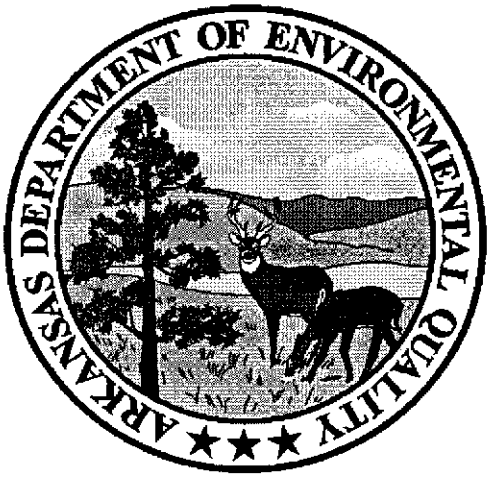
WATER QUALITY SURVEY

OF

THE MOUNTAIN HOME STP EFFLUENT

ON

HICKS CREEK



ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

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INTRODUCTION

A water quality investigation was conducted on Hicks Creek, which is the receiving stream of the Mountain Home municipal wastewater treatment facility. Big Creek, the stream receiving the Hicks Creek tributary, was selected as an unimpacted site for data comparison. This stream survey had a dual purpose: (1) to determine the presence and extent of water quality degradation and its impact on the aquatic life, and (2) to establish the need or value of a TMDL (total maximum daily load) for nutrients on Hicks Creek. This investigation was conducted on August 30 through September 1, 1993. A preliminary survey was completed on June 15, 1993 for the purpose of determining stream accessibility, the zone of impact from the STP effluent, and potential station locations.

GENERAL DISCUSSION

Waterway Description

Hicks Creek has its origin approximately one mile north of the Mountain Home city limits in the west central part of Baxter County. It flows in a southerly direction through Mountain Home for about four miles prior to receiving the sewage treatment plant (STP) outfall. Hicks Creek then continues south for another 2.9 miles to its confluence with Big Creek. Big Creek flows 6.3 miles in a south-southeast direction to its confluence with the White River. Hicks Creek drains approximately 15 square miles at its mouth. Big Creek has a watershed of 12 square miles at the Hicks Creek confluence. The stream gradient for Hicks Creek in the vicinity of the municipal treatment facility is on the order of 20-25 feet/mile. As this creek nears the Big Creek confluence, the watershed becomes more hilly, with the stream slope increasing to around 40 feet/mile. The upper portion of Big Creek has a slope of 30 feet/mile and also increases to 40 feet/mile near the Hicks Creek confluence. The substrate composition of both streams consists predominantly of rubble and gravel in the upper reaches, with bedrock and boulders being more prevalent near the confluence of the two streams. The pool/riffle ratio in the study area of Hicks Creek was approximately 5 to 1 in the upper region, with a long, wide pool present approximately one half mile below the treatment plant outfall which served as a nutrient "sink". Filamentous algae streamers were prevalent in this pool during the study period. Due to the increase in stream slope there is a greater incidence of riffles in both streams in the region of the confluence.

There is an abundance of habitat cover available to both aquatic invertebrates and fish in both streams, however the riffle areas in Big Creek were narrower, dominated by bedrock and boulders, and had a steeper gradient. The substrate composition and gradient resulted in higher velocities in Big Creek during this survey. At the time of the August/September survey, stream flow in Hicks Creek above the STP was measured at 0.37 cfs (cubic feet per second), the Big Creek flow above the Hicks Creek confluence was 1.0 cfs.

Previous Studies

In October of 1981, the consulting firm of Mayes, Sudderth and Etheredge, Inc. was hired to conduct a water quality investigation for the purpose of determining the impact of the Mountain Home STP on the water quality of the receiving stream and to project future effluent limitations that would maintain the water quality standards in existence at that time. At the time of this survey, the Mountain Home wastewater treatment facility consisted of an activated sludge system designed to produce a secondary effluent which was averaging 0.8 MGD discharge volume. Two separate surveys were conducted by this firm: an early November calibration survey and a late November verification survey. Effluent quality during the initial survey averaged 27 mg/l BOD5, and NH3N of 8.4 mg/l. During the second survey a slug of untreated wastewater was discharged, resulting in BOD5 concentrations of 78 mg/l and NH3N of 26 mg/l. Their dissolved oxygen analysis in Hicks Creek over the survey period revealed a minimum concentration of just over 2 mg/l in the zone of degradation, with a maximum deficit of 8 mg/l. Stream temperatures ranged from 15 to 18 degrees Centigrade during the first survey and from 7 to 10 degrees during the second. Their conclusions stated that Hicks Creek was being impacted by the Mountain Home STP effluent in terms of dissolved oxygen concentration, but that the existing facility was generally operating at its design capabilities. Their recommendations were that an upgrade or replacement of the existing treatment facility with the capability of producing a 10/15/2 (CBOD5/TSS/NH3N) effluent would be necessary to achieve maintenance of the water quality standards that existed for Hicks Creek at the time of their survey.

On August 5, 1987, personnel from the ADPC&E ecology section performed a macroinvertebrate survey of Hicks Creek above and below the Mountain Home STP outfall in order to assess the impact of the wastewater effluent on the benthic community. These Mountain Home sites are two of many ADPC&E biomonitoring locations designed to assess the impact of known pollutant sources on the quality of the receiving stream. The stations surveyed in 1987 coincide with two of the 1993 survey sites. The ADPC&E rapid bioassessment protocol was used in each of the surveys so a direct comparison of the benthic community could be made. The assessment of community integrity determined in each of these surveys will be addressed in the results section of this report.

Land Use

Based on aerial photographs of the study area, approximately 20 percent of the Hicks Creek watershed has been converted to agricultural uses--predominantly pasturelands for cattle grazing. Most of the upper watershed (above the STP) is dominated by urban development which is continually expanding toward the south. Approximately 50 percent of the lower watershed is still forested, with much of the stream length below the STP being bordered with trees. During the time of the survey Big Creek was relatively unimpacted from urban development, with about a 40% conversion to cleared land and 60% forested. Occasional pastures border Hicks and Big Creeks, creating the potential for cattle access to the streams. During the survey a dairy farm was noted (with cows in stream) in the lower portion of the Big Creek drainage, but this has since been converted to a beef cattle operation (personal communication-SCS). Currently, there are no records of poultry production houses or confined swine operations within the Hicks Creek watershed.

Geology

Hicks Creek, Big Creek, and their tributaries lie within the Salem Plateau of the Ozark Highlands ecoregion. The Salem Plateau is characterized by gently sloping to rolling uplands, and steep, stony side slopes with outcrops of dolomite. The elevation ranges from 700 to 1000 feet above sea level. The geology of this drainage is characterized by Cotter and Jefferson City Dolomites, with small areas of Powell Dolomites interspersed in the drainage basin. Soil types in the survey area above the STP are comprised of the Arkana-Moko, Captina-Tonti-Nixa, Doniphan-Nixa, and Doniphan-Ventris Associations. The Arkana-Moko type, located primarily in the upper watershed west of Mountain Home (upper Dodd Creek tributary), is characterized by moderately deep and shallow, gently sloping to steep, well drained, cherty and stony soils that formed in residuum of dolomite and limestone. The Captina-Tonti-Nixa type, which surrounds the upper Hicks Creek channel, is characterized by deep, nearly level to moderately sloping, moderately well drained, loamy and cherty soils. The soil type in the watershed below the STP (including the Big Creek drainage) is dominated by the Doniphan-Gassville Association, characterized by deep and moderately deep, moderately sloping to steep, well drained, very cherty soils that formed in residuum of cherty dolomite.

Water Quality Standards And Beneficial Uses

Hicks Creek, which drains a 10 mi^2 watershed above the STP effluent discharge, is classified as an Ozark Highlands mid-size watershed perennial fishery, and as such, has an applicable dissolved oxygen standard of 5 mg/l, with a 1 mg/l diurnal fluctuation being allowed for no longer than 8 hours in a 24 hour period when the stream

temperature exceeds 22 degrees Centigrade. At stream temperatures of 22 degrees C. or less, a 6 mg/l standard generally applies. The exception to this is during the March through May time frame when the stream temperature is 10 degrees or less, and the stream flow exceeds 15 cfs. At these conditions, the dissolved oxygen standard is 6.5 mg/l. Big Creek, which has a drainage area of 12 mi^2 at the Hicks Creek confluence, has the same standards. Designated beneficial uses of these streams, in addition to the previously mentioned fishery use, consists of primary and secondary contact recreation-which includes wading, canoeing, fishing, and swimming-as well as a source of water for domestic, industrial and agricultural uses.

DATA ACQUISITION

During the afternoon of June 15, 1993, ADPC&E personnel arrived at the Hicks Creek area for the purpose of locating stream access and to conduct a dissolved oxygen profile for determination of the impact area and length of the zone of recovery. Preliminary sampling stations were identified as a result of this investigation. The stream survey was initiated on the afternoon of August 30, 1993 when continuous dissolved oxygen meters were installed at three of the seven stream stations. On August 31, stream flows were measured at two sites, the physical characterization and habitat availability was evaluated, the time of travel was measured, three of the five macroinvertebrate sites were sampled, and fish collections were completed on the Hicks Creek and Big Creek sites. On September 1, the remaining flow measurements were completed, two additional macroinvertebrate sites were sampled, and the in-situ measurements and water chemistry samples were collected at each station. This was followed with the calibration and removal of the continuous dissolved oxygen meters. The water samples were returned to the laboratory for analysis.

Parameters

In addition to the in-situ measurements of dissolved oxygen, temperature, and pH, the water samples were analyzed for chlorides, total organic carbon (TOC), five day biochemical oxygen demand (BOD5), total suspended solids (TSS), total dissolved solids (TDS), ammonia nitrogen (NH3N), nitrite + nitrate nitrogen (NO2+NO3), orthophosphate, and total phosphate. The results of the water chemistry analyses for this survey are included as Appendix A.

Collection, Preservation And Measurements

Stream samples were collected, preserved, and analyzed according to the 16th Edition of Standard Methods for Examination of Water and Wastewater. Analysis was conducted under ADPC&E's existing Quality Assurance Program. Dissolved oxygen and stream temperature during sample collection were measured by a Y.S.I. Model 57 portable dissolved oxygen meter, which was calibrated by a Winkler titration

prior to use. Three Model 56 continuous dissolved oxygen meters were used to determine diurnal variation in the dissolved oxygen concentration in Hicks Creek above the STP outfall, at the Military Road site (HIC 04) approximately 1 1/4 miles below the STP, and the third located another 1 1/2 miles below this site at the last downstream station on Hicks Creek (HIC 05). Stream pH was analyzed by an Orion Model 230A portable pH meter, which was calibrated using buffer solutions of pH 7 and 10. Stream flow was measured using a Marsh-McBirney Model 201 meter by obtaining a representative number of velocities and depths across suitable stream locations. Flows were taken in Hicks Creek above and below the Mountain Home STP outfall, at the Military Road site, and above the confluence of Big Creek. An additional flow measurement was made on Big Creek above the Hicks Creek confluence.

Macroinvertebrate samples were collected at the same station locations. These samples were collected using an indestructible Turtox benthos net. An attempt was made to sample similar riffle habitats for five minutes at each site, in accordance with established protocol for rapid bioassessments. The fish community of Hicks Creek was sampled from the Military Road bridge downstream by use of a Smith-Root Model 15-A POW DC backpack electrofisher. Riffle areas were sampled by driving the fish into a seine, while the fish in the pools were collected by electroshocking favorable habitat areas. The same methodology and level of effort was applied to the Big Creek sampling area.

Station Description

A total of five water chemistry stations were established on Hicks Creek, with two additional stations on Big Creek. These stations were selected for the purpose of determining any impacts from non-point source contaminants (upstream Hicks Creek site), as well as assessing the impact from the Mountain Home STP effluent on Hicks Creek, with the Big Creek site used for comparison. Stations were spaced in order to determine any dissolved oxygen sag due to the effluent load on the receiving stream. The station descriptions are as follows:

Station HIC 01. Hicks Creek above STP outfall

Station HIC 02E. Mountain Home STP outfall

Station HIC 03. Hicks Creek 200 yards below STP outfall

Station HIC 04. Hicks Creek at the Military Road bridge

Station HIC 05. Hicks Creek 100 yards above Big Creek

Station BIG 06. Big Creek 100 yards above Hicks Creek

Station BIG 07. Big Creek 50 yards below Hicks Creek

Five stations were sampled for macroinvertebrates and two sites for fishes. These macroinvertebrate communities were analyzed on an upstream/downstream basis for determination of any adverse impacts from pollution sources on population diversity and density. The fish communities were sampled for comparison of an "unimpacted" community and an "impacted" community. Figures 1 and 2 provide the locations of water sampling stations, as well as areas sampled for aquatic life.

