
	In-stream gravel mining and the resulting channel alteration may be the causative agents of the impairment. The channel had been totally altered from the winter reconnaissance visit to the summer sampling event. The tracks from heavy equipment were still evident in the stream bed at the time of sampling.			
WHR02	0.4117	0.9156	2.2239	Moderately Impaired
	This station exhibited a severe reduction is taxa richness and an associated reduction in diversity. The macroinvertebrate fauna was dominated by tolerant forms of caddisflies. No indication of the specific cause of the impairment was found in examining the benthic community. The RBA score at the next downstream station shows good recovery. Therefore, the causative agent may be confined to the immediate vicinity.			
WHR03	0.8235	0.8916	1.0827	Not Significantly Impaired
	This macroinvertebrate community displayed a significant improvement over the upstream community. Two of the five dominant taxon were the tolerant forms of caddisflies, but the dominant taxon had shifted to a mayfly. The taxa richness had increased, resulting in an increase in diversity.			
RCH03	0.8235	0.8315	1.0097	Not Significantly Impaired
	This station displayed a good diversity, DI >3.0, and good taxa richness with 17 taxa present. The only impairment indicator was the SC/FC ratio. This sites proximity to Beaver Lake is perhaps influencing the macroinvertebrate fauna.			

Table M-1. Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA

Station ID	RBA Score	Habitat "r"	Habitat/RBA "r"	Impairment Status
BRS02	0.8235	0.9046	1.0985	Not Significantly Impaired
	The macroinvertebrate community was dominated by five EPT taxa. The diversity index was slightly above three and the remaining taxa all suggested good water quality.			
WRE02	0.7647	0.8885	1.1619	Not Significantly to Slightly Impaired
	Fourteen taxa were collected at this site with a diversity index greater than three. *Corbicula* was one of the dominant taxa, as were two tolerant forms of caddisflies. The EPT index and percent dominant contribution criteria scores cause the RBA score of this station to be listed as slightly impaired.			
WRE03	0.8235	0.9169	1.1134	Not Significantly Impaired
	Dominant taxa were all from the EPT complex with the top three taxa displaying equal distribution and comprising most of the community. This caused the diversity index to be somewhat reduced, however, all of the RBA criteria displayed values in the higher ranges. Some periphyton growth was evident, but did not seem to have a significant impact on the macroinvertebrate community.			
WRE04	0.6471	0.9375	1.4488	Slightly to Moderately Impaired
	The SC/FC ratio and the EPT index suggested some impairment of the macroinvertebrate community. The cause of the impairment is not identifiable at this time, however, it is most likely not the habitat because it is quite similar to the reference stream.			
WRE05	0.7058	0.9398	1.3315	Slightly Impaired
	Three taxa of mayfly nymphs, including *Ephoron album*, a burrowing mayfly, and a viviparid snail were all dominant. The presence of these two taxa usually suggest a loose, shifting substrate. Algal foraging taxa comprised a large portion of the fauna indicating the presence of some sort of nutrient enrichment .			
CLF01	0.1764	0.8443	4.7863	Not Significantly Impaired
	Despite the results of the RBA, this station is not impaired. It is located on a spring-fed stream just a few hundred yards below the source. The cold water influence on the macroinvertebrate community is not considered in the RBA, thus the low score. The macroinvertebrate fauna present represents typical communities normally found in spring-influenced streams of the ecoregion.			

Table M-1. **Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA**

Station ID	RBA Score	Habitat "r"	Habitat/RBA "r"	Impairment Status
WRE06	0.7647	0.8912	1.1654	Not Significantly to Slightly Impaired
	The community indicators were driven predominantly by the percent contribution of the three dominant taxa. However, the remainder of the indices did indicate some impairment, perhaps mostly caused by differences in habitat between this site and the reference stream.			
KGS02	0.8235	0.8315	1.0097	Not Significantly Impaired
	The RBA score indicates no impairment, but the actual macroinvertebrate fauna and habitat assessment do not substantiate this. The community was dominated by *Corbicula*, the Asiatic clam, occurring in approximately equal numbers to the dominant organism at the reference site, *Cheumatopsyche*, but is a much less desirable taxa. The habitat analysis indicates a significant (70%) amount of the substrate surface area is covered by periphyton, possibly due to a reduction in canopy cover and excessive nutrient enrichment. Surrounding land use is predominantly pasture. Therefore, this site may best be classified as slightly impaired.			
KGS03	0.9412	0.9673	1.0277	Not Significantly Impaired
	The dominant taxa were all from the EPT complex and displayed very even distribution. Ephemeroptera was the dominant order comprising 70% of the eighteen taxa collected. The habitat assessment indicated some enhanced periphyton growth, perhaps caused by the lack of canopy.			
DRF01	0.6471	0.8282	1.2799	Slightly Impaired
	A reduction in diversity is evident as *Isonychia*, the dominant organism, comprised more than 50% of the macroinvertebrate community. A snail was also one of the five dominant taxa, perhaps indicating enhanced algal growth. These factors are perhaps indicating excess nutrient enrichment.			
PNY01	1.0000	1.0000	1.0000	Not Significantly Impaired
	This site was selected as the reference site for the survey. It received the highest possible scores in five of the six RBA categories. The percent dominant contribution was the only score less than the highest. Seventeen taxa were collected with only the KGS03 site having more taxa present. The diversity index was good, 3.3, with two taxa of stoneflies present. The habitat correlation indicated acceptable correlations with all but one other station, OSG04.			

Table M-1. Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA

Station ID	RBA Score	Habitat "r"	Habitat/RBA "r"	Impairment Status
KGS05	0.8824	0.9432	1.0689	Not Significantly Impaired
	The macroinvertebrate community was dominated by ephemeropterans (mayflies) which comprised three of the five dominant taxa. Two algal foraging species constituted the other two dominant taxa. There was no canopy at this station, therefore, additional periphyton growth would be expected.			
KGS06	0.6471	0.9800	1.5144	Slightly to Moderately Impaired
	This site had the best habitat correlation coefficient with the reference site. However, only 11 taxa were collected, dominated by two taxa of mayflies and a snail taxon. While some impairment is suggested, it may not be as impaired as is indicated by the RBA score.			
WHI007	0.7059	0.8870	1.2566	Slightly Impaired
	The major source of impairment is perhaps the gravel mine operation located immediately above this sight, not degraded water quality. The substrate has been reduced to a shifting gravel/sand/silt complex, filling the crucial interstitial spaces, preferred macroinvertebrate habitat. Macroinvertebrate fauna quality is noticeably impaired, as is indicated by the size reduction in the taxa, such as the hellgrammites and mayflies. Therefore, the RBA score may not be adequately reflecting the true impairment status of this site.			
OSG03	0.8235	0.7347	0.8922	Not Significantly Impaired
	The macroinvertebrate community indicated lower scores in the percent dominant contribution and EPT index categories of the RBA. The other four categories rated the highest scores possible, resulting in a no impairment rating.			
OSG04	0.5294	0.6067	1.1460	Slightly to Moderately Impaired
	This station received the lowest habitat correlation coefficient of all the stations compared with the reference site. Therefore, interpretation of the impairment values is more difficult (i.e. is it because of habitat or water quality). The HBI and SC/FC ratios were both high, but the other four category scores were low to zero. As a result, the RBA index indicated moderate impairment. When the score was coupled with the "r" value from the habitat correlation, it indicated only slight impairment. Perhaps the best categorization is somewhere between slightly to moderately impaired.			

Table M-1. Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA

Station ID	RBA Score	Habitat "r"	Habitat/RBA "r"	Impairment Status
YOC01	0.8235	0.9448	1.1473	Not Significantly Impaired
	Diversity and taxa richness were both good with values of 3.13 and 16, respectively. The macroinvertebrate fauna was dominated by two tolerant taxa, a caddisfly and a mayfly. The remainder of the community was a mix of both tolerant taxa and stoneflies, usually intolerant. Therefore, this station showed no significant impairment, despite the intense in-stream gravel mining that was severely altering the channel. A study for the Arkansas Game and Fish Commission indicated that the macroinvertebrate community directly in a mining area quickly recovered (Brown, A.V. and Lyttle, M.M., 1992. Impacts of gravel mining on Ozark Stream ecosystems: a final report. Arkansas Game and Fish Commission, Little Rock.) That is apparently happening at this site. The major impacts of in-stream gravel mining usually occur below the removal area where silts associated with the mining activity begin to settle out onto the substrate.			
YOC02	0.7647	0.9870	1.2907	Slightly Impaired
	The percent dominant contribution is the driving factor in the RBA score. Most of the macroinvertebrate fauna is distributed among three taxa, with one caddisfly comprising almost 40% of the sample. None of the taxa are intolerant forms. Snails, while not a major contributor to the community, were present on the periphyton-covered rocks. This may be indicating excess nutrient enrichment perhaps originating from the surrounding land uses; animal related agriculture.			
DRY01	0.7059	0.9132	1.2937	Slightly Impaired
	Cheumatopsyche, a caddisfly larva, comprised a larger percentage of this sample than it did at the reference site. The overall macroinvertebrate community displayed some reduction in diversity. The habitat analysis indicated some periphyton growth suggesting some nutrient enrichment.			
LNG02	0.9387	1.0000	0.9387	Not Significantly Impaired
	The RBA score of 0.9387 indicates that this macroinvertebrate community was extremely similar to that of the reference site. There were 16 taxa sampled with a diversity index greater than 3. The five dominant organisms were from the EPT complex and displayed even distribution. There is no water quality related impact on the macroinvertebrate community at this site. Evidence of gravel mining and channel alteration were visible, but they were not reflected in the RBA.			

Table M-1. **Macroinvertebrate Stations of the Upper White River and Discussion of Water Quality Status as determined by RBA**

<table>
<tr><th>Station ID</th><th>RBA Score</th><th>Habitat "r"</th><th>Habitat/RBA "r"</th><th>Impairment Status</th></tr>
<tr><td rowspan="2">LNG03</td><td>0.8824</td><td>0.9611</td><td>1.0892</td><td>Not Significantly Impaired</td></tr>
<tr><td colspan="4">Only 13 taxa were collected at this site and a reduction in diversity is evident. Four of the five dominant taxa were from the EPT complex. The diversity reduction and taxa richness diminished the RBA score, but this station still displayed no significant impairment.</td></tr>
</table>

FISH COMMUNITIES

As a part of this study, fish community samples were conducted in the main fork of the Upper White River, in the Middle Fork and in the West Fork White River during the summer of 1993. Fish samples were also conducted in War Eagle Creek and in Brush Creek during this same time period. In addition, assistance was given to U.S. Geological Survey (USGS) personnel in conducting fish community sampling on Kings River and Yocum Creek. The USGS fish samples were collected in the summer of 1994, as part of the Ozark Region NAWQA study.

