WILSON CREEK MINERALS WATER QUALITY STANDARDS EVALUATION

Prepared for:

UMETCO MINERALS CORPORATION
Little Rock, Arkansas

WEI

WASTE ENGINEERING, INC.

DECEMBER 2004

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TABLE OF CONTENTS

TABLES

FIGURES
(END OF REPORT)

APPENDICES
(END OF REPORT)

WILSON CREEK MINERALS
WATER QUALITY STANDARDS EVALUATION

1.0 SUMMARY AND CONCLUSIONS

Wilson Creek is a small tributary to Lake Catherine in the Ouachita Mountain Ecoregion. The creek is currently classified for the following uses:

- Secondary contact recreation.
- Domestic, industrial, and agricultural water supply.
- Seasonal Ouachita Mountain Ecoregion fishery.

The minerals water quality standards associated with these uses are as follows:

- Total dissolved solids (TDS)—142 milligrams per liter (mg/L)
- Chloride—15 mg/L
- Sulfate—20 mg/L

These water quality standards have not been met for some time, and are not presently being met. Concentrations of sulfate and TDS in Wilson Creek typically exceed the water quality criteria downstream of several springs in the upper watershed. Maximum concentrations of these parameters have been 472 and 700 mg/L for sulfate and TDS, respectively. Sources of sulfate and TDS include both natural background sources and non-point sources.

Chloride typically exceeds the water quality standard in the lower portion of the watershed, downstream of the East Wilson Pond. The maximum concentration of chloride is 155 mg/L. East Wilson Pond is part of the Umetco Minerals Corporation (Umetco) treatment system, and the outfall from this pond is included as Outfall No. 001 in the National Pollutant Discharge Elimination System (NPDES) permit for the mine. The source of high chloride appears to be from reclaimed mine areas in the Lecroy portion of the mine. This source will be eliminated when Indian Creek Pond is removed as part of the LeCroy area reclamation.

A bioassessment found that fish and macroinvertebrate communities exist in Wilson Creek. The creek supports a limited, seasonal fishery. A macroinvertebrate community dominated by species adapted to flowing water exists upstream of East Wilson Pond. The community includes more species adapted to pools in the lower watershed. Fish and macroinvertebrates are limited by a lack of water, instream cover, and habitat conditions. There are no significant differences in aquatic life due to existing minerals concentrations.

Wilson Creek has never been used for domestic water supply use.

No economically feasible treatment methods exist to reduce concentrations of sulfate, TDS, or chloride to less than the standards. Alternatives evaluated include chemical precipitation, ion exchange, and membrane treatments. The only alternative that could reduce levels to below existing standards is reverse osmosis. However, the estimated cost of this technology is cost-prohibitive. Controls more stringent than required by Sections 301(b) and 306 of the *Clean Water Act* (CWA) would be required.

1.1 Recommendations

The "Domestic Water Supply" use on Wilson Creek should be removed because this use is not an existing use, it is not attainable due to exceedences of the secondary drinking water standards for sulfate and TDS, and because there is no economically feasible treatment method for these parameters. Wilson Creek has not been approved as, nor is it under consideration for, use as a public water supply (Appendix D). Removal of the Domestic Water Supply use will not affect the *Arkansas State Water Plan* (Arkansas Soil and Water Conservation Commission, 1975) (Appendix D).

The minerals water quality standards should be changed to the following to reflect existing and attainable conditions consistent with the removal of the Domestic Water Supply use:

- TDS—600 mg/L
- Chloride—116 mg/L
- Sulfate—277 mg/L

The above criteria are based on post-reclamation data and represent 90th percentile values. Use of these values would result in an allowable number of exceedances, based on the 10 percent exceedances allowed under *Regulation Establishing Water Quality Standards for Surface Waters for the State of Arkansas—Regulation No. 2* (Arkansas Pollution Control and Ecology Commission, Effective October 28, 2002) (Regulation No. 2).

Modification of the standards to the criteria above will not affect existing aquatic life uses or existing water supply uses of Wilson Creek. The proposed standards also will not cause a measurable increase in minerals loading or affect uses or water quality standards of Lake Catherine, which is the downstream receiving stream.

2.0 INTRODUCTION AND PURPOSE

This report presents the results of an evaluation of the appropriateness of the existing water supply classification and minerals water quality standards for Wilson Creek. This work was completed to support modifications to the classifications and standards to reflect existing conditions, pursuant to Section 2.306 of Regulation No. 2.

The scope of this investigation was developed in concert with the Arkansas Department of Environmental Quality (ADEQ), Water Division staff. The overall approach was developed at a joint meeting held in August 2003. The specific scope of work was developed after this meeting, and is detailed in the *Work Plan for Wilson Creek Minerals Water Quality Standards Evaluation* (Waste Engineering, Inc., February 2004) (Work Plan), which was approved by the ADEQ. The approach used includes a combination of office evaluations, research, and fieldwork. Fieldwork included fish and macroinvertebrate collections, habitat assessment, and water quality sampling.

This investigation meets the requirements specified in Section 2.306 of Regulation No. 2 for "...removal of any designated use except fishable/swimmable, and modifications of water quality criteria not related to fishable/swimmable uses", and in Section IX of the *State of Arkansas Continuing Planning Process* (ADEQ, revised January 2000) (CPP). The following are addressed in this report:

1. Existing uses and mineral water quality.
2. Watershed and waterbody characteristics.
3. Treatability of water for minerals.
4. Minerals loading.
5. Recommended modifications to the existing water supply classification and minerals water quality standards.

In addition, documentation is provided that:

1. The use to be removed is not an existing use, as defined in CFR 131.3.
2. The fishable/swimmable use will be maintained.
3. All designated uses and criteria will be met in downstream waters.

This report is intended to support a request to the Arkansas Pollution Control and Ecology Commission (Commission) to modify the minerals water quality standards and to remove the Domestic Water Supply use for Wilson Creek.

3.0 BACKGROUND

3.1 Watershed and Waterbody Characteristics

Wilson Creek is a small tributary to the Ouachita River that flows into Lake Catherine, approximately 5 miles east of Hot Springs, Arkansas (Figure 1—Vicinity Map). The watershed for the creek encompasses 1.28 square miles and is located in the Ouachita Mountain Ecoregion (Regulation No. 2). The creek originates in relatively undisturbed forest and then flows through portions of Umetco's Wilson Vanadium Mine. Based on aerial photograph analysis, the land use distribution in the watershed is as follows:

- Forest—80 percent
- Reclaimed mine area—19 percent
- Developed area—1 percent

The only developed area in the watershed is a small amount of residential and commercial development south of Highway 270 in the southern portion of the watershed.

U.S. Vanadium Corporation started mining activities in the watershed in 1968. The operation produced high-grade vanadium trioxide and pentoxide which are alloying agents for hardening steel and other metals. Mining ceased in 1997.

Mine reclamation in the Wilson Creek watershed occurred in 1998-1999 and included grading and revegetation of mined areas to restore the original drainage patterns, and reclaiming the Wilson Creek streambed with a series of grouted low-water crossings, drop structures, and culverts. The reclamation was coordinated with and approved by the ADEQ Mining Division, and is detailed in a series of reports and construction plans and documents (see letter to James Stephens dated March 6, 2003 in Appendix A for a list of documents). While most of the reclamation was completed in 1998-1999, additional reclamation activities in the LeCroy area, an adjacent watershed, are ongoing.

3.2 Point and Non-Point Sources

Wilson Creek receives periodic point source discharges from the East Wilson Pond and non-point source runoff from its watershed, including reclaimed mine areas. Baseflow in the creek is maintained by groundwater flow, including flows from several springs in the upper watershed.

East Wilson Pond is the primary treatment facility for the Wilson Mine. Water from upper Wilson Creek is diverted into the pond where it commingles with smaller flows from the Lecroy mine area. The pH of the water in the pond is adjusted using lime, and the water is discharged to lower Wilson Creek at Outfall 001 under NPDES Permit No. AR0048950. Discharges occur only when the pond reaches its full level. The amount of discharge from the East Wilson Pond has diminished in recent years with the completion of reclamation. The discharge is intermittent, and only occurs an average of 3.6 times each year, with an average of 4.04 million gallons per day each time.

Non-point source discharges to Wilson Creek include runoff from native and reclaimed areas in the watershed. The amount of non-point source discharge has decreased in recent years with the completion of reclamation.

3.3 Uses and Existing Water Quality

Wilson Creek is included in the Ouachita Mountain Ecoregion (OM-2) and is classified for the following designated uses:

- Secondary contact recreation.
- Domestic, industrial, and agricultural water supply.
- Seasonal Ouachita Mountain Ecoregion fishery.

Lake Catherine, the downstream waterbody, is classified for the same uses, except it is classified as a perennial fishery.

The applicable minerals water quality standards for Wilson Creek are as follows:

- TDS—142 mg/L
- Chloride—15 mg/L

- Sulfate—20 mg/L

The above concentrations are not to be exceeded in more than one in ten samples collected over a period of not less than 30 days, and not more than 360 days (Regulation No. 2).

Existing minerals water quality along Wilson creek is summarized in Table 1. The locations of the data (and other sampling completed for this evaluation) are shown on Figure 2. The data in Table 1 are from the ongoing water quality monitoring program from February 1999 to June 2004 (including data collected May 11-13, 2004 when biological data were collected). These data represent existing, post-reclamation water quality conditions, which are anticipated to continue in the future. The following conclusions are drawn from the data in Table 1:

- Concentrations of minerals in the upper watershed are relatively low and are less than the existing water quality standards.

- Concentrations of sulfate and TDS increase at WIL-1, which is downstream of several springs. High concentrations of these parameters in the springs may be due to a combination of natural background conditions and mining/reclamation activities. Concentrations of TDS may increase in the lower portion of the creek from the lime added to East Wilson Pond.

- Concentrations of sulfate and TDS exceed water quality standards in most of Wilson Creek.

- Chloride is less than the standard in the upper portion of the creek. Chloride increases markedly downstream of the East Wilson Pond where it typically exceeds the stream standard. A principal source of chloride is from the LeCroy mine area, which will be eliminated when reclamation of the LeCroy area is completed.

TABLE 1

Wilson Creek Minerals Water Quality

Monitoring Location	Parameter	Stream Standard	UNITS	NUMBER OF SAMPLES	MAXIMUM	MINIMUM	MEAN
WILS	Chloride	15	mg/L	22.0	4.0	1.0	2.0
WILS	Sulfate	20	mg/L	22.0	10.0	1.0	7.7
WILS	TDS	142	mg/L	22.0	60.0	10.0	35.2
WILS	TSS	2	mg/L	19.0	36.0	1.0	8.8
WILS1	Chloride	15	mg/L	1.0	2.0	2.0	2.0
WILS1	Sulfate	20	mg/L	1.0	10.0	10.0	10.0
WILS1	TDS	142	mg/L	1.0	30.0	30.0	30.0
WILS1	TSS	2	mg/L	0.0	-	-	-
WIL-1	Chloride	15	mg/L	12.0	2.7	1.0	2.0
WIL-1	Sulfate	20	mg/L	12.0	472.0	4.9	51.7
WIL-1	TDS	142	mg/L	12.0	651.0	20.0	92.1
WIL-1	TSS	2	mg/L	9.0	10.0	0.8	2.6
WIL-2	Chloride	15	mg/L	14.0	3.0	1.0	2.1
WIL-2	Sulfate	20	mg/L	14.0	130.0	48.2	92.7
WIL-2	TDS	142	mg/L	14.0	214.0	87.5	156.4
WIL-2	TSS	2	mg/L	13.0	40.0	2.3	11.7
HSWIL-2	Chloride	15	mg/L				
HSWIL-2	Sulfate	20	mg/L	Duplicate sample WIL-2.			
HSWIL-2	TDS	142	mg/L	Statistics summarized with WIL-2.			
HSWIL-2	TSS	2	mg/L				
WIL-3*	Chloride	15	mg/L	10.0	9.0	1.0	4.5
WIL-3	Sulfate	20	mg/L	10.0	280.0	87.9	153.4
WIL-3	TDS	142	mg/L	10.0	462.0	140.0	271.3
WIL-3	TSS	2	mg/L	8.0	12.0	1.0	3.5
WIL-4	Chloride	15	mg/L	10.0	154.3	36.5	79.1
WIL-4	Sulfate	20	mg/L	10.0	270.0	130.0	198.1
WIL-4	TDS	142	mg/L	10.0	653.0	280.0	492.0
WIL-4	TSS	2	mg/L	6.0	16.0	1.0	5.6
HSWIL-4	Chloride	15	mg/L				
HSWIL-4	Sulfate	20	mg/L	Duplicate sample WIL-4.			
HSWIL-4	TDS	142	mg/L	Statistics summarized with WIL-4.			
HSWIL-4	TSS	2	mg/L				
WIL-5	Chloride	15	mg/L	10.0	146.0	19.5	91.4
WIL-5	Sulfate	20	mg/L	10.0	277.0	131.0	178.0
WIL-5	TDS	142	mg/L	10.0	660.0	300.0	506.1
WIL-5	TSS	2	mg/L	9.0	10.0	2.0	4.7
WIL-6	Chloride	15	mg/L	12.0	121.0	19.9	90.6
WIL-6	Sulfate	20	mg/L	12.0	287.0	170.0	203.1
WIL-6	TDS	142	mg/L	12.0	603.0	440.0	518.9
WIL-6	TSS	2	mg/L	11.0	8.0	1.0	2.9
HSWIL-6	Chloride	15	mg/L				
HSWIL-6	Sulfate	20	mg/L	Duplicate sample WIL-6.			
HSWIL-6	TDS	142	mg/L	Statistics summarized with WIL-6.			
HSWIL-6	TSS	2	mg/L				
WILL	Chloride	15	mg/L	23.0	155.0	4.0	72.6
WILL	Sulfate	20	mg/L	23.0	360.0	120.0	256.9
WILL	TDS	142	mg/L	23.0	700.0	380.0	545.0
WILL	TSS	2	mg/L	19.0	106.0	4.0	14.3

Notes: 1) Data not included in statistical summary if MDL>stream standard.
2) Duplicate samples included in statistics.
[light shading] - Biological sampling site for this study.
[dark shading] - Exceeds existing water quality standard.
* Data from this site used for WIL-2.5.

3.4 Sources of Wastewater

The only water discharged to Wilson Creek is the periodic discharge of water from East Wilson Pond, as described in Section 3.2. No domestic wastewater is discharged to the creek.

4.0 FIELDWORK

Fieldwork completed for this evaluation included habitat assessment, collection of macroinvertebrates and fish, and water quality sampling at selected locations. A total of six sites were sampled. The locations sampled are shown on Figure 2, and the sites are described in Table 2.

TABLE 2

Sampling Locations

Site Name	Location	Purpose
WILS	Upper-most site	Reference site not affected by mine, springs, or high minerals.
WIL-1	Below Spring SPRD3 in Wilson Creek	Similar to WILS, but affected by Spring SPRD3.
WIL-2	Immediately below Spring SPRD2 on Wilson Creek	Similar to WILS, but affected by Springs SPRD2 and SPRD3.
WIL-2.5	Below T-pit	Effects of T-pit.
WIL-5	Near mouth of creek	Representative of lower Wilson Creek, below mine area.
WIL-6	Near mouth of creek	Representative of lower Wilson Creek, below mine area.

The sampling sites were selected to represent undisturbed conditions upstream of the mine area (WILS), sites below springs (WIL-1 and WIL-2) and the mine area (WIL-2.5), and conditions downstream of the mine and Outfall 001 (WIL-5 and WIL-6).

Several modifications were made to the sampling locations proposed in the Work Plan. It was planned to sample at WIL-3; however, it was not possible to collect fish at this location due to soft sediment that made wading difficult and hazardous. This site is affected by artificial ponding from a road crossing and culvert that has resulted in sediment deposition and growth of wetlands so that this site is not typical of the creek. It was also planned to sample north Wilson Creek at NWPO, but this site was not used since this drainage did not exist prior to mine reclamation. Lastly, the Work Plan included sampling at WILL towards the mouth of the creek. Sampling was completed at WIL-5 and WIL-6 in the lower watershed instead (Figure 2).

Fieldwork was completed jointly by Waste Engineering, Inc (WEI) and GBMc and Associates (GBMc) on May 11-13, 2004.

4.1 Habitat Assessment

Instream habitat was evaluated using Tier One of the ADEQ habitat rating method. This method involves scoring of substrate type, instream cover, and sedimentation for each habitat type present (run, riffle, and pool), as per the "ADEQ Instream and Riparian Habitat" rating form. A "habitat score" and "index of habitat integrity" (IHI) were calculated for the site. An average IHI weighted by habitat length was calculated for each site.

Habitat was also evaluated using the "Riffle (or Pool) Habitat Assessment for Aquatic Macroinvertebrate" rating forms provided by the ADEQ. (This method is referred to as the "Rapid Bioassessment Protocols" [RBP] in this report.) These forms are based on and are similar to the habitat rating procedure for the U.S. Environmental Protection Agency's *Rapid Bioassessment Protocols for Use in Streams and Rivers and Wadeable Rivers* (U.S. Environmental Protection Agency [USEPA], 1998). This method entails rating nine habitat parameters for a total possible score of 220. One form was completed for representative riffle and pool habitats at each site.

Measurements of channel geometry were also completed, streamflow was estimated, and photographs were taken. The results of the habitat assessment are summarized in Table 3, and habitat field sheets and photographs are included in Appendix B.

TABLE 3

Habitat Score Summary[1]

Location[2]	Habitat No.	Type[3]	Length (ft)	Habitat Score[4]	IHI[4]	RBP Rating[6]	Notes
WILS	1	P	155	31.7	49.1	162	Pools and riffles similar, so one habitat sheet was used for each type.
	2	R	270	34.0	91.8	187	
			425		Ave. = 76.2[5]	Ave. = 178[5]	
WIL-1	1	R	190	40.0	76.0	166	Pools and riffles similar, so one habitat sheet was used for each type.
	2	P	70	42.9	30.0	171	
			260		Ave. = 63.6[5]	Ave. = 167[5]	
WIL-2	1	P	120	21.4	25.7	104	Sediment from road is deposited in this reach.
	2	R	110	26.1	28.7	105	
	3	P	190	21.2	40.3		
	4	RN	60	22.6	13.6		
			480		Ave. = 30.7[5]	Ave. = 105[5]	
WIL-2.5	1	RN	80	31.6	25.3		Flow doubled at this site due to rain the previous day.
	2	R	100	33.6	33.6	138	
	3	P	160	37.6	60.2	126	
			340		Ave. = 44.2[5]	Ave. = 130[5]	
WIL-5	1	P	165	39.2	64.7	148	Only ± 5' of riffle in reach (not scored).
	2	P	90	40.4	36.4		
	3	RN	60	43.8	26.3		
			315		Ave. = 49.3[5]	Ave. = 148[5]	
WIL-6	1	P	60	60.7	36.4	176	Good in-stream cover, under cut banks.
	2	RN	130	46.6	60.6		
	3	P	100	50.1	50.1		
	4	R	80	60.0	48.0	191	
			370		Ave. = 51.1[5]	Ave. = 181[5]	

[1] See habitat field sheets and photographs in Appendix B.
[2] Sampling locations on Drawing 1.
[3] P = pool; R = riffle; RN = Run.
[4] As per ADEQ habitat procedure. Habitat score = sum of substrate type, instream cover, and sedimentation. IHI = index of habitat integrity = length x habitat score x 0.01.
[5] Weighted by length, equals Σ(length x IHI or RBP)/total length.
[6] From rifle or pool habitat assessment forms.

4.1.1 Habitat Description

Wilson Creek is a small, perennial stream with a moderate gradient. The creek consists of alternating riffles and pools but, during most of the year, only a trickle of flow exists (3 to 10 gallons per minute) so that water does not cover the substrate in riffles (see Photos 4, 7, and 8). Water is very shallow (3 to 6 inches deep) in pools (see Photos 5, 6, and 9). No large, deep pools exist (except for the artificial pool at WIL-3), and riffles are very shallow. The creek generally lacks instream cover, including undercut banks, root wads, and aquatic vegetation. A relatively large amount of the channel bottom is exposed, and most of the water present is standing in shallow pools (see Photos 3 through 7). Habitat is slightly better in the lower reach of the creek due to more flow, deeper pools, and some undercut banks (see Photos 13 through 19).

The average IHI values and RBP ratings (see Table 3) show habitat as being the best (higher values) at the upstream-most and downstream-most sites (WILS and WIL-6, respectively). Habitat is the worst at WIL-2, which is downstream of and affected by sediment from an un-culverted dirt road crossing. This sediment has covered gravel and cobble substrate in this reach (see Photo 2). Habitat scores are also lower at WIL-2.5 due to lack of flow and instream cover (see Photos 10 through 12).

The major limiting habitat factors in Wilson Creek are the lack of water depth, deep pools, and instream cover. Portions of the watershed and riparian zone are relatively undisturbed, particularly in the upper and lower reaches of the watershed (the middle reach has been impacted by mining).

4.2 Water Quality Sampling

A grab water quality sample was obtained at each site and submitted to a laboratory for analysis for TDS, sulfate, chloride, and total suspended solids. Water temperature, conductivity, pH, and dissolved oxygen were measured in the field with instruments. The results of the laboratory analyses are included in Table 1. Table 4 shows the results of the field measurements.

TABLE 4

Field Water Quality Measurements[1]

	Locations					
Parameter[2]	**WILS**	**WIL-1**	**WIL-2**	**WIL-2.5**	**WIL-5**	**WIL-6**
pH (s.u.)	6.77	6.37	5.01	NA	6.72	7.52
Temp (°C)	17.0	17.4	17.2	NA	20.3	NA
D.O. (mg/L)	7.62	8.24	8.03	NA	5.59	NA
Flow (gpm)	± 5	± 5	± 8	± 10	± 10	± 10

[1] On days of field sampling (May 11-13, 2004).
[2] All taken with field instruments. Flow estimated visually.

Water quality data from an ongoing monitoring program of Wilson Creek were also used in this evaluation. Data have been collected at nine sites along the creek. Data collected from February 1999 through June 2004, which represent recent, post-reclamation data, were used in this evaluation. These data are summarized in Table 1.

4.3 Macroinvertebrates

Macroinvertebrates were collected at each site with a D-frame net. A constant level of effort was used to sample all available habitat/substrate types over an approximately 100-foot reach of the creek. Samples were preserved with 10 percent ethanol in the field, and organisms were identified to the genus (or family) level in the laboratory by GBMc. Several metrics were calculated to characterize the nature of the macroinvertebrate community present. The procedures in the ADEQ's "Aquatic Macroinvertebrate Sample Collection and Processing Protocols" were followed. The list of taxa at each sampling location is included in Appendix C; Table 5 summarizes the data and provides the metrics.

TABLE 5

Macroinvertebrate Metrics[1]

Metric	Site[2]					
	WILS	WIL-1	WIL-2	WIL-2.5	WIL-5	WIL-6
Taxa richness	20	20	19	13	14	17
EPT Index	8	7	4	1	2	2
% Dominant taxon	21	18	25	37	20	28
Dominant taxon	Chironimid	Mayfly	Stonefly	Chronomid	Chronomid	Isopod
% Shredders	9	23	27	28	20	21
Scrapers/filtering collectors	0.54	0.08	0	0.05	0.02	0
EPT/Chironimid	1.18	2.56	1.00	0.29	0.03	0.32
HBI[3]	4.68	4.43	3.75	5.18	5.81	6.20

[1] See table of species collected at each site in Appendix C.
[2] See Drawing 1 for locations.
[3] Hilsenhoff Biotic Index—family level used.

The following summarizes the results of the macroinvertebrate sampling:

- The number of species present (taxa richness) was relatively constant at 19 or 20 species at WILS (background site), WIL-1 (downstream of Spring SPRD3 in the upper watershed), and WIL-2 (downstream of all springs in upper watershed) despite a reduction in habitat quality and a large increase in TDS and sulfate at WIL-1 and WIL-2. Taxa richness decreased at WIL-2.5 and WIL-5, but increased at WIL-6.

- The EPT Index was highest at WILS and WIL-1, and decreased downstream. Sulfate and TDS are significantly higher at WIL-1 versus WILS, but both have high habitat ratings. Sediment from the un-culverted road crossing below WIL-1 has covered substrate at WIL-2 (see Photo 2). This sediment may be the reason for the decrease in EPT taxa at this site, since many of the EPT taxa upstream were scrapers (Stenacron, Stenonema, and Psephenus), which would be negatively affected by sediment.

- The ratio of EPT taxa to chironomids was highest at WIL-1, downstream of SPRD3. It was relatively high at WIL-2, but this metric decreased significantly downstream. Sulfate and TDS were significantly higher at WIL-1 and WIL-2 than at WILS, but habitat varied from 167 to 105 at these sites.