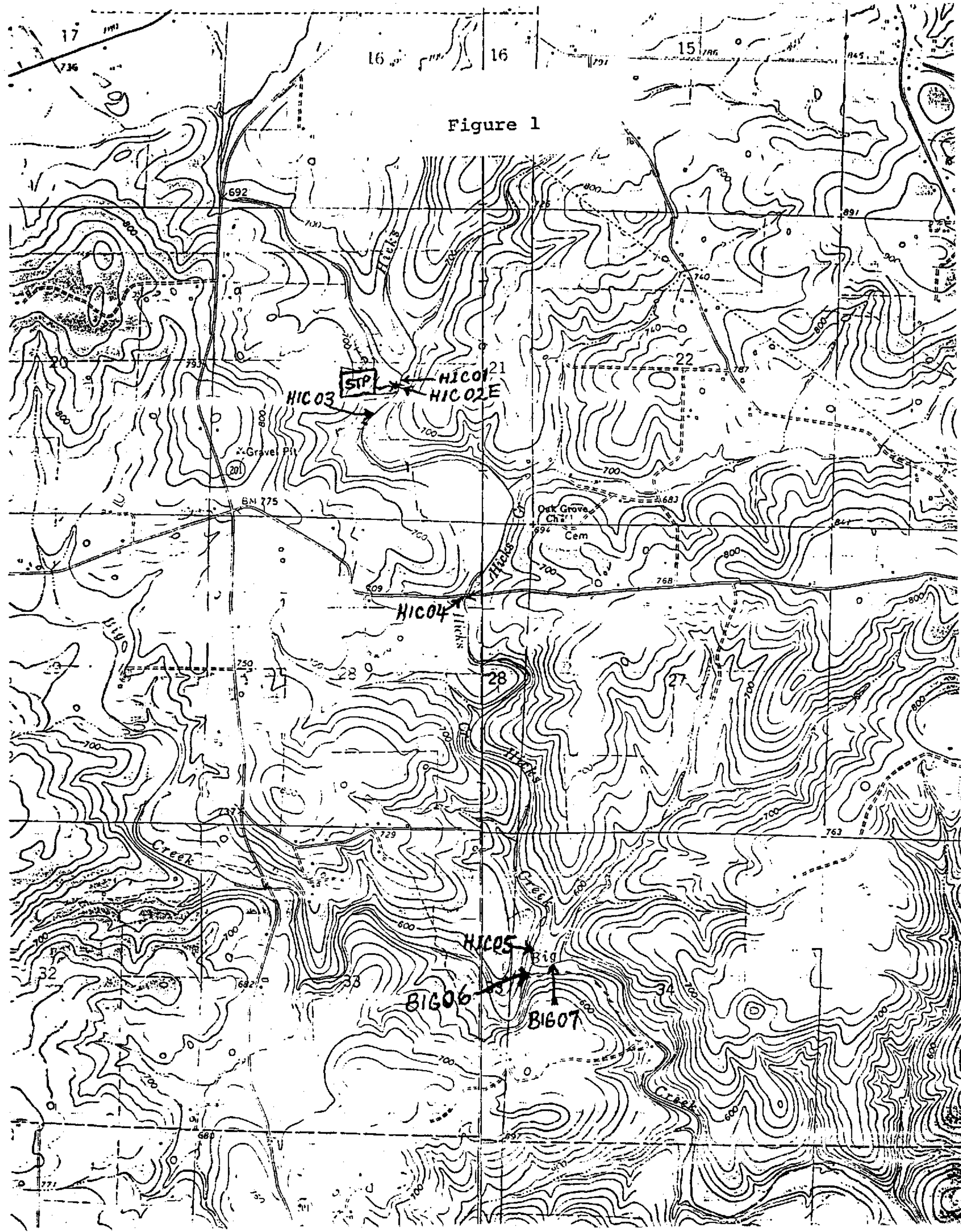
DATA RESULTS

Dissolved Oxygen

The dissolved oxygen profile was evaluated two times during the survey of Hicks Creek and Big Creek. During the preliminary investigation the dissolved oxygen concentrations were at or above 100% saturation, with the exception of the Big Creek site and the lower Hicks Creek site (Stations BIG 06 and HIC 05-both at 90%), and also the STP effluent (94%). All these measurements were taken during mid-afternoon when photosynthetic activity is highest. Hicks Creek stream temperatures ranged from 25.5 to 28.5 degrees Centigrade, with the STP effluent at 24 degrees. Big Creek also had a temperature of 24 degrees near the confluence of Hicks Creek, which may indicate springwater influence. The second profile was taken during the morning water chemistry sampling effort on September 1. The saturation values of the upper stations were about 10% lower than the earlier profile (90% range), but the effluent was super-saturated (106%). Saturation dropped to 73% at the Military Road station, which was identified as the D.O. sag point during both profiles. The lower Hicks Creek site and the Big Creek site had saturation values similar to the earlier profile, at 92% and 91%, respectively. These dissolved oxygen measurements were made in the morning hours, which would reflect some depression in the D.O. concentrations due to the effect of respiration, and before the peak D.O. production from photosynthetic activity.

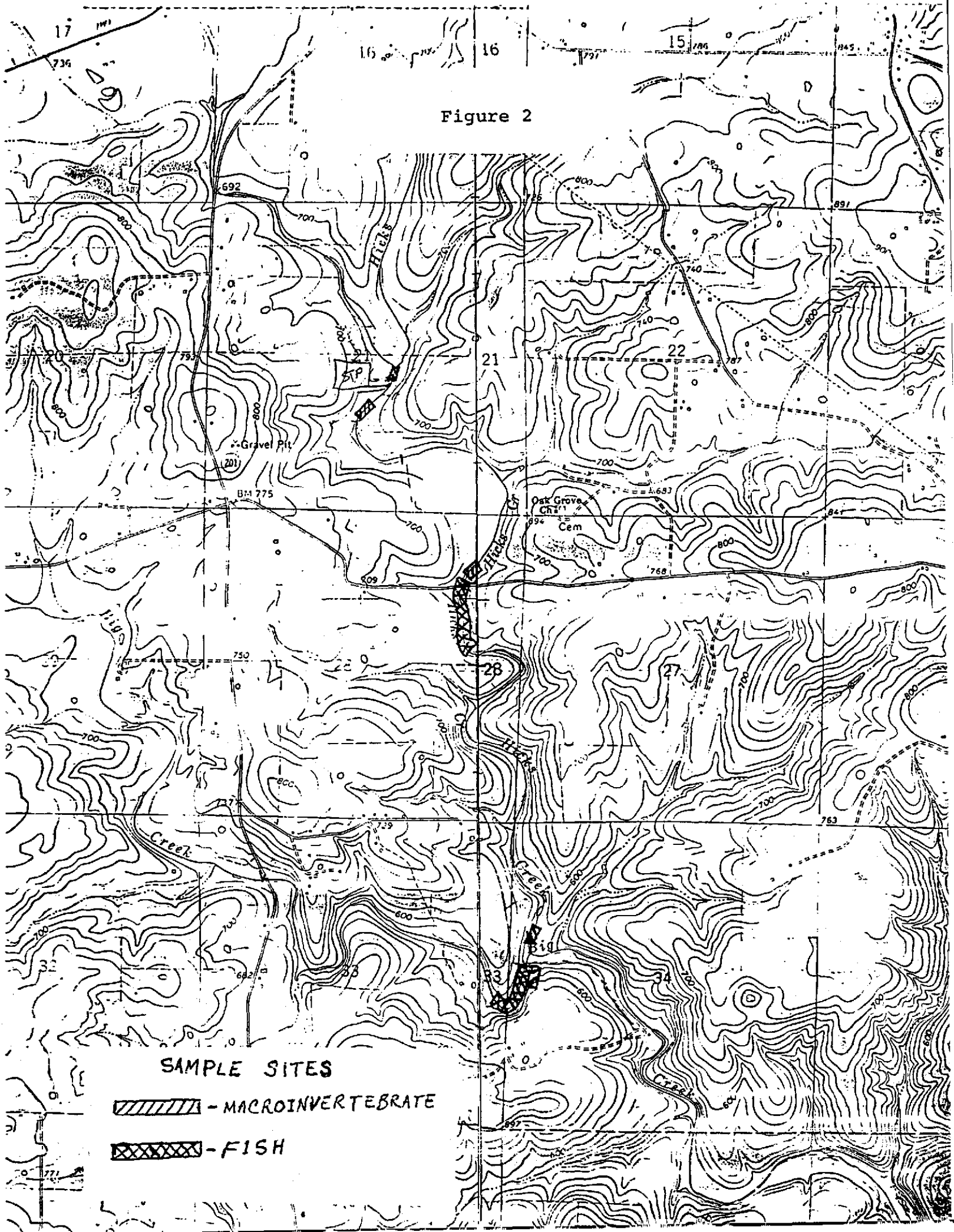
Three continuous dissolved oxygen meters were used to get an accurate measurement of the diurnal fluctuation in both dissolved oxygen and stream temperature. A meter was placed in Hicks Creek just above the STP outfall (HIC 01), the second was located at the Military Road site (HIC 04), and the third meter was placed in Big Creek (BIG 06). Figures 3, 4, and 5 show the dissolved oxygen fluctuation at these stations during the August 30-September 1 survey. The upstream meter indicated a diurnal fluctuation of approximately 6 mg/l, while the Military Road site had a fluctuation of 5.5 mg/l. Saturation values at these two sites ranged from 65% to 145%, indicating the degree of impact from photosynthetic activity in the Hicks Creek drainage. When comparing these two stations with the Big Creek site, which had a diurnal fluctuation of 1.5 mg/l and saturation values of 85 to 105%, it shows the effect of urban and point source contributions of nutrient loading to Hicks Creek.

Figure 1



STP
HIC01
HIC02E
HIC03
HIC04
HIC05
BIG06
BIG07
Hicks
Hicks Cr
Big
Creek
Oak Grove Ch
Cem
Gravel Pit
BM 775
201

Figure 2


SAMPLE SITES
- MACROINVERTEBRATE
- FISH
Hicks
Creek
Big
Gravel Pit
Oak Grove Ch
Cem
BM 775
STP

Temperature fluctuations were similar at both Hicks Creek stations--approximately 4.5 degrees, while the Big Creek site had a 3 degree fluctuation. Figures 3 through 5 graphically depict the temperature variation at these sites. Temperatures were cooler in Big Creek (26 degrees versus 28 degrees) which also reflects the nature of the watersheds drained. The Hicks Creek diurnal dissolved oxygen fluctuation values are higher than the 4 mg/l range of fluctuations recorded in the ecoregion study of the Ozark Highlands. Ecoregion fluctuation data generally reflected the land use patterns--the predominance of pasturelands, poultry production, and subsequent land application of waste products from these activities, however the Hicks Creek fluctuation can be attributed to urban and STP nutrient influx. By comparison, the Big Creek fluctuation also reflects its watershed activities--the lack of poultry and swine operations and their associated waste products.

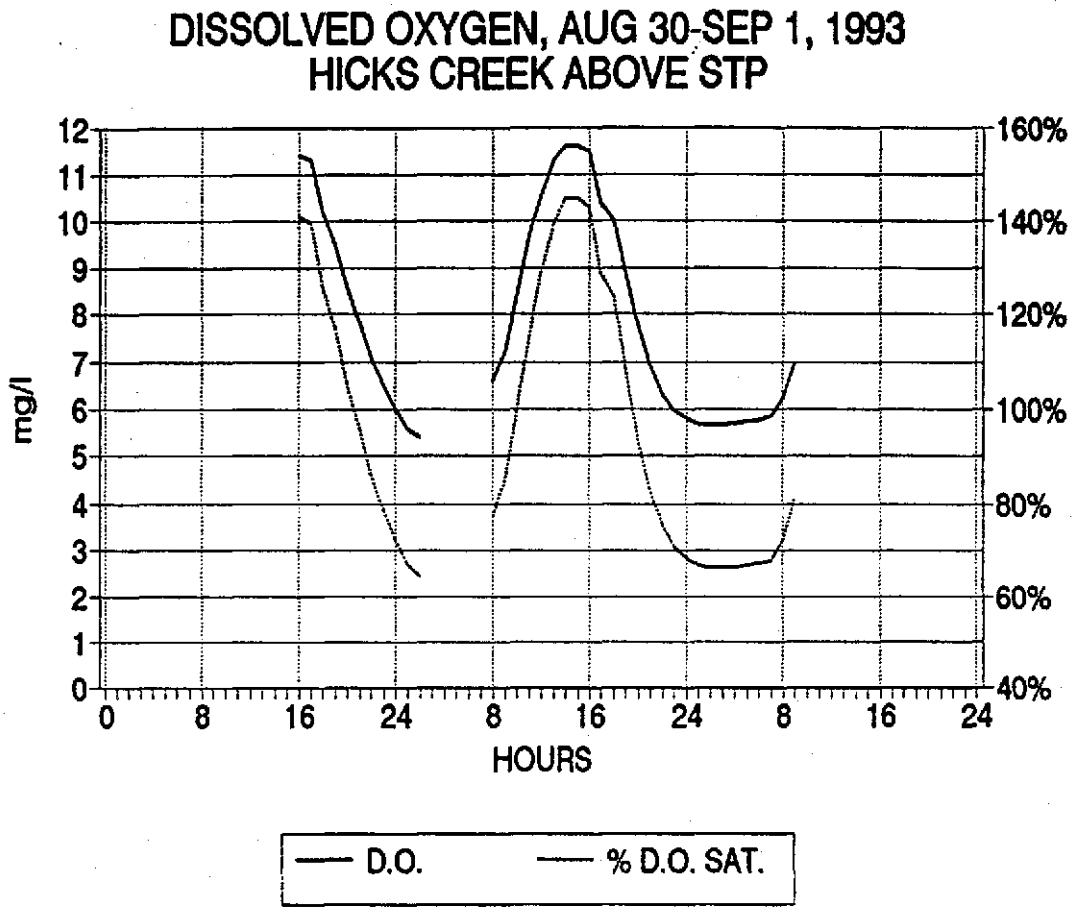
pH And Temperature

Stream pH values measured during this survey were typical for streams in the Ozark Highlands ecoregion. The values ranged from 7.6 to 7.9 at all sample stations. The samples were collected in the morning, and based on other field work in this ecoregion, a small pH increase takes place in the afternoon hours. The rise in pH is associated with the photosynthetic activity during this time frame. The initial ecoregion study produced an average pH of 7.6 for all size watersheds studied. The stream temperatures noted above were generally higher than those values measured in the ecoregion study. The ecoregion streams were also surveyed in September, but the smaller watershed streams had a greater karst geology influence. The smaller watersheds and shallow depths of Hicks and Big Creeks are more conducive to greater temperature fluctuations, as noted earlier by the 4.7 degree diurnal fluctuation observed at the Hicks Creek continuous dissolved oxygen meter sites.

Flow

According to USGS data Hicks Creek at Mountain Home has a Q7-10 between 0 and 1 cfs; however, Big Creek has a Q7-10 of 0 cfs. During the survey the greater flow was measured at Big Creek (1 cfs) compared to .37 cfs at Hicks Creek above the STP. During the Mays, Sudderth, and Etheredge, Inc. November 1981 wasteload study, stream flow in Hicks Creek above the discharge was 0.48 cfs, while Big Creek flow was 0.32 cfs above the Hicks Creek confluence. These flow measurements followed several weeks of little to no rainfall and probably represented a base flow for the late fall and winter months. The Mountain Home STP discharge averaged 2.6 cfs during the 1993 survey. During the stream sampling a flow of 3.1 cfs was measured at HIC 04.

Figure 3


DISSOLVED OXYGEN, AUG 30-SEP 1, 1993
HICKS CREEK ABOVE STP
mg/l
12
11
10
9
8
7
6
5
4
3
2
1
0
160%
140%
120%
100%
80%
60%
40%
0
8
16
24
8
16
24
8
16
24
HOURS
D.O.
% D.O. SAT.