All sampling was generally done in the same manner. Pulsed D.C. current was used to electroshock the fish for the current study. The electrodes were hand-held by personnel wading in the stream and dippers wading between the electrodes captured the stunned fish. Riffle areas were blocked with a small mesh seine and the riffles were shocked from upstream to downstream to allow stunned fish to drift into the seine; but, the general movement of the collection crew was from downstream to upstream in all other areas collected. As many fish as possible were dipped from the waters and preserved for identification and enumeration; however, the large specimens which were easily identified were counted and released.

The fish community data from the three forks of the White River and War Eagle Creek were compared to fish community data collected 30 years previously as a part of the Beaver Reservoir watershed pre-impoundment study. These collections were made at identical or very similar locations and using very similar techniques. The electrofishing device used in 1963 was variable voltage A.C. current, however this resulted in very little difference in gear efficiency because of the desirable range of conductivity in these waters. Data from the Kings River and Yocum Creek samples in 1994, were compared with fish community data collected approximately 10 years previously as part of the Department of Pollution Control and Ecology's least-disturbed reference stream study. No suitable comparison was found for the Brush Creek sample; therefore, the data from this site was not reported.

The diversity index calculated for each community was the Shannon-Wiener dominance diversity index using a log to base 2. The similarity index comparing the two samples from the same site is a modification of Odum's index of similarity comparing the number of species between two samples (Odum, E.P. Fundamentals of Ecology. Third Edition. 1971). The modification used compared the proportions of each species common to both samples and also factored the difference in the proportions of the common species as follows:

$$\frac{\Sigma C}{A+B+D}$$

C = Sum of the proportions of species common to both sample A and sample B.
A = Total proportions of sample A (= 100).
B = Total proportions of sample B (= 100).
D = Sum of the differences of the proportions of species common to sample A and B.

Identical communities having the same species in both communities and the same proportion of each species in both communities will have a similarity index of one.

A comparison of comparable streams (least-disturbed streams with similar size watersheds, within the same river basin and ecoregion) had similarity indexes that averaged 0.69 with a standard deviation of 0.04. Using the mean value minus one standard deviation, it was concluded that a similarity index of 0.65 or larger would indicate relatively similar communities.

White River

The collection site on the main fork of the White River was approximately two miles NW of Durham, Arkansas, at station WHR03. This site was sampled on June 7, 1963, and on July 26, 1993.

Table F-1 compares the fish communities at this site within the 30-year period. In 1963, 40 species were collected and the species dominance diversity index was 3.79. In comparison, 32 species were collected in 1993, and the diversity index was 3.65. A similarity index of 0.70 indicates a relatively similar community. A single specimen of the Longnose darter was collected in both samples. Important species which were collected in 1963, but were absent from the 1993 collection were Horneyhead chub, Checkered madtom, Speckled darter and Smallmouth bass.

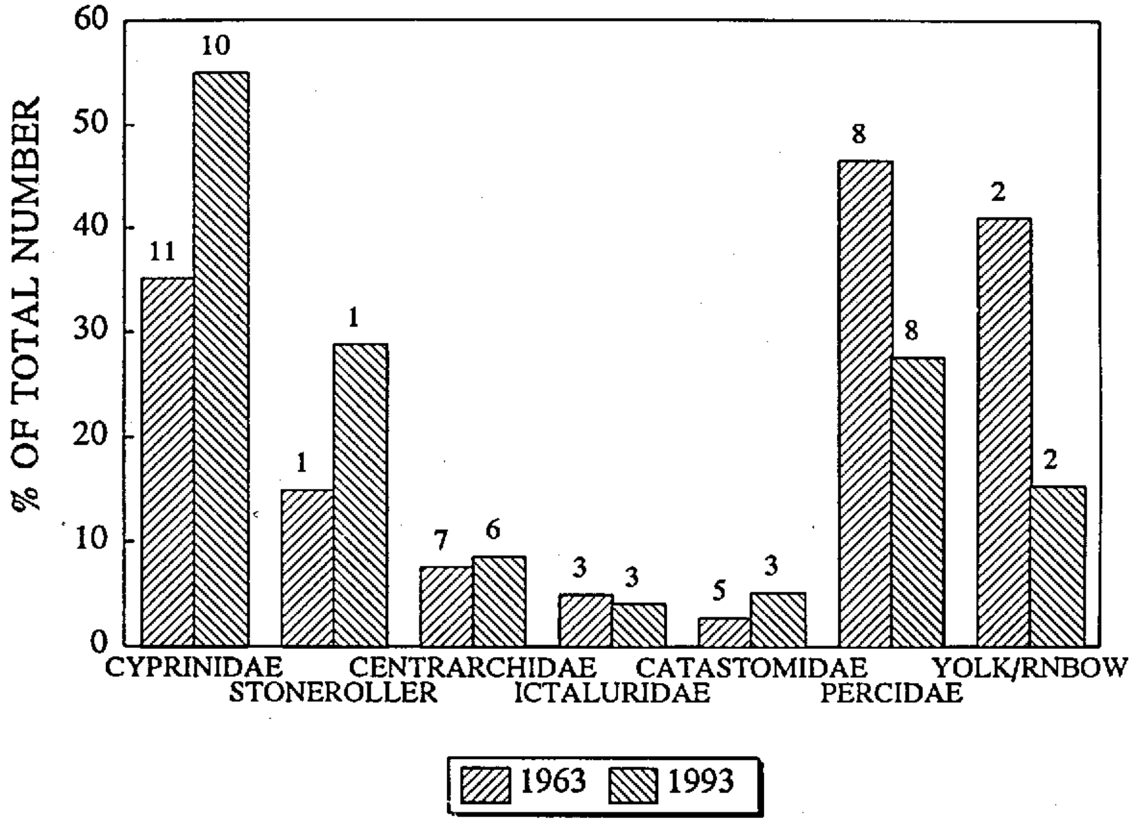
A graphic comparison of the fish family composition of the two samples is shown in Figure F-1. Cyprinidae made up 35.1% of the total number of individuals in 1963 and 55% in 1993. One less minnow species was collected in 1993. The major increase in the minnow community was caused by a higher percentage of Stonerollers in the recent sample. This single species increased from 14.9% to

TABLE F-1

WHITE RIVER FISH FAMILY & SPECIES		1993 NO.	1993 % TOTAL	1963 NO.	1963 % TOTAL
Lepisosteidae	Gars				
Lepisosteus osseus	Longnose Gar	1	0.1		
Clupeidae	Herrings				
Dorosoma cepedianum	Gizzard shad			49	2.2
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	356	28.7	335	14.9
Cyprinella whipplei	Steelcolor shiner	52	4.2	40	1.8
Hybopsis amblops	Bigeye chub	8	0.6	140	6.2
Luxilus chrysocephalus	Striped shiner	8	0.6	29	1.3
Luxilus pilsbryi	Duskystripe shiner	207	16.7	95	4.2
Nocomis biguttatus	Hornyhead chub			12	0.5
Notropis boops	Bigeye shiner	11	0.9	59	2.6
Notropis nubilus	Ozark minnow	31	2.5	13	0.6
Notropis rubellus	Rosyface shiner	2	0.2	15	0.7
Pimephales notatus	Bluntnose minnow	6	0.5	49	2.2
Pimephales tenellus	Slim minnow			2	0.1
Semotilus atromaculatus	Creek chub	1	0.1		
Catostomidae	Suckers				
Carpiodes velifer	Highfin carpsucker			1	0.0
Hypentelium nigricans	Northern hogsucker	24	1.9	18	0.8
Moxostoma carinatum	River redhorse			1	0.0
Moxostoma duquesnei	Black redhorse	21	1.7	25	1.1
Moxostoma erythrurum	Golden redhorse	18	1.5	17	0.8
Ictaluridae	Freshwater catfishes				
Ameirus melas	Black bullhead			1	0.0
Ictalurus natalis	Yellow bullhead			2	0.1
Ictalurus puntatus	Channel catfish	1	0.1		
Noturus albater	Ozark madtom	32	2.6	58	2.6
Noturus exilis	Slender madtom	16	1.3	50	2.2
Noturus flavater	Checkered madtom			1	0.0
Cyprinodontidae	Killifishes				
Fundulus catenatus	Northern studfish			1	0.0
Fundulus olivaceus	Blackspotted topminnow	2	0.2	19	0.8
Atherinidae	Silversides				
Labidesthes sicculus	Brook silversides			4	0.2
Centrarchidae	Sunfishes				
Ambloplites constellatus	Ozark bass	11	0.9	2	0.1
Lepomis cyanellus	Green sunfish	6	0.5	13	0.6
Lepomis macrochirus	Bluegill	6	0.5	16	0.7
Lepomis megalotis	Longear	63	5.1	92	4.1
Micropterus dolomieu	Smallmouth bass			3	0.1
Micropterus punctulatus	Spotted bass	16	1.3	42	1.9
Micropterus salmoides	Largemouth bass	2	0.2	1	0.0
Percidae	Perches				
Etheostoma blennioides	Greenside darter	69	5.6	35	1.6
Etheostoma caeruleum	Rainbow darter	116	9.4	394	17.5
Etheostoma juliae	Yoke darter	73	5.9	530	23.5
Etheostoma punctulatum	Stippled darter	7	0.6		
Etheostoma spectabile	Orangethroat darter	11	0.9	9	0.4
Etheostoma stigmaeum	Speckled darter			8	0.4
Etheostoma zonale	Banded darter	31	2.5	54	2.4
Percina caprodes	Logperch	31	2.5	17	0.8
Percina nasuta	Longnose darter	1	0.1	1	0.0
TOTAL		1240	100.0	2253	100.0
NUMBER OF SPECIES		32		40	
DIVERSITY INDEX		3.65		3.79	
SIMILARITY INDEX			0.70		

Figure F-1

WHITE RIVER FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

28.7% of the total community. The Duskystripe shiner also showed a substantial increase in abundance. In contrast Percidae made up 46.6% of the 1963 community and only 27.5% in 1993. Eight species of darters were collected in each sample. The major changes in the Percidae population was a reduction in the relative abundance of the Rainbow darter from 17.5% to 9.4% and the Yolk darter from 23.5% to 5.9% between the two samples.