- The percent contribution of the dominant taxon varied from a low of 18 percent at WIL-1 to 37 percent at WIL-2.5. This metric did not vary much at WILS, WIL-1, and WIL-2. The dominant taxon itself varied along the creek. For example, chironominae was the dominant taxon at WILS; the mayfly *Paraleptophlebia* was dominant at WIL-1; the stonefly *Allocapnia* was dominant at WIL-2; and tanypodinae and isopoda were dominant at WIL-5 and WIL-6, respectively.

- The Hilsenhoff Biotic Index (HBI), which is an integrated measure of the overall pollution tolerance of the community, ranged from 3.75 at WIL-2 to 6.2 at WIL-6. The lower value at WIL-2 was due to the presence of relatively high numbers of *Allocapnia*, which is relatively sensitive.

4.3.1 Discussion

The nature of the macroinvertebrate community in Wilson Creek varies due to changes in substrate, habitat quality, water quality, temperature, and other factors—all of which change along the creek. The community present is relatively tolerant, even at upstream sites. For example, the dominant taxon at WILS, located upstream of the springs and mining area, was Chironominae, which are relatively tolerant midges. (Chironimids comprised much of the community throughout the creek [see Appendix C]). The dominant taxon at WIL-2 downstream of springs where TDS and sulfate increase was the relatively sensitive stonefly *Allocapnia.*

Data do not show significant negative impacts on the macroinvertebrate community from increased minerals concentrations. Figure 3 shows average minerals concentrations versus taxa richness and the HBI. Taxa richness was relatively high at WILS, WIL-1, and WIL-2, which are all located relatively close to each other in the upper watershed, where TDS and sulfate increased significantly. Taxa richness declined at WIL-2.5, but then increased as concentrations of all three minerals increased significantly at WIL-5 and WIL-6. The HBI also decreased from WILS to WIL-2 (indicating a less pollution tolerant community), while TDS and sulfate increased greatly.

Taxa richness appeared to correlate better with habitat quality, as is evidenced from Figures 4A and 4B, which shows habitat quality (RBP values) versus taxa richness and EPT/chironimid ratio.

A detailed analysis of changes in the community immediately downstream of the largest increases in minerals was conducted. This evaluation compared the nature of the community upstream and downstream of the minerals sources. An upstream and downstream comparison is relevant for Wilson Creek, instead of comparisons back to WILS, since many factors change within a relatively short distance along the creek. An upstream and downstream comparison isolates water quality influences to the maximum extent possible. The sites used in this evaluation are as follows: Sulfate: WIL-1 v. WIL-2; TDS: WILS v. WIL-1; Chloride: WIL-2.5 v. WIL-5.

The biological condition and degree of impairment of the downstream site was determined using the upstream site, as described in the USEPA's *Bioassessment Protocols for Use in Streams and Rivers and Wadeable Rivers.* The biological condition scores are shown in Table 6. The evaluation of upstream versus downstream sites is shown in Table 7. As Table 7 shows, the macroinvertebrate community was either not impaired or slightly impaired downstream of the largest changes in minerals concentrations. This was found even though average minerals concentrations increased 79 to 1,931 percent at the downstream comparison sites.

The lack of effects from the minerals is consistent with published toxicity data that show the levels of chloride, sulfate, and TDS in Wilson Creek to be well below levels shown to be toxic to aquatic life. For example, studies have shown no effect on survival from TDS of 10,000 to 20,000 mg/L (Rawson & Moore, 1944).

TABLE 6

Biological Condition Evaluation

Metric	WIL-2 (v. WIL-1)			WIL-1 (v. WILS)			WIL-5 (v. WIL-2.5)		
	WIL-2	% of WIL-1	Score	WIL-1	% of WILS	Score	WIL-5	% of WIL-2.5	Score
Taxa richness	19	95	6	20	100	6	14	108	6
EPT index	4*	57	0	7	88	4	2	200	6
% Dominant taxon	25	NA	4	18	NA	6	20	NA	4
EPT/chironimid	1.00	39	2	2.56	217	6	0.03	10	0
HBI	3.75	120	6	4.43	106	6	5.81	89	6
% Shredders	27	117	6	23	256	6	20	71	6
Scrapers/filtering collectors	0*	0	0	0.08	15	0	0.02	40	4
Community Loss Index	NA	0.53	6	NA	0.40	4	NA	0.43	6
TOTAL			30 (30)**			38			38
% of upstream site			63 (83)**			79			79
Impairment			Slight (none)*			Slight			Slight

* Low score is likely due to sediment from road crossing covering sediment, which greatly affected scrapers (many of which are mayflies).

** Value without EPT index and scrapers/filtering collectors, which are affected by sediment.

TABLE 7

Analysis of Sites Upstream and Downstream of Major Mineral Sources[1]

	Average Concentration (mg/L)	% Change	RBP Habitat Score	% Change	Biological Condition Impairment[2]
	Sulfate				
Upstream site (WIL-1)	51.7		167		None to slightly impaired
Downstream site (WIL-2)	92.7	+79	105	-37	
	Total Dissolved Solids				
Upstream site (WILS)	35.2		178		
Downstream site (WIL-1)	92.1	+162	167	-6	Slight
	Chloride				
Upstream site (WIL-2.5)[3]	4.5		130		
Downstream site (WIL-5)	91.4	+1,931	148	+14	Slight

[1] Consecutive sites with the largest change in concentration used.
[2] See Table 6 for details as per USEPA Guidance.
[3] Water quality data from WIL-3 used.

4.4 Fish Collections

Fish were collected with a backpack shocker. A representative reach was sampled at each location, which equated to a 100- to 300-foot length. The species of fish were identified, and the fish were noted for the presence of any deformities or disease. The collections were performed under a state collection permit by GBMc. The fish found at each site are shown in Table 8.

TABLE 8

Fish Collected From Wilson Creek May 11-13, 2004

Scientific Name	Common Name	WILS	WIL-1	WIL-2[1]	WIL-2.5[1]	WIL-5	WIL-6
CYPRINIDAE							
Semotilus atromaculatus	Creek chub	153	66	2	--	--	--
CATOSTOMIDAE							
Erimyzon oblongus	Creek chubsucker	--	--	--	--	13	13
CENTRARCHIDAE							
Lepomis cyanellus	Green sunfish	--	--	--	--	61	14
Lepomis megalotis[2]	Longear sunfish	--	--	--	--	--	4
Micropterus salmoides	Large mouth bass	--	--	--	--	--	2
PERCIDAE							
Etheostoma radiosum[2]	Orange belly darter	27	--	--	--	--	21
Total no. taxa collected		2	1	1	0	2	5
Total fish collected		180	66	2	0	74	54
Level of effort (min.) PDT[3]		15.93	4.63	39.17	19.40	15.27	15.73
Catch per minute, PDT		11.30	14.24	0.05	---	4.85	3.43
Shannon-Wiener Diversity Index		0.61	0.00	0.00	---	0.67	1.98

[1] Two sample runs were completed at this site.
[2] Key or indicator Ecoregion species (Regulation No. 2).
[3] PDT = Pedal Down Time = actual time of current generation.

Limited numbers and species of fish were collected from Wilson Creek. Only creek chubs and orange belly darters were found in the upper watershed. Only two creek chubs were found at WIL-2, and no fish were found at WIL-2.5 downstream of T-Pit. Five species, including orange belly darters, were found at WIL-6. The only key species found was the orange belly darter.

Creek chubs and orange belly darters were more prevalent in the upper watershed likely because of the preference of these species for flowing water and gravel, cobble substrate. All of the orange belly darters at WIL-6 were collected from a riffle with cobble substrate. Large mouth bass, green sunfish, longear sunfish, and chub suckers were only collected from the lower watershed where there are larger pools.

4.4.1 Discussion

The character of the fish community in Wilson Creek is greatly affected by habitat and flow. Instream habitat is very limited in the upper watershed. Most of the fish found at WILS and WIL-1 occurred either in several small pools or in cobble. The cobble was generally exposed so that fish were in interstices (see Photos 6 through 8). Few fish were found at WIL-2, and this is likely due to the lack of any pools and cobbles, which is where fish were found at WILS and WIL-1, and sedimentation from the road crossing (see Photos 1 and 2). As shown in Photo 4, the creek is only a small ribbon of flow at WIL-2, and this site lacks the cobble present at WILS and WIL-1. The lack of fish at WILS-2.5 is also likely due to the very small channel and lack of habitat at this site (see Photos 10 and 11). Fish were observed at WIL-3 (which was not sampled, as previously described) approximately 400 feet downstream in a pool that provides habitat and cover.

The presence of fish is not well related to minerals concentrations:

- The most diverse fish community was found at WIL-6, which has much higher concentrations of minerals than WILS. Only two species were found at WILS. Five species were found at WIL-6, where average concentrations of minerals are 15 to 45 times higher.

- The only key species found, the orange belly darter, was only found at WILS and WIL-6. Relatively similar numbers were found (27 versus 21 fish for WILS and WIL-6, respectively), though minerals are much higher at WIL-6. These two sites had the best habitat, which likely explains the presence of this fish.

- Moderate numbers of fish were collected at WIL-1 and WIL-5, which have increased levels of minerals compared to WILS.
- No fish were collected at WIL-2.5, but fish (sunfish and bass) were observed at WIL-3 immediately downstream. Minerals concentrations at WIL-3 are equal to or higher than those at WIL-2.5.

The fish community of Wilson Creek is not comparable to reference sites in the Ouachita Mountain Ecoregion. For example, Board Camp Creek, which is a regional reference site in Regulation No. 2, has been found to have 21 species with several "sensitive species." However, this creek and other potential reference creeks (e.g., upper Cove Creek) are significantly larger and have much more flow than Wilson Creek. The watershed for the Board Camp Creek reference site is 19 square miles. The channel averages 61 feet, and 2.67 cubic feet per second of flow was reported in the creek. These numbers compare to a watershed of 1.28 square miles, a channel width of 2 to 4 feet, and flows of several gallons per minute (0.01 to 0.03 cfs) for Wilson Creek. Upper Cove Creek was observed as a part of this study to locate a comparable reference site. The one location that was potentially accessible in the upper watershed has a drainage area of 2.34 square miles, but several cfs per second of flow was observed, and the channel is 10 to 15 feet wide with water depths of 0.5 to 1.5 feet. Therefore, no comparable reference sites have been identified for Wilson Creek at this time.

5.0 RESULTS AND DISCUSSION

5.1 Contaminants Which Exceed Water Quality Standards

The contaminants that exceed water quality standards and are the subject of this evaluation are TDS, sulfate, and chloride.

5.2 Technological Treatment

The only treatment that has been provided to date is the addition of hydrated lime to the water in East Wilson Pond for pH adjustment. Settling occurs as the water is retained in the pond before discharge. Aeration occurs through turbulent flow in the discharge channel when water is pumped from the pond for discharge to Wilson Creek.

Treatment for sulfate, chloride, and TDS has never been required or provided. The discussion in Section 5.3, below, shows that treatment is not feasible from a cost standpoint and is not warranted to protect the uses of the creek.

5.3 Treatability Analysis for Chloride, Sulfate, and TDS

Chloride, sulfate, and TDS are major components of salinity in environmental waters. Salinity in rivers and streams is one of the most difficult water quality issues to control. In most remediation programs, such as state Total Maximum Daily Load evaluations, source control by diversion, injection, evaporation, ponding, and promoting more efficient irrigation practices is the most effective control approach. None of these approaches are feasible or desirable for Wilson Creek. Because the sources of salinity in Wilson Creek are diffuse, any treatment would have to be applied to the entire stream flow.

The alternative treatments described below were evaluated for Wilson Creek.

5.3.1 Precipitation

Chloride

There are no passive treatment technologies for reducing chloride in water. All chloride salts are very water soluble except for those of lead, silver, and mercury. Consequently, chloride cannot be precipitated except by adding expensive and toxic metal ions to the water. Thus, it is not environmentally or economically feasible at the Wilson Mine site to remove chloride by precipitating and immobilizing it on site.

Sulfate and TDS

Sulfate salts are also generally very soluble, except for those of strontium, lead, barium, silver, and mercury. Calcium sulfate is moderately soluble. Like chloride, efficient precipitation of sulfate requires the addition of expensive and toxic metal ions to the water. The addition of sufficient calcium could provide up to 30 percent sulfate removal. However, calcium treatment would not bring Wilson Creek into compliance with the current stream standard of 20 mg/L.

Another alternative is to convert sulfate to sulfide in an anaerobic wetland and precipitate it as metal sulfides. This has the advantage of also removing some of the TDS. There are two main drawbacks to this alternative:

1. It requires a large surface area of wetland.

2. Its ability to remove sufficient sulfate is uncertain. Even if 100 percent conversion of sulfate to sulfide is assumed, the levels of dissolved metals in Wilson Creek are not high enough to precipitate more than 5 to 10 percent of the sulfide formed. Unless additional metal were added, most of the sulfide would be in the form of hydrogen sulfide, a more objectionable pollutant than the original sulfate.

The difficulty of economical sulfate removal is well established. In 1990, the USEPA proposed a primary drinking water standard for sulfate that was subsequently withdrawn because of public comments about the high cost of compliance. The USEPA finally elected to set only a secondary standard for sulfate, based on its low risk to public health. High sulfate levels are a continuing problem in many rivers in the western states. In cases where the source control methods listed above are inadequate, regulatory policy has usually been to modify the stream uses and standards.

5.3.2 Ion Exchange

Ion exchange (IX) substitutes one ion for another. It has only a small effect on the weight concentration of TDS in the treated water. TDS is little affected by IX; only its chemical makeup is changed. For example, removal of chloride by IX requires that another anion, generally sulfate, be added. In this case, IX only substitutes one contaminant of concern for another. Hydroxide could be used as the substitute anion, but it would raise the water pH and possibly require additional treatment.

In any case, the ions removed from the input water appear in a more concentrated form in the IX waste stream. Without an acceptable means of disposal, the waste stream will be as great, or more of a liability, than the untreated Wilson Creek water. Additionally, because of the need for constant power and regular maintenance, IX cannot be designed to be a passive treatment system.

5.3.3 Membrane Treatments

Membrane methods are the only alternative treatments that have the potential to remove chloride, sulfate, and TDS to acceptable levels. Potentially suitable membrane methods include reverse osmosis (RO), nanofiltration, and electrodialysis, all of which are regarded as expensive treatments that normally are considered as last resorts for industrial and municipal treatment systems. Membrane treatments all have the same liabilities of generating a concentrated waste stream and requiring constant power and regular maintenance.

Membrane Treatment Costs

Although capital and operation and maintenance (O&M) costs vary by location, the current cost of RO treatment was estimated using a worksheet provided by the Wisconsin Department of Natural Resources (DNR) available at http://www.dnr.state.wi.us/org/water/wm/ww/applications/chloride_wksht.pdf. The worksheet is part of a chloride variance application for end-of-pipe treatment systems. It can be assumed that the same RO unit would serve to remove chloride, sulfate, and TDS. Other membrane treatment systems would have comparable or higher (in the case of electrodialysis) costs. The calculation below shows that an RO treatment installation for Wilson Creek could have a capital cost around 8.4 million dollars and O&M costs around 2.7 million dollars, annually.

In the Wisconsin DNR worksheet, capital cost is estimated to be $1.125 per gallon per day of design flow, and O&M costs are estimated to be $1 per 1,000 gallons per day.

Measured daily maximum flows in Wilson Creek range between 4.26 to 9.82 million gallons per day (mgd) with a highest monthly average of 6.28 mgd in June 2003. We have chosen 7.5 mgd as a reasonable design target.

For an RO treatment plant with a design flow of 7.5 mgd:

Estimated capital cost = ($1.125/gallon/day)($7.5\times10^6$ gal/day) = $\underline{\$8.4\times10^6}$

Estimated O&M costs = ($\$1/10^3$ gallon)(7.5×10^6 gal/day)(365 days/year)

= $\underline{\$2.7\times10^6}$

5.4 Economic Analysis

When under production, the Wilson Mine employed around 215 people from both Garland and Hot Spring Counties. The mine provided a significant employment base and contributed to the local and state economies.

Today, the mine employs less than five local people, all of whom are engaged in reclamation studies and design. Its contribution to the local employment base and economy has diminished. The costs of providing long-term treatment for minerals, which would only be possible by construction and operation of a mechanical water treatment plant, would make the operation uneconomical.

5.5 Environmental Benefits of Not Removing a Use or Closing the Operation

The mining portion of the operation is closed. Most of the mine has been reclaimed. The vanadium processing that is ongoing on an adjacent property does not affect the water quality or uses of Wilson Creek. Therefore, no further benefits to water quality can be achieved by closing the operation.

No environmental benefits would result from not removing the Domestic Water Supply classification. Aquatic life in Wilson Creek is very limited due to natural flow and habitat conditions. Decreasing existing concentrations of minerals (to the standards) would not result in a significant improvement in aquatic life, or other environmental benefits.

5.6 Existing Water Body Uses

Existing uses, as defined in 40CFR 131.3, are "...those uses actually attained in the water body on or after November 23, 1975, whether or not they are included in the water quality standards." The CWA does not allow the removal of any use that has been in existence any time since November 1975.

Designated uses are "...those uses actually included in the water quality standards." The designated uses for Wilson Creek are as follows (Regulation No. 2):

- Seasonal Ouachita Mountain fishery.
- Secondary contact recreation.
- Domestic, industrial, and agricultural water supply.

A seasonal Ouachita Mountain Ecoregion fishery is defined by the presence of "...water which is suitable for the protection and propagation of fish and other forms of aquatic life adapted to flowing water whether or not the flow is perennial," and which support "...communities of indigenous or adapted species of fish and other forms of aquatic life. The fish community is characterized by a major portion of sensitive species; a minnow-sunfish-dominated community exists, followed by darters" (Regulation No. 2). Furthermore, a seasonal fishery is designated where the watershed is less than 10 square miles in size.

Information indicates that the low pH, metals, suspended solids, and other conditions limited the aquatic life present in Wilson Creek when mining was active. The quality of the fishery and aquatic life have improved with the completion of the reclamation and associated improvements in water quality.

Fish have been observed in Wilson Creek in the past. Limited aquatic communities were found by the fieldwork for this study. Wilson Creek supports, and will continue to support, limited aquatic life in the future. The aquatic life is more limited, naturally, than that found in the Ouachita Mountain Ecoregion reference streams because Wilson Creek is significantly smaller and has much less flow than the reference streams.

5.7 Recommended Minerals Water Quality Standards

The existing minerals water quality should be adopted as the water quality standards for Wilson Creek. This evaluation has shown that existing minerals quality does not affect aquatic life. There are no practicable methods for treatment to achieve existing minerals standards. All existing uses will be protected by adopting revised minerals standards based on existing minerals quality.

It is recommended that the 90th percentile concentrations be used to reflect existing conditions for new standards, consistent with Regulation No. 2. The following are the 90th percentile values that were derived from all water quality data collected from Wilson Creek from February 1999 to June 2004, which are indicative of post-reclamation quality, presently, and in the future:

- TDS—600 mg/L
- Chloride—116 mg/L
- Sulfate—277 mg/L

Regulation No. 2 allows for one in ten samples taken over not less than 30 and not more than 360 days to exceed the standard. Use of the 90th percentile is proposed consistent with Regulation No. 2.

5.8 Additional Information for *Administrative Guidance Document*

The following provides the additional documentation required by the *Administrative Guidance Document* (ADEQ, January 2000).

5.8.1 Minerals Loading Analysis

An analysis was completed to determine the effects of the proposed minerals standards on minerals loading to the Ouachita River (Lake Catherine).

The proposed minerals standards represent existing water quality conditions. Water quality should remain the same or improve slightly in the future with the completion of mine reclamation. An increase in minerals loading is not proposed. Therefore, the effects of the proposed minerals water quality standards are already present in the Ouachita River downstream of Wilson Creek.

Existing minerals water quality on the Ouachita River (Lake Catherine) upstream and downstream of Wilson Creek were obtained from the USEPA STORET database. The available data are from 1999-2002, which represents post-Wilson mine reclaimed conditions and conditions with the proposed standards in place. Minerals water quality in Wilson Creek was obtained from the ongoing water quality monitoring program by Umetco. These data are shown in Table 9.

TABLE 9

Minerals Loading Evaluation—Water Quality and Flow Data[1]

Location	Average Flow (cfs)	Average Low Month Flow (cfs)	7Q10 (cfs)	Maximum Monthly Flow (cfs)	Average Concentration[4] (mg/L)			90 Percent Concentration[5] (mg/L)		
					TDS	Cl	SO_4	TDS	Cl	SO_4
Ouachita River—downstream of Carpenter Dam	2,200	1,095	202		62	2.6	4.3			
Wilson Creek[3]	1.8	0.03	0	9.7	545	73	257	600	116	277
Ouachita River—downstream Remmel Dam		1,095			145	29	5.3			

Used for average concentration calculation.
Used for maximum concentration calculation.
Used for both calculations.

[1] Flow data from USGS gauges 07359001 and 07359002.
[2] Reported in UAA FTN (1992).
[3] From discharge monitoring reports, measurements by Umetco. Values shown represent mostly average discharges from East Wilson Pond. Base flow in creek is typically 10 to 20 gpm at mouth (0.022 to 0.045 cfs).
[4] Average from USEPA STORET database.
[5] Determined from Wilson Creek water quality database.

Table 9 also shows flow data for the Ouachita River and Wilson Creek, and minerals water quality data for Wilson Creek. Flow data for the Ouachita River were obtained from U.S. Geological Survey stream gages at Malvern (gauge no. 07359500) and downstream of Remmel Dam (gauge nos. 07359001 and 07359002). Flow data reported in a previous analysis by FTN Associates in 1992 were also used. Flow data for Wilson Creek was obtained from discharge monitoring reports, and past estimates of flow in the creek by WEI. As previously discussed, the flow regime of Wilson Creek is characterized by very low base flow most of the year, higher flows in the spring, and then periodic high flows due to discharges from East Wilson Pond.

The data in Table 9 were used to calculate minerals concentrations in the Ouachita River downstream of Wilson Creek from the proposed standards for both average and a maximum concentration scenario. Average flows and concentrations were used to calculate average concentrations. The 7Q10 flow for the Ouachita River, highest average monthly discharge for Wilson Creek, and 90th percentile concentrations for minerals in Wilson Creek, were used for the maximum concentration scenario. The values used for the calculations are indicated in Table 9. The results of the calculations are shown in Table 10.

TABLE 10

Minerals Loading Evaluation

Location	Existing Average Concentration[1] (mg/L)			Calculated Average Concentration Using Wilson Creek Data[2] (mg/L)			Calculated Maximum Using Wilson Creek Water Quality Data[2] (mg/L)		
	TDS	Cl	SO_4	TDS	Cl	SO_4	TDS	Cl	SO_4
Ouachita River—upstream of Wilson Creek	62	2.6	4.3						
Ouachita River—downstream of Remmel Dam	145	28.5	5.3	62.4	2.7	4.5	79.9	6.4	13.4
Water Quality Standards: TDS—150 mg/L; Cl—50 mg/L; SO_4—40 mg/L									

[1] From USEPA STORET database.
[2] See Table 9 for data used.

Table 10 shows that the calculated average minerals concentrations are less than actual measured concentrations. This is because of additional sources of minerals to the river between the Carpenter and Remmel Dams. The calculated maximum concentrations downstream of Wilson Creek are lower than measured concentrations, except for sulfate. This is due to the conservative assumptions used in the maximum concentration scenario, which may never actually occur together (maximum discharge from Wilson Creek at the same time as the 7Q10 low flow in the Ouachita River). Overall, any increases in minerals concentrations in the Ouachita River from Wilson Creek will be very small due to the large difference in flow between the two.