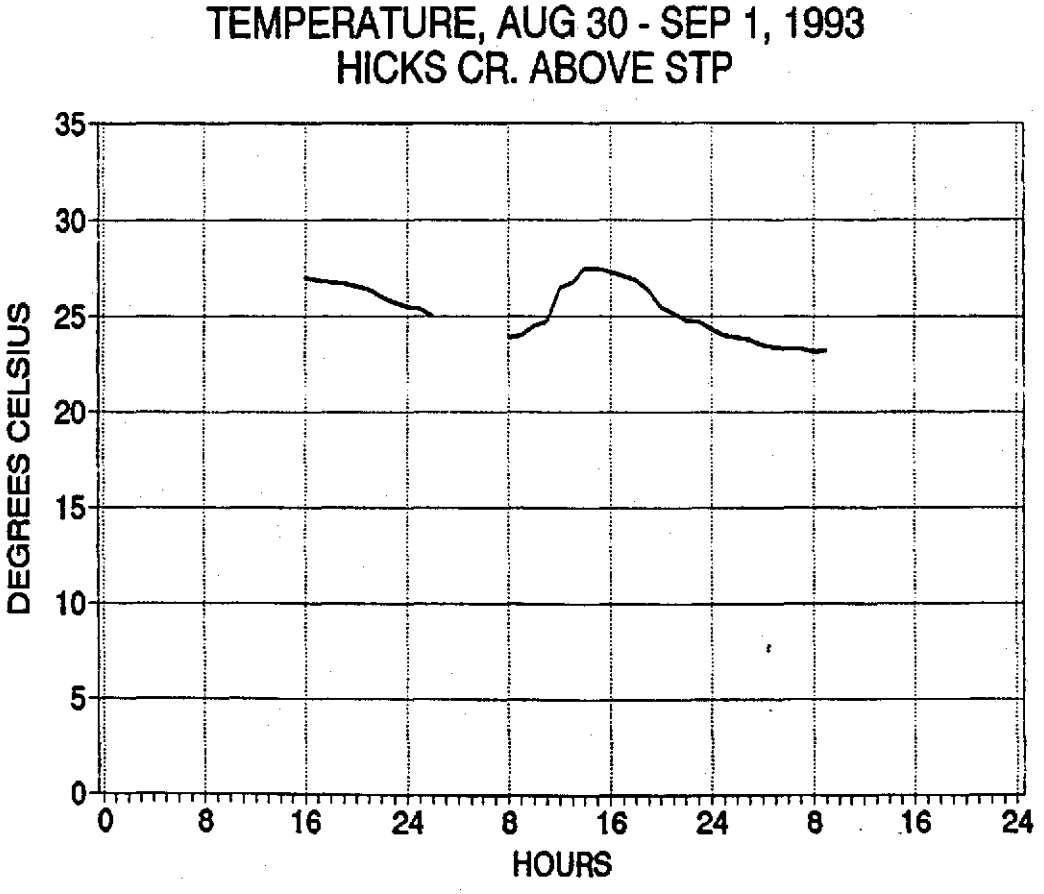
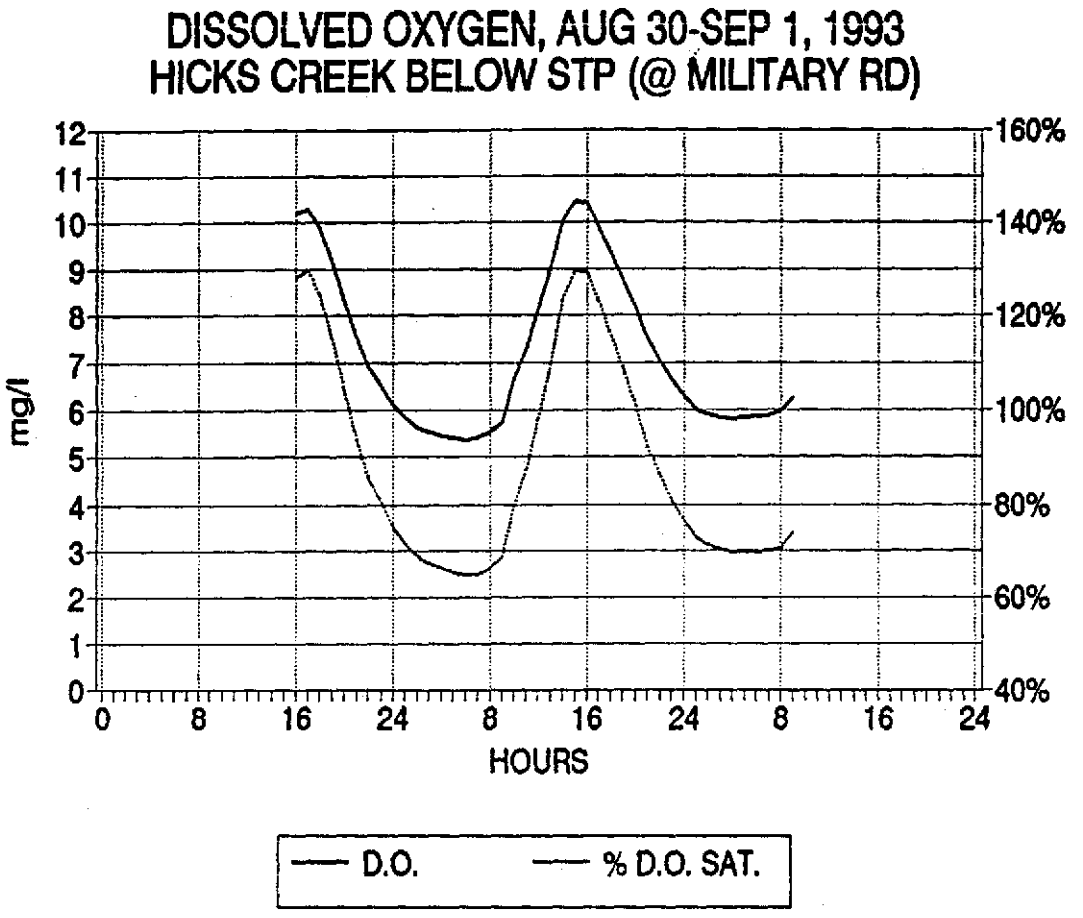

TEMPERATURE, AUG 30 - SEP 1, 1993
HICKS CR. ABOVE STP
DEGREES CELSIUS
35
30
25
20
15
10
5
0
0
8
16
24
8
16
24
8
16
24
HOURS

Figure 4


DISSOLVED OXYGEN, AUG 30-SEP 1, 1993
HICKS CREEK BELOW STP (@ MILITARY RD)
mg/l
12
11
10
9
8
7
6
5
4
3
2
1
0
160%
140%
120%
100%
80%
60%
40%
0
8
16
24
8
16
24
8
16
24
HOURS
D.O.
% D.O. SAT.

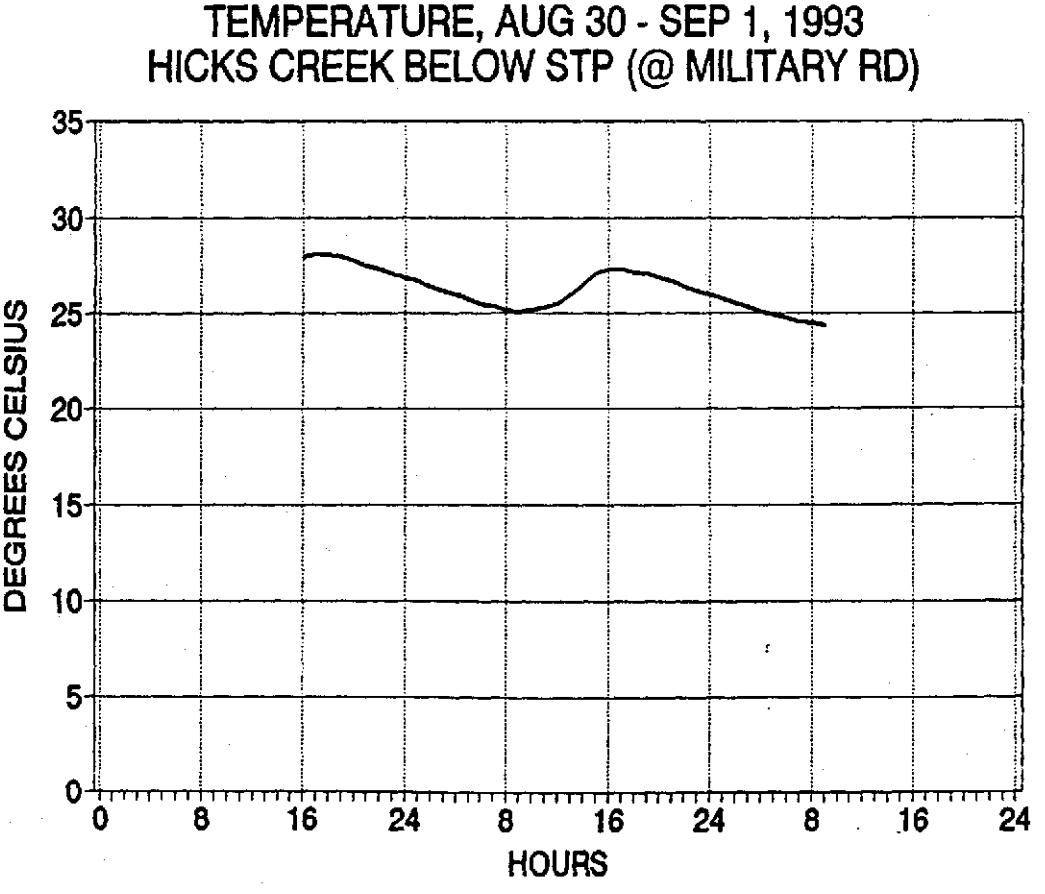
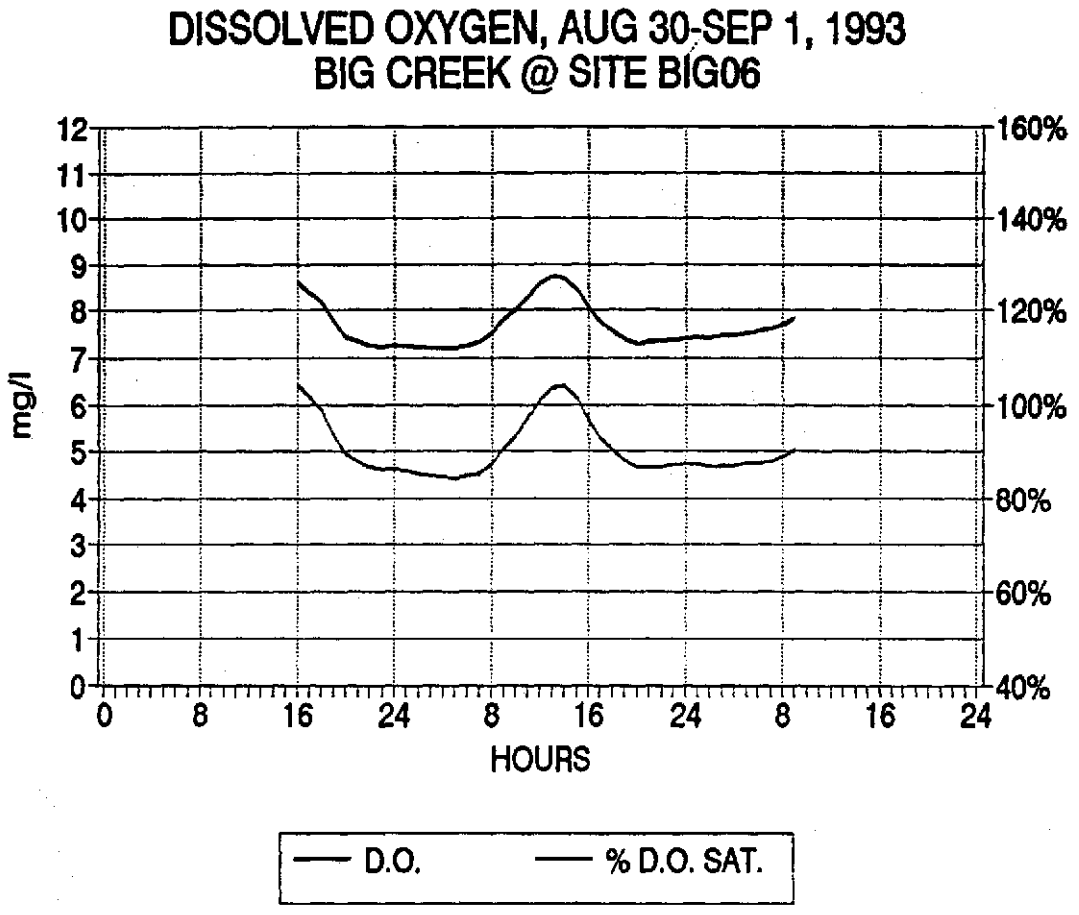
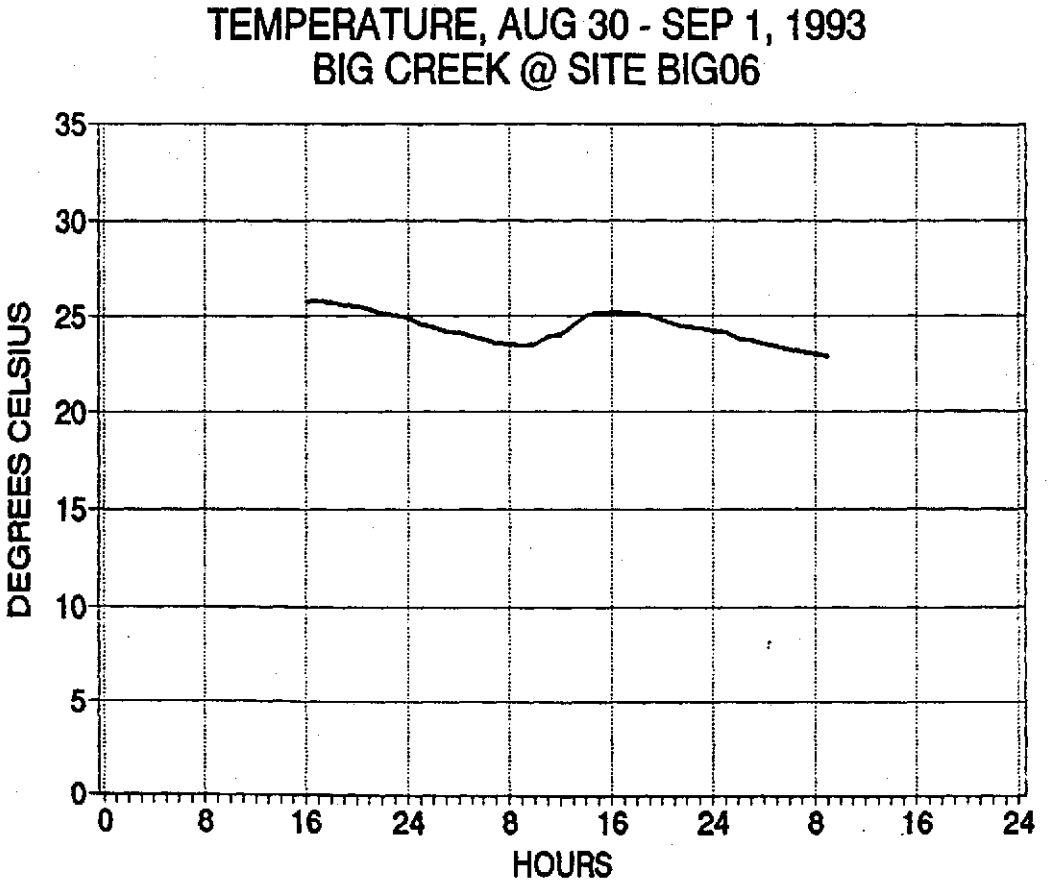

TEMPERATURE, AUG 30 - SEP 1, 1993
HICKS CREEK BELOW STP (@ MILITARY RD)
DEGREES CELSIUS
35
30
25
20
15
10
5
0
0
8
16
24
8
16
24
8
16
24
HOURS

Figure 5


DISSOLVED OXYGEN, AUG 30-SEP 1, 1993
BIG CREEK @ SITE BIG06
mg/l
12
11
10
9
8
7
6
5
4
3
2
1
0
160%
140%
120%
100%
80%
60%
40%
0
8
16
24
8
16
24
8
16
24
HOURS
D.O.
% D.O. SAT.