Although the watershed in this segment of the upper White River seems to be less impacted by land use changes such as land clearing, converting to pasture land and poultry production, the fish community has shifted to a more minnow dominant community with the predominant species being the herbivore, detritavore and omnivore trophic feeders. This shift is also resulting in the reduction of the Percidae population, particularly those species that inhabit stable and clean-gravel streams.

Middle Fork

The Middle Fork site which was sampled on June 30, 1993, is located at water quality monitoring site MFW03. In 1963, a site approximately four to five miles upstream was sampled on June 6. This site corresponds to the water quality monitoring site MFW02.

A comparison of the fish communities at these sites can be found in Table F-2. In 1963, a total of 34 species were collected and the diversity index of the community was 3.63. In 1993, the total number of species collected was 29 and the diversity index was 3.23. The sililarity index of 0.65 indicates that the communities sampled in 1963 and 1993 may have been somewhat dissimilar. Three less minnow species were collected in 1993, and the relative abundance of the Cyprinidae declined from 60.4% in 1963 to 39.1% in 1993 (Figure F-2). However, the Stoneroller population increased from 15.8% to 24.4% and the Duskystripe shiner population increased substantially between the two samples. Both species thrive in periphyton and other microscopic plant and animal rich environments which are often stimulated by increased nutrient inputs. In contrast, the Ozark minnow, also an omnivore, showed a significantly reduced population from 1963 to 1993. The Centrarchidae population declined from 15.1% in 1963, to 4.6% in 1993. Although seven species of sunfishes were collected in each sample, the largest reduction was in the Longear relative abundance.

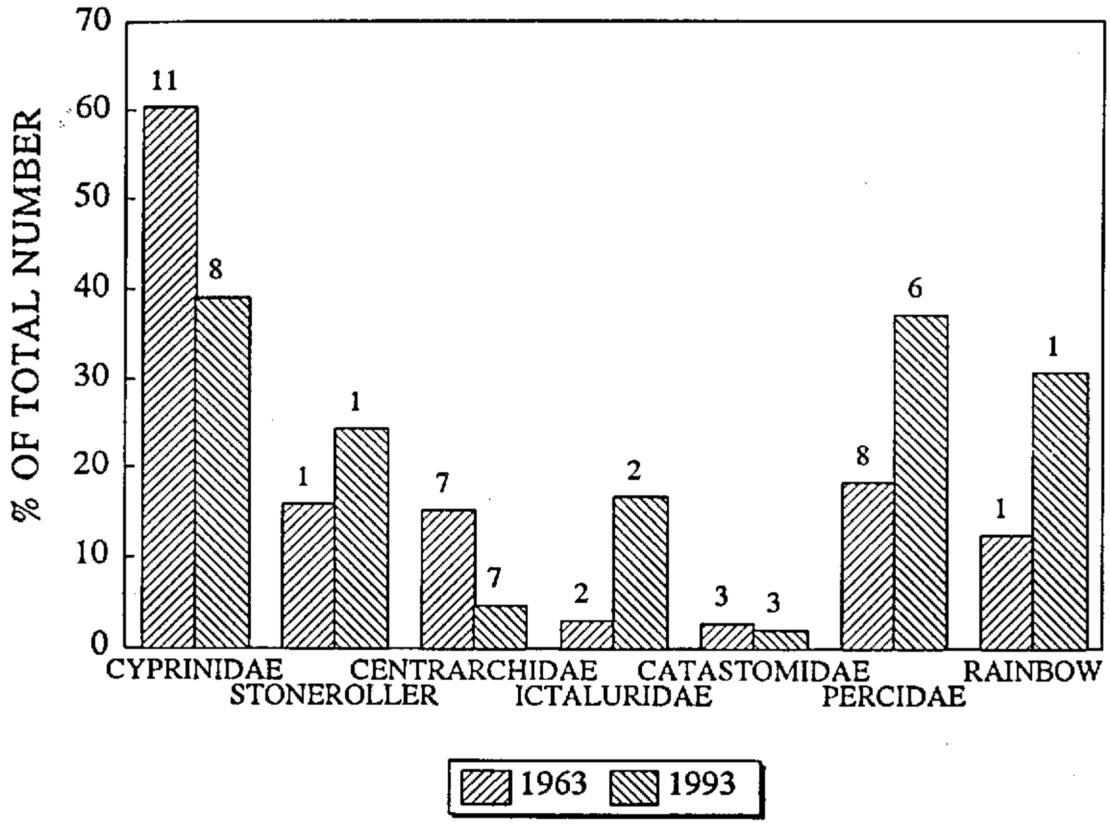
No Smallmouth bass were collected in 1993, compared to 20 in 1963. Ictaluridae made up only 3% of the community in 1963, but an atypically high 16.6% of the community sampled in 1993, was catfishes. These included a relatively larger number of young Ozark

TABLE F-2

MIDDLE FORK WHITE RIVER FISH FAMILY & SPECIES		1993 NO.	1993 % TOTAL	1963 NO.	1963 % TOTAL
Petromyzontidae	Lampreys				
Ichthyomyzon sp.	Ammocoetes			1	0.1
Clupeidae	Herrings				
Dorosoma cepedianum	Gizzard shad	1	0.1		
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	276	24.4	241	15.9
Cyprinella whipplei	Steelcolor shiner	39	3.5	1	0.1
Hybopsis amblops	Bigeye chub			7	0.5
Luxilus chrysocephalus	Striped shiner	7	0.6	15	1.0
Luxilus pilsbryi	Duskystripe shiner	48	4.2	169	11.1
Nocomis biguttatus	Hornyhead chub			48	3.2
Notropis boops	Bigeye shiner	44	3.9	93	6.1
Notropis nubilus	Ozark minnow	13	1.2	318	20.9
Notropis telescopus	Telescope shiner			3	0.2
Pimephales notatus	Bluntnose minnow	12	1.1	21	1.4
Semotilus atromaculatus	Creek chub	1	0.1	1	0.1
Catostomidae	Suckers				
Hypentelium nigricans	Northern hogsucker	10	0.9	19	1.3
Moxostoma duquesnei	Black redhorse	2	0.2	20	1.3
Moxostoma erythrurum	Golden redhorse	10	0.9	3	0.2
Ictaluridae	Freshwater catfishes				
Ameirus melas	Black bullhead			1	0.1
Noturus albater	Ozark madtom	95	8.4		
Noturus exilis	Slender madtom	93	8.2	44	2.9
Cyprinodontidae	Killifishes				
Fundulus olivaceus	Blackspotted topminnow	1	0.1	7	0.5
Atherinidae	Silversides				
Labidesthes sicculus	Brook silversides	1	0.1	4	0.3
Centrarchidae	Sunfishes				
Ambloplites constellatus	Ozark bass	1	0.1	6	0.4
Lepomis cyanellus	Green sunfish	8	0.7	48	3.2
Lepomis gulosus	Warmouth	3	0.3		
Lepomis macrochirus	Bluegill	5	0.4	1	0.1
Lepomis megalotis	Longear	30	2.7	150	9.9
Micropterus dolomieu	Smallmouth bass			20	1.3
Micropterus punctulatus	Spotted bass	8	0.7	1	0.1
Micropterus salmoides	Largemouth bass	2	0.2	1	0.1
Percidae	Perches				
Etheostoma blennioides	Greenside darter	35	3.1	13	0.9
Etheostoma caeruleum	Rainbow darter	347	30.7	188	12.4
Etheostoma juliae	Yoke darter			21	1.4
Etheostoma punctulatum	Stippled darter	2	0.2	2	0.1
Etheostoma spectabile	Orangethroat darter	13	1.2	40	2.6
Etheostoma stigmaeum	Speckled darter			2	0.1
Etheostoma zonale	Banded darter	9	0.8	1	0.1
Percina caprodes	Logperch	14	1.2	11	0.7
TOTAL		1130	100	1521	100
NUMBER OF SPECIES		29		34	
DIVERSITY INDEX		3.23		3.63	
SIMILARITY INDEX			0.65		

Figure F-2

MIDDLE FORK FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

and Slender madtoms collected in the latter sample. Similarly, the Percidae population increased substantially between 1963 and 1993. Although there were two fewer species collected in 1993, a major increase in the population of the Rainbow darter was indicated. The Yolk darter was a conspicuously missing species from the 1993 sample. Other important species missing from the latter sample was Hornyhead chub, Bigeye chub, Smallmouth bass, and the Speckled darter.

Land use changes in the watershed of the Middle Fork have been substantial as larger acreages of timberlands have been converted to pasture and large numbers of cattle and poultry are being produced. However, typical fish community responses to the watershed alterations were not demonstrated in the comparisons made. Only the characteristic increase in the Stoneroller community, loss of community diversity and loss of certain species indicates adverse impacts on the Middle Fork fish community. Substantial increase in the Ictaluridae and Percidae were not anticipated due to the apparent land use alterations. Some of the unexplained differences may be related to difference in sample site locations although this is not likely a significant explanation.

<u>West Fork</u>

The fish community of the West Fork White River was sampled on July 26, 1993, at the location of water quality monitoring site WFW03. For comparison, a fish community sample conducted on July 2, 1962, one mile below the Highway 71 bridge was used. This site is only one to two miles above the 1993 sample site. The former sample will be referred to as the 1963 sample for convenience and consistency with the other 30 year comparisons.

Table F-3 lists the 35 species collected in 1963 compared to the 26 species collected in 1993. The dominance diversity index for the 1963 sample was 3.66. It was 3.34 in 1993. Important species which were collected in 1963, but were absent in 1993 include the Horneyhead chub, Telescope shiner, Ozark bass, Yolk darter and Stippled darter. The similarity index of 0.65 indicates a likely dissimilarity of these two communities.