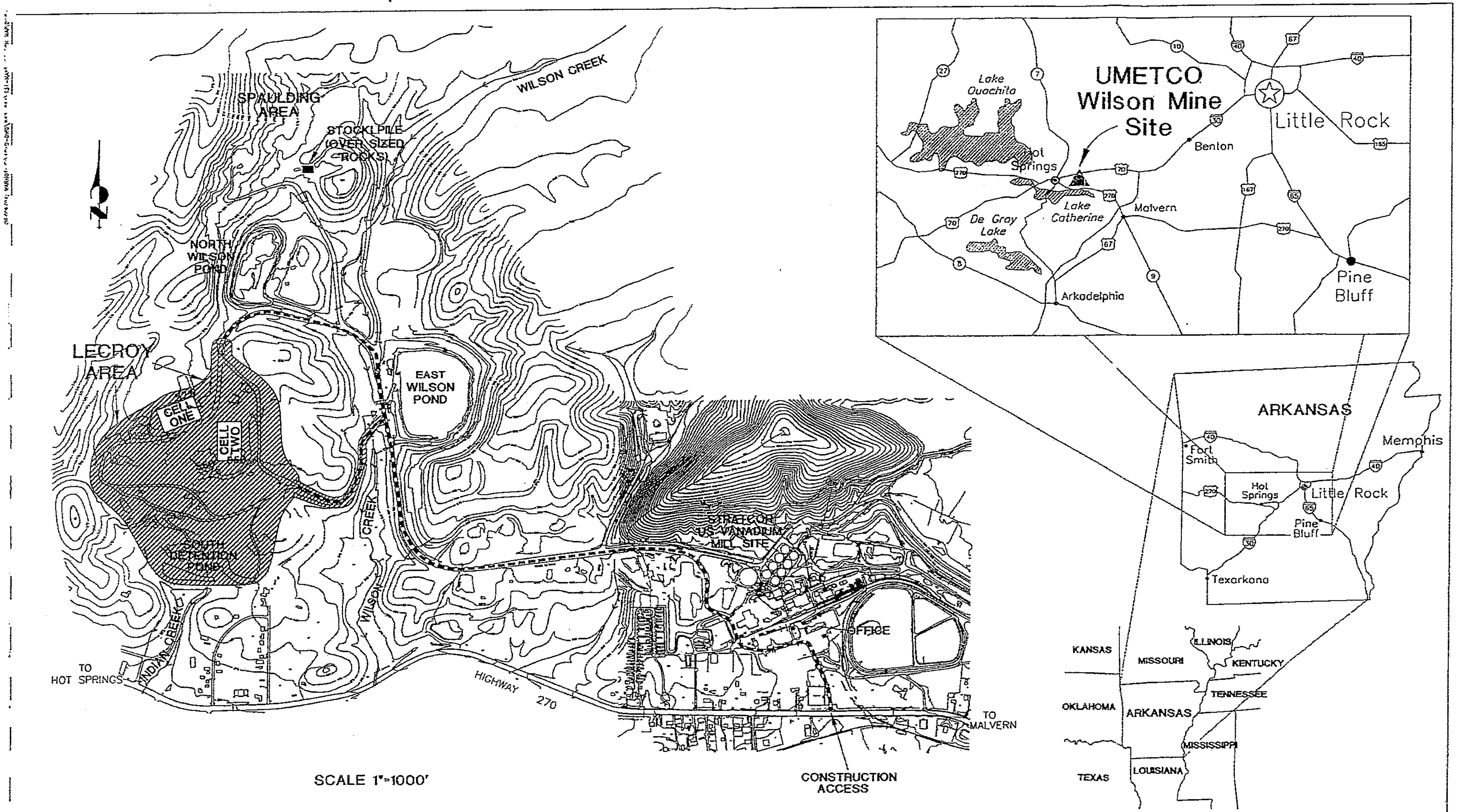
5.8.2 Maintenance of Existing Water Supply Uses

Wilson Creek has not been approved as, or used for, a public water supply. A letter from the Arkansas Department of Health documenting this is included in Appendix D. Wilson Creek is also not used for agricultural or industrial water supply. The proposed changes in uses and water quality standards in this evaluation will not prevent attainment of these water supply uses.

5.8.3 Maintenance of Existing Aquatic Life Uses

As described in Sections 4.3 and 4.4, adoption of the proposed minerals standards will not have an adverse affect on existing aquatic life uses. The proposed standards are based on existing minerals concentrations. Work for this assessment found that Wilson Creek presently supports aquatic communities at the existing minerals concentrations. Therefore, adoption of the proposed standards will maintain existing aquatic life conditions.

FIGURES



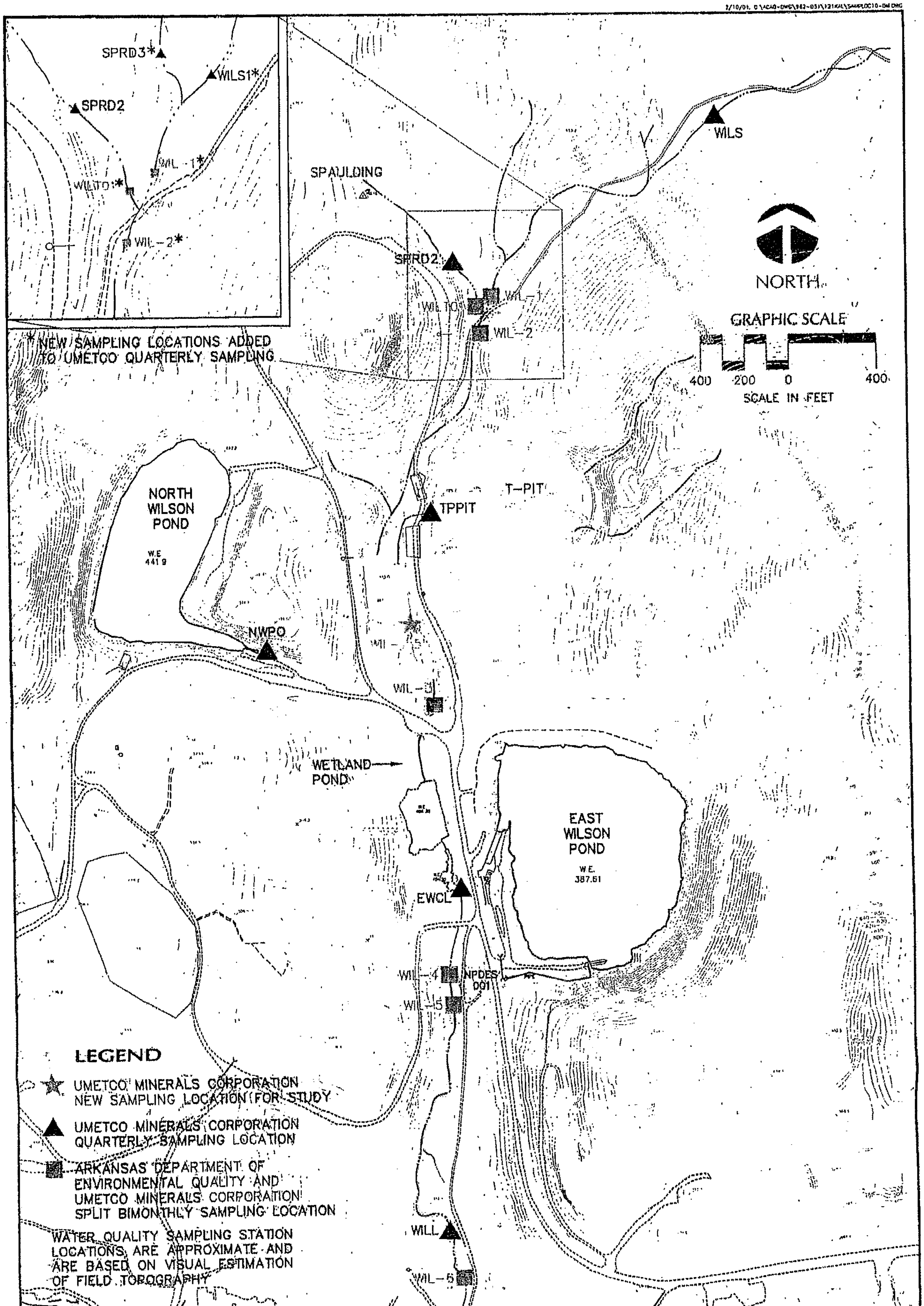
WWE WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700

DESIGN	RP
DETAIL	KAW
CHECK	RP
DATE	09/16/04

UMETCO
LECROY RECLAMATION PLAN
VICINITY MAP

PROJECT NO. 962-051.131

EXHIBIT 1



WEI WASTE ENGINEERING, INC.
2430 ALCOTT STREET
DENVER, CO 80211
(303)433-2788

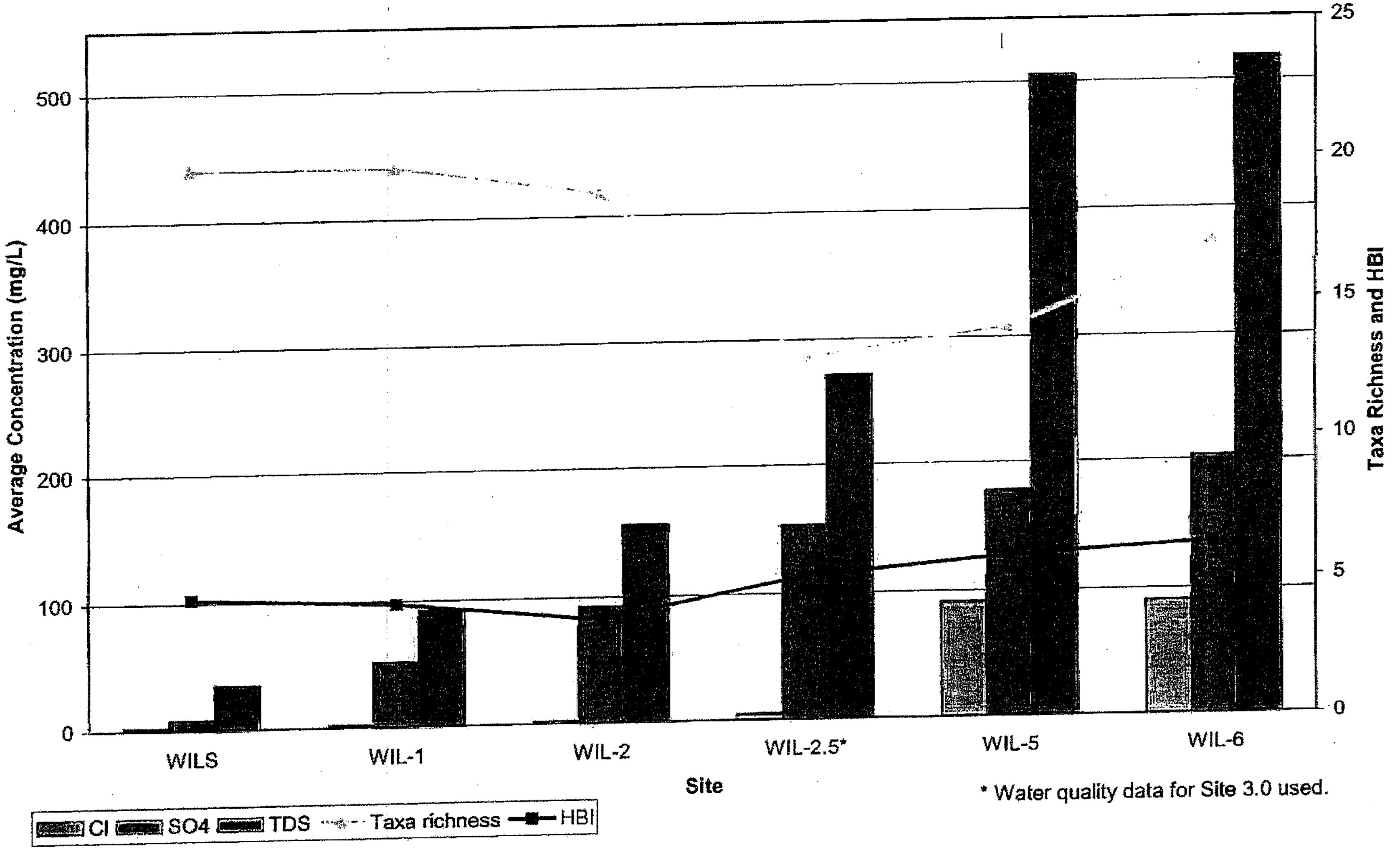
DESIGN	RP/DBM
DETAIL	KAL
CHECK	DMJ
DATE	2/10/04
SCALE	1"=400'

FIGURE 2

WILSON CREEK WATER QUALITY SAMPLING LOCATIONS

FIGURE 3

Taxa Richness and HBI v. Minerals Concentrations



* Water quality data for Site 3.0 used.

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FIGURE 4A

Taxa Richness v. Habitat Quality

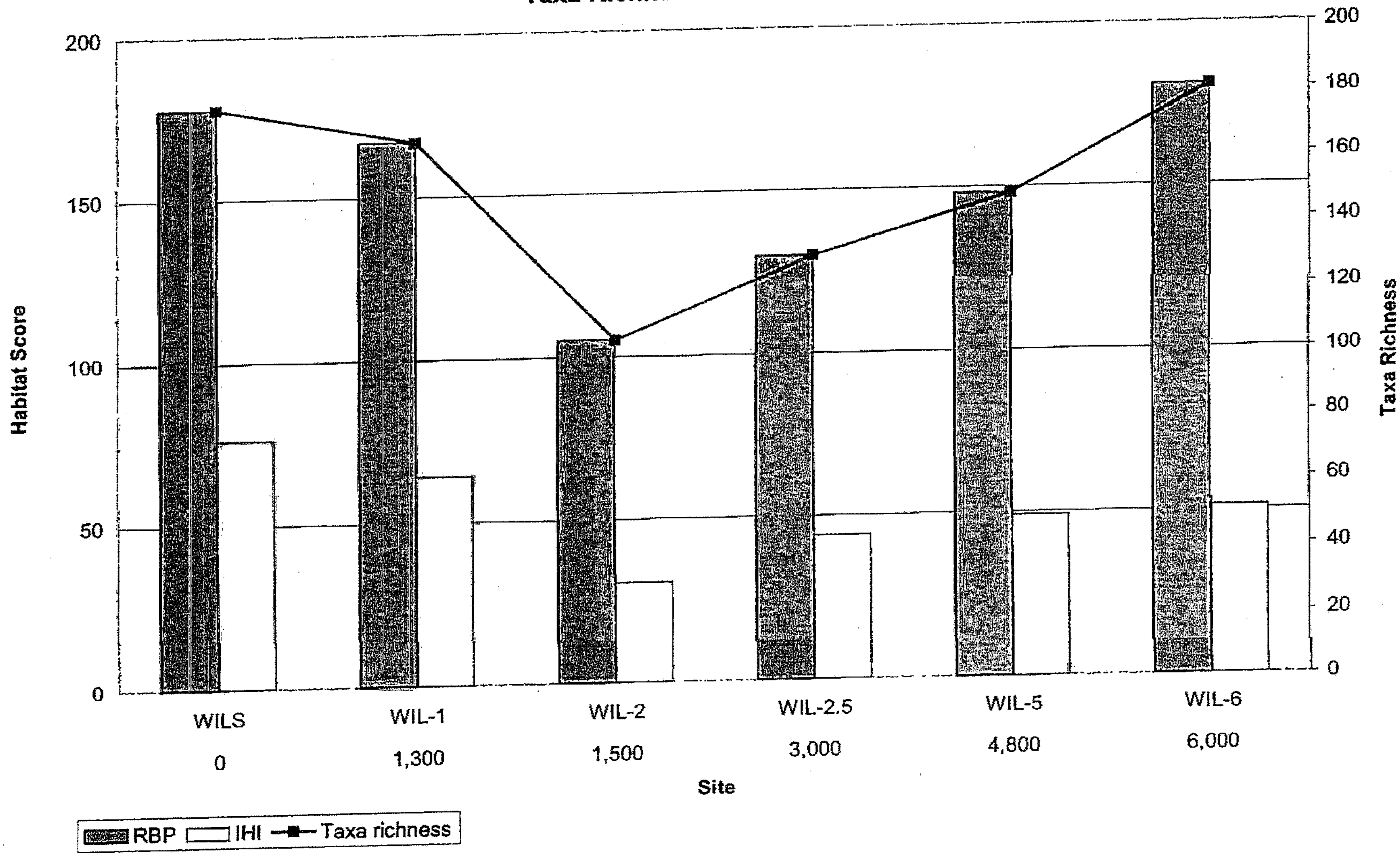

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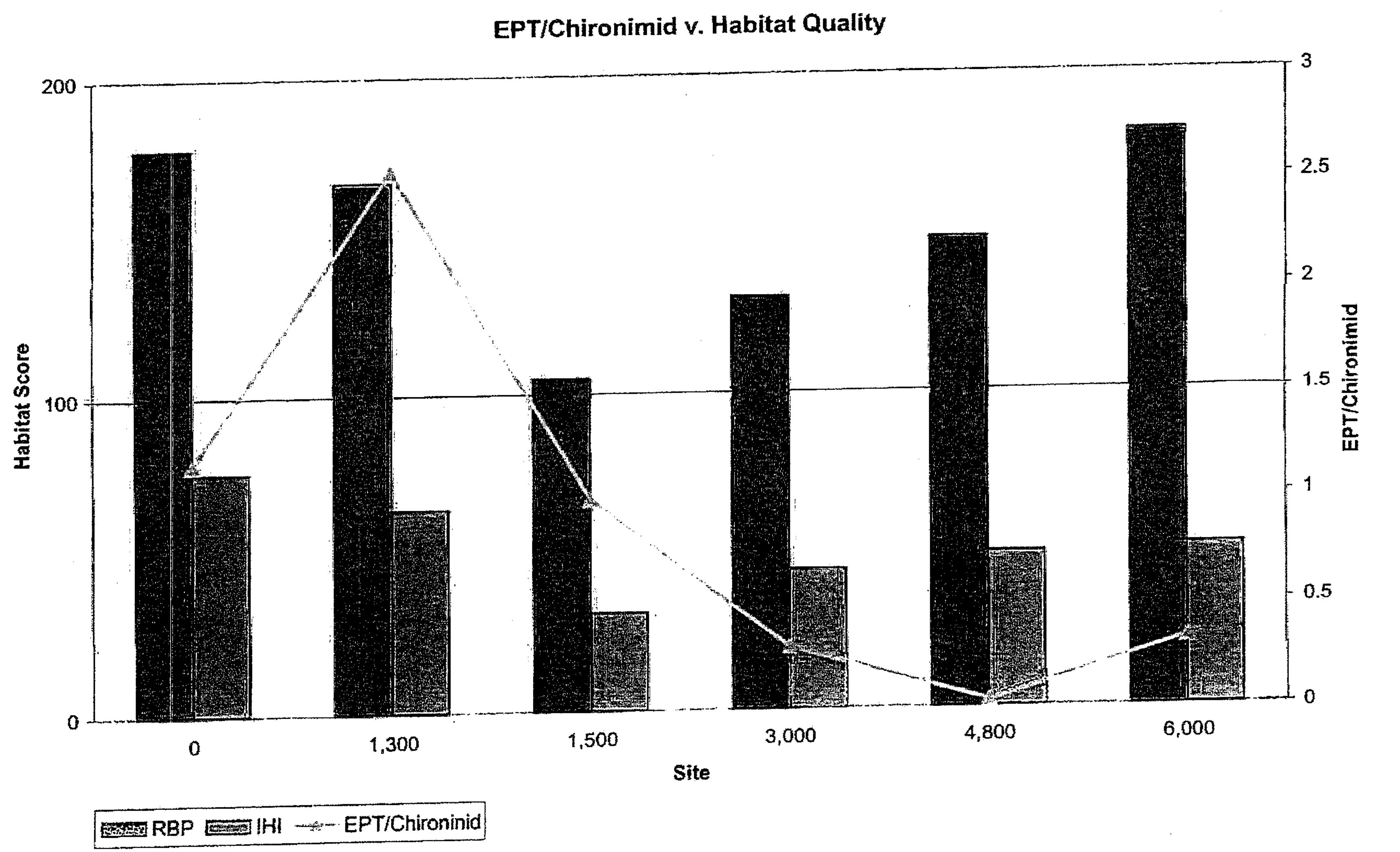
FIGURE 4B



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APPENDICES

APPENDIX A

Letter to James Stephens
Dated March 6, 2003

Umetco Minerals Corporation

P.O. BOX 1029
GRAND JUNCTION, COLORADO 81502
☎ (970) 245-3700

March 6, 2003

James Stephens, Chief of the Mining Division
Arkansas Department of Environmental Quality
8001 National Drive, Building D
Little Rock, Arkansas 72209

Re: **Wilson Mine Reclamation Project**
Garland County Arkansas
Reference Documents

Dear Mr. Stephens:

This letter presents a list of key references for the Wilson Mine reclamation project, which we committed to send you during the site visit and briefing on November 12, 2002.

- **Wilson Mine Site: Wetland Delineation and Mine Remediation, Garland County, Arkansas,** prepared by WEI August 1997 (962-051.060).
- **Analysis of Pumping Tests, Wilson Springs Mine Site, Hot Springs, Arkansas,** prepared by Yancey & Associates, Inc. (YAI) November 5, 1997.
- **Design Level Groundwater and Geotechnical Investigation, Lecroy Area, Wilson Vanadium Mine, Garland County, Arkansas,** prepared by WEI June 2000 (962-051.132).
- **Technical Specifications, Lecroy Area, Wilson Vanadium Mine, Garland County, Arkansas,** prepared by WEI October 2002 (962-051.131).
- **2002 Annual Solid Waste Permit Report, Lecroy Mine Spoils Landfill, Hot Springs, Arkansas,** prepared by Umetco Minerals Corporation January 2001.
- **Evaluation of Groundwater Conditions at the Wilson Springs Mine Site, Hot Springs, Arkansas,** prepared by YAI September 29, 1997.
- **Geophysical Surveys to Map Processed and Unprocessed Mine Waste at the Wilson Mine Site in Hot Springs, Arkansas,** prepared by Blackhawk Geometrics March 20, 1998.
- **Construction Report, Wilson Creek, North Wilson Pond & T-Pit, Wilson Vanadium Mine, Garland County, Arkansas,** prepared by WEI May 1999 (962-051.151) (two).

- **Construction Report, Spaulding Area, Wilson Vanadium Mine, Garland County, Arkansas**, prepared by WEI May 1999 (962-051.151).

- **Disposal Cell 1 Seep Investigation, Wilson Vanadium Mine, Hot Springs, Arkansas**, prepared by WEI December 1999 (962-051.190) (two).

- **Wilson Mine Surface Water Hydrology Study and Conceptual Drainage Plan**, prepared by WEI August 1996 (962-051.000).

- **Wilson Mine Surface Water Hydrology Study and Conceptual Drainage Plan Appendices**, prepared by WEI August 1996 (962-051.000) (two).

If you need any of these reports for your records, please advise us, and we will have copies sent to your office. If you have any questions concerning this information, please feel free to contact me or Tom Gieck.

Sincerely,

Curtis O. Sealy, P.E.
General Manager

COS:HAS:ses

cc: Timothy Kreese, Arkansas Dept. of Environmental Quality, Water Division
Gerald Delavan, Arkansas Dept. of Environmental Quality, Solid Waste Division
Tony Giles, Arkansas Dept. of Environmental Quality Solid Waste Division

APPENDIX B

Habitat Field Sheets and Photographs

ADEQ INSTREAM AND RIPARIAN HABITAT

WILS

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	75	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	6	Lg Boulder		x 1.0 =	Undercut Banks	1
Stream Width	4-5	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	1"	Rubble	13	x 1.0 = 13	Hanging Veg	
Max Depth	2"	Gravel	6	x 0.5 = 3	Root Wads	
		Sand		x 0.1 =	Leafy Debris	1
		Mud/Silt		x 0.1 =		
				16		4

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 14

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 34

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Very shallow, Flow through rocks

WILS

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1   X **Pool**   ____ **Riffle**   ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	30	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	12	Lg Boulder		x 1.0 =	Undercut Banks	2
Stream Width	11	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	6"	Rubble	11	x 1.0 = 11	Hanging Veg	1
Max Depth	12"	Gravel	6	x 0.5 = 3	Root Wads	1
		Sand	2	x 0.1 = .2	Leafy Debris	5
		Mud/Silt	5	x 0.1 = .5		
				14.7		11

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 6

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 31.7

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Arkansas Department of Environmental Quality

Riffle Habitat Assessment

Stream Name Wilson Creek	Location U.S. of road to ± 425'
Station ID WIL5	
Lat______ Long______	Date 5/11/04 Time 10:00 am pm
Investigators	Land Use Forest
Form Completed By MEHAN	Mean Velocity < 1 fps Flow ± 5 gpm (low)

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are <u>not</u> new fall and <u>not</u> transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow). (Slow is <0.3 m/s, deep is >0.5 m)	Only 3 or 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 or 4 regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 regime (usually slow-deep) only shallow riffle
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools Flow down between rubble
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of >25
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
	SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
	SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

road ±100' away

TOTAL SCORE 187

NOTES Good pattern of shallow riffles with pools. Pools deeper than at WIL-1 & WIL-2

Arkansas Department of Environmental Quality

Pool Habitat Assessment

Stream Name Wilson Creek	Location U.S. of road & 425'
Station ID WILS	
Lat ______ Long ______	Date 5/11/04 Time 1030 (am) pm
Investigators	Land Use Forest
Form Completed By MEHAN	Mean Velocity <1 fps Flow 5 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0

fine sediment

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

road at d.s. end of pool

road at lower end

TOTAL SCORE 162

NOTES

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

WILS

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	75	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	6	Lg Boulder		x 1.0 =	Undercut Banks	1
Stream Width	4-5	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	1"	Rubble	13	x 1.0 = 13	Hanging Veg	
Max Depth	2"	Gravel	6	x 0.5 = 3	Root Wads	
		Sand		x 0.1 =	Leafy Debris	1
		Mud/Silt		x 0.1 =		4
				16		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 14

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 34

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Very shallow, flow through rocks

WIL-1 1/6

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length		Bedrock		x 0.1 =	Woody Debris	5
Channel Width	6	Lg Boulder		x 1.0 =	Undercut Banks	3
Stream Width	10	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	24	Rubble	12	x 1.0 = 12	Hanging Veg	
Max Depth	44	Gravel	6	x 0.5 = 3	Root Wads	3
		Sand		x 0.1 =	Leafy Debris	2
		Mud/Silt		x 0.1 =		
				15		13

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals tlic substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 12

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 40

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

- little sediment, only small film on rocks

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2/6

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site. WL-1

Habitat Number 2   X **Pool**   ____ **Riffle**   ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	20	Bedrock		x 0.1 =	Woody Debris	8
Channel Width	8	Lg Boulder		x 1.0 =	Undercut Banks	1
Stream Width	7	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	6"	Rubble	11	x 1.0 = 11	Hanging Veg	
Max Depth	8"	Gravel	5	x 0.5 = 2.5	Root Wads	
		Sand	2	x 0.1 = .2	Leafy Debris	10
		Mud/Silt	2	x 0.1 = .2		
				13.9		19

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 10 slight film on rocks

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 42.9

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Arkansas Department of Environmental Quality

Riffle Habitat Assessment

Stream Name Wilson Creek	Location creek u.s. SPR02
Station ID WIL-1	
Lat______ Long______	Date 5/11/04 Time 0930 am pm
Investigators	Land Use Forest
Form Completed By MEHAN	Mean Velocity 1 fps Flow 5 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are <u>not</u> new fall and <u>not</u> transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow). (Slow is <0.3 m/s, deep is >0.5 m)	Only 3 or 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 or 4 regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 regime (usually slow-deep) shallow ripple shallow pool
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

creek small

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of >25
SCORE	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL SCORE 166   road on right bank ± 20-50'

NOTES substrate much cleaner, no evidence of road sediment.