TEMPERATURE, AUG 30 - SEP 1, 1993
BIG CREEK @ SITE BIG06
DEGREES CELSIUS
35
30
25
20
15
10
5
0
0
8
16
24
8
16
24
8
16
24
HOURS

Chlorides, Sulfates, And Total Dissolved Solids

ADPC&E's routine water monitoring network has established one station on Hicks Creek--at the Military Road bridge (WHI 65). This station, which was established for the purpose of monitoring the effects of the Mountain Home STP effluent on water quality, corresponds to the 1993 survey station HIC 04. The 1994 biennial Water Quality Inventory Report (305-b) summarized two years of monthly samples from this site. The mean value for chlorides at this station was 30.38 mg/l, with a range from 8 mg/l to 73 mg/l. The 1983 ecoregion data indicates a "background" level of 8 mg/l for chlorides for small watershed streams. The 1993 survey sample collected at this station had a concentration of 51.2 mg/l. In contrast, the upstream Hicks Creek station (HIC 01) had a concentration of 11.8 mg/l. The STP sample had a concentration of 78.3 mg/l--a seven-fold increase over background Hicks Creek concentrations. Smaller increases were noted in total dissolved solids. Storet data at WHI 65, listed as a two year summary in the 1994 305-b report, indicated a TDS range from 205 to 562 mg/l, with a mean of 314.5 mg/l. TDS data at HIC 04 was 372 mg/l at the survey date. The upstream station, HIC 01, had a TDS of 248 mg/l, while the upstream Big Creek site (BIG 06) had a concentration of 269 mg/l. Ecoregion data indicated an averarge value of 161 mg/l for all Ozark Highland watersheds studied. During this survey, the TDS concentration of the STP effluent was 405 mg/l.

Sulfate concentrations in the Hicks Creek watershed were relatively high as compared with background ecoregion data. The summertime ecoregion average for all watersheds surveyed was only 5 mg/l, with the small watersheds averaging only 1.5 mg/l. Contrasting these low numbers is the upstream Hicks Creek value of 18.1 mg/l and the Big Creek concentration of 10.4 mg/l. These high sulfates may reflect the nature of the watersheds drained--urban dominated for Hicks Creek, and pasture dominated for Big Creek. The STP effluent was 24.8 mg/l during the survey, with dilution reducing the concentration to 22.4 mg/l at HIC 04 (WHI 65). The 1994 305-b data indicates an average concentration of 19.75 mg/l at WHI 65, with a range of only 16 to 23 mg/l.

BOD, TSS, And Nutrients

As noted earlier, the 1981 Mayes, Sudderth and Etheredge report recorded five day BOD's averaging 27 mg/l and ammonia nitrogen concentrations of 8.4 mg/l in the early November survey. An analysis of the BOD data from WHI 65 for the last ten years shows several high BOD values occuring at this site prior to 1988 when the new treatment facility became operable. Since that time the highest BOD_5 has been 6.3 mg/l in May 1992, and 4.9 mg/l in August 1993, with an average value of 1.94 mg/l. The 1993 survey data for this site had a BOD_5 of 1.1 mg/l. This data indicates obvious treatment improvement in BOD removal has occurred since 1988.

Total suspended solids data has generally been fairly low over the ten year record at WHI 65. Occasional high fluctuations can be attributed to rainfall events because high turbidity values occur simultaneously. The effluent TSS concentration during the 1993 survey was 2 mg/l. The TSS value at WHI 65 during the survey was only 1 mg/l.

An analysis of the most recent ten years of nutrient data at the WHI 65 station indicated a reversal in the concentrations of ammonia nitrogen and nitrate nitrogen when the new plant went into operation in January 1988. Prior to that time ammonia nitrogen concentrations ranging from three to eight mg/l were common at this location, but post-1988 data revealed concentrations rarely exceeding 0.1 mg/l. Conversely, the nitrate values exhibited periodic high concentrations since January 1988. Post-88 nitrate data from this station averaged 6.1 mg/l, with a high value of 18.3 mg/l. Although there are exceptions, generally when ammonia nitrogen concentrations are low, the nitrate values are elevated. This is evidenced by the data base from the WHI 65 (HIC 04) station. The 1993 survey data also verifies this assumption. The effluent ammonia nitrogen concentration was 0.08 mg/l, while the nitrate nitrogen was 15.6 mg/l. Stream dilution and utilization by vascular plants, algae and periphyton only reduced the nitrate concentration to 11.2 mg/l at the WHI 65 site. The nitrates remained high to the confluence of Big Creek, which afforded a 50% dilution of the nutrient concentrations. Figures 6 and 7 provide the nitrate nitrogen concentrations and loadings analyzed during this survey of Hicks Creek.

There is no definable pattern in phosphorus concentrations at WHI 65 over the ten year data base. Values range from 0.2 mg/l up to 5.7 mg/l at this stream site. The 1993 survey data indicated normal background levels of phosphorus (0.05 mg/l) upstream of the STP and effluent concentrations generally representative of advanced treatment municipal systems having no specialized phosphorus removal capability. A concentration of 3.0 mg/l total phosphorus was measured in the effluent during this survey. The WHI 65 site had a total phosphorus concentration of 2.1 mg/l during the survey period. Figures 6 and 7 give an indication of the total phosphorus stream concentrations and loadings for the 1993 survey and indicate the rate of uptake and utilization from the effluent down to HIC 05.

Metals and Total Residual Chlorine

An analysis of metals concentrations was conducted on the STP effluent and downstream at HIC 04 in order to evaluate any potential toxicity from this source. The HIC 04 (WHI 65) is one of the ADPCE ambient monitoring locations so any trend in metals concentrations would be detectable at this site. An evaluation of the data base has not revealed any high concentrations in any of the metals analyzed. Total residual chlorine was also sampled at

FIGURE 6

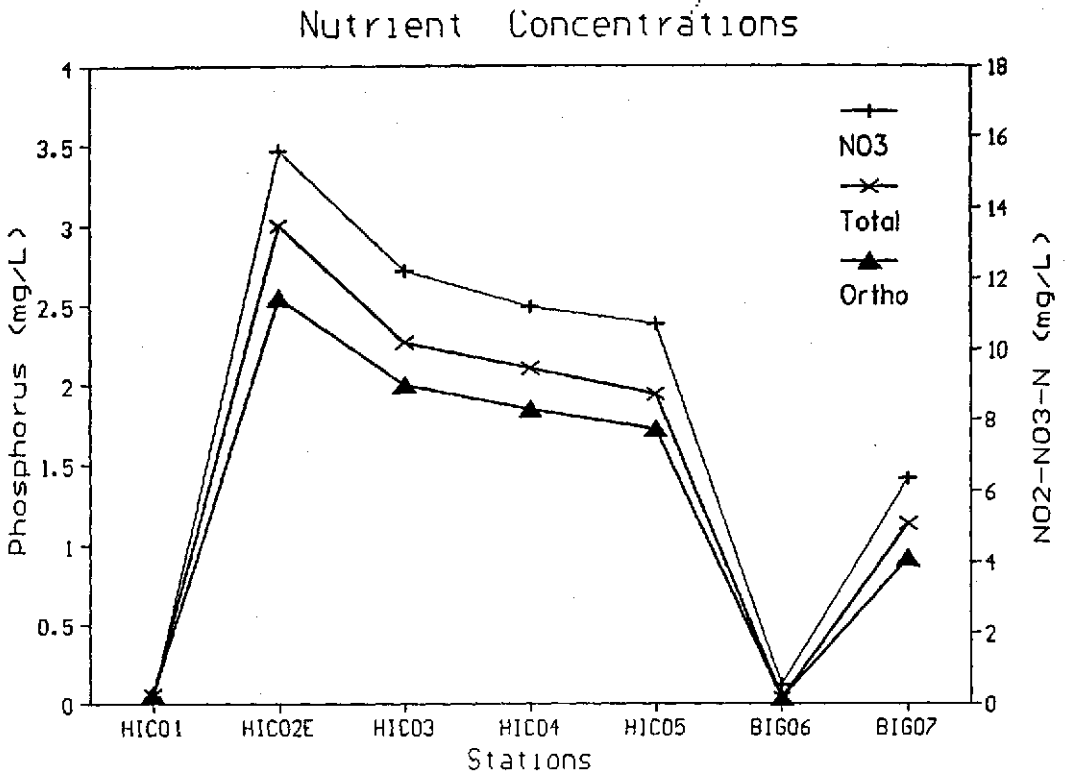
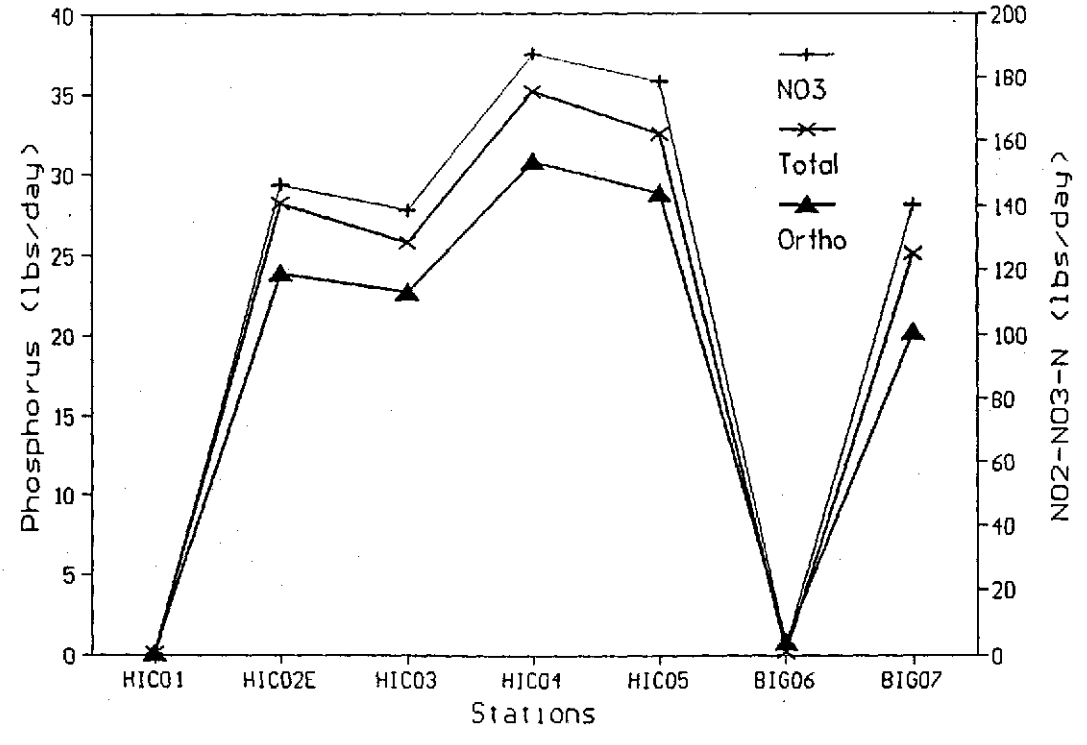


FIGURE 7



these two locations. A concentration of 0.38 mg/l was measured in the STP effluent during this survey. This level has the potential to cause toxicity to aquatic life in a stream dominated by effluent flow. Due to the stream turbulence and distance downstream, total residual chlorine was not detectable at the HIC 04 site.

Macroinvertebrates

A total of five macroinvertebrate stations were established in the Hicks Creek-Big Creek watershed for purpose of determining any impact on the benthic community from the Mountain Home wastewater treatment plant effluent discharge. One site was located in Hicks Creek just above the STP outfall; another site was sampled on Big Creek above the Hicks Creek confluence in order to assess the benthic community that receives no impact from the STP effluent. Three additional sites were established downstream of the effluent discharge in order to assess the degree of impact of the wastewater on the benthic community structure.

As was noted previously, these sites were sampled according to established rapid bioassessment protocol, with a five minute riffle search performed at each location. One hundred organisms were randomly selected and preserved at each site, then identified in the central laboratory. The extent of impairment of the benthic community below the wastewater discharge is determined by use of the biometric scoring system. This system, which assigns scores to various characteristics of the benthic community, can define relative change between communities upstream and downstream of a pollutant source. A mean biometric score is assigned to each community identifying its aquatic life use status, as determined by the extent of impairment ranging from none, minimal, substantial to excessive.