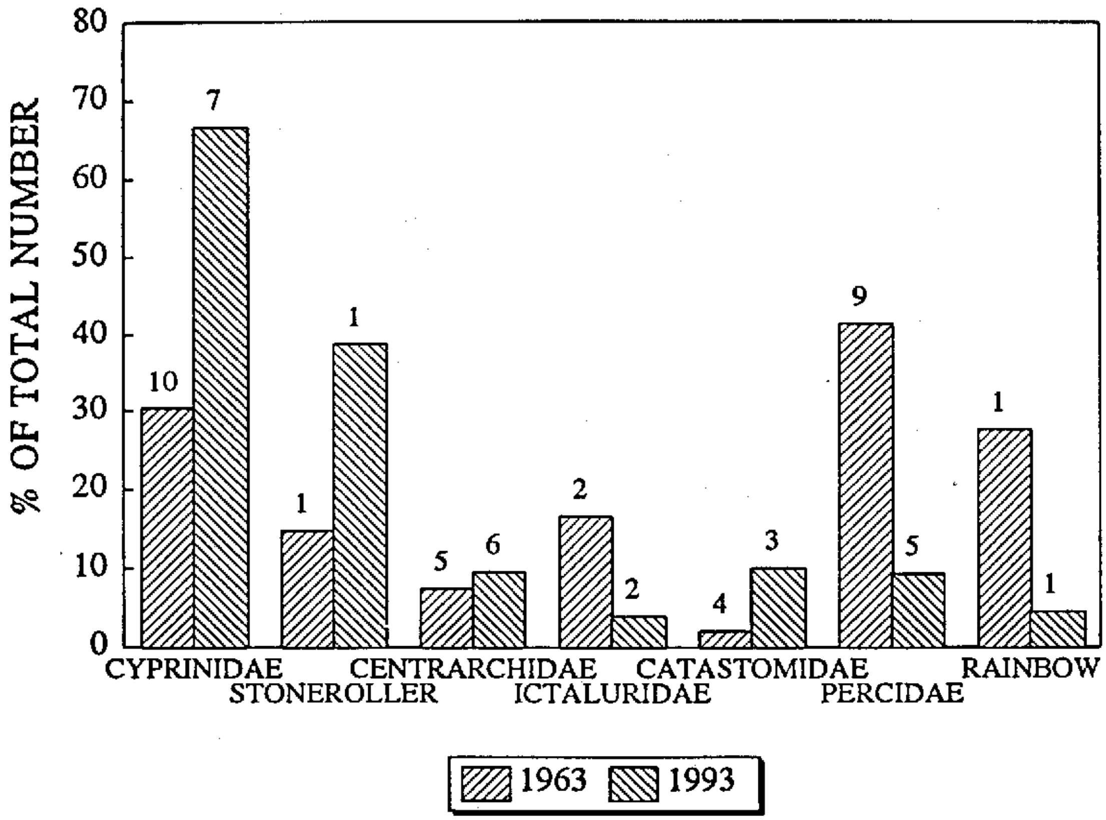
Community comparisons of major fish families are shown in Figure F-3. The Cyprinidae family had three fewer species in 1993 than in 1963, but the relative abundance of this family increased from 30.4% in 1963, to 66.6% in 1993. The species which increased the greatest within this family was the Stoneroller. It increased from 14.7% to 38.8%. A modest increase in the Duskystripe shiner was also noted. Also, notable is the significant reduction of the two species of Ictaluridae from 16.4% in 1963 to 3.9% in 1993. In contrast, the Catastomidae population increased from 1.9% in 1963 to 10% in 1993. The largest increase in this group was the Golden

TABLE F-3

WEST FORK WHITE RIVER FISH FAMILY & SPECIES		1993 NO.	1993 % TOTAL	1963 NO.	1963 % TOTAL
Petromyzontidae	Lampreys				
Ichthyomyzon sp.	Ammocoetes	4	0.4		
Lepisosteidae	Gars				
Lepisosteus osseus	Longnose Gar	2	0.2		
Clupeidae	Herrings				
Dorosoma cepedianum	Gizzard shad			15	0.7
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	422	38.8	313	14.7
Cyprinella whipplei	Steelcolor shiner	96	8.8	2	0.1
Nocomis biguttatus	Horneyhead Chub			26	1.2
Luxilus chrysocephalus	Striped shiner	1	0.1	24	1.1
Luxilus pilsbryi	Duskystripe shiner	137	12.6	171	8.0
Notropis boops	Bigeye shiner	34	3.1	11	0.5
Notropis nubilus	Ozark minnow	23	2.1	48	2.2
Notropis telescopus	Telescope shiner			35	1.6
Notemigonus crysoleucas	Golden shiner			1	0.0
Pimephales notatus	Bluntnose minnow	12	1.1	18	0.8
Semotilus atromaculatus	Creek chub			3	0.1
Catostomidae	Suckers				
Hypentelium nigricans	Northern hogsucker	16	1.5	18	0.8
Moxostoma carinatum	River redhorse			2	0.1
Moxostoma duquesnei	Black redhorse	30	2.8	16	0.7
Moxostoma erythrurum	Golden redhorse	62	5.7	7	0.3
Ictaluridae	Freshwater catfishes				
Noturus albater	Ozark madtom	27	2.5	201	9.4
Noturus exilis	Slender madtom	15	1.4	150	7.0
Cyprinodontidae	Killifishes				
Fundulus catenatus	Northern studfish			5	0.2
Fundulus olivaceus	Blackspotted topminnow	3	0.3	17	0.8
Centrarchidae	Sunfishes				
Ambloplites constellatus	Ozark bass			4	0.2
Lepomis cyanellus	Green sunfish	17	1.6	22	1.0
Lepomis macrochirus	Bluegill	11	1.0		
Lepomis megalotis	Longear	41	3.8	93	4.4
Micropterus dolomieu	Smallmouth bass	3	0.3	5	0.2
Micropterus punctulatus	Spotted bass	27	2.5	35	1.6
Micropterus salmoides	Largemouth bass	3	0.3		
Percidae	Perches				
Etheostoma blennioides	Greenside darter	20	1.8	69	3.2
Etheostoma caeruleum	Rainbow darter	49	4.5	591	27.7
Etheostoma juliae	Yoke darter			13	0.6
Etheostoma punctulatum	Stippled darter			9	0.4
Etheostoma stigmaeum	Speckled darter			1	0.0
Etheostoma spectabile	Orangethroat darter	9	0.8	126	5.9
Etheostoma zonale	Banded darter	23	2.1	75	3.5
Percina caprodes	Logperch	1	0.1	3	0.1
Stizostedion vitreum	Walleye			1	0.0
Cottidae	Sculpins				
Cottus carolinae	Banded sculpin			5	0.2
TOTAL		1088	100	2135	100
NUMBER OF SPECIES		26		35	
DIVERSITY INDEX		3.34		3.66	
SIMILARITY INDEX			0.65		

Figure F-3

WEST FORK FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

redhorse population. One of the most notable changes occurred in the Percidae population, as the relative abundance of this family of fishes declined from 41.4% of the total community in 1963 to only 9.3% in 1993. The number of Percid species also declined from nine in 1963 (including one walleye) to five in 1993. The largest population reduction of a single species within this family was in the Rainbow darter population. The Orangethroat darter, which normally adjusts to stressed environmental conditions, also exhibited a noticeable population decline between the two samples.

The watershed area immediately upstream and adjacent to these sample areas is dominated by overgrazed pasture land with numerous areas of cattle access into and across the stream, and much of the riparian vegetation has been eliminated causing severe bank erosion. However, within the last three to five years, major highway construction along the western edge of this watershed has caused substantial increases in stream turbidity after rainfall events and the stream bottom exhibited heavy silt deposition. Riffle areas have excessive embeddedness of the gravel and rubble substrate. Such conditions have resulted in a significant reduction in the riffle-dwelling fishes including most of the darters and the madtoms. Conversely, the primary feeders and detrital feeding fishes such as Stonerollers and some of the suckers, have shown substantial population increases. In addition to these shifts in community dominance, the overall community diversity has declined due to loss of several species and the excessive dominance in numbers of a few species.

War Eagle Creek

War Eagle Creek was sampled at a low-water crossing of a county road in the extreme northeast corner of Washington County on August 18, 1993. This was also water quality sampling site WRE05. This same location had been sampled on June 18, 1963.

These two samples are compared in Table F-4. Thirty-seven (37) species were collected in 1963 and 32 species were collected in 1993. The community dominance diversity index was 3.81 for 1963 and 3.28 for 1993. Important species which were collected in the former sample but not in the latter, include the Bigeye chub, Streamline chub, Horneyhead chub, Ozark shiner, Telescope shiner,and the Gilt darter. The latter species formally inhabited the lower segment of the upper White River watershed. With the exceptions of this sample site and a few others, most of the range of the Guilt darter was inundated by Beaver Reservoir, and it now appears that stream degradation may have caused extirpation of this species from the upper White River watershed.