Arkansas Department of Environmental Quality

Pool Habitat Assessment

Stream Name WILSON CREEK	Location East u.s. SPR02
Station ID WIL-1	
Lat ______ Long ______	Date 5/11/04 Time 0945 (am) pm
Investigators	Land Use Forest
Form Completed By MEHAN	Mean Velocity 1 fps Flow 5 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Optimal	Suboptimal	Marginal	Poor
	Condition Category			
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent Bigger pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Some rubble, wood, roads

than in WIL-2

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance little sinuosity
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

reach further f/ road

TOTAL SCORE 171

NOTES - 2-3 larger pools, no sed., more rubble, wood, less embeddedness
- this reach is in an intact forest
- some overhung banks

1/8

WL-2
5/11/04
OBM

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1   X **Pool** (2)   ____ **Riffle**   ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	120	Bedrock		x 0.1 =	Woody Debris	6
Channel Width	25	Lg Boulder		x 1.0 =	Undercut Banks	
Stream Width	6	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	6"	Rubble		x 1.0 =	Hanging Veg	
Max Depth	8"	Gravel		x 0.5 =	Root Wads	
		Sand		x 0.1 =	Leafy Debris	13
		Mud/Silt	14	x 0.1 = 1.4		19

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 1

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 21.4

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

pools located below road crossing.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

C:\PF\962-051\121mds\Form ADEQ Instream and riparian Habitat Scoring.doc

Flow ≈ 10 gpm

2/8

WL-2

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	110	Bedrock	______	x 0.1 = ______	Woody Debris	2
Channel Width	15	Lg Boulder	______	x 1.0 = ______	Undercut Banks	______
Stream Width	4	Boulder	______	x 1.0 = ______	Aquatic Veg	______
Avg Depth	.2"	Rubble	6	x 1.0 = 6	Hanging Veg	______
Max Depth	3"	Gravel	8	x 0.5 = 4	Root Wads	1
		Sand	______	x 0.1 = ______	Leafy Debris	8
		Mud/Silt	11	x 0.1 = 1.1		
				11.1		11

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 4

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 26.1

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

used this riffle for reach.
Total length riffle = 110'

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

3/8

WIL-2

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 3 X **Pool** ____ **Riffle** ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	190	Bedrock		x 0.1 =	Woody Debris	5
Channel Width	15	Lg Boulder		x 1.0 =	Undercut Banks	1
Stream Width	6	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	.4"	Rubble	2	x 1.0 = 2	Hanging Veg	
Max Depth	6"	Gravel		x 0.5 =	Root Wads	
		Sand		x 0.1 =	Leafy Debris	11
		Mud/Silt	12	x 0.1 = 1.2		
				3.2		17

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 1

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 21.2

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

4/8

WIL-2

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 4 ____ **Pool** ____ **Riffle** X **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	60	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	15	Lg Boulder		x 1.0 =	Undercut Banks	
Stream Width	4	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	3"	Rubble	6	x 1.0 = 6	Hanging Veg	
Max Depth	4"	Gravel	8	x 0.5 = 4	Root Wads	1
		Sand		x 0.1 =	Leafy Debris	6
		Mud/Silt	6	x 0.1 = .6		
				10.6		9

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 3

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 22.6

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Arkansas Department of Environmental Quality

Riffle Habitat Assessment

Stream Name Wilson Creek	Location 120' d.s. road crossing
Station ID WL-2	
Lat ____ Long ____	Date 5/1/14 Time 0900 (am) pm
Investigators	Land Use Forest
Form Completed By MEHart	Mean Velocity 1 fps Flow 10 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 (1) 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow). (Slow is <0.3 m/s, deep is >0.5 m)	Only 3 or 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 or 4 regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 regime (usually slow-deep) only fast shallow
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	(5) 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 (4) 3 2 1 0

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of >25
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Road crossing is major sed. source

TOTAL SCORE 105

NOTES Road is on L. Bank ± 50'. Road crossing ± 120' U.S. is large source of sediment in this reach.

7/8

Arkansas Department of Environmental Quality
Pool Habitat Assessment

Stream Name WILSON CREEK	Location ± 50 d.s. road crossing
Station ID WIL-2	
Lat ______ Long ______	Date 5/11/04 Time 0915 (am) pm
Investigators	Land Use Forest
Form Completed By MEHAN	Mean Velocity < 1 fps Flow 10 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL SCORE 104

NOTES · pool substrate mud, silt w/ some leaves. Few root wads, undercut banks, some wood though sparse, shallow water (3-5").

WIL- 2,5

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1 ______ **Pool** ______ **Riffle** X **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	80	Bedrock		x 0.1 =	Woody Debris	3
Channel Width	2-3'	Lg Boulder		x 1.0 =	Undercut Banks	
Stream Width	2-3'	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	3"	Rubble	10	x 1.0 = 10	Hanging Veg	
Max Depth	6"	Gravel	10	x 0.5 = 5	Root Wads	
		Sand	6	x 0.1 = .6	Leafy Debris	2
		Mud/Silt		x 0.1 =		
				15.6		5

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 11

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 31.6

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

WIL 2.5

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	40	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	2	Lg Boulder		x 1.0 =	Undercut Banks	
Stream Width	2	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	2"	Rubble	11	x 1.0 = 11	Hanging Veg	
Max Depth	3"	Gravel	10	x 0.5 = 5	Root Wads	
		Sand	6	x 0.1 = .6	Leafy Debris	2
		Mud/Silt		x 0.1 =		4
				16.6		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 13

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 33.6

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores WIL 2.5

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 3 X **Pool** ____ **Riffle** ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	20	Bedrock		x 0.1 =	Woody Debris	2
Channel Width	6	Lg Boulder		x 1.0 =	Undercut Banks	
Stream Width	5	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	3"	Rubble	11	x 1.0 = 11	Hanging Veg	
Max Depth	5"	Gravel	8	x 0.5 = 4	Root Wads	
		Sand	4	x 0.1 = .4	Leafy Debris	8
		Mud/Silt	.2	x 0.1 = .2		
				15.6		10

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 12
Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 37.6

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

- pools very shallow, little cover
- mostly rubble, gravel
- little sediment

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Arkansas Department of Environmental Quality

Pool Habitat Assessment

Stream Name Wilson Creek	Location d.s. T-Pit, road crossing
Station ID WIL-2.5	
Lat ______ Long ______	Date 5/12/04 Time 0900 (am) pm
Investigators	Land Use reclaimed mine, Forest
Form Completed By MEHan	Mean Velocity <1 fps Flow 10 gpm

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
	SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
	SCORE	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 (3) 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
	SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0

w/ 3" deep.

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2 1 0

1st ± 150' straight d.s. of road

road + pit close

TOTAL SCORE 126

NOTES portion of creek u/ road d.s. is open & straight riffle/run. Pools occur intermit. Flow ends ± ' d.s. of road culvert

7.

Arkansas Department of Environmental Quality

Riffle Habitat Assessment

Stream Name Wilson Creek	Location d/s of road crossing at T-pit
Station ID WIL-2.5	
Lat ______ Long ______	Date 5/12/04 Time 9:30 (am) pm
Investigators	Land Use reclaimed mine, Forest
Form Completed By METHN	Mean Velocity < 1 fps Flow 10 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor	
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking	mainly rubble
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment	low
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow). (Slow is <0.3 m/s, deep is >0.5 m)	Only 3 or 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 or 4 regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 regime (usually slow-deep) only Fast, shallow habitat	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools	channel very small (2' wide)
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of >25
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Straight reach

Road, T-pit along reach

TOTAL SCORE 138

NOTES Ripples are very shallow, stream only ± 2' wide. Flow increased from rain yesterday.

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

WIL-5

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1   X **Pool**   ______ **Riffle**   ______ **Run**

Measurements (feet)		**Substrate Type (Score)**				**Instream Cover (Score)**	
Length	60	Bedrock		x 0.1 =		Woody Debris	6
Channel Width	5	Lg Boulder		x 1.0 =		Undercut Banks	7
Stream Width	5	Boulder		x 1.0 =		Aquatic Veg	
Avg Depth	8"	Rubble		x 1.0 =		Hanging Veg	
Max Depth	1.2'	Gravel	12	x 0.5 =	6	Root Wads	6
		Sand	10	x 0.1 =	1	Leafy Debris	8
		Mud/Silt	11	x 0.1 =	1		27
					6.2		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 6   some red, Fe

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 39.2

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

- Very slow, foam on surface
- Just upstream from ... WIL-6

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ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores WIL-5

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2 X **Pool** ____ **Riffle** ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	90	Bedrock		x 0.1 =	Woody Debris	6
Channel Width	3	Lg Boulder	1	x 1.0 = 1	Undercut Banks	8
Stream Width	3	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	.84	Rubble		x 1.0 =	Hanging Veg	
Max Depth	1.27	Gravel	12	x 0.5 = 6	Root Wads	7
		Sand	7	x 0.1 = .7	Leafy Debris	6
		Mud/Silt	7	x 0.1 = .7		27
				8.4		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals tlie substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 5

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 40.4

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

- Good wds, cut banks root wads, wood
- channel entrenched ±2'

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WIL-5

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 3 ______ **Pool** ______ **Riffle** X **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	30'	Bedrock		x 0.1 =	Woody Debris	7
Channel Width	3'	Lg Boulder		x 1.0 =	Undercut Banks	6
Stream Width	3'	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	6"	Rubble	2	x 1.0 = 2	Hanging Veg	
Max Depth	1'	Gravel	12	x 0.5 = 6	Root Wads	6
		Sand	3	x 0.1 = .3	Leafy Debris	6
		Mud/Silt	5	x 0.1 = .5		25
				8.8		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 10

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 43.8

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

Arkansas Department of Environmental Quality

Pool Habitat Assessment

Stream Name Wilson Creek	Location A.S. outfall 001
Station ID WIL-5	
Lat ________ Long ________	Date 5/13/04 Time 10:15 (am) pm
Investigators	Land Use Reclaimed mine, Forest
Form Completed By MEHAN	Mean Velocity 1 fps Flow 15 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Optimal	Suboptimal	Marginal	Poor
	Condition Category			
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	~~All~~ mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

very straight

road ±30 away

TOTAL SCORE 148

NOTES LWG, narrow pool, some undercut banks, v. wood, but sediment evident (Fe Floc)

WIL-6
5/13/04

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 1   X **Pool**   ____ **Riffle**   ____ **Run**

Measurements (feet)		**Substrate Type (Score)**				**Instream Cover (Score)** *	
Length	25	Bedrock		x 0.1 =		Woody Debris	12
Channel Width	6	Lg Boulder		x 1.0 =		Undercut Banks	11
Stream Width	6	Boulder		x 1.0 =		Aquatic Veg	
Avg Depth	6"	Rubble	9	x 1.0 =	9	Hanging Veg	
Max Depth	1'	Gravel	12	x 0.5 =	6	Root Wads	5
		Sand	6	x 0.1 =	.6	Leafy Debris	8
		Mud/Silt	1	x 0.1 =	.1		35
					15.7		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 10

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 60.7

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

WIL-6

5/13/04

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 2   ____ **Pool**   ____ **Riffle**   X **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	50	Bedrock		x 0.1 =	Woody Debris	5
Channel Width	5	Lg Boulder		x 1.0 =	Undercut Banks	2
Stream Width	5	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	2"	Rubble	14	x 1.0 = 14	Hanging Veg	
Max Depth	3"	Gravel	9	x 0.5 = 4.5	Root Wads	5
		Sand	1	x 0.1 = .1	Leafy Debris	5
		Mud/Silt		x 0.1 =		17
				18.6		

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 11 -

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 46.6

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Very shallow

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth. ✓

W1L-6
5/13/04

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 3   X **Pool**   ____ **Riffle**   ____ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	100	Bedrock		x 0.1 =	Woody Debris	8
Channel Width	12	Lg Boulder		x 1.0 =	Undercut Banks	11
Stream Width	11	Boulder		x 1.0 =	Aquatic Veg	
Avg Depth	4"	Rubble	7	x 1.0 = 7	Hanging Veg	
Max Depth	8"	Gravel	12	x 0.5 = 6	Root Wads	2
		Sand	6	x 0.1 = .6	Leafy Debris	6
		Mud/Silt	5	x 0.1 = .5		
				14.1		27

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 9

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 50.1

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

Good undercut banks; wood, Gravel; pretty clean

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

WIL-6

ADEQ INSTREAM AND RIPARIAN HABITAT

Procedures for Obtaining Habitat and Index of Habitat Integrity Scores

Example: The following is provided as a fictitious example to help explain how a habitat score is obtained by ADEQ ecologists. There typically are multiple habitats (i.e. riffle, run, pool) sampled per site to obtain a representative sample of the fish community inhabiting that site.

Habitat Number 4 ______ **Pool** X **Riffle** ______ **Run**

Measurements (feet)		**Substrate Type (Score)**			**Instream Cover (Score)**	
Length	50	Bedrock	______	x 0.1 = ______	Woody Debris	6
Channel Width	6-8	Lg Boulder	______	x 1.0 = ______	Undercut Banks	10
Stream Width	5-6	Boulder	______	x 1.0 = ______	Aquatic Veg	______
Avg Depth	3"	Rubble	13	x 1.0 = 13	Hanging Veg	______
Max Depth	4"	Gravel	10	x 0.5 = 5	Root Wads	5
		Sand	5	x 0.1 = .5	Leafy Debris	7
		Mud/Silt	5	x 0.1 = .5		
				19		28

Habitat Scoring Categories: Abundant 11-15; Common 6-10; Sparce 1-5; Absent 0

(Note: Habitat scoring categories are assigned to substrate type and instream cover based on visual observations. Scores are assigned to each substrate type then multiplied by a fixed number (0.1, 0.5, or 1.0) to get a final score for each substrate type category. The sum of all substrate type categories equals the substrate type score. The same habitat scoring categories are used for instream cover. The sum of all instream cover categories equals the instream cover score)

Sedimentation on Substrate: 13

Sedimentation Score: None 11-15; Light 6-10; Noticeable 1-5; Excessive 0

Habitat Score (Sum Substrate Type, Instream Cover and Sedimentation): 60

Index of Habitat Integrity

Average Habitat Length (i.e. all pools or all riffles) multiplied by Average Habitat Score (i.e. all pools or all riffles) multiplied by 0.01

DEFINITIONS

Riffle: Shallow, turbulent areas where water passes through or over stones or gravel of a fairly uniform size.

Pool: Deeper areas with relatively slow-moving water.

Run: Intermediate areas of moderate current and depth.

C:\PF\962-051\121mds\Form ADEQ Instream and riparian Habitat Scoring.doc

Arkansas Department of Environmental Quality
Riffle Habitat Assessment

Stream Name Wilson creek	Location d.s. of WILL
Station ID WIL-6	
Lat ______ Long ' ______	Date 5/13/04 Time 0900 (am) pm
Investigators	Land Use Reclaimed mine, Forest
Form Completed By MEHAN	Mean Velocity 1 fps Flow 10 gpm

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Embeddedness	Gravel, cobble and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles are more than 75% surrounded by fine sediment
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow). (Slow is <0.3 m/s, deep is >0.5 m)	Only 3 or 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 or 4 regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 regime (usually slow-deep) only Fast/shallow
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

very small channel

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of >25
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL SCORE 191

NOTES

Arkansas Department of Environmental Quality

Pool Habitat Assessment

Stream Name Wilson Creek	Location lower creek, d.s. of WILL
Station ID WIL-C	
Lat _____ Long _____	Date 9/12/14 Time 0900 (am) pm
Investigators	Land Use Reclaimed mine, Forest
Form Completed By MEHAN	Mean Velocity 1 fps Flow 15 gpm

Parameters to be evaluated in sampling reach

Habitat Parameter	Optimal	Suboptimal	Marginal	Poor
	Condition Category			
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are <u>not</u> new fall and <u>not</u> transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat of vegetation
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, larg-deep, small -shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
SCORE	20 19 18 17 16	15 14 13 12 11	10 (9) 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed	Very little water in channel and mostly present as standing pools
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	The bends in the stream increase the stream <1 time longer than if it was in a straight line	Channel straight; waterway has been channelized for a long distance
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	8. Bank Stability (Score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
	SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	9. Riparian Vegetative Zone Width (Score each bank riparian zone)	Width of riparian zone >18 m; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone	Width of riparian zone 12-18 m; human activities have impacted zone only minimally	Width of riparian zone 6-12 m; human activities have impacted zone a great deal	Width of riparian zone <6 m; little or no riparian vegetation due to human activities
	SCORE LB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	SCORE RB	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

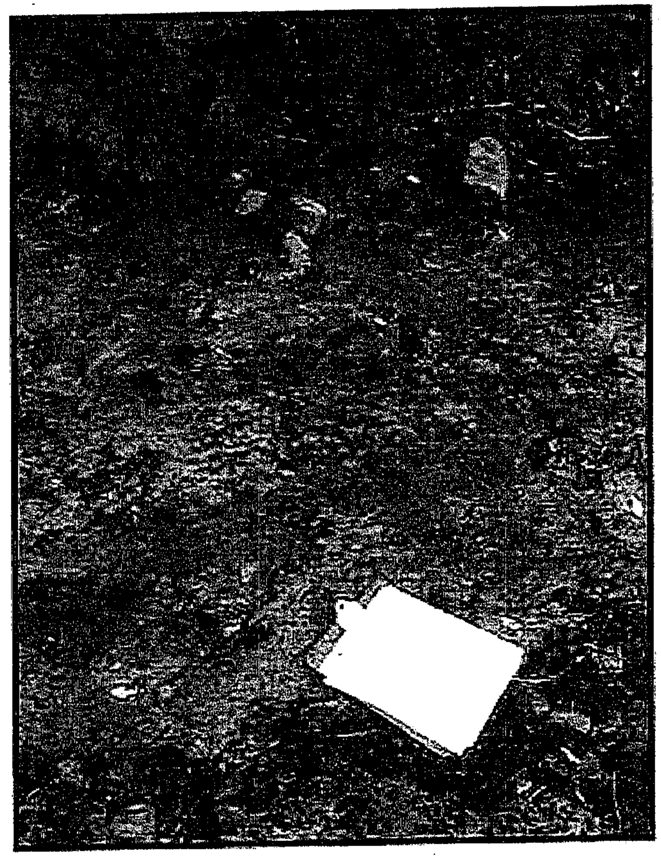
Road ±75' away

TOTAL SCORE 176

NOTES Big pool, undercut bank on far side, some rubble + wood. Deepest at head (±1').

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004

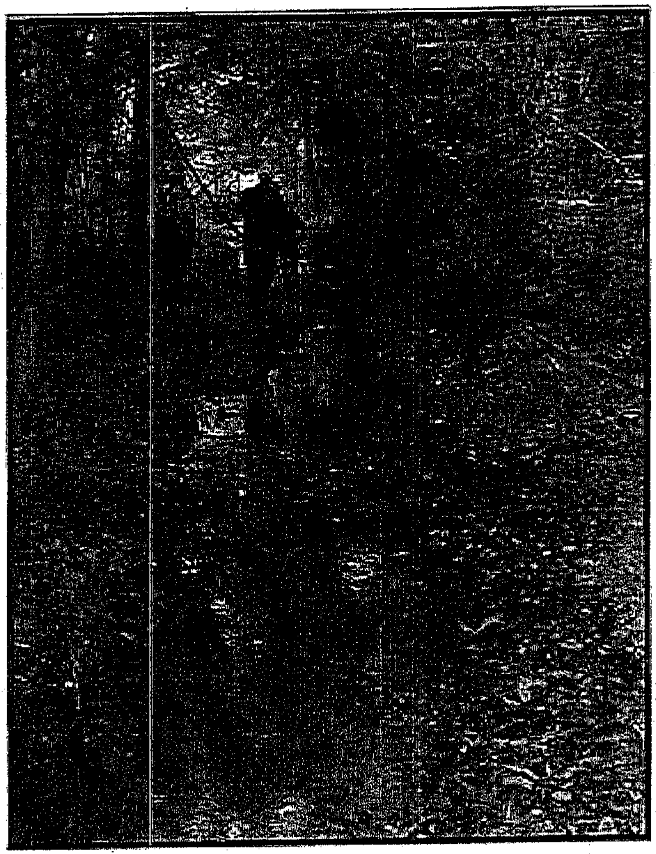
1. Sediment deposited on riffle below road crossing at WIL-2.



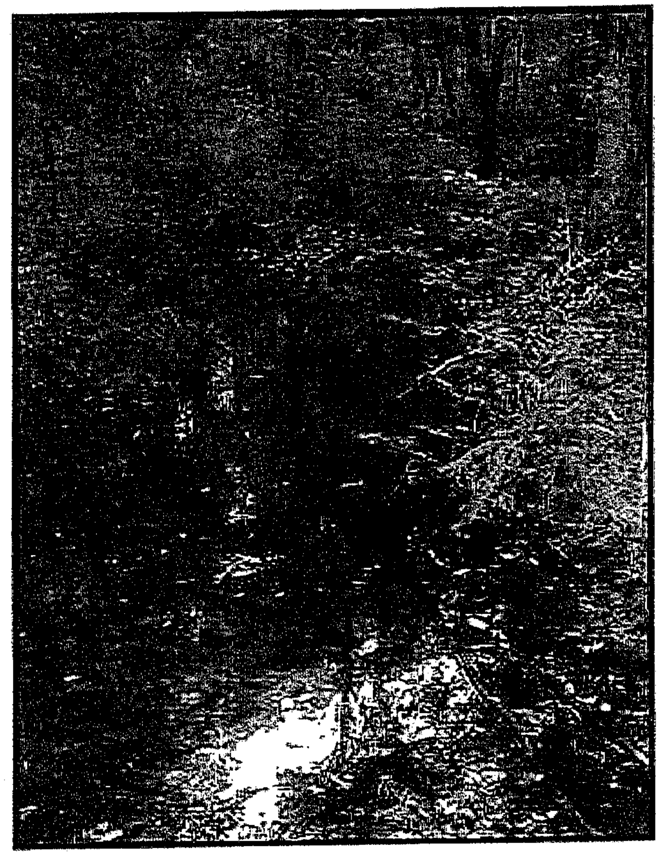
2. Close-up of sediment deposited on substrate from road crossing at WIL-2.