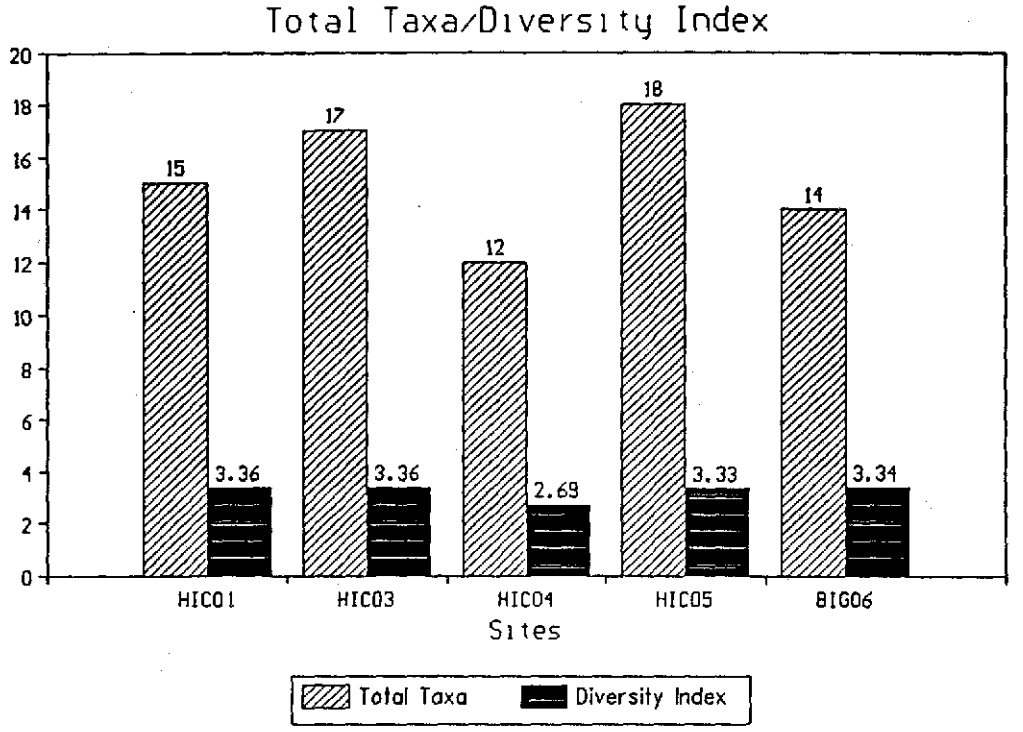
The biometrics evaluated from the 1993 survey data focus primarily on community diversity, and consist of Dominants in Common (DIC), Common Taxa Index (CTI), Quantitative Similarity Index (QSI) and Taxa Richness (Shackleford, 1988). Community comparisons were made between the Big Creek and upstream Hicks Creek inhabitants (Stations BIG 06 and HIC 01), BIG 06 and HIC 03, BIG 06 and HIC 04, BIG 06 and HIC 05, as well as community comparisons between HIC 01 and HIC 03, HIC 01 and HIC 04, HIC 01 and HIC 05. Figure 2 identifies the sites where macroinvertebrate samples were collected.

A comparison of the benthic community from the Big Creek station to those in the Hicks Creek drainage revealed differences in community structure. For instance, the HIC 01 (upstream Hicks Creek) comparison had a DIC of 2, CTI of .6, and a QSI of 55. Two of these three metrics are in the substantial impairment category. A comparison of Big Creek with the downstream Hicks Creek (HIC 04) revealed a DIC of 1, CTI of .64, and a QSI of 32. Two of the three metrics were in the excessive impairment category. These comparisons reflect the differing nature of the watersheds of the

two streams, and also reveal the limitations for use of the RBA technique. Community comparisons within the same drainage provide a more accurate assessment of pollutant impacts. Although not as expected, the Hicks Creek benthic community immediately below the STP outfall (HIC 03) appears to be less impacted more than the next Hicks Creek site downstream (HIC 04). The stream flow is consistently dominated by the municipal effluent, except possibly during rainfall events, so any type of deviations from the normal high quality effluent would be expected to be more visable at this site. However, a comparison of this site to that located at HIC 01--the background site on Hicks Creek--revealed more taxa, a DIC value of 4, CTI of 0.71 and a QSI of 63. The DIC, CTI, and QSI values correspond to no impairment, no impairment, and minimal impairment, respectively.

Although rapid bioassessment metrics are designed to measure impacts above and below point source discharges (i.e. above and below the STP), some of the metrics evaluated for these two stations indicate a relatively healthy macroinvertebrate community existing in the "effluent stream". A benthic diversity index of 3.36 upstream compared to 3.35 at the first downstream site indicates no community impact, yet as seen in figures 8, 9, and 10, an impact is evident at the next downstream site. The "impact" is more likely explained by differences in stream morphology rather than direct point source influence. Hicks Creek above the HIC 04 site consists of a reach of lower gradient than exists in the HIC 03 area, contains longer and wider pools, and the presence of instream nutrients are evident in filamentous algae covering the substrate. These factors and a reduced velocity through the riffle area at HIC 04 may be responsible for the community differences observed. Subsequent recovery is seen at the following downstream station, which was located in a steeper gradient reach of stream. In figures 9 and 10, the data displayed as WHI 65A and 65B (87) are from a rapid bioassessment collection perfromed by ADPC&E ecologists during August of 1987. These sites were established on Hicks Creek above and below the wastewater treatment facility and correspond to HIC 01 and HIC 03. Metrics evaluated for the benthic communities existing at that time indicated excessive impairment at the downstream site. A comparison of the 1987 community analyses with the 1993 analyses demonstrates a significant improvement in the downstream benthic assemblage in all the metrics evaluated. One of the more notable changes is in the Quantitative Similarity Index, which increased from 6 to 63, and also the Diversity Index, which rose from 0.08 to 3.35. The magnitude of the recovery of the benthic community at this site is very significant. It improved from a severely impacted assemblage consisting of 99% bloodworms to a community comprising a good diversity of pollution-intolerant organisms. This verifies that if the sources of pollution are removed, or if an effective treatment of existing point sources is achieved, then streams can and do recover to a level supportive of growth and propagation of aquatic life. The benthic species lists and associated biometrics generated from this survey are included as Appendix B.

Figure 8


Total Taxa/Diversity Index
20
18
16
14
12
10
8
6
4
2
0
15
3.36
17
3.36
12
2.69
18
3.33
14
3.34
HIC01
HIC03
HIC04
HIC05
BIG06
Sites
Total Taxa
Diversity Index

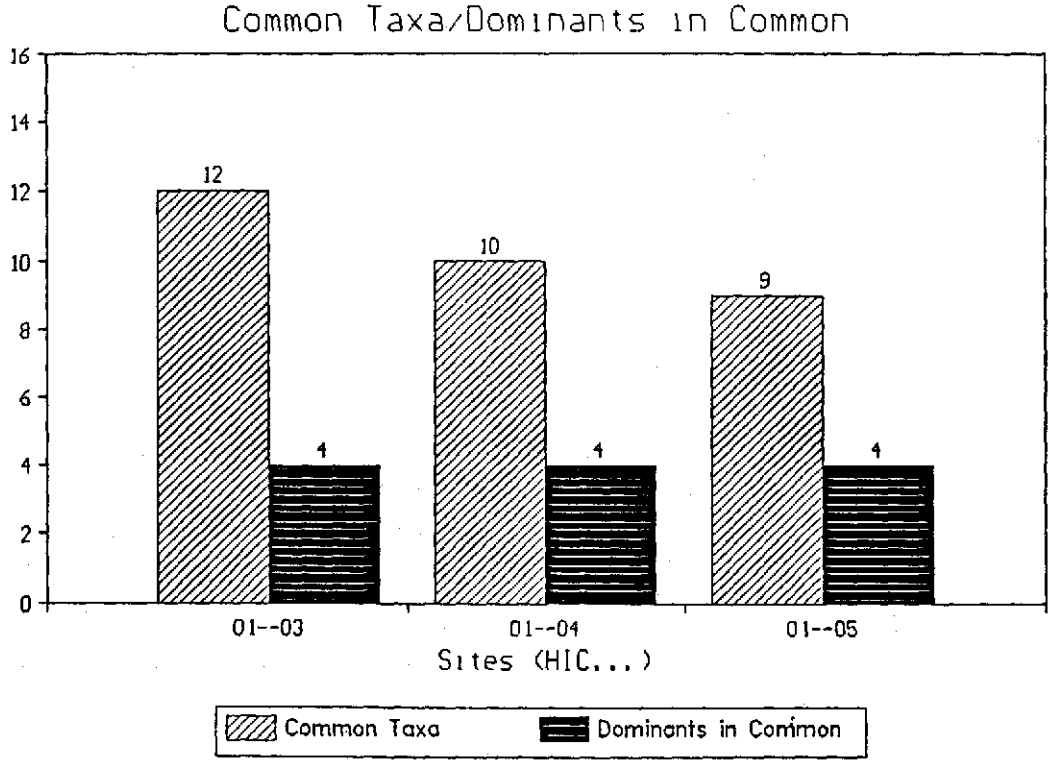
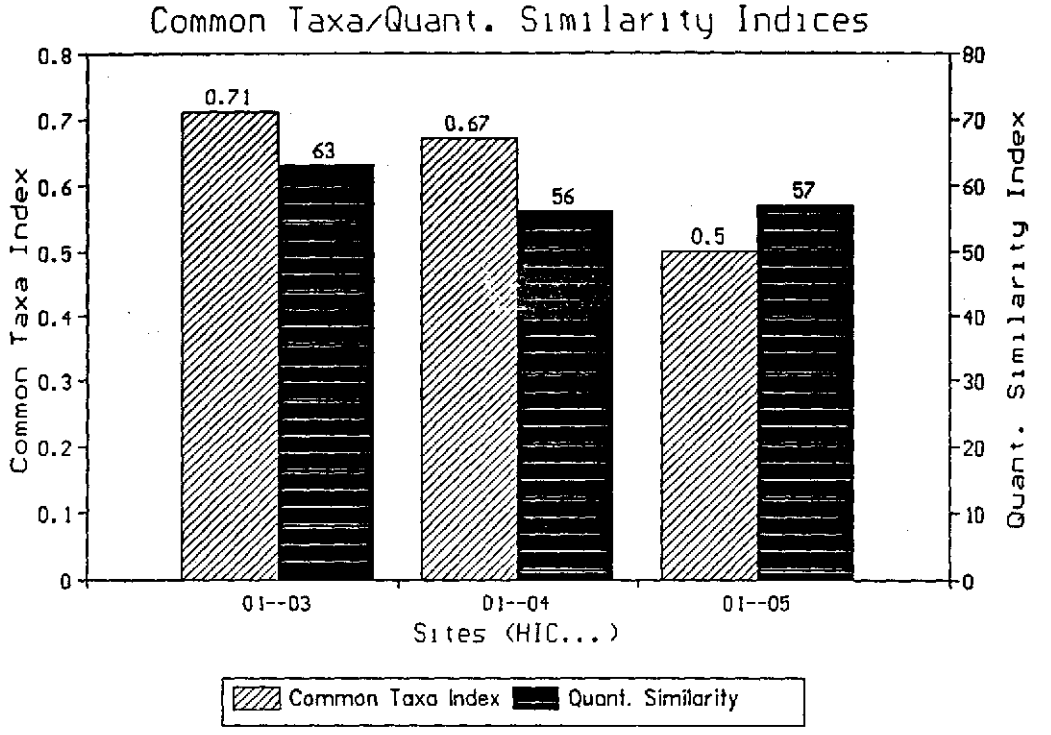

Common Taxa/Dominants in Common
16
14
12
10
8
6
4
2
0
12
4
10
4
9
4
01--03
01--04
01--05
Sites (HIC...)
Common Taxa
Dominants in Common

Figure 9


Common Taxa/Quant. Similarity Indices
Common Taxa Index
Quant. Similarity Index
0.71
63
0.67
56
0.5
57
01--03
01--04
01--05
Sites (HIC...)
Common Taxa Index
Quant. Similarity

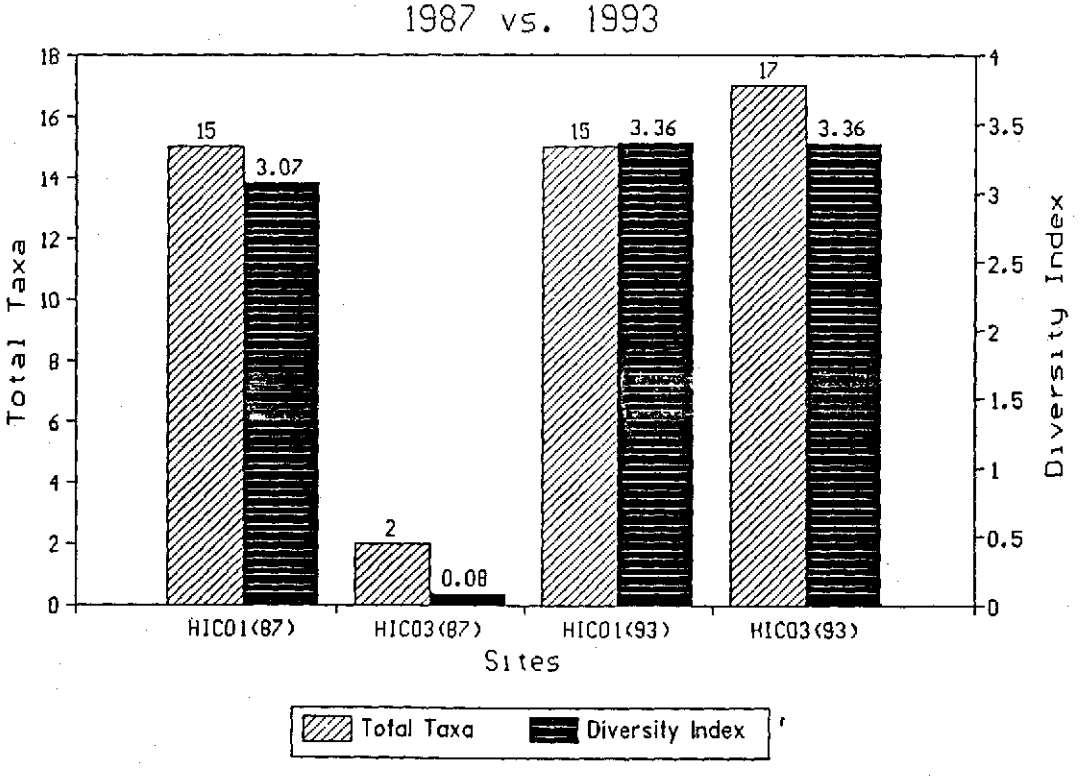
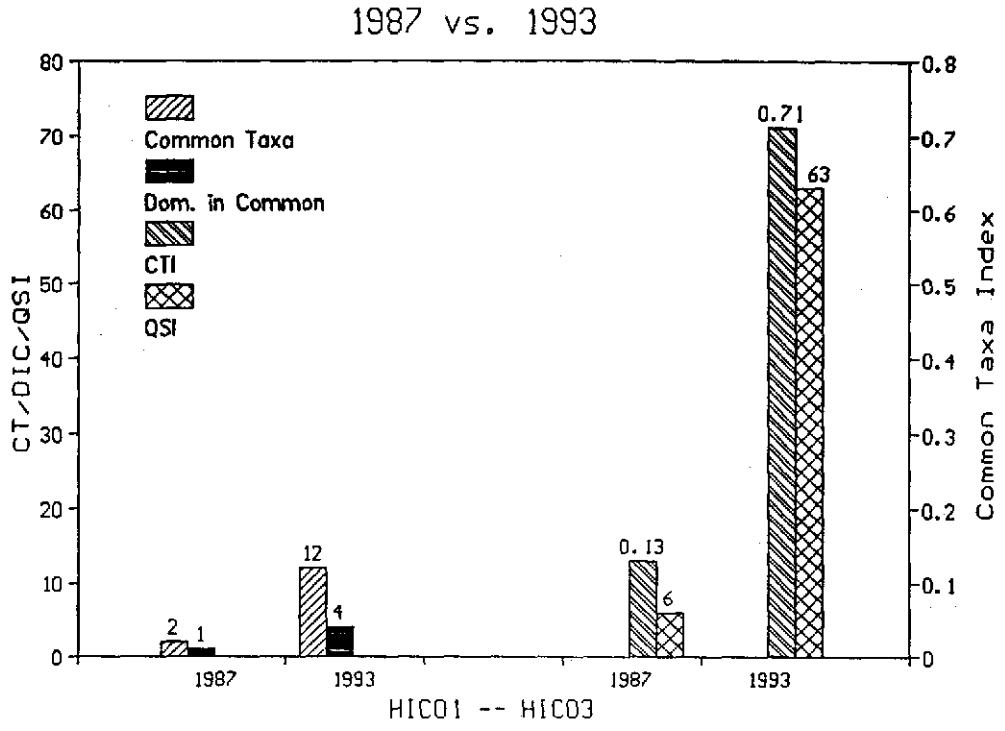

1987 vs. 1993
Total Taxa
Diversity Index
15
3.07
2
0.08
15
3.36
17
3.36
HIC01(87)
HIC03(87)
HIC01(93)
HIC03(93)
Sites
Total Taxa
Diversity Index

Figure 10



Fish Community

Fish communities were sampled at two locations during the Hicks Creek survey:

Site # 1--Hicks Creek at the Military Road bridge downstream for 1/4 mile (HIC 04).