TABLE F-4

WAR EAGLE CREEK FISH FAMILY & SPECIES		1993 NO.	1993 % TOTAL		1963 NO.	1963 % TOTAL
Lepisosteidae	Gars			*		
Lepisosteus osseus	Longnose Gar	1	0.1	*		
Cyprinidae	Minnows			*		
Campostoma anomalum	Stoneroller	441	36.1	*	497	18.8
Cyprinella whipplei	Steelcolor shiner	1	0.1	*		
Cyprinus carpio	Carp	2	0.2	*		
Hybopsis amblops	Bigeye chub			*	73	2.8
Erimystax harryi	Streamline chub			*	11	0.4
Luxilus chrysocephalus	Striped shiner	1	0.1	*	16	0.6
Luxilus pilsbryi	Duskystripe shiner	147	12.0	*	207	7.8
Nocomis biguttatus	Hornyhead chub			*	43	1.6
Notropis nubilus	Ozark minnow	74	6.1	*	145	5.5
Notropis ozarkanus	Ozark shiner			*	37	1.4
Notropis rubellus	Rosyface shiner	16	1.3	*	69	2.6
Notropis telescopus	Telescope shiner			*	48	1.8
Pimephales notatus	Bluntnose minnow	4	0.3	*	40	1.5
Catostomidae	Suckers			*		
Hypentelium nigricans	Northern hogsucker	21	1.7	*	48	1.8
Moxostoma carinatum	River redhorse	1	0.1	*	2	0.1
Moxostoma duquesnei	Black redhorse	19	1.6	*	32	1.2
Moxostoma erythrurum	Golden redhorse	14	1.1	*	33	1.2
Ictaluridae	Freshwater catfishes			*		
Ameirus melas	Black bullhead	1	0.1	*		
Ameirus natalis	Yellow bullhead			*	4	0.2
Ictalurus puntatus	Channel catfish			*	3	0.1
Noturus albater	Ozark madtom	32	2.6	*	67	2.5
Noturus exilis	Slender madtom	1	0.1	*	12	0.5
Cyprinodontidae	Killifishes			*		
Fundulus catenatus	Northern studfish				2	0.1
Fundulus olivaceus	Blackspotted topminnow	1	0.1	*	7	0.3
Centrarchidae	Sunfishes			*		
Ambloplites constellatus	Ozark bass	12	1.0	*	41	1.5
Lepomis cyanellus	Green sunfish	22	1.8	*	8	0.3
Lepomis gulosus	Warmouth	1	0.1	*		
Lepomis macrochirus	Bluegill	3	0.2	*		
Lepomis megalotis	Longear	113	9.3	*	96	3.6
Micropterus dolomieu	Smallmouth bass	2	0.2	*	27	1.0
Micropterus punctulatus	Spotted bass	6	0.5	*	22	0.8
Micropterus salmoides	Largemouth bass	1	0.1	*	2	0.1
Percidae	Perches			*		
Etheostoma blennioides	Greenside darter	26	2.1	*	65	2.5
Etheostoma caeruleum	Rainbow darter	65	5.3	*	64	2.4
Etheostoma juliae	Yoke darter	125	10.2	*	737	27.8
Etheostoma punctulatum	Stippled darter			*	1	0.0
Etheostoma stigmaeum	Speckled darter	1	0.1	*	7	0.3
Etheostoma zonale	Banded darter	19	1.6	*	63	2.4
Percina caprodes	Logperch			*	19	0.7
Percina nasuta	Longnose darter	1	0.1	*	2	0.1
Percina evides	Gilt darter				8	0.3
Cottidae	Sculpins			*		
Cottus carolinae	Banded sculpin	47	3.9	*	92	3.5
TOTAL		1221	100		2650	100
NUMBER OF SPECIES		32			37	
DIVERSITY INDEX		3.28			3.81	
SIMILARITY INDEX			0.74			

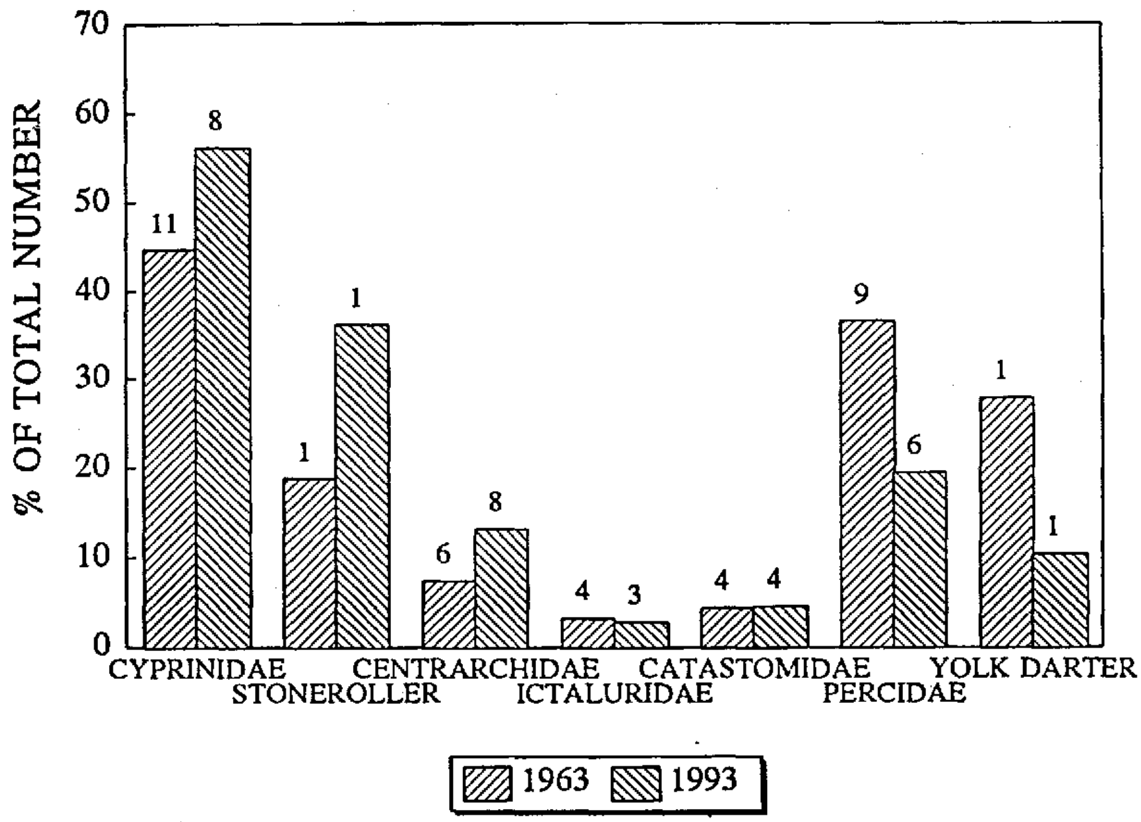
Although differences are noted, the community similarity index of 0.74 indicates that the two communities are relatively similar. In Figure F-4 it is evident that the Cyprinidae community increased from 44.7% in 1963 to 56.2% in 1993 even though three less species were collected in the latter sample. More significant, however, is the increase in the Stoneroller population from 18.8% to 36.1% over the 30 year period. A typical pattern of a substantial decrease in the Percidae family is also evident. This reduction is most evident in the Yolk darter population which declined from 27.8% in 1963 to 10.2% in 1993. There were also three less darter species collected in the 1993 sample.

Differences in the minnow communities in War Eagle Creek and in the three main forks of the White River is demonstrated in Figure F-5. In each of these waters, a reduction in the number of Cyprinid species was seen from 1963 to 1993. However, in each stream except Middle Fork White River, the minnow community increased its proportion of the total community during the 30 year period, primarily due to a substantial increase in the Stoneroller community (Figure F-6). Although the Cyprinid community made up a smaller proportion of the total fish community in Middle Fork in 1993, compared to 1963, the Stoneroller community increased in population size during the period. The Percidae community (Figure F-7) also showed a reduction in the number of species collected during the 30 year period between sampling and a significant reduction in the proportion of darters in the community was found in War Eagle Creek, the main fork of White River and in West Fork. However, in the Middle Fork, the proportion of darters increased substantially.

There was a total of 12 species of fish that were collected in one or more of these streams in 1963, which were not found at the same location in 1993. The Horneyhead chub was missing from all four stream sites in 1993, the Telescope shiner was missing from three of the four sites, and the Yolk darter, Bigeye chub, Smallmouth bass, and Speckled darter were missing from two of the four sites.

Figure F-4

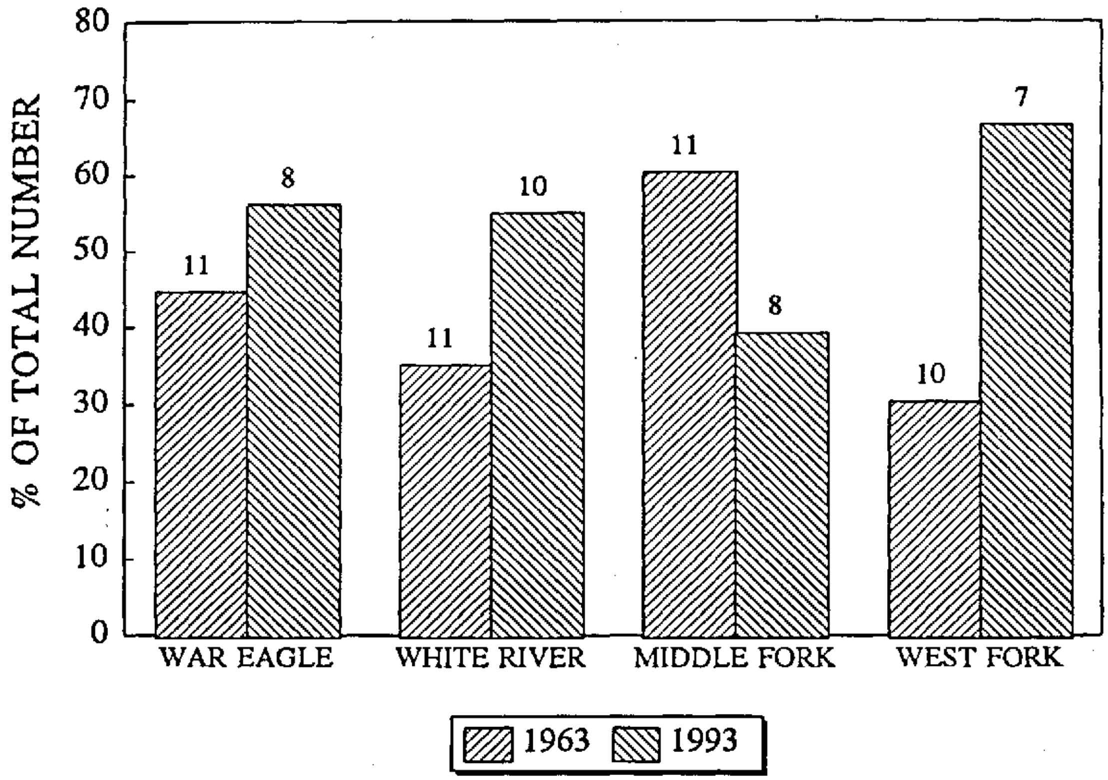
WAR EAGLE CREEK FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