3. Small pool at downstream end of reach shocked at WIL-2.

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004

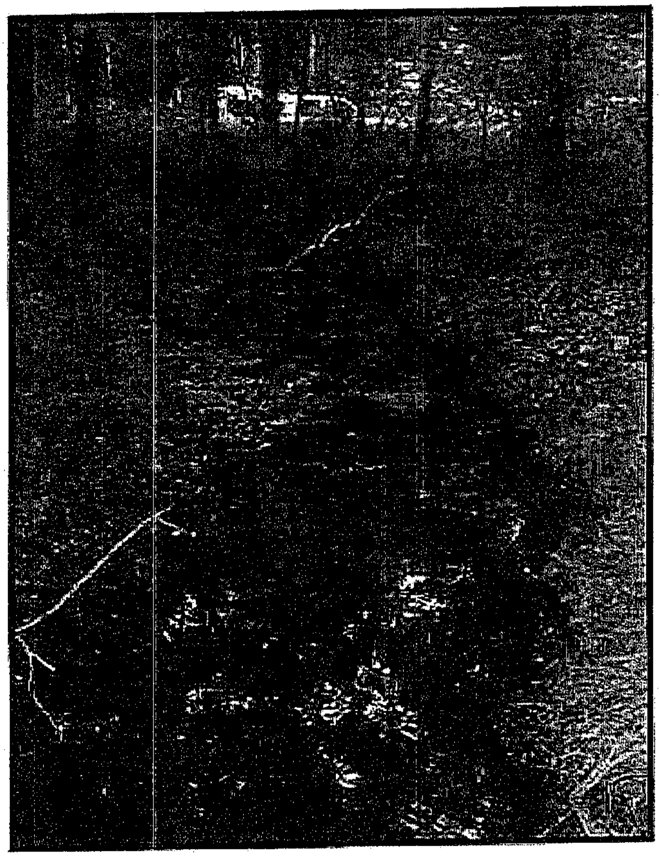


4. WIL-2 showing sediment on substrate and lack of flow in channel.

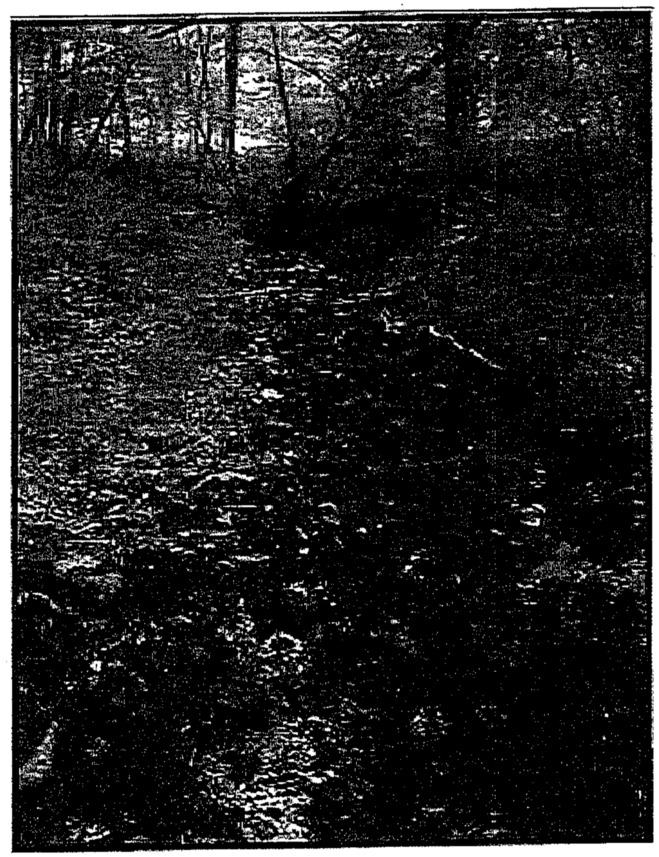


5. Pool in WIL-1.

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004



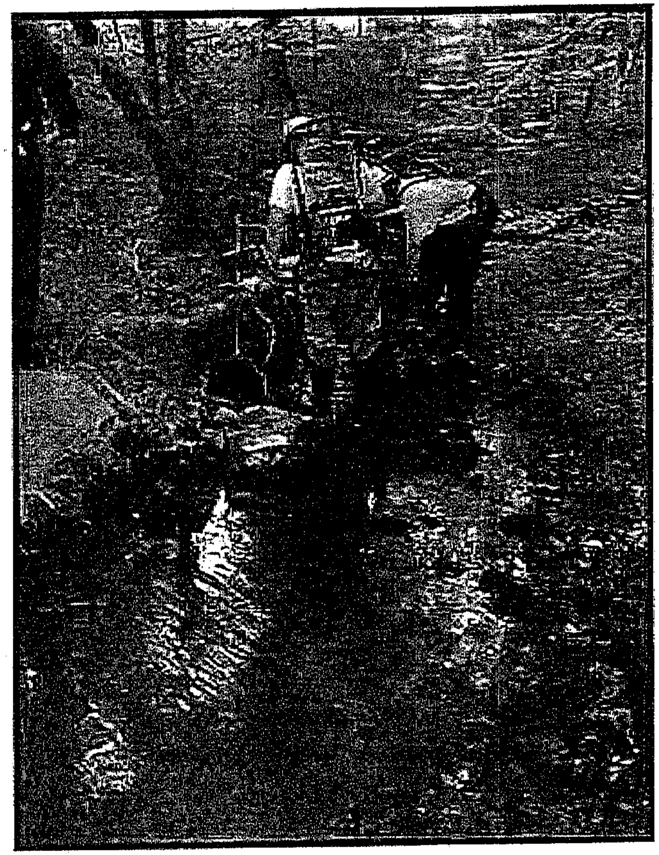
6. Pool (foreground) and riffle (background) in WIL-1.
Note lack of water in riffle



7. Pool in foreground with riffle in WILS.

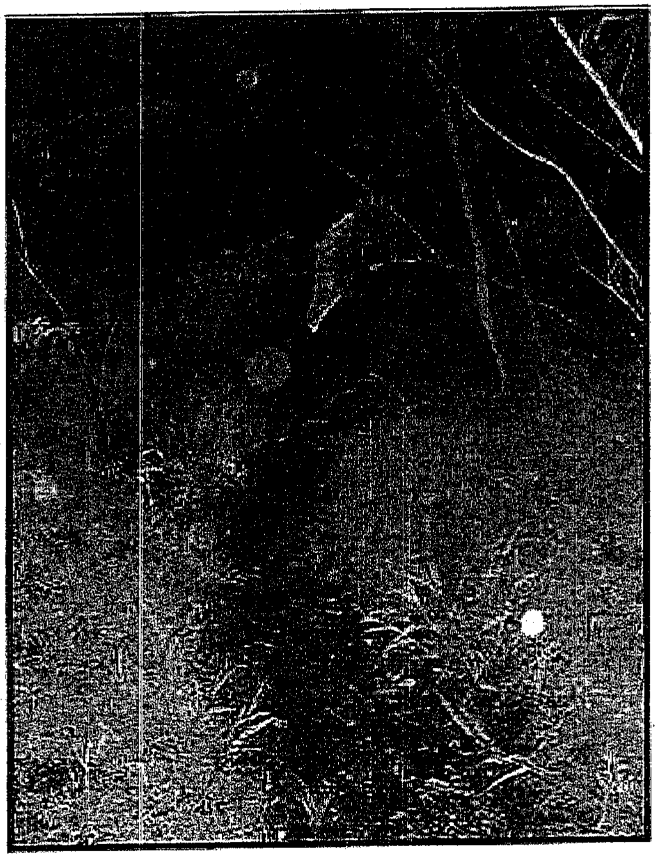
Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004

8. Riffle WILS showing lack of flow.



9. Pool at upstream end of WILS.

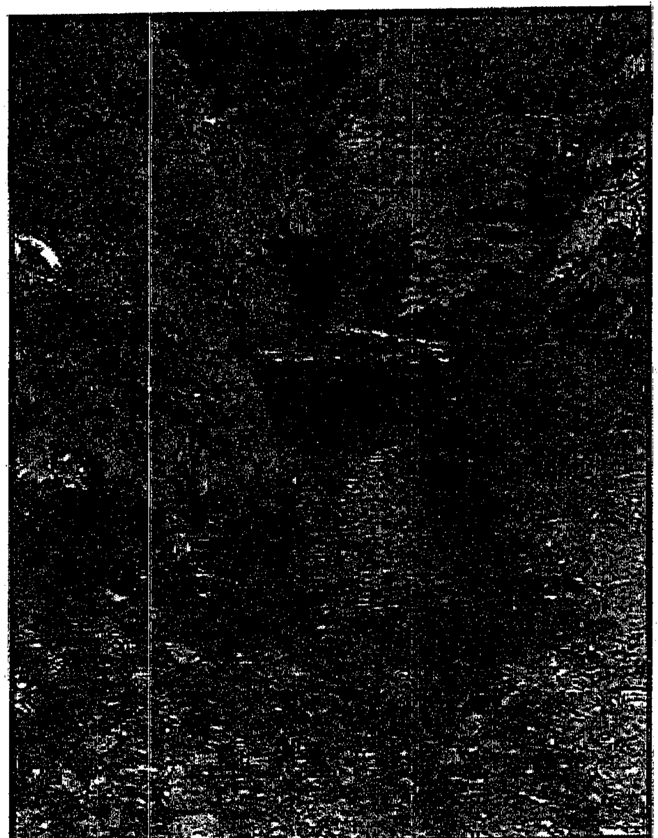
Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004



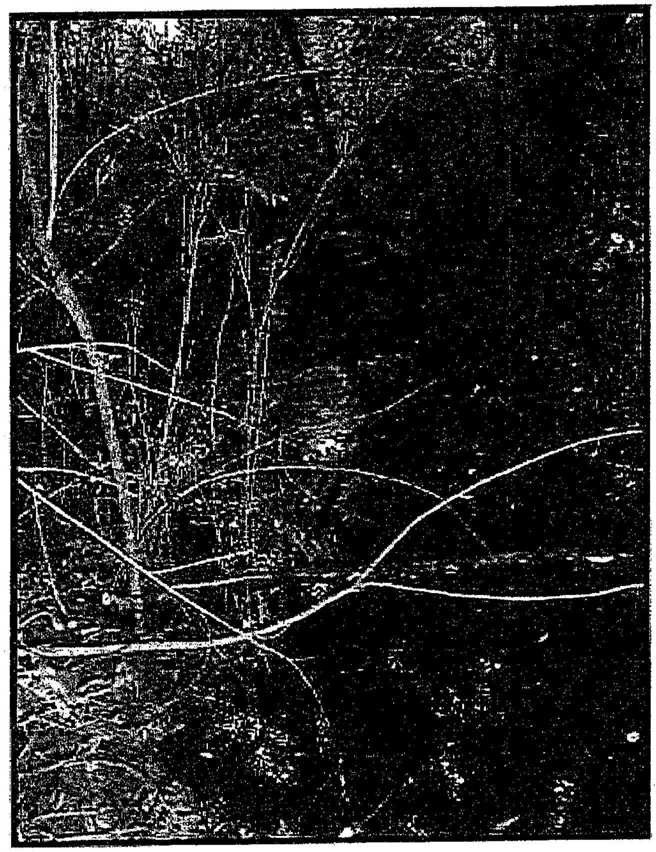
10. Riffle in WIL-2.5. Creek is only ± 2 feet wide.

11. Riffle in WIL-2.5. Creek is only ± 2 feet wide.

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004

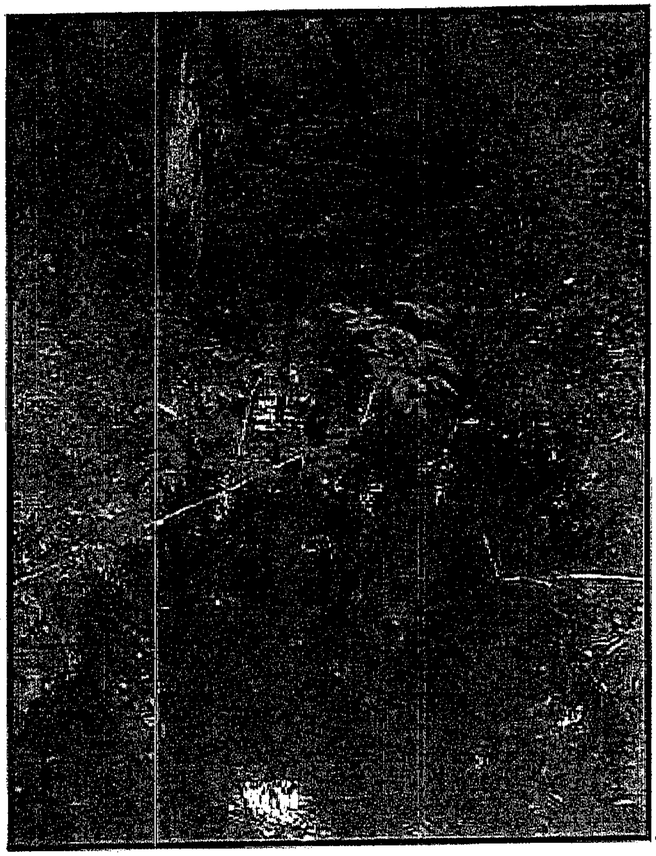


12. Pools in trees at WIL-2.5.

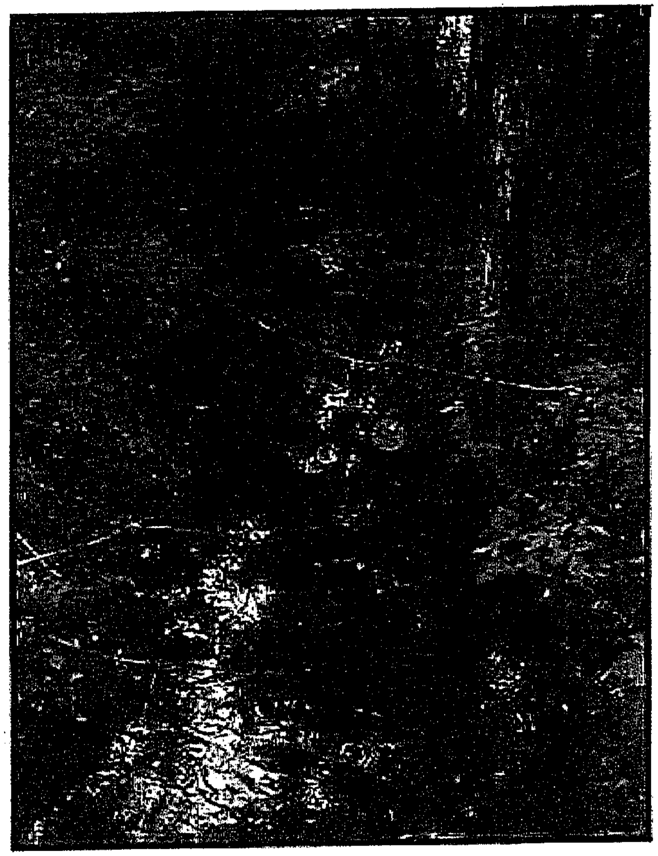


13. Pool at WIL-5.

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004

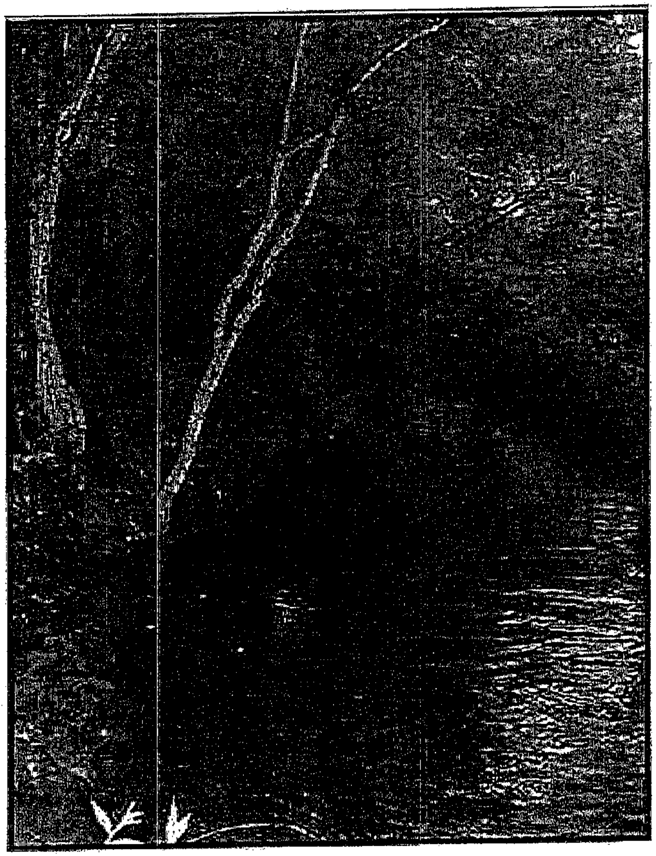


14. Narrow pool/run at WIL-5.



15. Long reach of pool at WIL-5.

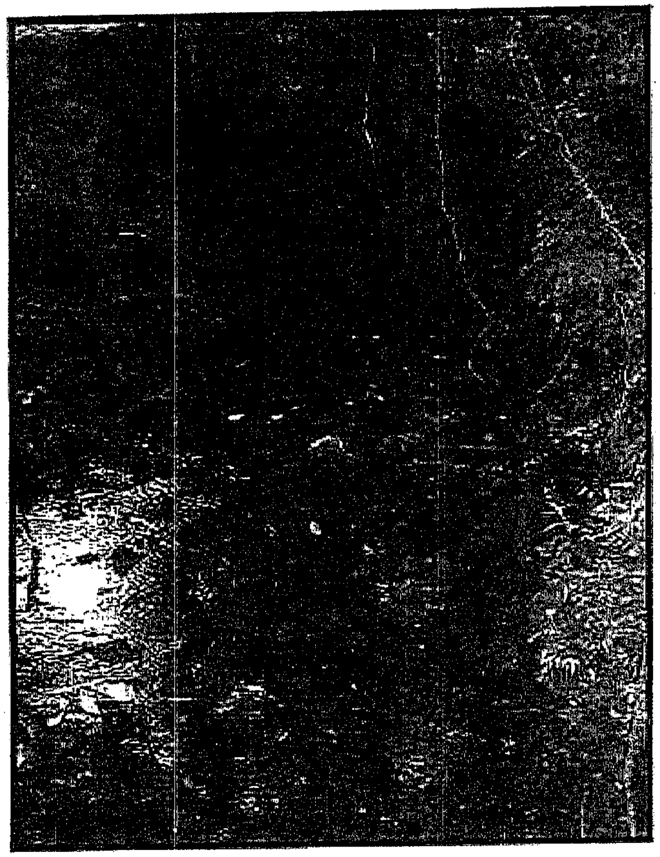
Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004



16. Relatively large pool/run at WIL-6.

17. Undercut bank at WIL-6

Site Visit Conducted by WEI and GBMc Associates on March 11-13, 2004



18. WIL-6 riffle/run.

APPENDIX C

List of Macroinvertebrate Taxa From Sampling Locations

Table 2. Macroinvertebrates collected in the Wilson Creek in Garland Co. AR. May 11-13, 2004

Taxa	FFG	[illegible]	[illegible]	Wil 2	Wil 2.5	NWRO	Wil 5	Wil 6
TURBELLARIA								
Planariidae	PR	--	--	--	--	4	--	1
ANNELIDA								
Oligochaeta	GC	--	--	--	--	8	5	1
PELECYPODA								
Corbicula	FC	2	1	--	--	--	5	5
CRUSTACEA								
Cambarinae	SH	8	17	--	8	14	17	24
Isopoda	GC	10	24	3	4	6	12	38
Orconectes	GC	--	--	--	--	--	1	--
Procamburus	GC	--	--	1	1	--	--	--
EPHEMEROPTERA								
Caenis	GC	--	1	--	--	--	--	--
Callibaetis	GC	5	--	--	--	--	--	--
Eurylobdella	GC	5	14	--	--	--	--	--
Paraleptophlebia	GC	11	25	--	--	--	--	--
Stenacron	SC	12	--	--	--	--	--	--
Stenonema	SC	13	4	--	--	--	--	--
ODONATA								
Argia	PR	--	--	--	--	8	--	4
Archelstes	PR	--	--	--	--	--	1	--
Calopteryx	PR	--	1	7	--	4	--	2
Cordullgaster	PR	--	--	--	--	--	--	1
Lanius	PR	--	1	--	--	--	--	--
Orithemus	PR	--	1	--	--	2	--	--
Stylogomphus	PR	1	--	--	--	--	--	--
Sympetrum	PR	--	--	--	2	--	--	--
PLECOPTERA								
Allocapnia	SH	3	14	28	18	--	--	--
HEMIPTERA								
Corixidae	PR	--	--	--	2	6	--	--
Gerris	PR	--	--	--	--	2	--	1
Trepobates	PR	--	--	1	--	--	--	--
MEGALOPTERA								
Corydalus	PR	1	--	3	--	--	--	--
Sialis	PR	2	--	9	--	--	--	--
TRICHOPTERA								
Agapetus	FC	1	--	--	--	--	--	--
Chematopsyche	FC	--	--	--	--	--	--	6
Chimarra	FC	--	--	--	--	--	--	7
Limnophlia	FC	--	--	1	--	--	--	--
Pycnopsyche	SH	--	--	--	--	--	1	--
Polycentropus	PR	3	5	3	--	--	1	--
Potamyia	PR	--	3	7	--	--	--	--
COLEOPTERA								
Curculeionidae	PR	--	--	1	--	2	--	--
Dtyiscus	SC	--	--	--	2	--	1	--
Hydrocanthus	SH	1	--	--	1	--	--	--
Hydroporous	PR	--	1	--	1	--	--	--
Psephenus	SC	10	2	--	--	--	--	--
LEPIDOPTERA								
Archips	SH	--	--	1	--	--	--	--
DIPTERA								
Anopheles	PR	--	--	--	--	--	--	1
Bezzia	GC	2	1	2	1	4		5
Chironominae	FC	29	13	13	38	31	20	18
Diptera Sp.1	GC	--	--	2	--	2	--	--
Hexatoma	PR	2	--	2	--	--	--	--
Psycoda	PR	--	--	--	--	--	1	--
Tanypodinae	PR	16	9	3	23	11	21	10
Tanytarsini	PR	--	4	24	--	9	18	9
Tipula	SH	--	1	1	1	2	3	4
Sum of Percentage		100	100	100	100	100	100	100
Total Abundance		137	142	114	102	115	107	136
Species Richness		20	20	19	13	16	14	17
Shannon Wiener Diversity Index		3.35	3.54	3.26	2.59	3.48	3.36	2.59

APPENDIX D

Letters From Arkansas Department of Health and Arkansas Soil and Water Conservation Commission

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WEI

WASTE ENGINEERING, INC.

ftn Associates Ltd.
water resources / environmental consultants

ADDENDUM TO THE DECEMBER 2004 WILSON CREEK MINERALS WATER QUALITY STANDARDS EVALUATION

UMETCO MINERALS CORPORATION FORMER MINE SITE GARLAND COUNTY, ARKANSAS

August 28, 2009

ADDENDUM TO THE DECEMBER 2004 WILSON CREEK MINERALS WATER QUALITY STANDARDS EVALUATION

UMETCO MINERALS CORPORATION
FORMER MINE SITE
GARLAND COUNTY, ARKANSAS

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August 28, 2009

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The overall objective of this study was to assess whether water quality (particularly dissolved solids and sulfate) in Wilson Creek upstream-downstream of the UMETCO Minerals Corporation (UMETCO) discharge from Outfall 001 will support Ouachita Mountain ecoregion aquatic life uses (Arkansas Pollution Control and Ecology Commission (APCEC) 2007). Towards this end, the study specifically addresses the following:

- Whether water quality limits aquatic life in Wilson Creek in the vicinity of the UMETCO former mine site (i.e., is aquatic life in Wilson Creek consistent with expectations based on habitat?), and
- Is there potential for instream toxicity due to dissolved solids from the discharge?

The study finding that current total dissolved solids (TDS) and sulfate concentrations in Wilson Creek support and do not limit attainable aquatic life uses supports a proposal that was previously submitted (WEI 2004) for site-specific water quality criteria for minerals.

Previous data collection (WEI 2004) and site evaluations/sampling indicated that low levels of diversity and abundance of aquatic life in a reach of Wilson Creek that were associated with seep inflows from the previously reclaimed Spaulding area entering Wilson Creek upstream of Outfall 001. Low pH is a likely cause of at least some of the aquatic life suppression; however, other factors were suspected. The toxicity was evaluated to determine if factors in addition to, or interacting with, low pH were potentially affecting aquatic life in Wilson Creek.