Site # 2--Big Creek upstream of the Hicks Creek confluence (BIG 06).

The fish sampling sites are depicted in figure 2. Each site was sampled for approximately 40-45 minutes hours using a Smith-Root backpack electrofisher. Riffle areas were sampled by placing a seine below the riffle and driving the fish into the seine by shocking and substrate manipulation. The larger specimens collected were identified, recorded, and released. Smaller specimens were preserved and returned to the central laboratory for counting and identification.

The fish community survey was completed on August 31, 1993 in Hicks Creek (HIC04) and Big Creek (BIG06). Fourteen species, 1174 specimens, were collected from Hicks Creek and eighteen species,

900 specimens, were collected from Big Creek. Appendix C is a list of the species collected from Hicks Creek and Big Creek including the percent community for each species.

The Cyprinidae family comprised 83% and 85% of the communities at HIC04 and BIG06, respectively. The stoneroller comprised about 68% of the total community at each location. There was a slight increase in the duskystripe shiner in Big creek over Hicks Creek, and a larger population of the southern redbelly dace in Hicks Creek. The duskystripe shiner feeds primarily on small insects and crustaceans, while the dace is more of an algae eater. This perhaps is indicating the presence of a more nutrient rich environment in Hicks Creek as compared to Big Creek.

There does seem to be a difference in the Centrarchidae community between the two sites not related to habitat. With the greater pool habitat in Hicks Creek versus Big Creek one would expect to find a larger Centrarchid community. The sunfishes comprised less than two percent (2%) of the community in Hicks Creek as compared to almost five percent (5%) of the community in Big Creek. This may be indicating the presence of some form of toxicity inhibiting the spawning activities of the Centrarchid family in Hicks Creek.

The Percidae family comprised 13% and 7% of the communities in Hicks Creek and Big Creek, respectively. However, almost 95% of the Hicks Creek darter community was comprised of the orangethroat darter. This is one of the few darter species that is opportunistic and adapts well to conditions that reduce other darter populations. The Big Creek darter community was fairly well distributed between three species with the rainbow darter being dominant, followed by the orangethroat and greenside darters.
The fish communities in Hicks Creek and Big Creek are quite similar, however notable differences do occur. Some of these differences may be due to habitat difference between the two sites. However, nutrient enrichment may be contributing to the shift in some of Cyprinid species. Also, there may be some form of toxicity occurring in Hicks Creek inhibiting the sunfish family, and the notably skewed darter community is likely a result of stressed conditions instream. Appendix C lists the species collected at each site and the percent composition of each family identified.

CONCLUSIONS

A review of the water chemistry analyses in terms of permitted constituents in the Mountain Home wastewater effluent discharge indicates an excellent removal efficiency for BOD, TSS, and NH_3N, with measured values of 2.4, 4.0, and 0.08 mg/l, respectively, at the outfall to Hicks Creek. A comparison of the effluent concentrations with those recorded at the upstream Hicks Creek site--which had a BOD, TSS, and NH_3N of 0.4, 2.0, and 0.08 mg/l, respectively. This verifies the presence of excellent treatment for the permitted parameters. If the review of the chemical

analyses ended with these parameters, it would seem evident that there should be no adverse impacts on the receiving stream water quality from this wastewater discharge; however, a review of some of the non-permitted wastewater constituents, such as chlorides, nitrates, and phosphates, indicates that a change in water quality is occuring due to the wastewater influence. A five-fold increase in chloride concentration, a 76-fold increase in nitrate concentration, and a 45-fold increase in total phosphorus concentration from the upstream Hicks Creek station to the first station below the STP effluent lends credence to the assumption that significantly elevated levels of these constituents are occuring in this stream due to the STP effluent. Further comparisons of these three parameters in Hicks Creek in a downstream progression indicate minimal utilization and removal is occuring. Nitrate nitrogen concentrations were still 67 times higher, chlorides 4.9 times higher, and total phosphorus concentrations were 38.8 times greater at HIC 05 than at HIC 01. Figures 6-7 depict the utilization/removal rates for nitrates and phosphorus in a downstream direction. Sufficient concentrations of these nutrients still exist at the lower Hicks Creek stations to produce algae populations capable of causing large dissolved oxygen diurnal fluctuations, as noted in figure 4. Even with the dilution of the upstream Big Creek flow, with its "background" concentrations, nutrients are still present in sufficient concentrations to create nuisance algae. If extended periods of hot, dry weather occur in this area, the nutrient contributions from the Mountain Home STP effluent could result in substantial algae blooms and subsequent die-off. This cycle will stress the aquatic inhabitants and further impact the macroinvertebrate and fish community currently inhabiting Hicks and Big Creeks.

RECOMMENDATIONS

It is recommended that the Mountain Home wastewater treatment facility address the problem of periodic high nitrate discharges into Hicks Creek. Additionally, investigations should be made to identify any treatment plant modifications required to achieve a more efficient removal of nitrate nitrogen, as well as establish requirements for better control of influent chlorides. Instream chlorides concentrations, as well as total dissolved solids, were exceeding water quality standards established for Ozark Highland ecoregion streams.

Future permit limits for this facility should consider limitations on nitrate discharges to no more than the 10 mg/l MCL for drinking water supplies, since this stream is designated for drinking water uses. Additionally, most streams in this area of the state enter the groundwater which also may be used for drinking water supplies. Finally, residual chlorine limitations should be addressed, based on the effluent total residual chlorine concentration analyses listed in Appendix A.

Appendix A

MOUNTAIN HOME
HICKS CREEK WATER QUALITY DATA

Site	DO mg/l	pH	TEMP (C)	TOC mg/l	BOD mg/l	NH3-N mg/l	NO3-N mg/l	O-PHOS mg/l	T-PHOS mg/l	CL mg/l	TDS mg/l	SO4 mg/l	T-HARD mg/l	TURB NTU	TSS mg/l	FLOW cfs
HIC01	7.8	7.90	23.8	5.69	0.4	0.08	0.16	0.05	0.05	11.80	248	18.1	231	3.4	2	0.37
HIC02E	8.6	7.63	26.7	7.44	2.4	0.08	15.60	2.54	3.00	78.30	405	24.8	188	2.0	4	1.74
HIC03	7.6	7.81	25.8	6.20	2.8	0.08	12.20	1.99	2.26	60.70	366	23.2	188	3.0	4	2.11
HIC04	6.2	7.62	24.1	6.27	1.1	0.07	11.20	1.84	2.10	56.70	372	22.4	206	2.4	1	3.10
HIC05	7.7	7.72	24.9	6.23	0.6	0.07	10.70	1.72	1.94	57.60	364	22.4	201	1.8	1	3.10
BIG06	7.9	7.64	22.8	4.40	0.5	0.05	0.51	<0.03	<0.03	6.09	269	10.4	258	1.4	1	1.01
BIG07	7.0	7.57	24.2	6.50	0.7	0.05	6.33	0.91	1.13	36.30	329	17.2	234	3.6	10	4.11

Total Residual Chlorine & Total Recoverable Metals

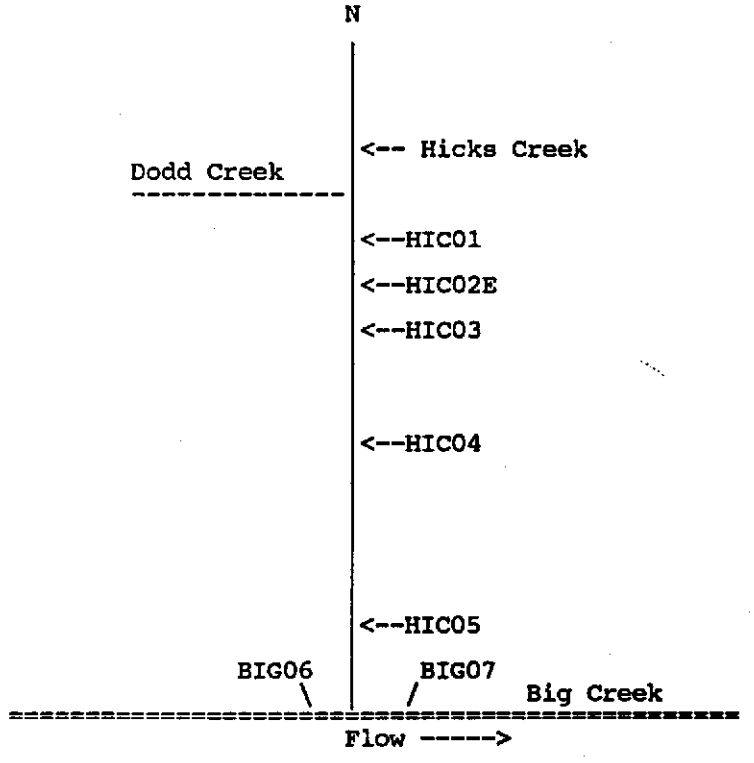
Site	TRC mg/l	Cd ug/l	Cr ug/l	Cu ug/l	Pb ug/l	Zn ug/l
HIC02E	0.38	<0.5	1.0	4.0	<2.0	17.0
HIC04	0.00	<0.5	<1.0	4.0	<2.0	<8.0

LOADINGS (lbs/day)

Site	FLOW	NH3-N	NO3-N	O-PHOS	T-PHOS	CL	SO4
HIC01	0.37	0.16	0.32	0.10	0.10	23.52	36.08
HIC02E	1.74	0.75	146.24	23.81	28.12	734.02	232.49
HIC03	2.11	0.91	138.69	22.62	25.69	690.03	263.74
HIC04	3.10	1.17	187.06	30.73	35.07	946.99	374.12
HIC05	3.10	1.17	178.71	28.73	32.40	962.02	374.12
BIG06	1.01	0.27	2.78	0.16	0.16	33.14	56.59
BIG07	4.11	1.11	140.17	20.15	25.02	803.80	380.86

SITE LOCATIONS

HIC01	Hicks Creek 20yds above Mountain Home STP
HIC02E	Mountain Home STP effluent
HIC03	Hicks Creek 150yds below Mountain Home STP effluent
HIC04	Hicks Creek @ Military Road
HIC05	Hicks Creek 50yds above Big Creek confluence
BIG06	Big Creek above Hicks creek confluence
BIG07	Big Creek 50 yds below Hicks Creek confluence



Appendix B

Benthic Community Comparision

Stations: WHI0065A Hicks Cr AB Mountain Home AR
Sample Date 93-09-01
Sample Time 0900
Sampling technique employed SMR
WHI0139 HICKS CR. 200 YARDS BELOW MOUNTAIN HOME
Sample Date 93-09-01
Sample Time 1000
Sampling technique employed SMR

Printed on 3-FEB-1994

Qual. Similarity Index	= 63.
Dominants in Common	= 4
Taxa in Common	= 12
Common Taxa Index	= 0.71
Pro. Judgement Score	= 2

			WHI0065A	WHI0139
# of Taxa		=	15	17
# of organisms		=	100	100
# Ephemeroptera	taxa	=	4	4
# Trichoptera	taxa	=	1	1
# Coleoptera	taxa	=	3	3
# Chironomidae	taxa	=	3	2
Annelida	cnt/%	=	1/ 1.0	1/ 1.0
Ephemeroptera	cnt/%	=	52/ 52.0	38/ 38.0
Trichoptera	cnt/%	=	13/ 13.0	7/ 7.0
Coleoptera	cnt/%	=	6/ 6.0	11/ 11.0
Chironomidae	cnt/%	=	7/ 7.0	6/ 6.0
Biotic score		=	0	0

Taxa @ WHI0065A but not @ WHI0139

MAYFLY NYMPH	Isonychia		5	5.0
BLOODWORM	Cricotopus		1	1.0
WATER SCAVINGER BEET	Hydrochara		1	1.0

Taxa @ WHI0139 but not @ WHI0065A

DAMSELFLY NAIAD	Argia		6	6.0
SNIPEFLY LARVA	Atherix	variegata	1	1.0
DAMSELFLY NAIAD	Hetaerina		1	1.0
MAYFLY NYMPH	Stenacron	interpunctatum	1	1.0
BEETLE,PREDACEOUS DI	Hydrovatus		1	1.0

Benthic Community Comparision

Stations: WHI0065A Hicks Cr AB Mountain Home AR
Sample Date 93-09-01
Sample Time 0900
Sampling technique employed SMR
WHI0065 Hicks Cr BL Mt Home AR
Sample Date 93-08-31
Sample Time 1000
Sampling technique employed SMR

Printed on 3-FEB-1994

Qual. Similarity Index = 56.
Dominants in Common = 4
Taxa in Common = 10
Common Taxa Index = 0.67
Pro. Judgement Score = 2

			WHI0065A	WHI0065
# of Taxa		=	13	13
# of organisms		=	100	100
# Ephemeroptera	taxa	=	4	3
# Trichoptera	taxa	=	1	1
# Coleoptera	taxa	=	3	3
# Chironomidae	taxa	=	3	1
Annelida	cnt/%	=	1/ 1.0	0/ 0.0
Ephemeroptera	cnt/%	=	52/ 52.0	26/ 26.0
Trichoptera	cnt/%	=	13/ 13.0	36/ 36.0
Coleoptera	cnt/%	=	6/ 6.0	3/ 3.0
Chironomidae	cnt/%	=	7/ 7.0	13/ 13.0
Biotic score		=	3	0