Figure F-5

CYPRINIDAE COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

Figure F-6

STONEROLLER COMMUNITY
UPPER WHITE RIVER WATERSHED

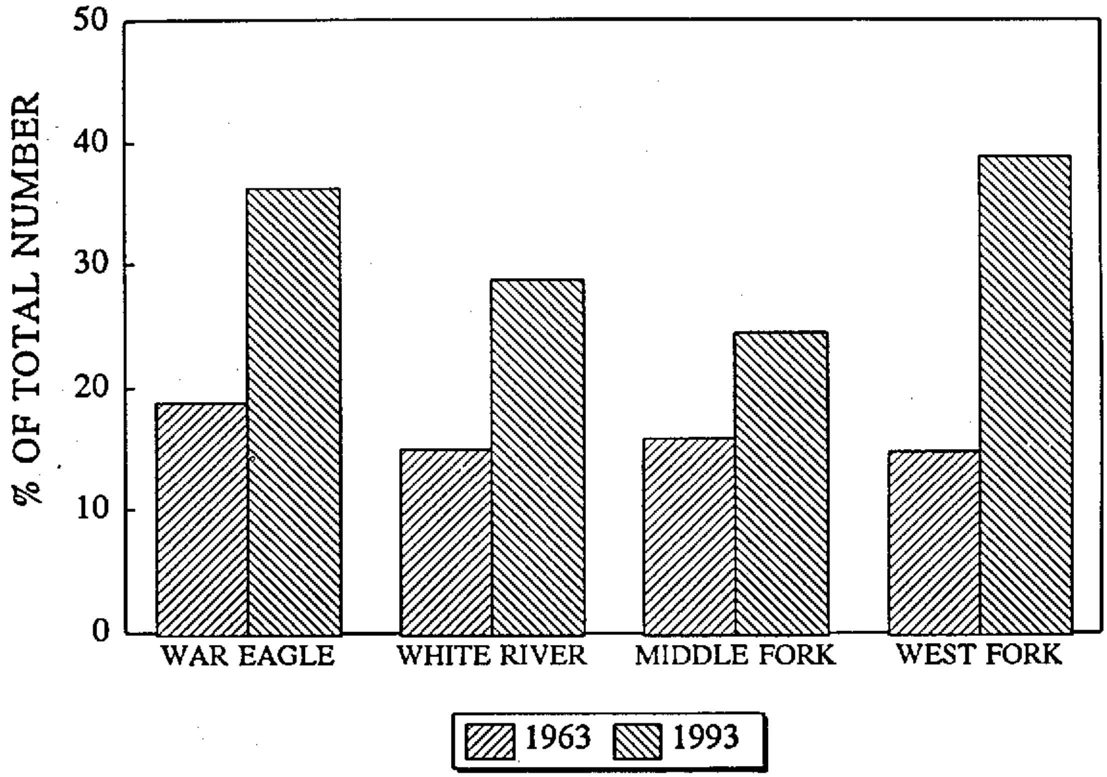
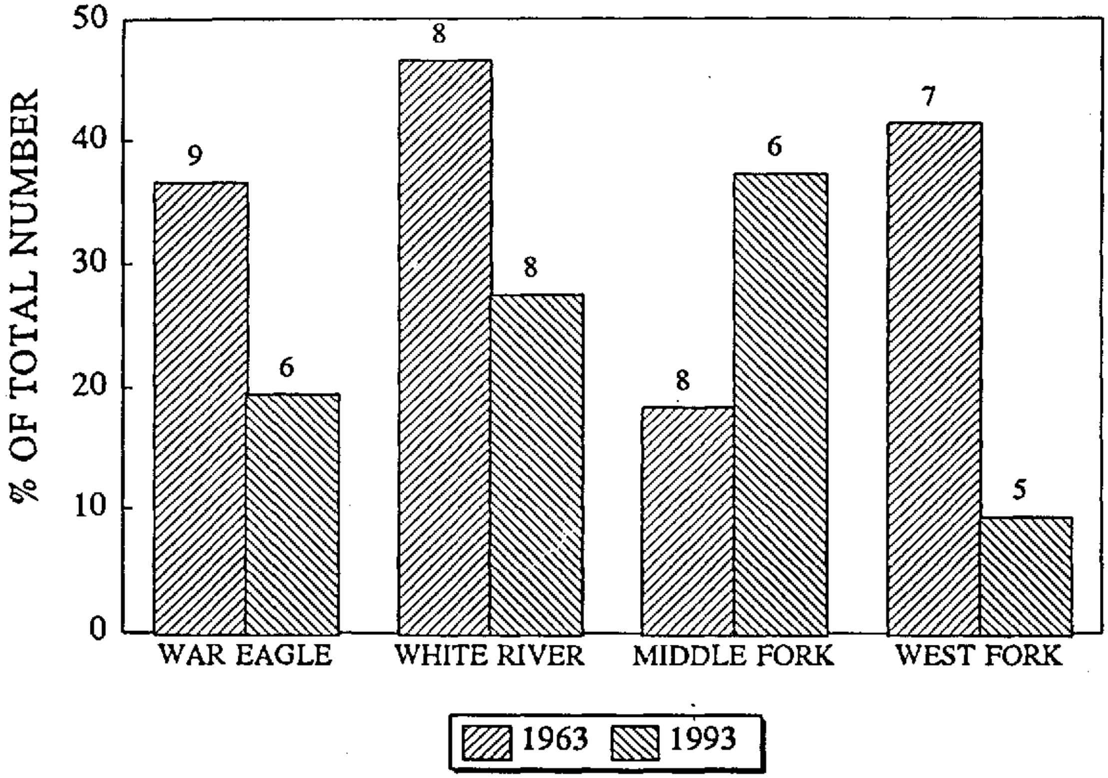


Figure F-7

PERCIDAE COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

Kings River

In 1985, sampling on the Kings River occurred about one mile above the Grandview Bridge; in 1994, sampling occurred about two miles above the Grandview Bridge, which is also about 1½ miles below the Highway 62 bridge. Table F-5 lists the 35 species collected in 1985, and the 44 species collected in 1994. Most of the species collected in 1994, which were not collected in 1985, were represented by only one or two individuals. These include: Longnose gar, Yellow bullhead, Northern studfish, Brook silversides, Redear sunfish, Stippled darter and Orangethroat darter. Although a larger number of species was collected in 1994, the diversity index was 3.46 compared to 3.98 for the 1985 sample. A very high similarity index of 0.80 indicates quite similar communities at this site between the 1985 and 1994 period. The community distribution and comparison of the primary fish families are demonstrated in Figure F-8. The proportion of Cyprinids increased from 1985 to 1994, even though the number of minnow species remained the same. This increase is primarily caused by the increase in the Stoneroller population from 27.4% of the total community in 1985 to 40% in 1994. A slight increase in the Duskystripe shiners was noted in this comparison. In contrast, the populations of the Streamline chub and the Rosyface shiner declined during this period. Also, the Percidae community declined from 27.7% of the total in 1985 to 13.3% in 1994. There were two more species of darters collected in 1994, but they were represented by one Stippled darter specimen and one Orangethroat darter. These were likely transient individuals in this segment of the river. A noticeable reduction in the proportion of Rainbow darters, Arkansas saddled darters, Yolk darters and Banded darters was evident between the 1985 and the 1994 samples.

Yocum Creek

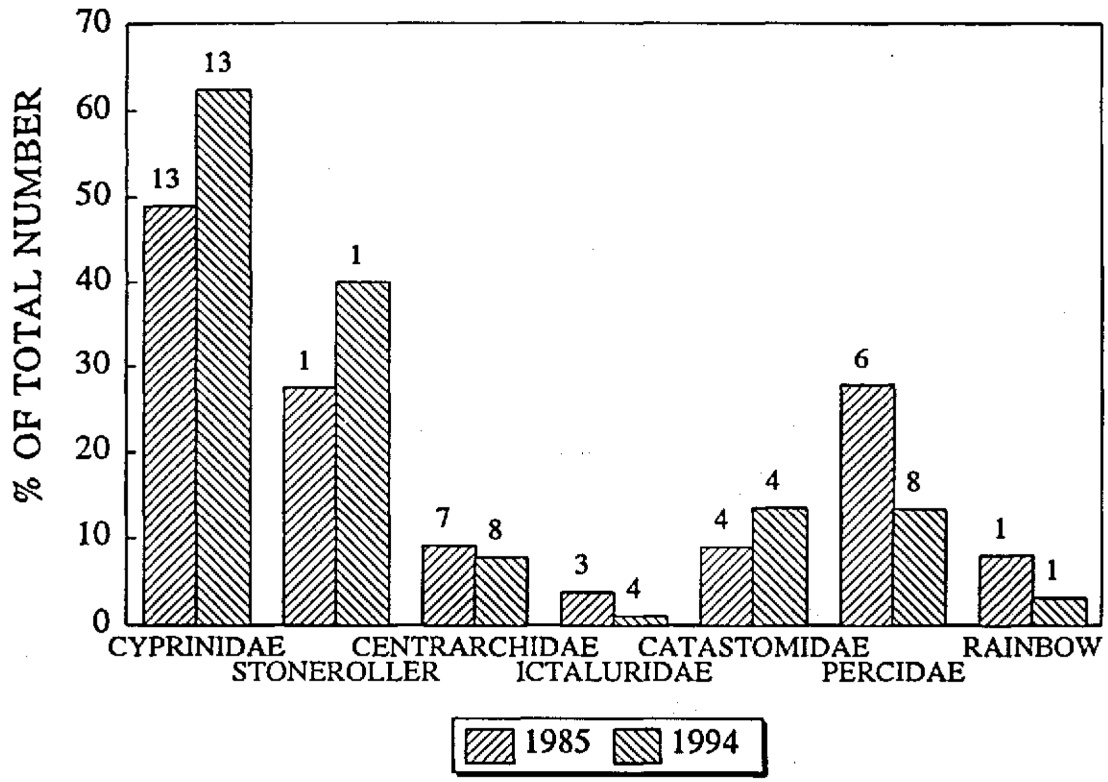
The fish community of Yocum Creek was sampled above a county road bridge approximately three miles south of the Missouri state line. This was also water quality sampling site YOC02. The same location was sampled in August 1984, and in August 1994. Twenty (20) species of fish were collected in 1984 and the diversity index was 2.68. In 1994, 20 species were collected and the diversity index was 2.79 (Table F-6). These two communities were generally quite similar (Figure F-9) as indicated by the similarity index of 0.81. The proportion of Cyprinids decreased slightly during the 10 year period from 66% to 60.6%; however, the Stoneroller population increased slightly from 30.2% to 38.2%. The largest population decline was Duskystripe shiners from 32.9% in 1984 to 19% in 1994. This change is unexplained. The Percidae increased slightly from 12.1% of the total community in 1984 to 18.9% in 1994. The Rainbow darter showed the largest population increase between the sample