2.0 SAMPLING LOCATIONS

The study site is a reclaimed mine site operated by UMETCO in Garland County, Arkansas (Figure 2.1). Sampling locations used for this study (Figure 2.2) were a subset of those used for previous water quality and biological assessment studies associated with this Use Attainability Analysis (WEI 2004). They were chosen to allow upstream-downstream comparisons of the effects of the Outfall 001 discharge and reclaimed areas on the water quality and biological communities of Wilson Creek within the property boundaries of the UMETCO site and to allow comparisons with previous studies, if needed. Sampling sites WILS, WIL-1, WIL-2, WIL-2.5, WIL-5, and WIL-6 are located on Wilson Creek, which drains portions of the former mine site. A sampling site is located on a seep that drains into Wilson Creek between WIL-1 and WIL-2 ("SPRD Seeps" on Figure 2.2). Sampling location descriptions for Wilson Creek stations are provided in Table 2.1.

Table 2.1. Description of Wilson Creek sampling locations.

Location	Description
WILS	Reference site upstream of Outfall 001; not affected by former mine activities or seeps.
WIL-1	Upstream of Outfall 001; similar to WILS but affected by a seep.
WIL-2	Upstream of Outfall 001; affected by seep area.
WIL-2.5	Upstream of Outfall 001; downstream of reclaimed areas.
WIL-5	Immediately downstream of Outfall 001.
WILL and WIL-6	Downstream of Outfall 001.

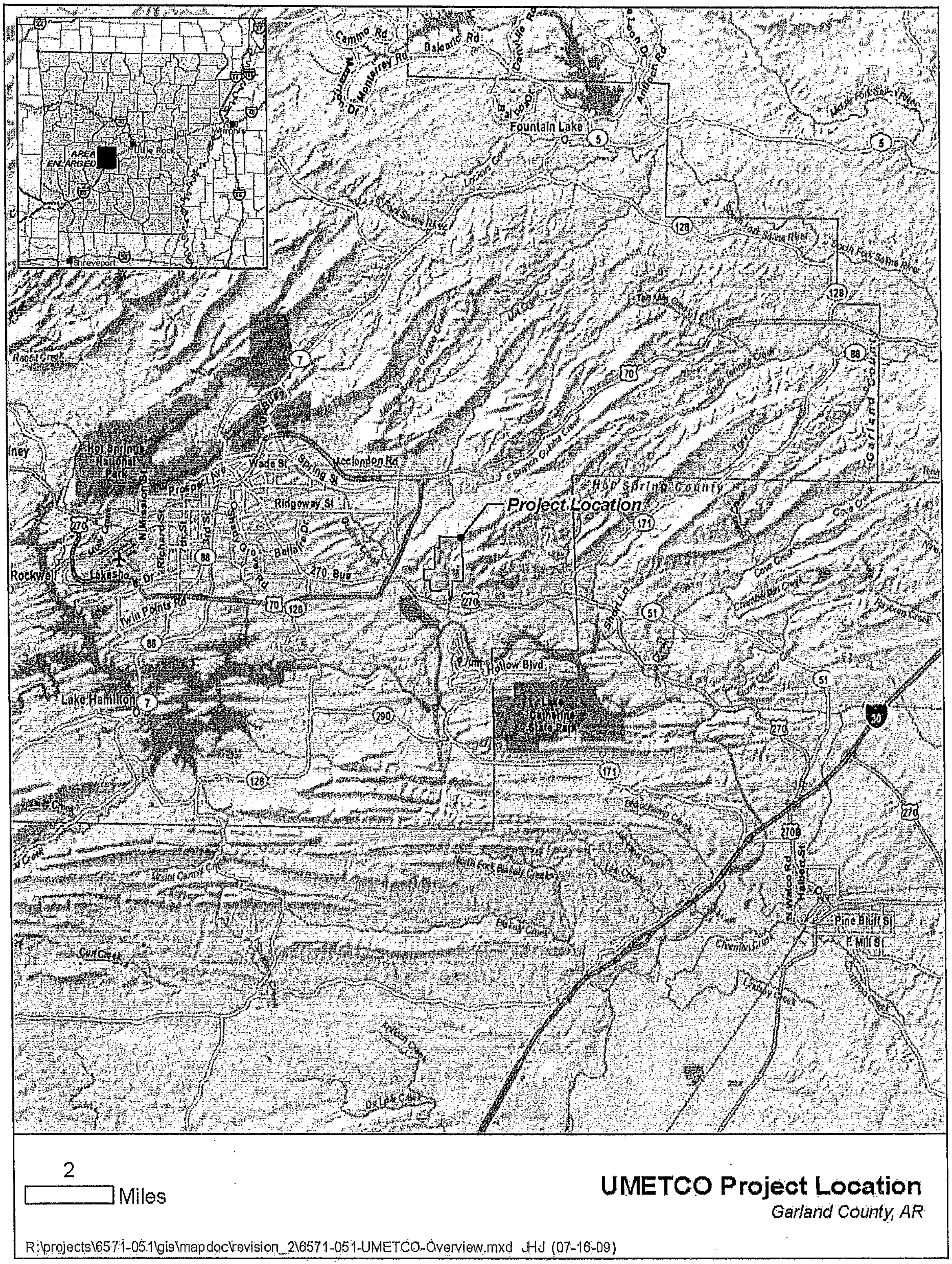

Figure 2.1. Area map showing location of site.

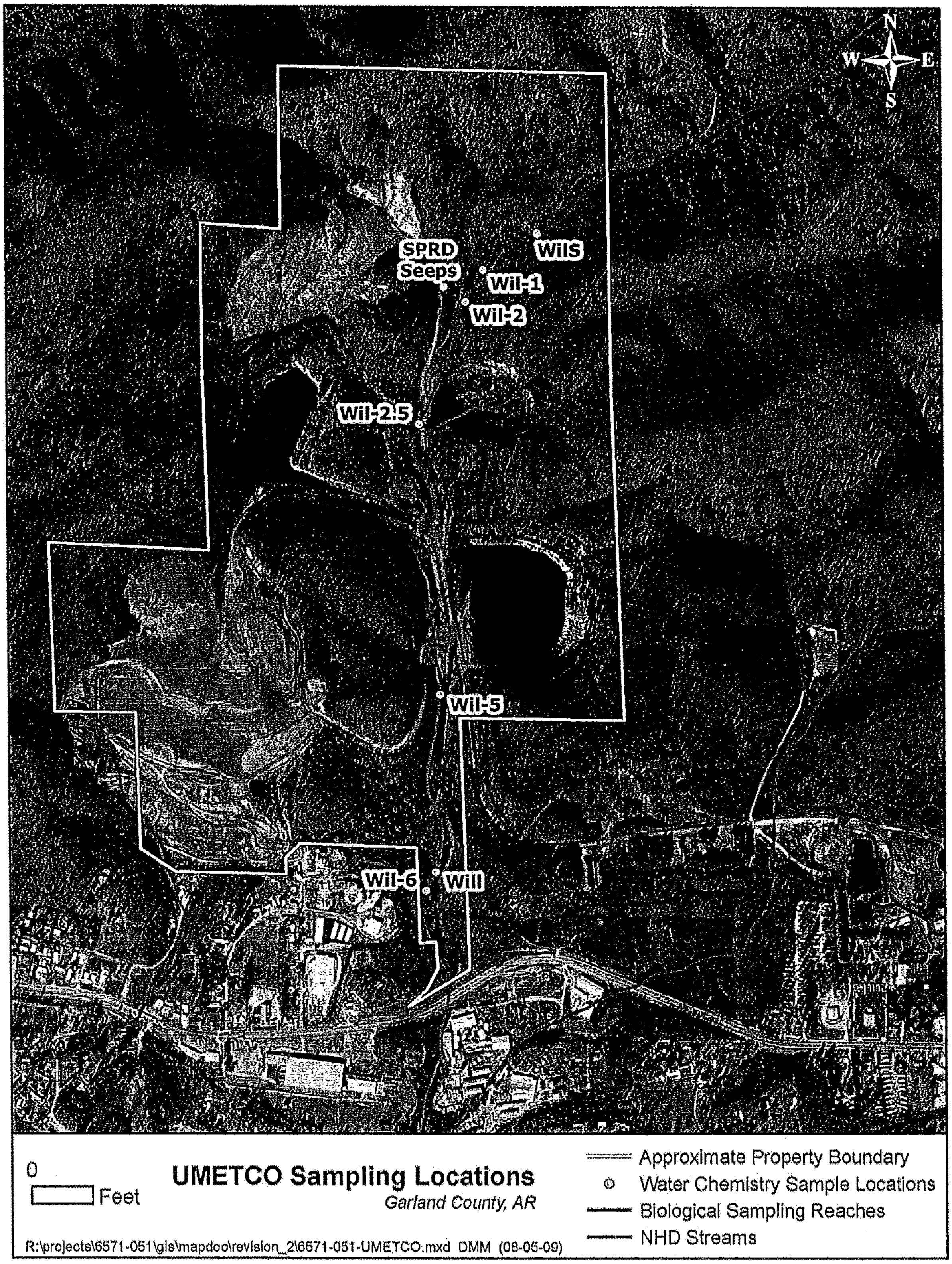

Figure 2.2. Site map showing sampling locations and reaches.

3.0 METHODS AND MATERIALS

3.1 Water Sampling and Flow Measurement Methods

Grab samples were collected at all sample locations according to FTN Associates, Ltd. (FTN) sampling protocols that are based on applicable US Environmental Protection Agency (EPA) guidance. Samples were taken from approximately 0.5 ft below the surface from flowing portions of the stream using a clean plastic bucket. The sample was then split into aliquots and placed into sample containers containing preservatives appropriate for the selected analyses. Samples were placed on ice immediately upon collection and delivered to American Interplex Corporation (AIC) (8600 Kanis Road, Little Rock, AR 72204), which is certified by the Arkansas Department of Environmental Quality (ADEQ) for the selected analyses. Samples from all locations were analyzed for chloride, sulfate, and TDS according to the methods given in Table 3.1. Samples collected from WIL-5 were analyzed for additional anions and cations (sodium, potassium, calcium, magnesium, and alkalinity) for use in the STR-based toxicity evaluation.

In situ physical-chemical measurements of dissolved oxygen (DO), pH, temperature, and specific conductance were made using a Hydrolab MiniSonde™, calibrated per the manufacturer's requirements. Instruments were calibrated in the morning on the day measurements were made. Calibration was checked at the end of the day using calibration buffers, standards, and a DO saturation table. All in situ measurements were taken concurrently with grab sample collection.

Stream flow was measured at the upstream end of each sampling reach. Flows were measured by measuring stream width, depth, and current velocity per US Geological Survey (USGS) guidelines (1982) using a calibrated wading rod and a Marsh-McBirney flow meter (Flo-Mate™ Portable Velocity Meter, Model 2000). All flow measurements were made concurrently with grab sample collection.

Table 3.1. Analyte methods on reporting limits (RL) for analysis of the seep sample.

Analyte	Method	RL*	Analyte	Method	RL*
Alkalinity as CaCO3	SM 2320B	1	Selenium	ICP-AES	0.07
Silicon Dissolved	EPA 200.7	0.2	Silicon	ICP-AES	0.2
Strontium Dissolved	EPA 200.7	0.005	Silver	ICP-AES	0.007
Sulfur Dissolved	EPA 200.7	0.1	Sodium	ICP-AES	1
Bromide	EPA 300.0	0.2	Strontium	ICP-AES	0.005
Chloride	EPA 300.0	0.2	Sulfur	ICP-AES	0.1
Fluoride	EPA 300.0	0.1	Thallium	ICP-AES	0.04
Nitrate as N	EPA 300.0	0.05	Tin	ICP-AES	0.2
Sulfate	EPA 300.0	2	Titanium	ICP-AES	0.005
Aluminum	ICP-AES	0.04	Vanadium	ICP-AES	0.008
Antimony	ICP-AES	0.03	Zinc	ICP-AES	0.002
Arsenic	ICP-AES	0.05	Dissolved Organic Carbon	SM 5310C	1
Barium	ICP-AES	0.002	Dissolved Aluminum	EPA 200.7	0.04
Beryllium	ICP-AES	0.0003	Dissolved Barium	EPA 200.7	0.002
Boron	ICP-AES	0.1	Dissolved Beryllium	EPA 200.7	0.0003
Cadmium	ICP-AES	0.004	Dissolved Cadmium	EPA 200.7	0.004
Calcium	ICP-AES	0.1	Dissolved Calcium	EPA 200.7	0.1
Chromium	ICP-AES	0.007	Dissolved Cobalt	EPA 200.7	0.007
Cobalt	ICP-AES	0.007	Dissolved Copper	EPA 200.7	0.006
Copper	ICP-AES	0.006	Dissolved Iron	EPA 200.7	0.007
Iron	ICP-AES	0.007	Dissolved Magnesium	EPA 200.7	0.03
Lead	ICP-AES	0.04	Dissolved Manganese	EPA 200.7	0.002
Magnesium	ICP-AES	0.03	Dissolved Nickel	EPA 200.7	0.01
Manganese	ICP-AES	0.002	Dissolved Potassium	EPA 200.7	1
Molybdenum	ICP-AES	0.007	Dissolved Sodium	EPA 200.7	1
Nickel	ICP-AES	0.01	Dissolved Zinc	EPA 200.7	0.002
Phosphorous	ICP-AES	0.1	Total Dissolved Solids	SM 2540C	10
Potassium	ICP-AES	1			

*All units are mg/L.

3.2 Toxicity Evaluation

Toxicity of the seep sample was evaluated using EPA methodology (EPA 1991a, 1993) for toxicity identification evaluations (TIEs). Before initial testing, the pH of an aliquot of the sample was adjusted to pH of 7.5 using sodium hydroxide (NaOH), allowed to equilibrate overnight, and adjusted again the next day. The adjusted and unadjusted samples were tested for acute toxicity to *Ceriodaphnia dubia* and *Pimephales promelas* in 48-hour static non-renewal tests. Toxicity present in the pH-adjusted sample was interpreted as being due to factors other than low pH. Phase 1 TIE procedures (EPA 1991b) were then applied to determine the physical characteristics of the toxicant(s) present in the pH-adjusted sample. These procedures involve manipulation and subsequent toxicity testing of the sample through aeration, filtration, solid phase extraction, anion exchange, cation exchange, addition of ethylenediaminetetra-acetic acid (EDTA), and sodium thiosulfate. Manipulations that remove toxicity, compared to an unmanipulated baseline, provide clues regarding the physical properties of the toxicant(s). Subsequent tests are then designed to confirm or eliminate suspect toxicants (EPA 1993).

Upon submittal to the laboratory, the seep sample was analyzed for the suite ions and metals listed in Table 3.1.

Phase 1 TIE procedures are not well-suited to directly evaluate toxicity caused by dissolved solids. Therefore, the evaluation of potential TDS toxicity applied published relationships between toxicity and dissolved solids (Mount et al. 1997) based on toxicity testing of mixtures of inorganic calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate salts. The potential for toxicity due to dissolved solids in the grab sample from the seep area and from Wilson Creek immediately below the Outfall 001 discharge (WIL-5) was evaluated by assessing how close to a predicted toxic threshold the existing ion concentrations are under current conditions. The approach to estimating the toxic (acute and chronic) thresholds was as follows:

1. The *acute* toxic response of increasing the anion and cation concentrations of the June samples from the seep area and WIL-5 was simulated by increasing the ion concentrations of the June samples (based on measured values) by factors of 2 to 20 and using these hypothetical values as input into the salinity-toxicity relationship (STR) model developed by Mount et al. (1997). The resulting response curve for TDS versus predicted toxicity provided an indication of how high the sample in question must be concentrated to reach a toxic threshold. This concentration factor was then be multiplied by the sample TDS to estimate the concentration of TDS that would result in 50% mortality (LC50) in the sample matrix. This LC50 was then compared to current TDS concentrations to evaluate the potential for acute toxicity due to TDS under current conditions. The same approach was used to estimate the acute toxic threshold for sulfate.
2. The *chronic* toxic response of increasing the anion and cation concentrations was evaluated by applying an acute-to-chronic ratio (ACR) to the acute LC50s for sulfate and TDS obtained in step 1 above. The ACR was derived based on routine acute and chronic *C. dubia* reference testing performed by AIC using sodium chloride (NaCl) during 2008 and 2009. This testing is performed as part of AIC's

routine internal quality assurance/quality control (QA/QC) procedures. Reference testing using NaCl is appropriate for this evaluation because toxicity in the NaCl reference tests, as well as the potential toxicity due to mineral concentrations in the effluent, are, presumably, both due to ionic stress. *C. dubia* reference data were used because *C. dubia* is known to be more sensitive to toxicity due to dissolved solids than other standard toxicity test organisms such as *P. promelas* or *Daphnia pulex* (Goodfellow et al. 2000). The data used for this evaluation are presented in Table 3.2, which presents acute LC50 values from acute reference toxicant testing and IC25 values from chronic reference testing from January 2008 through February 2009. Inhibition concentration values (concentration resulting in 25% reduction of combined survival and reproduction; IC25) were used because they are a continuous variable (as opposed to a discreet variable such as the "no observed effect concentration," or NOEC) that estimates the NOEC (EPA 2002). Using all data ($n = 14$), the average acute LC50 was divided by the average chronic IC25. The ACR from this data set was computed as $2.31 \div 0.90 = 2.6$ (Table 3.2).

Table 3.2. Sodium chloride (NaCl) reference test data for *C. dubia* used for computation of the ACR for TDS.

Acute Test Date	48-Hour Acute LC50 (mg/L NaCl)	Chronic Test Date	7-Day Chronic IC25 (mg/L)	
			As Chloride	As NaCl
01/17/08	1,860	01/10/08	491	809
02/25/08	2,880	02/11/08	238	393
04/08/08	3,070	04/01/08	356	586
05/30/08	2,020	05/20/08	596	982
06/01/08	2,320	06/11/08	655	1,080
07/09/08	2,760	07/02/08	471	776
08/22/08	2,670	08/13/08	350	577
09/09/08	2,210	09/02/08	385	634
10/01/08	2,330	10/01/08	668	1,100
11/11/08	1,980	11/11/08	607	1,000
12/16/08	1,830	12/16/08	465	766
01/29/09	1,840	01/27/09	1,010	1,660
02/26/09	2,110	02/17/09	752	1,240
03/18/09	2,400	03/18/09	619	1,020
Average Acute LC50	2,300	Average Chronic IC25	546	900
Average ACR (NaCl)		2.6		

3.3 Biological Assessment Methods

Biological assessment procedures for fish and benthic macroinvertebrates followed rapid bioassessment protocols given in Barbour et al. (1999). The length of each reach sampled was approximately 40 stream widths per Barbour et al (1999). A habitat assessment was performed as part of the biological assessment to aid in the interpretation of the benthic and fish sampling results.

3.4 Habitat Assessment

Physical and habitat characteristics based on the entire length of each sampling reach were documented by visual assessment using the approach outlined in Barbour et al. (1999). Field forms used for this assessment of physical characteristics were taken directly from Barbour et al (1999). Physical variables assessed included the following:

1. Canopy cover,
2. Substrate type,
3. Sediment characteristics,
4. Dominant aquatic vegetation,
5. Proportion of reach with aquatic vegetation,
6. Pool/riffle ratio,
7. Pool depths,
8. Pool widths,
9. Dominant riparian vegetation, and
10. Watershed features.

Habitat characterization followed high-gradient stream habitat assessment procedures per Barbour et al. (1999). Field forms used for the habitat assessment were taken directly from Barbour et al. In contrast to the evaluation of physical variables, the habitat characterization per Barbour et al. provides a scoring methodology that allows a rough comparison of habitat quality among sites.

Scored habitat variables included the following:

1. Epifaunal substrate/available cover,
2. Substrate characterization,
3. Velocity/depth regime,
4. Sediment deposition,
5. Channel flow status deposition,
6. Channel alteration,
7. Frequency of riffles,
8. Bank stability,
9. Vegetative protection, and
10. Riparian vegetative zone width.

3.5 Benthic Invertebrate Community Sampling

Prior to sampling each reach, the upper and lower ends of the reach were cordoned off using block nets. Invertebrate sampling was conducted before fish sampling in order to avoid disturbing substrate. Invertebrates were sampled using D-frame kick nets with 0.5-mm mesh net. A total of 20 individual samples were collected from all available habitat, including woody debris, emergent vegetation, snags, undercut banks, open substrate, and riffles (if present). The sampling effort was distributed among habitat types in proportion to the availability of habitats as assessed by visual inspection. After removal and washing of large debris, the entire contents of the net were washed into wide-mouth glass jars and immediately preserved with 70% isopropyl alcohol.

Samples were sorted in the laboratory by dispensing the entire sample onto a Caton grid. All organisms were sorted from randomly selected grids until a minimum of 160 organisms were collected. Sorted organisms were transferred to 70% ethanol in glass vials. To assure thorough removal of specimens from the sample, the sorted residue was retained and examined by a second biological technician. If the second sorting produced fewer than 10% of the number of organisms found in the initial sorting, the sorting of that sample was considered complete. If the second sorting produced more than 10% of the number of organisms found in the initial sorting, the sample was resorted until the 10% goal was reached.

Taxonomic identifications were carried out to the lowest practical taxon according to Merritt and Cummins (1996), Thorp and Covich (2001), and Houston (1980). In general, macroinvertebrates were identified to genus except for bivalve mollusks, gastropods, dipteran larvae, and decapod shrimp, which were identified to family when possible. A voucher collection of invertebrate taxa collected at the sites was retained for further reference. All invertebrate taxa were classified into functional feeding groups (Predator, Shredder, Omnivore, Gatherer/Collector, Scraper, and Filterer) per Barbour et al. (1999).

3.6 Fish Community Sampling

Fish sampling was conducted using a Smith-Root LR-24 DC current backpack electroshocker. Sampling of each reach was conducted by probing all available habitat beginning at the downstream end of the reach and proceeding upstream. Two sampling passes were performed on each reach. Stunned fish were collected in a plastic bucket and maintained with aeration until processed. Each individual captured was identified in the field to species according to Robison and Buchanan (1988). Individuals that could not be positively identified in the field were killed, preserved in formalin, and identified in the laboratory. Up to 25 individuals of each species were weighed to the nearest 0.1 gram and measured (total length) to the nearest millimeter. After processing, all living fish were returned to the sampling reach.

Fish data were evaluated by visually examining differences in species richness and species composition among locations in relation to habitat.

4.0 RESULTS

4.1 Water Chemistry and Flows

Results of water quality analyses, in situ measurements, and flow measurements at the Wilson Creek sampling locations are provided in Table 4.1. It was not feasible to measure flows at WIL-2.5 and WIL-5 due to the braided nature of the channel of these locations.

Table 4.1. Summary of flow and water quality data at Wilson Creek sampling locations collected June 2, 2009.

Parameter (Unit)	WILS	WIL-1	WIL-2	WIL-2.5	WIL-5	WIL-6
Flow (cfs)	0.2	0.1	0.2	NM	NM	1.6
Temperature (°C)	21.0	19.3	18.9	22.2	21.6	20.3
Dissolved Oxygen (mg/L)	7.9	5.7	7.6	5.9	8.9	8.4
pH (su)	5.7	4.8	4.5	5.0	6.2	5.9
Specific Conductance (uS)	24	23.2	134	99.3	439	458
Total Dissolved Solids (mg/L)	54	45	130	88	330	340
Chloride (mg/L)	1.9	2.0	2.1	1.7	9.0	11
Sulfate (mg/L)	3.6	3.8	52	30	160	160
Total Alkalinity (mg/L as $CaCO_3$)					18	
Calcium (mg/L)					63	
Magnesium (mg/L)					7.0	
Sodium (mg/L)					4.4	
Potassium (mg/L)					3.2	

NM = Not measured

4.2 Toxicity Assessment

4.2.1 Seep Sample

Results of cation, anion, and metals analyses of the unadjusted seep sample as well as in situ measurements made at the time of sample collection are provided in Table 4.2. Examination of this table reveals dissolved aluminum, manganese, and zinc concentrations (3.9 mg/L, 12 mg/L, and 0.55 mg/L, respectively) that might be at acutely toxic levels. Also, as expected of a sample with a pH of 3.4 at collection, there was no measurable bicarbonate alkalinity. Bicarbonate alkalinity was also less than detection (1 mg/L) in the pH-adjusted sample.

Table 4.2. Results of anion, cation, and metals analyses in the unadjusted seep sample collected June 2, 2009.