Taxa @ WHI0065A but not @ WHI0065

MAYFLY NYMPH	Caenis			3	3.0
BLOODWORM	Pentaneura			3	3.0
WATER SCAVINGER BEET	Hydrochara			1	1.0
LEECH	Helobdella			1	1.0
BLOODWORM	Cricotopus			1	1.0

Taxa @ WHI0065 but not @ WHI0065A

DAMSELFLY NAIAD	Hetaerina			3	3.0
BEETLE, ELMID,ADULT	Dubiraphia		quadrinotata	1	1.0

Benthic Community Comparision

Stations: WHI0065A Hicks Cr AB Mountain Home AR
Sample Date 93-09-01
Sample Time 0900
Sampling technique employed 5MR
WHI0140 HICKS CR. 100 YARDS ABOVE BIG CREEK CONF
Sample Date 93-08-31
Sample Time 0900
Sampling technique employed 5MR

Printed on 3-FEB-1994

Qual. Similarity Index = 57.
Dominants in Common = 4
Taxa in Common = 9
Common Taxa Index = 0.50
Pro. Judgement Score = 2

		WHI0065A	WHI0140
# of Taxa	=	15	13
# of organisms	=	100	100
# Ephemeroptera taxa	=	4	4
# Trichoptera taxa	=	1	2
# Coleoptera taxa	=	2	2
# Chironomidae taxa	=	3	2
Annelida cnt/%	=	1/ 1.0	0/ 0.0
Ephemeroptera cnt/%	=	52/ 52.0	34/ 34.0
Trichoptera cnt/%	=	12/ 12.0	27/ 27.0
Coleoptera cnt/%	=	6/ 6.0	3/ 3.0
Chironomidae cnt/%	=	7/ 7.0	4/ 4.0
Biotic score	=	3	3

Taxa @ WHI0065A but not @ WHI0140

MAYFLY NYMPH	Stenonema		22	22.0
MAYFLY NYMPH	Caenis		9	9.0
BEETLE, ELMID, LARVA	Stenelmis		2	2.0
LEECH	Helobdella		1	1.0
BLOODWORM	Cricotopus		1	1.0
WATER SCAVINGER BEET	Hydrochara		1	1.0

Taxa @ WHI0140 but not @ WHI0065A

CLAM	Corbicula	flueminia	3	3.0
CADDISFLY,LARVA	Hydropsyche sp.		3	3.0
SNAIL	Goniobasis		2	2.0
MAYFLY NYMPH	Tricorythodes		2	2.0
MAYFLY NYMPH	Ephemerella		1	1.0
BEETLE, ELMID	Nerpus		1	1.0
DAMSELFLY NAIAD	Argia		1	1.0
HORSEFLY LARVA	Tabanus		1	1.0
DANCEFLY LARVA	Hemerodromia		1	1.0

Benthic Bioassessment
Station # WHI0065A
Hicks Cr AB Mountain Home AR
Eco Reg.# OZHI
Segment # 4F
Sample Date 93-08-31
Sample Time 0900
Sampling technique employed EMR
Printed on 4-FEB-1994

# of Taxa = 15	# of organisms = 100		Biotic score = 0		
			% Annelida	=	1.0
# Ephemeroptera	taxa = 4		% Ephemeroptera	=	52.0
# Trichoptera	taxa = 1		% Trichoptera	=	12.0
# Coleoptera	taxa = 3		% Coleoptera	=	6.0
# Chiroromidae	taxa = 3		% Chironomidae	=	7.0

Diversity index = 3.3540146

Group summary

SH= 7 SC= 27 PR= 14 GC= 35 FC= 17

SH%= 7 SC%= 27 PR%= 14 GC%= 35 FC%= 17

Bio #	Name		Gr	Count	%
18030510007	MAYFLY NYMPH	Stenonema	SC	22	22.0
18020508002	MAYFLY NYMPH	Baetis	GC	16	16.0
18020704002	CADDISFLY LARVA	Cheumatops	FC	12	12.0
18021302011001	HELLGRAMMITE	Corydalus cornutus	PR	10	10.0
18020503002	MAYFLY NYMPH	Caenis	SC	9	9.0
18021215020	RIFFLE BEETLE, ADULT	Stenelmis adult	GC	5	5.0
18031311005	MAYFLY NYMPH	Isonychia	FC	5	5.0
18010302002	CRAYFISH	Orconectes	SH	3	3.0
18021115085	BLOODWORM	Pentaneura	PR	3	3.0
18021115067999	BLOODWORM	Polypedilu	SH	3	3.0
18021217004	WATER PENNY	Psephenus	SC	3	3.0
18021215020	BEETLE, ELMID, LARVA	Stenelmis	SC	2	2.0
18021115025	BLOODWORM	Cricotopus	SH	1	1.0
17020101004	LEECH	Helobdella	PR	1	1.0
18021203019	WATER SCAVINGER BEET	Hydrochara	GC	1	1.0

Benthic Bioassessment
Station # WHI0139
HICKS CR. 200 YARDS BELOW MOUNTAIN HOME STP
Eco Reg.# OZHI
Segment # 4F
Sample Date 93-09-01
Sample Time 1000
Sampling technique employed SMR
Printed on 4-FEB-1994

# of Taxa = 17 # of organisms = 100 Biotic score = 0

		% Annelida	= 1.0
# Ephemeroptera	taxa = 4	% Ephemeroptera	= 36.0
# Trichoptera	taxa = 1	% Trichoptera	= 7.0
# Coleoptera	taxa = 3	% Coleoptera	= 11.0
# Chironomidae	taxa = 2	% Chironomidae	= 6.0

Diversity index = 3.3500148

Group summary

SH=	7	SC=	14	PR=	22	GC=	50
SH%=	7	SC%=	14	PR%=	22	GC%=	50

FC= 7
FC%= 7

Tic #	Name			Gr	Count	%
18020508002	MAYFLY NYMPH	Baetis		GC	23	23.0
90218150 20	RIFFLE BEETLE, ADULT	Stenelmis	adult	GC	13	13.0
18020302031011	HELLGRAMMITE	Corydalus	cornutus	PR	12	12.0
18020704002	CADDISFLY LARVA	Cheumatopa		FC	7	7.0
18020408003	DAMSELFLY NAIAD	Argia		PR	6	6.0
18021217004	WATER PENNY	Psephenus		SC	5	5.0
18021215020	BEETLE, ELMID, LARVA	Stenelmis		GC	5	5.0
18020508002	MAYFLY NYMPH	Caenis		GC	4	4.0
18021115087030	BLOODWORM	Polypedilu		GC	4	4.0
18010302003	CRAYFISH	Orconectes		SH	3	3.0
18020510007	MAYFLY NYMPH	Stenonema		SC	3	3.0
18021115085	BLOODWORM	Pentaneura		PR	2	2.0
18021117001001	SNIPEFLY LARVA	Atherix	variegata	PR	1	1.0
18020411002	DAMSELFLY NAIAD	Hetaerina		PR	1	1.0
17020101004	LEECH	Helobdella		PR	1	1.0
18020510011005	MAYFLY NYMPH	Stenacron	interpunct	SC	1	1.0
18021205023	BEETLE,PREDACEOUS DI	Hydrovatus		PR	1	1.0

Benthic Bioassessment
Station # WHI0065
Hicks Cr BL Mt Home AR
Eco Reg.# OZHI
Segment # 4F
Sample Date 93-08-31
Sample Time 1000
Sampling technique employed SMR
Printed on 4-FEB-1994

# of Taxa = 12 # of organisms = 100 Biotic score = 0

			% Annelida	=	0.0
# Ephemeroptera	taxa =	3	% Ephemeroptera	=	26.0
# Trichoptera	taxa =	1	% Trichoptera	=	36.0
# Coleoptera	taxa =	3	% Coleoptera	=	3.0
# Chironomidae	taxa =	1	% Chironomidae	=	13.0

Diversity index = 2.6888025

Group summary

SH= 14 SC= 3 PR= 15 GC= 37 FC= 41

SH%= 14 SC%= 3 PR%= 15 GC%= 37 FC%= 41

Bio #	Name			In	Count	%
18020704002	CADDISFLY LARVA	Pteumatopa		FC	36	36.0
18020508002	MAYFLY NYMPH	Baetis		GC	20	20.0
18021115037999	BLOODWORM	Polycedilu		SH	13	13.0
18020802001001	HELLGRAMMITE	Corydalus	cornutus	PR	12	12.0
8021315020	RIFFLE BEETLE, ADULT	Stenelmis	adult	SC	6	6.0
18020511005	MAYFLY NYMPH	Isonychia		FC	5	5.0
18020411002	DANSELFLY NAIAD	Hetaerina		PR	3	3.0
18021215035002	BEETLE, ELMID,ADULT	Dubiraphia	quadrivata	GC	1	1.0
18010802303	CRAYFISH	Crustacea		SH	1	1.0
18021217004	WATER PENNY	Psephenus		GC	1	1.0
18021215020	BEETLE, ELMID, LARVA	Stenelmis		GC	1	1.0
18020510007	MAYFLY NYMPH	Stenonema		GC	1	1.0

Benthic Bioassessment

Station # WHI0140
HICKS CR. 100 YARDS ABOVE BIG CREEK CONFLUENCE
Eco Reg.# OZHI
Segment # 4F
Sample Date 93-08-31
Sample Time 0900
Sampling technique employed SMR
Printed on 4-FEB-1994

# of Taxa = 18 # of organisms = 100 Biotic score = 0

			% Annelida	=	0.0
# Ephemeroptera	taxa =	4	% Ephemeroptera	=	34.0
# Trichoptera	taxa =	2	% Trichoptera	=	27.0
# Coleoptera	taxa =	2	% Coleoptera	=	3.0
# Chironomidae	taxa =	2	% Chironomidae	=	4.0

Diversity index = 3.3348860

Group summary

SH= 4 SC= 4 PR= 17 GC= 27 FC= 48

SH%= 4 SC%= 4 PR%= 17 GC%= 27 FC%= 48

Bio #	Name			Gr	Count	%
18020704002	CADDISFLY LARVA	Cheumatops		FC	24	24.0
18020511005	MAYFLY NYMPH	Isonychia		FC	18	18.0
18020508002	MAYFLY NYMPH	Baetis		GC	11	11.0
18020802001001	HELLGRAMMITE	Corydalus	cornutus	PR	12	12.0
18021215020	RIFFLE BEETLE, ADULT	Stenelmis	adult	GC	10	10.0
19050404001001	CLAM	Corbicula	fluminia	FC	3	3.0
18020704	CADDISFLY,LARVA	Hydropsych		FC	3	3.0
18020502002	MAYFLY NYMPH	Tricorythо		GC	2	2.0
19030215002	SNAIL	Goniobasis		GC	2	2.0
18010302003	CRAYFISH	Orconectes		SH	2	2.0
18021115085	BLOODWORM	Pentaneura		PR	2	2.0
18021115087998	BLOODWORM	Polypedilu		SH	2	2.0
18021217004	WATER PENNY	Psephenus		SC	2	2.0
18020408003	DAMSELFLY NAIAD	Argia		PR	1	1.0
18020504001	MAYFLY NYMPH	Ephemerell		GC	1	1.0
18021120001	DANCEFLY LARVA	Hemerodrom		PR	1	1.0
18021215022	BEETLE, ELMID	Narpus		GC	1	1.0
18021118001	HORSEFLY LARVA	Tabanus		PR	1	1.0

Benthic Bioassessment
Station # WHI0141
BIG CREEK 100 YARDS ABOVE HICKS CREEK CONFLUENCE
Eco Reg.# OZHI
Segment # 4F
Sample Date 93-08-31
Sample Time 1300
Sampling technique employed SMR
Printed on 7-FEB-1994

# of Taxa = 14 # of organisms = 100 Biotic score = 0

			% Annelida	=	0.0
# Ephemeroptera	taxa =	3	% Ephemeroptera	=	43.0
# Trichoptera	taxa =	3	% Trichoptera	=	21.0
# Coleoptera	taxa =	1	% Coleoptera	=	3.0
# Chironomidae	taxa =	1	% Chironomidae	=	2.0

Diversity index = 3.3982897

Group summary

SH= 14 SC= 24 PR= 13 GC= 8 FC= 41

SH%= 14 SC%= 24 PR%= 13 GC%= 8 FC%= 41

Big #	Name		Gr	Count	%
18020510007	MAYFLY NYMPH	Stenonema	SC	21	21.0
18020511005	MAYFLY NYMPH	Isonychia	FC	20	20.0
18020702701999	CADDISFLY LARVA	Chimarra	FC	10	10.0
18020803004	STONEFLY NYMPH	PERLOMYIA	SH	9	9.0
18020704002	CADDISFLY LARVA	Cheumatops	FC	6	6.0
18020807001	STONEFLY NYMPH	Acroneuria	PR	7	7.0
18020803011001	HELLGRAMMITE	Corydalus cornutus	PR	8	8.0
18021215120	RIFFLE BEETLE, ADULT	Stenelmis adult	GC	6	6.0
18021217004	WATER PENNY	Psephenus	SC	3	3.0
18020704	CADDISFLY,LARVA	Hydropsych	FC	3	3.0
18020502002	MAYFLY NYMPH	Baetis	SC	2	2.0
18010302003	CRAYFISH	Orconectes	SH	2	2.0
18021115087996	BLOODWORM	Polypedilu	SH	2	2.0
18021110	CRANEFLY LARVA	Tipulidae	SH	1	1.0

Benthic Community Comparision

Stations: WHI0141 BIG CREEK 100 YARDS ABOVE HICKS CREEK CO
Sample Date 93-08-31
Sample Time 1300
Sampling technique employed SMR
WHI0140 HICKS CR. 100 YARDS ABOVE BIG CREEK CONF
Sample Date 93-08-31
Sample Time 0900
Sampling technique employed SMR

Printed on 3-MAR-1994

Qual. Similarity Index = 49.
Dominants in Common = 2
Taxa in Common = 9
Common Taxa Index = 0.50
Pro. Judgement Score = 2

		WHI0141	WHI0140
# of Taxa	=	24	18
# of organisms	=	100	100
# Ephemeroptera taxa	=	7	4
# Trichoptera taxa	=	8	8
# Coleoptera taxa	=	1	2
# Chironomidae taxa	=	1	2
Annelida cnt/%	=	0/ 0.0	0/ 0.0
Ephemeroptera cnt/%	=	43/ 43.0	34/ 34.0
Trichoptera cnt/%	=	21/ 21.0	27/ 27.0
Coleoptera cnt/%	=	3/ 3.0	3/ 3.0
Chironomidae cnt/%	=	2/ 2.0	4/ 4.0
Biotic score	=	3	0