TABLE F-5

KINGS RIVER FISH FAMILY & SPECIES		1994 NO.	1994 % TOTAL	1985 NO.	1985 % TOTAL
Lepisosteidae	Gars				
Lepisosteus osseus	Longnose Gar	1	0.0		
Clupeidae	Herrings				
Dorosoma cepedianum	Gizzard shad	37	1.1	17	1.3
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	1357	40.0	352	27.4
Cyprinella galactura	Whitetail shiner	7	0.2	1	0.1
Cyprinella whipplei	Steelcolor shiner	72	2.1	1	0.1
Cyprinus carpio	Carp	1	0.0	3	0.2
Erimystax harryi	Streamline chub	43	1.3	32	2.5
Luxilus chrysocephalus	Striped shiner	16	0.5	3	0.2
Luxilus pilsbryi	Duskystripe shiner	458	13.5	151	11.8
Notropis amblops	Bigeye chub	2	0.1	4	0.3
Notropis boops	Bigeye shiner	9	0.3	7	0.5
Notropis greenei	Wedgespot shiner	7	0.2	3	0.2
Notropis nubilus	Ozark minnow	115	3.4	45	3.5
Notropis rubellus	Rosyface shiner	15	0.4	24	1.9
Pimephales notatus	Bluntnose minnow	13	0.4	2	0.2
Catostomidae	Suckers				
Hypentelium nigricans	Northern hogsucker	232	6.8	23	1.8
Moxostoma carinatum	River redhorse	23	0.7	21	1.6
Moxostoma duquesnei	Black redhorse	146	4.3	55	4.3
Moxostoma erythrurum	Golden redhorse	55	1.6	15	1.2
Ictaluridae	Freshwater catfishes				
Ameirus natalis	Yellow bullhead	2	0.1		
Ictalurus puntatus	Channel catfish	16	0.5	21	1.6
Noturus albater	Ozark madtom	14	0.4	26	2.0
Noturus exilis	Slender madtom	2	0.1		
Pylodictus olivaris	Flathead catfish			3	0.2
Cyprinodontidae	Killifishes				
Fundulus catenatus	Northern studfish	1	0.0		
Fundulus olivaceus	Blackspotted topminnow	1	0.0	2	0.2
Atherinidae	Silversides				
Labidesthes sicculus	Brook silversides	1	0.0		
Moronidae	Temperate basses				
Morone chrysops	White bass	6	0.2		
Centrarchidae	Sunfishes				
Ambloplites constellatus	Ozark bass	24	0.7	9	0.7
Lepomis cyanellus	Green sunfish	5	0.1	22	1.7
Lepomis macrochirus	Bluegill	31	0.9	12	0.9
Lepomis megalotis	Longear	135	4.0	50	3.9
Lepomis microlophus	Redear sunfish	1	0.0		
Micropterus dolomieu	Smallmouth bass	42	1.2	9	0.7
Micropterus punctulatus	Spotted bass	26	0.8	9	0.7
Micropterus salmoides	Largemouth bass	1	0.0	6	0.5
Percidae	Perches				
Etheostoma blennioides	Greenside darter	72	2.1	43	3.3
Etheostoma caeruleum	Rainbow darter	110	3.2	103	8.0
Etheostoma euzonum	Arkansas saddled darter	47	1.4	48	3.7
Etheostoma juliae	Yoke darter	51	1.5	47	3.7
Etheostoma punctulatum	Stippled darter	1	0.0		
Etheostoma spectabile	Orangethroat darter	1	0.0		
Etheostoma zonale	Banded darter	69	2.0	77	6.0
Percina caprodes	Logperch	104	3.1	39	3.0
Cottidae	Sculpins				
Cottus carolinae	Banded sculpin	18	0.5		
TOTAL		3390	100	1285	100
NUMBER OF SPECIES		44		35	
DIVERSITY INDEX		3.46		3.98	

Figure F-8

KINGS RIVER FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



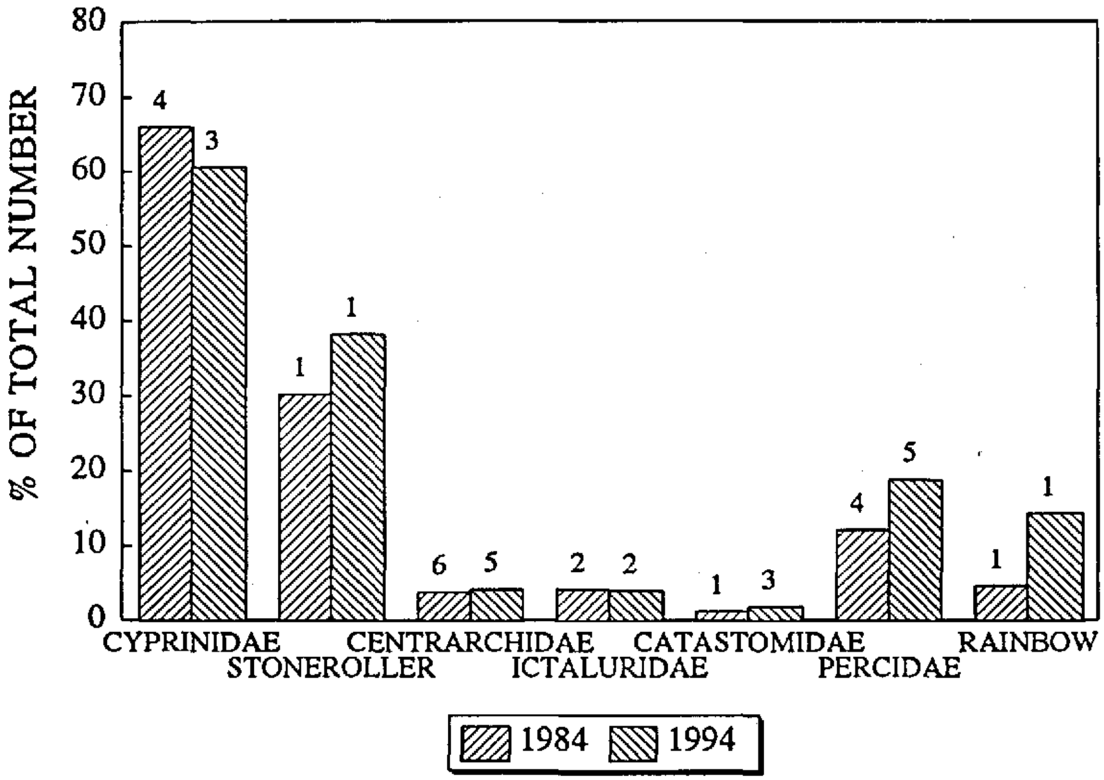
NUMBER OF SPECIES AT EACH BAR

TABLE F-6

YOCUM CREEK FISH FAMILY & SPECIES		1994 NO.	 % TOTAL	1984 NO.	 % TOTAL
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	359	38.2	595	30.2
Luxilus pilsbryi	Duskystripe shiner	178	19.0	647	32.9
Nocomis biguttatus	Hornyhead chub	32	3.4	55	2.8
Notropis nubilus	Ozark minnow			1	0.1
Catostomidae	Suckers				
Catostomus commersoni	White sucker	1	0.1		
Hypentelium nigricans	Northern hogsucker	14	1.5	23	1.2
Moxostoma erythrurum	Golden redhorse	2	0.2		
Ictaluridae	Freshwater catfishes				
Noturus exilis	Slender madtom	16	1.7	76	3.9
Noturus albater	Ozark madtom	22	2.3	4	0.2
Cyprinodontidae	Killifishes				
Fundulus olivaceus	Blackspotted topminnow	1	0.1	4	0.2
Fundulus catenatus	Northern studfish			8	0.4
Centrarchidae	Sunfishes				
Ambloplites constellatus	Ozark bass	16	1.7	33	1.7
Lepomis cyanellus	Green sunfish	2	0.2	15	0.8
Lepomis macrochirus	Bluegill	4	0.4	4	0.2
Lepomis megalotis	Longear	4	0.4	12	0.6
Micropterus dolomieu	Smallmouth bass	14	1.5	8	0.4
Micropterus salmoides	Largemouth bass			1	0.1
Percidae	Perches				
Etheostoma blennioides	Greenside darter				
Etheostoma caeruleum	Rainbow darter	134	14.3	93	4.7
Etheostoma punctulatum	Stippled darter				
Etheostoma flabellare	Fantail darter	31	3.3	122	6.2
Etheostoma spectabile	Orangethroat darter	6	0.6	18	0.9
Etheostoma zonale	Banded darter	1	0.1		
Percina caprodes	Logperch	6	0.6	1	0.1
Cottidae	Sculpins				
Cottus carolinae	Banded sculpin	96	10.2	249	12.6
TOTAL		939	100	1969	100
NUMBER OF SPECIES		20		20	
DIVERSITY INDEX		2.79		2.68	
SIMILARITY INDEX			0.81		

Figure F-9

YOCUM CREEK FISH COMMUNITY
UPPER WHITE RIVER WATERSHED



NUMBER OF SPECIES AT EACH BAR

periods. This was from 4.7% to 14.3%. In contrast, the Fantail darter population declined in 1994 to about one-half the 1984 density.

Within the silt impacted streams, the fish community comparisons showed a distinct and fairly consistent trend of a reduction in number of species, primarily in the Cyprinidae and Percidae families. The proportion of Cyprinids in the communities generally have increased, but this increase, in almost all cases, is the result of rather substantial increases in the Stoneroller populations. The increasing population of this specialized herbivore/detritavore is reflecting the environmental changes that are occurring in these streams. In contrast, the Percidae communities show a trend toward reduced species and reduced densities within the total communities. Disturbances in the watershed which modifies the stream hydrology and increases stream siltation, and in-stream activities which destabilize the stream bed and banks have resulted in habitat modifications which are negatively impacting these fish communities.

SUMMARY AND CONCLUSIONS

1. The water quality in the upper White River watershed in Arkansas was sampled at 41 stations between May 1992 and April 1994. Each station was sampled seven times during this period for seventeen parameters.

2. Nitrate levels (analyzed as nitrate+nitrite nitrogen) generally averaged below 0.5 mg/L in surface flow dominated streams. Elevated levels were apparent below municipal point source discharges, but the highest levels were found in the base flow of groundwater dominated streams.

3. Total phosphorus levels had a similar pattern as nitrate in this watershed. Most average and many maximum values were near or below the guideline values for total phosphorus in streams. In contrast, below municipal point sources, both orthophosphorus and total phosphorus values were noticeably elevated, and during storm events, total phosphorus levels increased substantially, particularly when excessive suspended solids occurred such as in West Fork White River. Groundwater dominated streams, without point source discharges, generally did not exhibit high phosphorus levels.