Analyte	Concentration (mg/L)	RL	Analyte	Concentration (mg/L)	RL
Temperature (°C)*	16.3	NA	Strontium	0.15	0.005
Dissolved Oxygen*	7.5	NA	Sulfur	56	0.1
pH (su)*	3.4	NA	Thallium	0.04	0.04
Specific Conductance (uS)*	398	NA	Tin	0.2	0.2
Silicon Dissolved	9.5	0.2	Titanium	0.005	0.005
Strontium Dissolved	0.15	0.005	Vanadium	0.008	0.008
Sulfur Dissolved	56	0.1	Zinc	0.55	0.002
Aluminum	3.9	0.04	Dissolved Organic Carbon	1	1
Antimony	0.03	0.03	Bromide	0.2	0.2
Arsenic	0.05	0.05	Chloride	1.9	0.2
Barium	0.026	0.002	Fluoride	0.94	0.1
Beryllium	0.0035	0.0003	Nitrate as N	0.41	0.05
Boron	0.1	0.1	Sulfate	170	2
Cadmium	0.0054	0.004	Alkalinity as CaCO3	1	1
Calcium	27	0.1	Total Dissolved Solids	300	10
Chromium	0.007	0.007	Dissolved Beryllium	0.0035	0.0003
Cobalt	0.027	0.007	Dissolved Aluminum	3.9	0.04
Copper	0.028	0.006	Dissolved Barium	0.026	0.002
Iron	0.066	0.007	Dissolved Cadmium	0.0052	0.004
Lead	0.04	0.04	Dissolved Calcium	26	0.1
Magnesium	12	0.03	Dissolved Cobalt	0.027	0.007
Manganese	12	0.002	Dissolved Copper	0.027	0.006
Molybdenum	0.007	0.007	Dissolved Iron	0.033	0.007
Nickel	0.12	0.01	Dissolved Manganese	12	0.002
Phosphorous	0.1	0.1	Dissolved Magnesium	12	0.03
Potassium	3.8	1	Dissolved Nickel	0.12	0.01
Selenium	0.07	0.07	Dissolved Potassium	3.8	1
Silicon	9.6	0.2	Dissolved Sodium	2.4	1
Silver	0.007	0.007	Dissolved Zinc	0.55	0.002
Sodium	2.5	1			

*= In situ measurements; RL = reporting limit.

Results of initial screening toxicity tests are presented in Table 4.3. Results show that the unadjusted sample was acutely toxic to both test organisms. The pH-adjusted sample showed less toxicity to *C. dubia* and no acute lethal toxicity to *P. promelas*. Accordingly, Phase 1 TIE procedures focused on the pH-adjusted sample using *C. dubia*.

Results of Phase 1 TIE testing on the adjusted seep sample are summarized in Table 4.4. None of the sample manipulation removed toxicity. This result was surprising given the potentially toxic concentrations of zinc, whose toxicity is known to be reduced by the addition of EDTA and sodium thiosulfate (Hockett and Mount 1996). It is possible, however, that the combination of pH, alkalinity, and other ions in a sample matrix that has been only recently pH-adjusted showed unusual results in standard TIE manipulations. Accordingly, additional testing was conducted on the adjusted sample in which the bicarbonate alkalinity was augmented to approximately 100 mg/L (as $CaCO_3$) through the addition of $NaHCO_3$. Toxicity tests on this augmented sample indicated no change in acute toxicity compared to the un-augmented baseline (Table 4.4).

Table 4.3. Summary of initial screening toxicity tests on the unadjusted and adjusted seep samples collected June 2, 2009.

Test Organism	Sample	Sample Concentration (% sample)	% Survival at 48 Hours (n = 10)	Test pH/Specific Conductance (su / uS)
P. promelas	Unadjusted	Control	100	7.8 / 305
		6.25	100	7.9 / 305
		12.5	100	7.9 / 311
		25	100	7.7 / 323
		50	90	7.3 / 346
		100	0	4.2 / 385
	Adjusted	Control	100	7.8 / 335
		6.25	100	7.9 / 344
		12.5	100	7.9 / 343
		25	100	7.9 / 343
		50	100	7.7 / 352
		100	100	7.3 / 396
C. dubia	Unadjusted	Control	100	7.9 / 313
		6.25	90	7.8 / 322
		12.5	70	7.7 / 321
		25	60	7.6 / 324
		50	0	7.1 / 331
		100	0	4.0 / 382
	Adjusted	Control	100	7.9 / 313
		6.25	90	7.9 / 364
		12.5	90	7.9 / 325
		25	80	7.9 / 337
		50	60	7.7 / 369
		100	30	7.4 / 402

Table 4.4. Summary of acute Phase I TIE tests conducted on the adjusted seep sample collected June 2, 2009.

Sample Manipulation		Percent Survival (n = 10) at 48 Hours (100% Test Concentration)
Baseline		30
Filtration		0
Aeration		30
Sublimation		40*
Cation Exchange		0
Anion Exchange		0
Alkalinity Augmentation		0
EDTA	High Reagent Addition	0
	Low Reagent Addition	0

* This test result is believed to be aberrant because parameters indicated by this test (e.g., polymers or detergents) are not expected to be present in the seep samples.

4.2.2 Potential TDS Toxicity

The response curves for TDS versus predicted toxicity for the seep and WIL-5 samples are provided on Figures 4.1 and 4.2, respectively. The curves indicate that the seep and WIL-5 samples collected on June 2, 2009, would have to be concentrated by a factor of approximately 9 to reach an ionic strength that is acutely toxic to *C. dubia.* Based on measured TDS concentrations in the WIL-5 sample (Table 4.1) and the seep sample (Table 4.2), this concentration factor corresponds to toxic threshold TDS concentrations of 9 x 330 = 2,970 mg/L for WIL-5 and 9 x 300 mg/L = 2,700 mg/L for the seep (pH-neutral) sample.

Using the same approach for sulfate, the toxic threshold concentrations are 9 x 160 = 1,440 mg/L for WIL-5 and 9 x 170 mg/L = 1,530 mg/L for the seep (pH-neutral) sample.

Using the ACR of 2.6 developed in Section 3.1, this analysis predicts that that the WIL-5 and seep samples would have to be concentrated by a factor of approximately 9 ÷ 2.6 = 3.5 to reach an ionic strength that is sub-lethally toxic to *C. dubia.* The chronic toxicity thresholds for TDS using the ACR are 2,970 mg/L ÷ 2.6 = 1,142 mg/L for the WIL-5 sample, and 2,700 mg/L ÷ 2.6 = 1,038 mg/L for the seep (pH-neutral) sample.

Using the same approach for sulfate, the predicted chronic toxic thresholds are 1,440 mg/L ÷ 2.6 = 554 mg/L for the WIL-5 sample and 1,530 mg/L ÷ 2.6 = 588 mg/L for the seep (pH-neutral) sample.

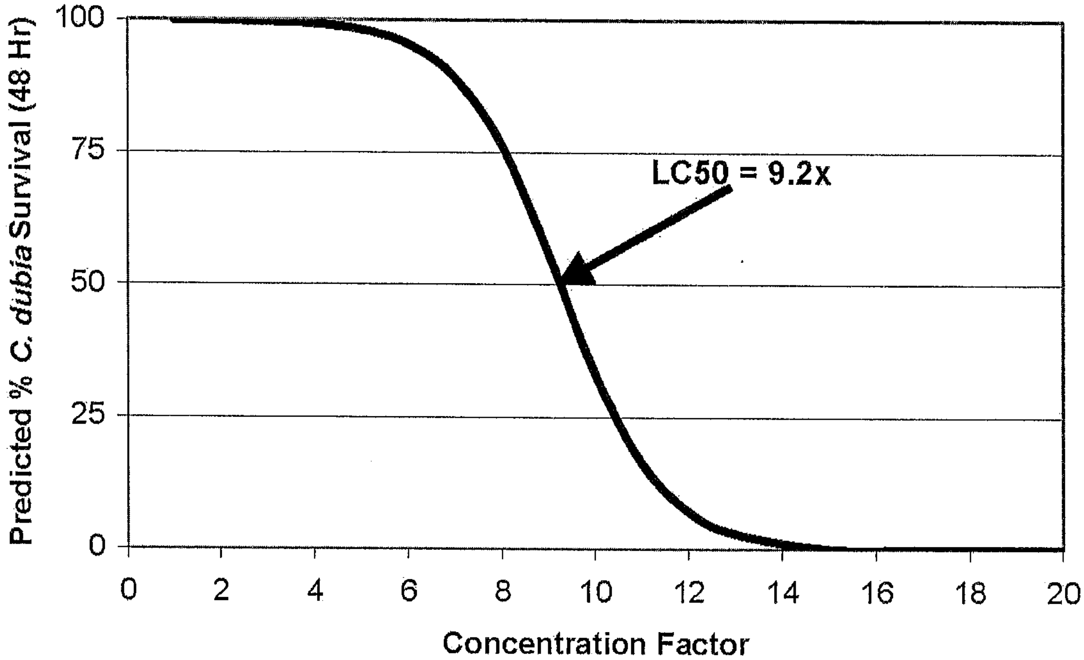

Figure 4.1. Predicted dose-response curve (based on Mount et al. 1997) for the WIL-5 sample concentrated by a factor up to 20.

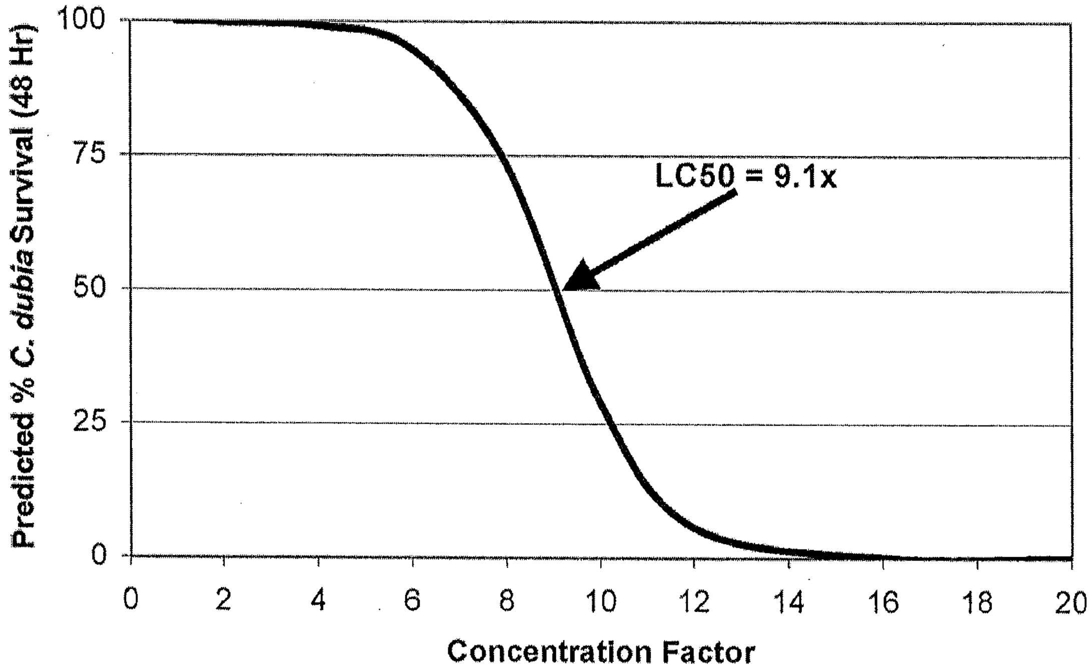

Figure 4.2. Predicted dose-response curve (based on Mount et al. 1997) for the seep sample concentrated by a factor up to 20.

A similar approach to evaluate toxicity for minor ions such as chloride (9 mg/L and 1.9 mg/L in the WIL-5 and seep samples, respectively) is not valid. This is because major ions drive toxicity in the STR model, while ions at low concentration have little or no effect on model output. For example, using the same approach to evaluate potential chloride toxicity in the seep samples would indicate a chronic threshold value of 6.6 mg/L for chloride. This value is far below the ecoregion chloride criterion (15 mg/L), far below the lowest IC25 value from AIC chronic reference testing (Table 3.2), and not supported by the literature (e.g., Tables 2 and 3 in Mount et al. 1997).

4.3 Biological Assessment

4.3.1 Habitat

Results of the assessment of physical and habitat features of each Wilson Creek sampling location are presented in Tables 4.5 and 4.6, respectively. Table 4.5 indicates a general increase in stream size (average width and depth) from the upstream WILS location to the downstream WIL-6 location. There was a corresponding general decrease in substrate size (from boulders/cobble to cobble/gravel) and increase in the pool to riffle ratio. No sludges or deposits were noted except at WIL-2, where there was a precipitate on rocks and what appeared to be compacted or consolidated precipitate covering the substrate. There was an inflow from seeps that enter Wilson Creek immediately upstream of WIL-2.

Sampling locations WILS, WIL-1, and WIL-6 showed similar higher-quality habitat relative to WIL-2 and WIL-2.5. WIL-2.5 showed intermediate habitat quality due primarily to less stream bank stability and vegetation and greater substrate sediment deposition and embeddedness.

UMETCO representatives indicated that flows at WILS and WIL-1 typically cease during warm, dry summer months, leaving only isolated pools in those reaches.

Table 4.5. Summary of physical characteristics evaluation performed during June 2009 sampling.

Category	WILS	WIL-1	WIL-2	WIL-2.5	WIL-6
Canopy Cover	Shaded	Shaded	Partly open	Shaded	Shaded
Inorganic Substrate (% coverage)	Bedrock: 0 Boulder: 5 Cobble: 60 Gravel: 30 Sand: 5 Silt: 0 Clay: 0	Bedrock: 0 Boulder: 0 Cobble: 80 Gravel: 15 Sand: 5 Silt: 0 Clay: 0	Bedrock: 0 Boulder: 0 Cobble: 20 Gravel: 30 Sand: 20 Silt: 0 Clay: 30*	Bedrock: 0 Boulder: 0 Cobble: 10 Gravel: 80 Sand: 10 Silt: 0 Clay: 0	Bedrock: 0 Boulder: 0 Cobble: 20 Gravel: 75 Sand: 5 Silt: 0 Clay: 0
Organic Substrate (% coverage)	CPOM: 0 FPOM: 0 Shell: 0	CPOM: 0 FPOM: 0 Shell: 0	CPOM: 0 FPOM: 0 Shell: 0	CPOM: 0 FPOM: 0 Shell: 0	CPOM: 0 FPOM: 0 Shell: 0
Dominant Aquatic Vegetation	None	None	None	None	None
Percent of reach with aquatic vegetation	0	0	0	0	0
Pool/Riffle Ratio	2:3	1:1	NR	3:2	5:3
Average Stream Depth (m)	0.1	0.1	0.1	0.2	0.15
Average Stream Width (m)	1	1.0	1.5	2	2
Average Current Velocity (m/sec)	0.1	0.3	0.1	0.2	0.2
Substrate odors	Normal	Normal	Normal	Normal	Normal
Substrate oils	Absent	Absent	Absent	Absent	Absent
Substrate deposits	None	None	Sludge*	None	None
Embedded stones black on underside?	No	No	Yes	No	Yes
Dominant Riparian Vegetation	Trees	Trees	Trees	Trees	Trees
Watershed Features	Landuse: Forrest Pollution sources: Reclaimed mine Erosion: None	Landuse: Forrest Pollution sources: Reclaimed mine Erosion: None	Landuse: Forrest Pollution sources: Reclaimed mine Erosion:Moderate	Landuse: Forrest Pollution sources: Spoil seeps Erosion: None	Landuse: Forrest Pollution sources: Reclaimed mine; Outfall 001 Erosion: None
Weather	Clear	Clear	Clear	Clear	Clear

CPOM = coarse particulate organic matter; FPOM = fine particulate organic matter. * = consolidated precipitate.

Table 4.6. Summary of habitat characteristics evaluation performed during June 2009 sampling.

Category	WILS	WIL-1	WIL-2	WIL-2.5	WIL-6
Epifaunal substrate/available cover	18	16	10	6	16
Embeddedness	18	18	5	11	13
Velocity/depth regime	10	10	8	7	16
Sediment deposition	18	18	8	5	13
Channel flow status	15	16	13	12	14
Channel alteration	20	20	10	18	19
Frequency of riffles	20	18	15	13	18
Bank stability	10/10	8/8	3/10	6/6	9/9
Vegetative protection	10/10	7/7	3/10	6/6	10/10
Riparian vegetative zone width	10/10	10/10	1/10	9/9	10/10
Total habitat score	179	166	80	114	170

4.3.2 Fish Communities

Four species of fish were captured from among all locations in the June 2009 sampling: creek chub (*Semotilis atromaculatus*), green sunfish (*Lepomis cyanellus*), creek chubsucker (*Erimyzon oblongus*), and orangebelly darter (*Etheostoma radiosum*) (Table 4.7).

Table 4.7 indicates the key and indicator species (and relative abundance of each) collected in the waterbodies in this study. Table 4.8 provides the key/indicator species for the Ouachita Mountain ecoregion (APCEC 2007) and indicates which of the key/indicator species were collected from the waterbodies of this study. Only one ecoregion key species, the orangebelly darter (*E. radiosum*), was collected from among all sites, and no indicator species were collected.

Creek chubsucker (*S. atromaculatus*) dominated the collections in both of the upstream locations (WILS and WIL-1).

Table 4.7. Fish species composition (% relative abundance) from June 2009 sampling.

Species	Site				
	WILS	WIL-1	WIL-2	WIL-2.5	WIL-6
Semotilis atromaculatus	77	100		56	3
Lepomis cyanellus				44	23
Erimyzon oblongus					30
*Etheostoma radiosum**	23				43
Total Taxa	**2**	**1**	**0**	**2**	**4**
Total Number	**132**	**70**	**0**	**9**	**30**
CPUE (Fish/100 m)	**189**	**117**	**0**	**15**	**40**

* Ouachita Mountain ecoregion key species.

Table 4.8. Ouachita Mountain ecoregion key and indicator species.

Key Species		Indicator Species	
Bigeye shiner	*Notropis boops*	Shadow bass	*Ambloplites ariommus*
Northern hogsucker	*Hypentelium nigricans*	Gravel chub	*Erimystax x-punctatus*
Freckled madtom	*Noturus nocturnus*	Northern studfish	*Fundulus catenatus*
Longear sunfish	*Lepomis megalotis*	Striped shiner	*Luxilus chrysocephalus*
Orangebelly darter*	*Etheostoma radiosum**		
Smallmouth bass	*Micropterus dolomieu*		

* Present in waterbodies sampled in this study.

4.3.3 Benthic Invertebrates

Results of benthic macroinvertebrate collection are summarized in Table 4.9 and provided in greater detail in Appendix A. All sampling locations showed relatively low number of individuals. At each location, the entire sample was sorted because the normal minimum sorting goal of 160 organisms was not met. Therefore, the "Total Abundance" row in Table 4.9 is a valid reflection of relative number of individuals present at each location. There were few general patterns apparent in the benthic community metrics from upstream to downstream locations. The highest taxa richness was found at the middle three locations (WIL-1, WIL-2, and WIL-2.5), with the lowest taxa richness found at the uppermost and lowermost locations (WILS and WIL-6, respectively). Gatherers/collectors, the most abundant functional feeding group at all locations, ranged in relative abundance from 47 to 83% of the community. The second most abundant functional group included all of the remaining observed groups and ranged in relative abundance from 15 to 45% of the community. There was no apparent pattern in the functional feeding group makeup among locations.

Table 4.9. Summary of benthic macroinvertebrate sampling from June 2009 sampling.

Metric		WILS	WIL-1	WIL-2	WIL-2.5	WIL-6
Taxa Richness		9	11	14	14	9
Total Abundance		80	76	99	131	116
% Ephemeroptera, Plecoptera, and Trichoptera (EPT)		25	41	50	27	14
% Diptera		15	29	8	18	4
Functional Feeding Group	% Filterers	0	14	4	10	15
	% Shredders	5	3	45	23	0
	% Scrapers	20	34	1	2	0
	% Gatherers/Collectors	71	46	47	61	83
	% Predator	4	3	2	3	2

5.0 DISCUSSION

5.1 Water Chemistry and Flows

Water quality data for WILS indicate a stream with low TDS and relatively low pH that is typical for small Ouachita Mountain ecoregion steams (Arkansas Department of Pollution Control and Ecology (ADPCE) 1987). Water quality at the WIL-1 location shows the same low TDS as WILS with pH that is further lowered by the influence of the seep areas. WIL-2 shows higher sulfate and conductivity and lowered pH that are due to the influence of inflows from additional seep areas. WIL-2.5 shows a slight increase in pH and decrease in TDS and sulfate that is likely due to a combination of precipitation of dissolved minerals entering from the seep inflow and dilution from other inflows. Upstream of Outfall 001, chloride levels are uniformly low and pH levels are below 6.0 (the minimum Arkansas water quality criterion for pH; APCEC 2007). Downstream of Outfall 001, the characteristics of the NPDES discharge dominate flows and water chemistry. Flow measured at WIL-6 (downstream) is about eight times the upstream flow measured at WILS. Natural flow increases as a result of groundwater inflow to Wilson Creek and surface water inflow from small contributing drainages. The lime treatment at East Wilson raises the pH, sulfate, and TDS levels.

Based on longitudinal changes in water quality shown in this survey, reduced levels of biological diversity and/or production might be expected at WIL-1, WIL-2, and WIL-2.5 due to the direct effects of lowered pH and/or factors correlated with reduced pH (e.g., toxicity due to metals in dissolved form and/or in toxic valence states). Locations downstream of Outfall 001 (WIL-5 and WIL-6) show the effects of the discharge with increased flow, TDS, sulfate and pH.

5.2 Toxicity

5.2.1 Wilson Creek Toxicity Due to the Seep Inflow

TIE procedures conducted on pH adjusted seep sample did not indicate the presence of volatile, filterable, chelatable, oxidizing, ionic, or non-polar organic toxicants. The STR-based analysis of ionic composition indicated that the concentrations of sodium, potassium, calcium, magnesium, chloride, sulfate, and bicarbonate would need to be approximately nine times higher to cause acute toxicity and three times higher to cause sub-lethal toxicity. This analysis indicates that toxicity in the seep sample is not attributable to ionic stress due to high TDS concentrations.

Some dissolved components of the sample, particularly metals (e.g., copper, zinc, and aluminum), are at concentrations normally associated with acute toxicity to *C. dubia* (Schubauer-Berigan et al. 1993). It was expected at the outset of the testing that the EDTA and solid phase extraction sample manipulation would remove or reduce toxicity, thereby implicating cationic metals as a suspect toxicant. However, toxicity was not affected by these manipulations.

5.2.2 Wilson Creek Toxicity Potential

The primary concern regarding potential effects of the discharge with respect to TDS and sulfate criteria is potential toxic effects due to elevated TDS and sulfate concentrations in the receiving stream. Toxic effects of TDS and sulfate depend on the ionic composition of the entire matrix (Mount et al. 1997). Therefore, this analysis evaluated the predicted toxicity of the discharge after it is mixed with the upstream flow. Although the upstream flow dilutes the discharge, it also changes the ionic composition. The sample collected from WIL-5 represents the combined effects of TDS from upstream and the discharge and is therefore an appropriate sample to use as a basis for evaluating toxic effects of the discharge.

The STR-based analysis of ionic composition provided in Section 4.0 (Results) indicated that effluent concentrations of sodium, potassium, calcium, magnesium, chloride, sulfate, and bicarbonate would need to be approximately nine times higher than the June 2 sample to cause acute toxicity at WIL-5, and three times higher to cause sub-lethal toxicity at WIL-5. This analysis indicates that, in the context of the actual matrix to which aquatic life is exposed (i.e., Wilson Creek below Outfall 001), TDS and sulfate concentrations would need to reach approximately 1,142 mg/L and 554 mg/L, respectively, to cause sub-lethal toxicity. It is FTN's experience that the STR model typically overestimates toxicity. Therefore, these threshold estimates are conservative.

These values can be compared with the summary sulfate and TDS concentrations from combined data from Outfall 001, WIL-6, and WILL (Table 5.1). This comparison shows that Table 5.1 concentrations of sulfate and TDS are well below the conservative predicted sub-lethal toxicity thresholds. Therefore, sub-lethal toxicity due to TDS and/or sulfate should not occur in either the outfall or in Wilson Creek downstream of the outfall.

Table 5.1. Summary of combined mineral data from Outfall 001, WIL-6, and WILL monitoring.

Parameter		Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Percentile	10	7.7	140	260
	20	9	148.6	280
	30	12	181	341
	40	13	197.2	370
	50	14	210	390
	60	15	220	400
	70	16.9	240	419
	80	18.6	250	430
	90	41.3	260	460
	95	55.7	260	543
Maximum		78	260	850
Minimum		5	125	200
Average		18.9	202.7	380
Number		88	70	88
Period of Record		4/19/07 – 6/1/09	5/23/07 – 6/1/09	5/19/07 – 6/1/09

As explained in Section 4.2.2, a similar approach cannot be used to evaluate chloride toxicity. Accordingly, this evaluation of chloride toxicity focused chronic reference toxicant testing conducted as part of AIC's routine QA/QC program. This information (Table 3.2) indicates that the lowest IC25 value in routine QA/QC testing (conducted January 2008 through March 2009) was 238 mg/L chloride. This threshold is well above the maximum measured chloride concentration from Wilson Creek as provided in Table 5.1. Therefore, sub-lethal toxicity due to chloride should not occur in either the outfall or in Wilson Creek downstream of the outfall.