Taxa @ WHI0141 but not @ WHI0140

MAYFLY NYMPH	Stenonema		21	21.0
CADDISFLY LARVA	Chimarra		10	10.0
STONEFLY NYMPH	PERLOMYIA		3	3.0
STONEFLY NYMPH	Acroneuria		7	7.0
CRANEFLY LARVA	Tipulidae		1	1.0

Taxa @ WHI0140 but not @ WHI0141

CLAM	Corbicula	flueminia	3	3.0
BLOODWORM	Pentaneura		2	2.0
MAYFLY NYMPH	Tricorythodes		2	2.0
SNAIL	Goniobasis		2	2.0
DANCEFLY LARVA	Hemerodromia		1	1.0
DAMSELFLY NAIAD	Argia		1	1.0
HORSEFLY LARVA	Tabanus		1	1.0
MAYFLY NYMPH	Ephemerella		1	1.0
BEETLE, ELMID	Narpus		1	1.0

Benthic Community Comparision

Stations: WHI0141 BIG CREEK 100 YARDS ABOVE HICKS CREEK CO
Sample Date 93-08-31
Sample Time 1300
Sampling technique employed SMR
WHI0139 HICKS CR. 200 YARDS BELOW MOUNTAIN HOME
Sample Date 93-09-01
Sample Time 1000
Sampling technique employed SMR

Printed on 3-MAR-1994

Qual. Similarity Index	= 85.
Dominants in Common	= 0
Taxa in Common	= 16
Common Taxa Index	= 0.57
Pro. Judgement Score	= 2

		WHI0141	WHI0139
# of Taxa	=	28	17
# of organisms	=	200	100
# Ephemeroptera taxa	=	6	4
# Trichoptera taxa	=	6	1
# Coleoptera taxa	=	2	3
# Chironomidae taxa	=	2	2
Annelida cnt/%	=	0/ 0.0	1/ 1.0
Ephemeroptera cnt/%	=	86/ 43.0	36/ 36.0
Trichoptera cnt/%	=	42/ 21.0	7/ 7.0
Coleoptera cnt/%	=	6/ 3.0	11/ 11.0
Chironomidae cnt/%	=	4/ 2.0	6/ 6.0
Biotic score	=	2	0

Taxa @ WHI0141 but not @ WHI0139

MAYFLY NYMPH	Isonychia		21	10.5
MAYFLY NYMPH	Isonychia		20	10.0
CADDISFLY LARVA	Chimarra		10	5.0
CADDISFLY LARVA	Chimarra		10	5.0
STONEFLY NYMPH	PERLOMYIA		9	4.5
STONEFLY NYMPH	PERLOMYIA		9	4.5
STONEFLY NYMPH	Acroneuria		7	3.5
STONEFLY NYMPH	Acroneuria		7	3.5
CADDISFLY,LARVA	Hydropsyche sp.		3	1.5
CADDISFLY,LARVA	Hydropsyche sp.		3	1.5
CRANEFLY LARVA	Tipulidae		1	0.5
CRANEFLY LARVA	Tipulidae		1	0.5

Taxa @ WHI0139 but not @ WHI0141

DAMSELFLY NAIAD	Argia		6	6.0
BEETLE, ELMID, LARVA	Stenelmis		5	5.0
MAYFLY NYMPH	Caenis		4	4.0
BLOODWORM	Pentaneura		2	2.0
DAMSELFLY NAIAD	Hetaerina		1	1.0
LEECH	Helobdella		1	1.0
MAYFLY NYMPH	Stenacron	interpunctatum	1	1.0
SNIPEFLY LARVA	Atherix	variegata	1	1.0
BEETLE,PREDACEOUS DI	Hydrovatus		1	1.0

Benthic Community Comparision

Stations: WHI0141 BIG CREEK 100 YARDS ABOVE HICKS CREEK CO
Sample Date 93-08-31
Sample Time 1300
Sampling technique employed 5MR
WHI0065 Hicks Cr BL Mt Home AR
Sample Date 93-08-31
Sample Time 1000
Sampling technique employed 5MR

Printed on 3-MAR-1994

Qual. Similarity Index = 32.
Dominants in Common = 1
Taxa in Common = 9
Common Taxa Index = 0.64
Pro. Judgement Score = 2

		WHI0141	WHI0065
# of Taxa	=	14	12
# of organisms	=	100	100
# Ephemeroptera taxa	=	3	3
# Trichoptera taxa	=	2	1
# Coleoptera taxa	=	1	3
# Chironomidae taxa	=	1	1
Annelida cnt/%	=	0/ 0.0	0/ 0.0
Ephemeroptera cnt/%	=	43/ 43.0	26/ 26.0
Trichoptera cnt/%	=	21/ 21.0	36/ 36.0
Coleoptera cnt/%	=	3/ 3.0	3/ 3.0
Chironomidae cnt/%	=	2/ 2.0	13/ 13.0
Biotic score	=	0	0

Taxa @ WHI0141 but not @ WHI0065

CADDISFLY LARVA	Chimarra		10	10.0
STONEFLY NYMPH	PEPLOMYIA		9	9.0
STONEFLY NYMPH	Acroneuria		7	7.0
CADDISFLY,LARVA	Hydropsyche sp.		3	3.0
CRANEFLY LARVA	Tipulidae		1	1.0

Taxa @ WHI0065 but not @ WHI0141

DAMSELFLY NAIAD	Hetaerina		3	3.0
BEETLE, ELMID,ADULT	Dubiraphia	quadrinotata	1	1.0
BEETLE, ELMID, LARVA	Stenelmis		1	1.0

Benthic Community Comparision

Stations: WHI0065A Hicks Cr AB Mountain Home AR
Sample Date 93-09-01
Sample Time 0900
Sampling technique employed SMR
WHI0141 BIG CREEK 100 YARDS ABOVE HICKS CREEK CO
Sample Date 93-08-31
Sample Time 1300
Sampling technique employed SMR

Printed on 3-MAR-1994

Qual. Similarity Index	= 55.
Dominants in Common	= 2
Taxa in Common	= 9
Common Taxa Index	= 0.60
Pro. Judgement Score	= 2

		WHI0065A	WHI0141
# of Taxa	=	19	14
# of organisms	=	100	100
# Ephemeroptera taxa	=	4	3
# Trichoptera taxa	=	1	3
# Coleoptera taxa	=	3	1
# Chironomidae taxa	=	3	1
Annelida cnt/%	=	1/ 1.0	0/ 0.0
Ephemeroptera cnt/%	=	52/ 52.0	43/ 43.0
Trichoptera cnt/%	=	12/ 12.0	21/ 21.0
Coleoptera cnt/%	=	6/ 6.0	3/ 3.0
Chironomidae cnt/%	=	7/ 7.0	2/ 2.0
Biotic score	=	0	0

Taxa @ WHI0065A but not @ WHI0141

MAYFLY NYMPH	Caenis	9	9.0
BLOODWORM	Pentaneura	3	3.0
BEETLE, ELMID, LARVA	Stenelmis	2	2.0
WATER SCAVINGER BEET	Hydrochara	1	1.0
LEECH	Helobdella	1	1.0
BLOODWORM	Cricotopus	1	1.0

Taxa @ WHI0141 but not @ WHI0065A

CADDISFLY LARVA	Chimarra	10	10.0
STONEFLY NYMPH	PERLOMYIA	9	9.0
STONEFLY NYMPH	Acroneuria	7	7.0
CADDISFLY,LARVA	Hydropsyche sp.	3	3.0
CRANEFLY LARVA	Tipulidae	1	1.0

Benthic Bioassessment
Station # WHI0065A
Hicks Cr AB Mountain Home AR
Eco Reg.# OZHI
Segment # 4F
Sample Date 87-08-05
Sample Time 1000
Sampling technique employed 5MR
Printed on 2-FEB-1989

# of Taxa = 15 # of organisms = 100 Biotic score = 0

			% Annelida	=	1.0
# Ephemeroptera	taxa =	3	% Ephemeroptera	=	32.0
# Trichoptera	taxa =	2	% Trichoptera	=	3.0
# Coleoptera	taxa =	3	% Coleoptera	=	41.0
# Chironomidae	taxa =	1	% Chironomidae	=	5.0

Diversity index = 3.0678704

Group summary

SH=	4	CO=	5	SC=	62	PR=	14	PA=	1	GC=	10	FC=	4
SH%=	4	CO%=	5	SC%=	62	PR%=	14	PA%=	1	GC%=	10	FC%=	4

Bio #	Name		Gr	Count	%
18021215020	BEETLE, ELMID, LARVA	Stenelmis	SC	33	33.0
18020510007	MAYFLY NYMPH	Stenonema	SC	20	20.0
18020503002	MAYFLY NYMPH	Caenis	GC	10	10.0
18021217004001	WATER PENNY LARVA	Psephenus herricki	SC	7	7.0
18020408003	DAMSELFLY NAIAD	Argia	PR	6	6.0
18021115	BLOODWORM	Chironomid	CO	5	5.0
18010302	CRAYFISH	Cambarinae	SH	4	4.0
18020610002	BUG, POND SKATER	Metrobates	PR	4	4.0
18020802001001	HELLGRAMMITE	Corydalus cornutus	PR	3	3.0
18020704002	CADDISFLY LARVA	Cheumatops	FC	2	2.0
18020511005	MAYFLY NYMPH	Isonychia	FC	2	2.0
17020201	LEECH	Hirudinida	PA	1	1.0
18020705002	CADDISFLY LARVA	Hydroptila	SC	1	1.0
18020611001	BUG, BR SHD WATERSTR	Rhagovelia	PR	1	1.0
1802121500000001	BEETLE,RIFFLE-LARVA	Elmidae-la	SC	1	1.0

Benthic Bioassessment
Station # WHI0065
Hicks Cr BL Mt Home AR
Eco Reg.# OZHI
Segment # 4F
Sample Date 87-08-05
Sample Time 1200
Sampling technique employed 5MR
Printed on 2-FEB-1989

# of Taxa = 2 # of organisms = 100 Biotic score = 0

			% Annelida	=	0.0
# Ephemeroptera	taxa =	0	% Ephemeroptera	=	0.0
# Trichoptera	taxa =	0	% Trichoptera	=	0.0
# Coleoptera	taxa =	1	% Coleoptera	=	1.0
# Chironomidae	taxa =	1	% Chironomidae	=	99.0

Diversity index = 0.0812931

Group summary

CO= 99 SC= 1

CO%= 99 SC%= 1

Bio #	Name		Gr	Count	%
18021115	BLOODWORM	Chironomid	CO	99	99.0
18021215020	BEETLE, ELMID, LARVA	Stenelmis	SC	1	1.0

Benthic Community Comparision

Stations: WHI0065A Hicks Cr AB Mountain Home AR
Sample Date 87-08-05
Sample Time 1000
Sampling technique employed 5MR
WHI0065
Sample Date 87-08-05
Sample Time 1200
Sampling technique employed 5MR

Printed on 9-FEB-1989

Qual. Similarity Index = 6.
Dominants in Common = 1
Taxa in Common = 2
Common Taxa Index = 0.13
Pro. Judgement Score = 5

		WHI0065A	WHI0065
# of Taxa	=	15	2
# of organisms	=	100	100
# Ephemeroptera taxa	=	3	0
# Trichoptera taxa	=	2	0
# Coleoptera taxa	=	3	1
# Chironomidae taxa	=	1	1
Annelida cnt/%	=	1/ 1.0	0/ 0.0
Ephemeroptera cnt/%	=	32/ 32.0	0/ 0.0
Trichoptera cnt/%	=	3/ 3.0	0/ 0.0
Coleoptera cnt/%	=	41/ 41.0	1/ 1.0
Chironomidae cnt/%	=	5/ 5.0	99/ 99.0
Biotic score	=	0	0

Taxa @ WHI006 but not @ WHI006

MAYFLY NYMPH	Stenonema		20	20.0
MAYFLY NYMPH	Caenis		10	10.0
WATER PENNY LARVA	Psephenus	herricki	7	7.0
DAMSELFLY NAIAD	Argia		6	6.0
CRAYFISH	Cambarinae		4	4.0
BUG, POND SKATER	Metrobates		4	4.0
HELLGRAMMITE	Corydalus	cornutus	3	3.0
CADDISFLY LARVA	Cheumatopsyche		2	2.0
MAYFLY NYMPH	Isonychia		2	2.0
BEETLE,RIFFLE-LARVA	Elmidae-larvae		1	1.0
BUG, BR SHD WATERSTR	Rhagovelia		1	1.0
CADDISFLY LARVA	Hydroptila		1	1.0
LEECH	Hirudinidae		1	1.0

Taxa @ WHI006 but not @ WHI006

APPENDIX C

MOUNTAIN HOME FISH COMMUNITY

Hicks Creek -- Big Creek (1993)

FISH FAMILY & SPECIES		Hicks Creek # spc	Hicks Creek % com	Big Creek # spc	Big Creek % com
Cyprinidae	Minnows				
Campostoma anomalum	Stoneroller	804	68.48	611	67.89
Nocomis bigutattus	Hornyhead chub	32	2.73	25	2.78
Luxilus chrysocephalus	Striped shiner	14	1.19	20	2.22
*Luxilus pilsbryi	Duskystripe shiner	59	5.03	86	9.56
*Notropis boops	Bigeye shiner	4	0.34		
Phoxinus erythrogaster	Southern redbelly dace	62	5.28	24	2.67
Pimephales notatus	Bluntnose minnow	3	0.26	1	0.11
Ictaluridae	Freshwater catfishes				
Ameiurus natalis	Yellow bullhead	4	0.34	2	0.22
*Noturus exilis	Slender madtom	16	1.36	17	1.89
Centrarchidae	Sunfishes				
*Ambloplites ariommus	Shadow bass			1	0.11
Lepomis cyanellus	Green sunfish	5	0.43	9	1.00
Lepomis macrochirus	Bluegill			3	0.33
Lepomis megalotis	Longear	18	1.53	31	3.44
Lepomis hybrid	Green/Blue gill			1	0.11
Percidae	Perches				
*Etheostoma blennioides	Greenside darter			10	1.11
*Etheostoma caeruleum	Rainbow darter	2	0.17	31	3.44
*Etheostoma punctulatum	Stippled darter	5	0.43	8	0.89
Etheostoma spectabile	Orangethroat darter	146	12.44	17	1.89
Cottidae	Sculpins				
*Cottus carolinae	Banded sculpin			3	0.33
	TOTAL SPECIMENS	1174	100	900	100