4. Excessive turbidity values appear to be the most problematic water quality parameter identified in the study. Water quality standards for turbidity were frequently and excessively exceeded in almost all waters sampled except for some of the small tributary streams. West Fork of White River was impacted by storm water runoff from a major highway construction project, and Osage Creek was impacted by gravel roads crossing and immediately adjacent to the streambed. Recently cleared land for conversion to pasture caused temporary and rather substantial elevation of stream turbidity, however, the thousands of miles of gravel roads in this basin is likely causing the most severe and long-term impairment of these streams.

5. Total dissolved solids and hardness values were reflective of the ecoregion through which the streams drained. Many of the streams had large transition areas which had TDS and hardness values intermediate between the low Boston Mountains values and the high Ozark Highland levels.

6. Fecal coliform bacteria levels were strongly influenced by storm water runoff, although some areas exhibited continuous contamination. These included sites near small, unsewered communities, areas where actively grazed pastures were

immediately adjacent to and normally on both sides of the stream, and downstream from a tributary draining a dairy operation. Contamination from point source discharges was not evident from fecal coliform values. Small tributary streams generally had very low levels of bacteria contamination except during heavy, storm water runoff.

7. Twenty-six sites in the watershed were sampled to determine the status of the aquatic macroinvertebrate communities. Seven stations indicated slight impairment of the macroinvertebrate communities; four sites indicated slight to moderate impairment, one site each on the West Fork, Middle Fork and the main fork of the White River showed moderate impairment.

8. Changes in fish communities over a 30-year period were compared from four streams, and two additional streams were compared over an approximately 10-year period. Change seemed to be more evident over the 30-year period than during the last ten years, although the streams compared were different for the two periods. Differences within the fish communities were fairly consistent and appear indicative of the changes within the streams. Some of the notable differences in the fish communities over time include:

   a) a reduction in number of species, particularly in the Cyprinidae and Percidae families; the species not found in recent samples were generally the same species from all waters compared;

   b) the proportion of Cyprinidae normally increased over time, but this was typically due to a substantial increase in the stoneroller population;

   c) the Percidae communities were generally reduced in recent community samples; however when increases in the proportion of Percids was found it was normally a result of one species increasing substantially and usually resulted in a loss of other darter species from the community;

   d) the species dominance diversity index was lower at almost all sites during the most recent community samples; and

   e) community similarity indexes indicate that fish communities at several sites have a very low similarity rating compared to the historical fish community.

APPENDIX A

MACROINVERTEBRATE DATA FROM UPPER WHITE RIVER STUDY

Appendix A. Macroinvertebrate Data from Upper White River Study

TAXA	BRS02	CLF01	DRF01	DRY01	KGS02	KGS03	KGS05	KGS06	KGS07	LNG02	LNG03
Stenonema	18		15	12	28	38	28	19	42	20	25
Isonychia	8		55	2	12	18	33	37	21	29	30
Cheumato-psyche	25	4	5	41		11	2	11	3	15	20
Chimarra	4		1	2		1	2			12	
Baetis	21	2	6	18	1	7	12	5	14	6	9
Corydalus	5		5	3		1	1	7	1	3	5
Gammarus		90									
Viviparidae	1		8		5	2	12	14	11		1
Corbicula					29	3			2		
Psephenus	2				1						
Stenelmis adult	2				3	2	3		1	1	1
Chironomidae	3			3	1	1				3	
Ephoron							1	1	1		
Perlomyia			1	5						1	1
Helichus			1		12	2				1	1
Tricory-thodes				1	1	5			3	3	2
Caenis					1	2				2	2
Optioservus adult			2	4							
Cura foremanii					1		2				
Neoperla	7						1	1			
Tabanus					1	1				1	
Cambarinae				1							1
Lumbricu-lidae				2	1	2	1	1			

Appendix A Continued

TAXA	BRS02	CLF01	DRF01	DRY01	KGS02	KGS03	KGS05	KGS06	KGS07	LNG02	LNG03
Argia					3		1			1	
Stenelmis larva				4			1	1			
Helicopsyche	1					1			1	1	2
Sphaeriidae											
Hydopsyche		1									
Hexatoma	1										
Simulium		2									
Paralepto-phlebia	2										
Acroneuria											
Optioservus larva			1								
Lirceus											
Gyrinus											
Ephemera										1	
Oligochaeta											
Stylogomphus						1					
Calopteryx						1					
Polycentro-pus											
Prosimulium											
Hyalella azteca											
Ferrissia											
Parargyra-ctis											
Nigronia		1									
Hirudinea											

Appendix A Continued

TAXA	BRS02	CLF01	DRF01	DRY01	KGS02	KGS03	KGS05	KGS06	KGS07	LNG02	LNG03
Orthotrichia											
Nectopsyche											
Dineutus											
Sialis				1							
Tipula				1							
Total Taxa	15	7	12	16	16	19	15	11	12	17	14
Total Number	100	100	100	100	100	99	100	97	100	100	100
RBA Score	0.824	0.176	0.647	0.706	0.824	0.941	0.882	0.647	0.706	1	0.882
Diversity Index	3.07	0.68	2.23	2.84	2.82	3.03	2.67	2.7	2.43	3.04	2.68

RBA Score Categories:

Not Significantly Impaired = 0.83 - 1.00 Slightly Impaired = 0.54 - 0.79
Moderately Impaired = 0.21 - 0.50 Severely Impaired = <0.17

Appendix A Continued

TAXA	MFW03	OSG03	OSG04	PNY01	RCH03	WFW03	WHR01	WHR03	WHR02	WRE02	WRE03
Stenonema	12	35	21	17	2	11	24	32	19	31	26
Isonychia	14	29	42	6	2	30	6	29	9	9	28
Cheumato-psyche	36	21	9	26	26	36	32	4	36	20	26
Chimarra	24	1	12	3	26	14		22	25	10	4
Baetis			6	4	11						1
Corydalus	2	2	3	3	8	2	1	4	10	7	3
Gammarus											
Viviparidae		3	4	10	1						1
Corbicula						2				8	3
Psephenus							28			1	
Stenelmis **adult**	1	2		8	2		1			2	
Chironomidae	2		1		5	1	1	2		5	
Ephoron					1						
Perlomyia				17							
Helichus	2	1		1		1	1	1		1	1
Tricory-thodes		1		1	4			1		1	4
Caenis	4	1			5		3	2	1	3	1
Optioservus **adult**											
Cura foremanii				4							
Neoperla								1			
Tabanus	2	1		2				1		1	
Cambarinae		1				1	2	1	1		
Lumbricu-lidae											

Appendix A Continued

TAXA	MFW03	OSG03	OSG04	PNY01	RCH03	WFW03	WHR01	WHR03	WHR02	WRE02	WRE03
Argia	1			1		1					
Stenelmis larva											1
Helicopsyche											
Sphaeriidae		1	2		2						
Hydopsyche								1			
Hexatoma					1	1	1				
Simulium											
Paralepto-phlebia											
Acroneuria				1							
Optioservus larva				1							
Lirceus											
Gyrinus										1	1
Ephemera											
Oligochaeta		1									
Stylogomphus											
Calopteryx											
Polycentro-pus											
Prosimulium											
Hyalella azteca											
Ferrissia											
Parargyra-ctis					1						
Nigronia											
Hirudinea				1							

Appendix A Continued

TAXA	MFW03	OSG03	OSG04	PNY01	RCH03	WFW03	WHR01	WHR03	WHR02	WRE02	WRE03
Orthotrichia					1						
Nectopsyche					1						
Dineutus											
Sialis											
Tipula											
Total Taxa	12	15	10	18	18	12	12	14	8	15	14
Total Number	100	100	100	106	99	100	100	101	101	100	100
RBA Score	0.525	0.824	0.529	Ref. Site	0.824	0.471	0.647	0.824	0.647	0.765	0.824
Diversity Index	2.56	2.43	2.44	3.3	3.18	2.36	2.38	2.51	2.38	3	2.6

RBA Score Categories

Not Significantly Impaired = 0.83 - 1.00 **Slightly Impaired = 0.54 - 0.79**
Moderately Impaired = 0.21 - 0.50 **Severely Impaired = <0.17**

Appendix A Continued

TAXA	WRE04	WRE05	WRE06	YOC01	YOC02
Stenonema	12	25	34	6	20
Isonychia	30	20	25	25	17
Cheumatopsyche	21	6	19	27	39
Chimarra	9		1	8	
Baetis	1	3	6	4	6
Corydalus	13	3	7	2	4
Gammarus					
Viviparidae	1	12			1
Corbicula	6	3	2		
Psephenus					2
Stenelmis adult		2		2	
Chironomidae	1		1		
Ephoron	4	21			
Perlomyia				3	1
Helichus	1	1			
Tricorythodes			1		
Caenis					
Optioservus adult				8	7
Cura foremanii				8	
Neoperla					1
Tabanus	1				
Cambarinae				1	1
Lumbriculidae			1	1	

Appendix A Continued

TAXA	WRE04	WRE05	WRE06	YOC01	YOC02
Argia					
Stenelmis larva					
Helicopsyche					
Sphaeriidae					
Hydopsyche			3		
Hexatoma					
Simulium					
Paralepto-phlebia					
Acroneuria				1	
Optioservus larva					
Lirceus				2	
Gyrinus					
Ephemera					
Oligochaeta					
Stylogomphus					
Calopteryx					
Polycentropus					1
Prosimulium				1	
Hyalella azteca				1	
Ferrissia		1			
Parargyractis					
Nigronia					
Hirudinea					

Appendix A Continued

TAXA	WRE04	WRE05	WRE06	YOC01	YOC02
Orthotrichia					
Nectopsyche					
Dineutus		1			
Sialis					
Tipula					
Total Taxa	13	13	12	17	13
Total Number	100	98	100	100	100
RBA Score	0.647	0.706	0.764	0.824	0.764
Diversity Index	2.82	2.93	2.53	3.14	2.6

RBA Score Categories

Not Significantly Impaired = 0.83 - 1.00
Slightly Impaired = 0.54 - 0.79
Moderately Impaired = 0.21 - 0.50
Severely Impaired = <0.17