5.3 Biological Communities

5.3.1 Fish Communities

Overall fish species richness was low at all sites with a total of only four species present. This condition is expected given the perennial nature of Wilson Creek upstream of Outfall 001 and inflows from the Spaulding area seeps that affect water quality.

No fish were collected at WIL-2. This reach shows low pH levels due to the influence of seep inflow. The substrate at the WIL-2 reach was impacted with consolidated precipitate that provides a poor substrate for aquatic life support. These impacts to the physical substrate as well as toxic effects due to the influence of seep inflow (discussed below) account for the absence of fish at this location.

A similar effect was seen at WIL-1 relative to WILS. The orangebelly darter (*E. radiosum*) was absent at WIL-1, even though riffles were present and habitat scores were similar to WILS where orangebelly darters were present. This difference is likely due to lowered pH levels at WIL-1 (pH = 4.8; Table 4.1) due to the influence of the seeps. Orangebelly darters were similarly absent at WIL-2.5. Although this reach contained a larger proportion of pool habitat (Table 4.5), which is consistent with the presence of green sunfish (*L. cyanellus*), sufficient riffle habitat seemed to be present to support darters. As with WIL-2, the absence of darters at WIL-2.5 is likely due to lowered pH (pH = 5.0; Table 4.1).

The total habitat score (Table 4.6) downstream of Outfall 001 at WIL-6 was similar to upstream, but the distribution of scores among the habitat characteristics differed. WIL-6 had lower quality substrate (greater embeddedness) but a greater diversity of flow regimes. Higher fish species richness (four species) at WIL-6 compared to upstream locations is attributable to the stream's larger size (flows increase by a factor of 8 due to the discharge; Table 4.1). However, Wilson Creek at WIL-6 is still a small shallow stream, with an estimated average depth and width of only 0.1 meter and 2 meters, respectively. The absence of small cyprinids (minnows) in this portion of Wilson Creek is likely due to the high abundance of the predaceous creek chub whose numbers are, in turn, unchecked due to the absence of larger predators (e.g., *Micropterus* sp.). The absence of larger predators is likely a function of the small size of Wilson Creek.

5.3.2 Benthic Macroinvertebrate Communities

In contrast to the fish communities, benthic communities did not show strong differences among stations even immediately downstream of the influence of the seeps (e.g., WIL-2.5). There was no apparent pattern among locations in the number of taxa, % EPT or relative abundance functional feeding groups. Lower taxa richness and % EPT was observed below Outfall 001 (WIL-6) compared to upstream stations. This difference is likely due to a greater proportion of riffles in the upstream reaches. Riffle habitats are known to support, in general, a greater variety of benthic invertebrates than pools.

6.0 SUMMARY AND CONCLUSIONS

6.1 Aquatic Life-Limiting Factors

Benthic diversity and abundance increases below the toxic inflows from the seeps, even though there is a decrease in habitat quality. This result indicates that the fish community is the most sensitive indicator of water quality changes in the locations upstream of Outfall 001. Habitat, water quality, and biological sampling and toxicity evaluation in Wilson Creek indicate that aquatic life (as indicated by the fish community) in the stations upstream from Outfall 001, but downstream from the UMETCO property line, is limited by a combination of water quality and habitat. The seasonal nature of upper Wilson Creek within the UMETCO property supports a low-baseline level of diversity and abundance due to seasonal flows and small stream size that is further limited by inflows from seeps. Water quality limitation at these reaches is due to low pH and associated factors (e.g., zinc toxicity), but not to concentrations of sulfate and TDS.

Downstream of Outfall 001, the discharge dominates water quality. Fish diversity increases, and is likely limited by the size of the stream (small and shallow) and somewhat embedded substrate. The predominance of shallow pool habitat at the downstream location WIL-6 likely limits benthic diversity relative to the upstream locations. Although TDS and sulfate concentrations still exceed Ouachita Mountain ecoregion criteria below the discharge, these levels are well below conservative toxic thresholds based on the STR model (Mount et al. 1997). Because current sulfate and TDS concentrations do not appear to limit aquatic life in either the upstream reaches (aquatic life habitat- and water quality-limited) or downstream reaches (aquatic life habitat-limited), site-specific criteria for sulfate and TDS are appropriate and justified. The previous UAA submittal (WEI 2004) presented supporting justification for the criteria changes, including a discussion on the economic infeasibility of treatment for dissolved minerals as an option.

6.2 Recommended Site-Specific Criteria

Site-specific criteria for sulfate and TDS in Wilson Creek are justified because neither parameter limits aquatic life use attainment (seasonal Ouachita Mountain ecoregion fishery upstream of Outfall 001; perennial Ouachita Mountain ecoregion fishery downstream of Outfall 001 due to the presence of the continuous discharge). Accordingly, the recommended site-specific criteria should be concentrations that reflect current conditions.

6.2.1 Wilson Creek Downstream of Outfall 001

Because the Outfall 001 discharge dominates low flows in Wilson Creek downstream of the outfall, routine DMR monitoring data from the last 2 years of monitoring were selected as a partial basis for the site-specific criteria. Additional monitoring data were also used from UMETCO's monitoring of Wilson Creek at WIL-6 and WILL (see Figure 2.2) as part of the Consent Administrative Order (CAO) agreement with ADEQ. This summary indicates instream exceedances of the ecoregion minerals criteria. The derivation of the proposed site-specific criteria for chloride, sulfate, and TDS involved computing the 95th percentile of each parameter from the combined data set from Outfall 001, WIL-6, and WILL. These data are provided in Appendix A and summarized in Table 5.1. The 95th percentile sulfate and TDS concentrations from the combined data set were 260 mg/L sulfate and 543 mg/L TDS (Table 5.1). These values are herein proposed as site-specific criteria for Wilson Creek from Outfall 001 to Lake Catherine. They are well below the conservative chronic toxicity thresholds developed in Sections 4 and 5 of this document.

As explained in Section 4.2.2, a similar STR-model-based approach cannot be used to evaluate chloride toxicity. Accordingly, the evaluation presented in Section 5.2.2 is presented as a basis for a site-specific chloride criterion. The 95th percentile value of Wilson Creek chloride concentrations (Table 5.1) is 55.7 mg/L. This value is well below the lowest IC25 value in routine QA/QC testing (238 mg/L chloride; Table 3.2). Therefore, a value of 56 mg/L chloride is herein proposed as a site-specific chloride criterion for Wilson Creek downstream of Outfall 001.

6.2.2 Wilson Creek Upstream of Outfall 001

UMETCO has conducted semiannual sampling of selected locations, including WIL-2, on Wilson Creek since 1995. For this evaluation, monitoring data from WIL-2 from May 2007 through January 2009 were selected to represent current TDS and sulfate concentrations upstream of Outfall 001. Monitoring data are presented in Table 6.1. A valid 95th percentile value cannot be estimated using only five data points. Alternatively, the 95th percentile can be estimated by solving for y_i in the following equation:

$$Z = \frac{y_i - \bar{y}}{s_{y_i}}$$

Where:

	Z	is the area under the standardized normal curve containing 95% of the data,
	y_i	is the value of the variable corresponding to Z,
	$\bar{y}$	is the mean of y_i, and
	s_{y_i}	is the standard deviation of y_i.

This approach can be used only if the data are normally distributed. Both the TDS and sulfate data were normally distributed per the Shapiro-Wilkes test for normality ($p > 0.05$). Therefore, the calculated means and standard deviations (Table 6.1) were used in the above equation with a Z value of 1.645 interpolated from Table A in Rohlf and Sokal (1995). Accordingly, the 95th percentile values obtained were 203 mg/L for TDS and 119 mg/L for sulfate to represent current conditions in Wilson Creek upstream of Outfall 001.

Under current conditions, these values represent appropriate site-specific criteria for Wilson Creek upstream of the Outfall 001 discharge, but downstream of the UMETCO property line. However, if future activities at the UMETCO site include treatment of the water flowing from the seeps, elevated sulfate and TDS levels in the upper reaches of Wilson Creek can be expected. While such treatment activities, if implemented, will raise mineral concentrations, they will also make the water quality more suitable for aquatic life support. This treatment can be expected to raise mineral concentrations in Wilson Creek upstream of the Outfall 001 discharge to levels comparable to Wilson Creek downstream of the Outfall 001 discharge. Because the mineral concentrations in Wilson Creek do not limit aquatic life downstream of the discharge, similar concentrations should not limit aquatic life upstream of the discharge. Therefore, to allow future treatment of areas draining Wilson Creek upstream of Outfall 001, it is proposed that the same site-specific chloride, sulfate and TDS criteria (Table 6.2) be applied to the entirety of Wilson Creek from the upstream UMETCO property boundary to Lake Catherine.

Table 6.1. Results of routine semiannual TDS and sulfate measurements at WIL-2.

Sampling Date	TDS (mg/L)	Sulfate (mg/L)
05-23-07	130	70
12-31-07	70	40
01-30-08	100	50
07-08-08	200	120
01-12-09	70	40
Mean	**114.000**	**64.000**
Standard Deviation	**54.1295**	**33.6155**

Table 6.2. Summary of recommended site-specific TDS, sulfate, and chloride criteria for Wilson Creek.

Applicable Reach of Wilson Creek	Parameter	Existing Criterion	Proposed Criterion
Upstream of Outfall 001 from a point on Wilson Creek approximately 0.85 mile upstream from Outfall 001 at the UMETCO property line down to Outfall 001	TDS	142	543
	Sulfate	20	260
	Chloride	15	56
Downstream of Outfall 001 to Lake Catherine	TDS	142	543
	Sulfate	20	260
	Chloride	15	56

6.3 Downstream Effects on Lake Catherine

The criteria proposed herein do not represent a change from current conditions. Therefore, current water quality in Lake Catherine, which is meeting state water quality standards (as determined by its absence from the draft Arkansas 2008 303(d) list of impaired waters), will not change as a result of criteria implementation. Therefore, the current UMETCO discharge into Wilson Creek, and the proposed sulfate and TDS criteria, which are based on current conditions, are consistent with attainment of downstream water quality criteria and designated uses.

7.0 REFERENCES

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APPENDIX A

Chloride, Sulfate, and TDS Data Used to Derive Site-Specific Criteria

APPENDIX A

Table A1. Chloride, sulfate, and TDS data used to derive site-specific criteria for Wilson Creek.

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Chloride	OUTFALL 001	12-Jun-07	L63168	ACZ	15
Chloride	OUTFALL 001	15-Nov-07	L66336	ACZ	19
Chloride	OUTFALL 001	20-Nov-07	L66410	ACZ	19
Chloride	OUTFALL 001	27-Nov-07	L66501	ACZ	18
Chloride	OUTFALL 001	13-Dec-07	L66776	ACZ	16
Chloride	OUTFALL 001	18-Dec-07	L66834	ACZ	15
Chloride	OUTFALL 001	27-Dec-07	L66969	ACZ	14
Chloride	OUTFALL 001	03-Jan-08	L67032	ACZ	17
Chloride	OUTFALL 001	09-Jan-08	L67142	ACZ	17
Chloride	OUTFALL 001	16-Jan-08	L67276	ACZ	16
Chloride	OUTFALL 001	24-Jan-08	L67395	ACZ	15
Chloride	OUTFALL 001	30-Jan-08	L67465	ACZ	14
Chloride	OUTFALL 001	06-Feb-08	L67580	ACZ	16
Chloride	OUTFALL 001	14-Feb-08	L67686	ACZ	16
Chloride	OUTFALL 001	20-Feb-08	L67791	ACZ	13
Chloride	OUTFALL 001	27-Feb-08	L67892	ACZ	19
Chloride	OUTFALL 001	05-Mar-08	L68026	ACZ	8
Chloride	OUTFALL 001	11-Mar-08	L68119	ACZ	9
Chloride	OUTFALL 001	19-Mar-08	L68271	ACZ	9
Chloride	OUTFALL 001	26-Mar-08	L68373	ACZ	7
Chloride	OUTFALL 001	01-Apr-08	L68453	ACZ	8
Chloride	OUTFALL 001	09-Apr-08	L68617	ACZ	6
Chloride	OUTFALL 001	16-Apr-08	L68742	ACZ	5
Chloride	OUTFALL 001	22-Apr-08	L68812	ACZ	7
Chloride	OUTFALL 001	01-May-08	L69011	ACZ	8
Chloride	OUTFALL 001	07-May-08	L69103	ACZ	7
Chloride	OUTFALL 001	13-May-08	L69194	ACZ	10
Chloride	OUTFALL 001	20-May-08	L69324	ACZ	12
Chloride	OUTFALL 001	16-Sep-08	L71861	ACZ	12
Chloride	OUTFALL 001	06-Oct-08	L72251	ACZ	14
Chloride	OUTFALL 001	13-Oct-08	L72442	ACZ	13
Chloride	OUTFALL 001	20-Oct-08	L72583	ACZ	13
Chloride	OUTFALL 001	27-Oct-08	L72704	ACZ	14
Chloride	OUTFALL 001	03-Nov-08	L72821	ACZ	12
Chloride	OUTFALL 001	11-Nov-08	L73002	ACZ	14
Chloride	OUTFALL 001	17-Nov-08	L73100	ACZ	14
Chloride	OUTFALL 001	24-Nov-08	L73238	ACZ	14
Chloride	OUTFALL 001	01-Dec-08	L73293	ACZ	14

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Chloride	OUTFALL 001	06-Jan-09	L73828	ACZ	14
Chloride	OUTFALL 001	12-Jan-09	L73916	ACZ	15
Chloride	OUTFALL 001	19-Jan-09	L74021	ACZ	16
Chloride	OUTFALL 001	26-Jan-09	L74159	ACZ	13
Chloride	OUTFALL 001	02-Feb-09	L74227	ACZ	14
Chloride	OUTFALL 001	10-Feb-09	L74377	ACZ	15
Chloride	OUTFALL 001	16-Feb-09	L74450	ACZ	14
Chloride	OUTFALL 001	23-Feb-09	L74543	ACZ	14
Chloride	OUTFALL 001	02-Mar-09	L74651	ACZ	13
Chloride	OUTFALL 001	09-Mar-09	L74775	ACZ	14
Chloride	OUTFALL 001	16-Mar-09	L74860	ACZ	13
Chloride	OUTFALL 001	23-Mar-09	L74957	ACZ	13
Chloride	OUTFALL 001	30-Mar-09	L75055	ACZ	13
Chloride	OUTFALL 001	09-Apr-09	L75238	ACZ	11
Chloride	OUTFALL 001	14-Apr-09	L75293	ACZ	9
Chloride	OUTFALL 001	20-Apr-09	L75373	ACZ	9
Chloride	OUTFALL 001	28-Apr-09	L75502	ACZ	9
Chloride	OUTFALL 001	05-May-09	L75628	ACZ	8
Chloride	OUTFALL 001	05-May-09	L75628	ACZ	8
Chloride	OUTFALL 001	11-May-09	L75727	ACZ	6
Chloride	OUTFALL 001	19-May-09	L75900	ACZ	6
Chloride	OUTFALL 001	27-May-09	L76078	ACZ	6
Chloride	OUTFALL 001	01-Jun-09	L76150	ACZ	7
Chloride	WIL-6	19-Apr-07	L62148	ACZ	70
Chloride	WIL-6	26-Apr-07	L62246	ACZ	39
Chloride	WIL-6	03-May-07	L62384	ACZ	55
Chloride	WIL-6	10-May-07	L62546	ACZ	42
Chloride	WILL	23-May-07	L62821	ACZ	13
Chloride	WILL	06-Dec-07	L66678	ACZ	56
Chloride	WILL	31-Dec-07	L67005	ACZ	18
Chloride	WILL	08-Jan-08	L67099	ACZ	17
Chloride	WILL	30-Jan-08	L67467	ACZ	24
Chloride	WILL	20-Feb-08	L67784	ACZ	15
Chloride	WILL	11-Mar-08	L68140	ACZ	11
Chloride	WILL	01-Apr-08	L68444	ACZ	9
Chloride	WILL	12-May-08	L69164	ACZ	41
Chloride	WILL	24-Jun-08	L70082	ACZ	69
Chloride	WILL	02-Jul-08	L70264	ACZ	78
Chloride	WILL	08-Jul-08	L70373	ACZ	52
Chloride	WILL	04-Aug-08	L70935	ACZ	77
Chloride	WILL	08-Sep-08	L71684	ACZ	53

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Chloride	WILL	01-Oct-08	L72179	ACZ	39
Chloride	WILL	17-Nov-08	L73094	ACZ	26
Chloride	WILL	08-Jan-09	L73875	ACZ	20
Chloride	WILL	12-Jan-09	L73905	ACZ	18
Chloride	WILL	02-Feb-09	L74235	ACZ	18
Chloride	WILL	02-Mar-09	L74659	ACZ	17
Chloride	WILL	02-Apr-09	L75102	ACZ	18
Chloride	WILL	05-May-09	L75627	ACZ	11
Chloride	WILL	01-Jun-09	L76149	ACZ	11
Sulfate	OUTFALL 001	04-Jun-07	L63035	ACZ	260
Sulfate	OUTFALL 001	12-Jun-07	L63168	ACZ	250
Sulfate	OUTFALL 001	12-Jun-07	L63169	ACZ	260
Sulfate	OUTFALL 001	17-Sep-07	L65085	ACZ	260
Sulfate	OUTFALL 001	24-Sep-07	L65232	ACZ	250
Sulfate	OUTFALL 001	09-Oct-07	L65568	ACZ	250
Sulfate	OUTFALL 001	16-Oct-07	L65709	ACZ	260
Sulfate	OUTFALL 001	22-Oct-07	L65832	ACZ	260
Sulfate	OUTFALL 001	31-Oct-07	L66035	ACZ	260
Sulfate	OUTFALL 001	07-Nov-07	L66167	ACZ	250
Sulfate	OUTFALL 001	15-Nov-07	L66336	ACZ	260
Sulfate	OUTFALL 001	20-Nov-07	L66410	ACZ	250
Sulfate	OUTFALL 001	27-Nov-07	L66501	ACZ	260
Sulfate	OUTFALL 001	13-Dec-07	L66776	ACZ	260
Sulfate	OUTFALL 001	18-Dec-07	L66834	ACZ	240
Sulfate	OUTFALL 001	27-Dec-07	L66969	ACZ	230
Sulfate	OUTFALL 001	03-Jan-08	L67032	ACZ	240
Sulfate	OUTFALL 001	09-Jan-08	L67142	ACZ	250
Sulfate	OUTFALL 001	16-Jan-08	L67276	ACZ	250
Sulfate	OUTFALL 001	24-Jan-08	L67395	ACZ	240
Sulfate	OUTFALL 001	30-Jan-08	L67465	ACZ	240
Sulfate	OUTFALL 001	06-Feb-08	L67580	ACZ	240
Sulfate	OUTFALL 001	14-Feb-08	L67686	ACZ	230
Sulfate	OUTFALL 001	20-Feb-08	L67791	ACZ	210
Sulfate	OUTFALL 001	27-Feb-08	L67892	ACZ	181
Sulfate	OUTFALL 001	05-Mar-08	L68026	ACZ	150
Sulfate	OUTFALL 001	11-Mar-08	L68119	ACZ	147
Sulfate	OUTFALL 001	19-Mar-08	L68271	ACZ	134
Sulfate	OUTFALL 001	26-Mar-08	L68373	ACZ	134
Sulfate	OUTFALL 001	01-Apr-08	L68453	ACZ	131
Sulfate	OUTFALL 001	09-Apr-08	L68617	ACZ	125
Sulfate	OUTFALL 001	16-Apr-08	L68742	ACZ	125

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Sulfate	OUTFALL 001	22-Apr-08	L68812	ACZ	140
Sulfate	OUTFALL 001	01-May-08	L69011	ACZ	161
Sulfate	OUTFALL 001	07-May-08	L69103	ACZ	181
Sulfate	OUTFALL 001	13-May-08	L69194	ACZ	200
Sulfate	OUTFALL 001	20-May-08	L69324	ACZ	200
Sulfate	OUTFALL 001	16-Sep-08	L71861	ACZ	186
Sulfate	OUTFALL 001	06-Oct-08	L72251	ACZ	200
Sulfate	OUTFALL 001	13-Oct-08	L72442	ACZ	200
Sulfate	OUTFALL 001	20-Oct-08	L72583	ACZ	193
Sulfate	OUTFALL 001	27-Oct-08	L72704	ACZ	200
Sulfate	OUTFALL 001	03-Nov-08	L72821	ACZ	210
Sulfate	OUTFALL 001	11-Nov-08	L73002	ACZ	220
Sulfate	OUTFALL 001	17-Nov-08	L73100	ACZ	210
Sulfate	OUTFALL 001	24-Nov-08	L73238	ACZ	210
Sulfate	OUTFALL 001	01-Dec-08	L73293	ACZ	210
Sulfate	OUTFALL 001	06-Jan-09	L73828	ACZ	220
Sulfate	OUTFALL 001	12-Jan-09	L73916	ACZ	250
Sulfate	OUTFALL 001	19-Jan-09	L74021	ACZ	220
Sulfate	OUTFALL 001	26-Jan-09	L74159	ACZ	250
Sulfate	OUTFALL 001	02-Feb-09	L74227	ACZ	220
Sulfate	OUTFALL 001	10-Feb-09	L74377	ACZ	230
Sulfate	OUTFALL 001	16-Feb-09	L74450	ACZ	220
Sulfate	OUTFALL 001	23-Feb-09	L74543	ACZ	220
Sulfate	OUTFALL 001	02-Mar-09	L74651	ACZ	190
Sulfate	OUTFALL 001	09-Mar-09	L74775	ACZ	170
Sulfate	OUTFALL 001	16-Mar-09	L74860	ACZ	186
Sulfate	OUTFALL 001	23-Mar-09	L74957	ACZ	182
Sulfate	OUTFALL 001	30-Mar-09	L75055	ACZ	181
Sulfate	OUTFALL 001	09-Apr-09	L75238	ACZ	159
Sulfate	OUTFALL 001	14-Apr-09	L75293	ACZ	141
Sulfate	OUTFALL 001	20-Apr-09	L75373	ACZ	138
Sulfate	OUTFALL 001	28-Apr-09	L75502	ACZ	147
Sulfate	OUTFALL 001	05-May-09	L75628	ACZ	139
Sulfate	OUTFALL 001	05-May-09	L75628	ACZ	139
Sulfate	OUTFALL 001	11-May-09	L75727	ACZ	137
Sulfate	OUTFALL 001	19-May-09	L75900	ACZ	140
Sulfate	OUTFALL 001	27-May-09	L76078	ACZ	149
Sulfate	OUTFALL 001	01-Jun-09	L76150	ACZ	154
Sulfate	WILL	23-May-07	L62821	ACZ	180
Sulfate	WILL	06-Dec-07	L66678	ACZ	280
Sulfate	WILL	31-Dec-07	L67005	ACZ	240

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Sulfate	WILL	08-Jan-08	L67099	ACZ	240
Sulfate	WILL	30-Jan-08	L67467	ACZ	240
Sulfate	WILL	20-Feb-08	L67784	ACZ	210
Sulfate	WILL	11-Mar-08	L68140	ACZ	152
Sulfate	WILL	01-Apr-08	L68444	ACZ	140
Sulfate	WILL	12-May-08	L69164	ACZ	200
Sulfate	WILL	24-Jun-08	L70082	ACZ	260
Sulfate	WILL	02-Jul-08	L70264	ACZ	310
Sulfate	WILL	08-Jul-08	L70373	ACZ	240
Sulfate	WILL	04-Aug-08	L70935	ACZ	300
Sulfate	WILL	08-Sep-08	L71684	ACZ	160
Sulfate	WILL	01-Oct-08	L72179	ACZ	170
Sulfate	WILL	17-Nov-08	L73094	ACZ	240
Sulfate	WILL	08-Jan-09	L73875	ACZ	250
Sulfate	WILL	12-Jan-09	L73905	ACZ	240
Sulfate	WILL	02-Feb-09	L74235	ACZ	250
Sulfate	WILL	02-Mar-09	L74659	ACZ	230
Sulfate	WILL	02-Apr-09	L75102	ACZ	220
Sulfate	WILL	05-May-09	L75627	ACZ	150
Sulfate	WILL	01-Jun-09	L76149	ACZ	180
Total Dissolved Solids	OUTFALL 001	12-Jun-07	L63168	ACZ	450
Total Dissolved Solids	OUTFALL 001	15-Nov-07	L66336	ACZ	410
Total Dissolved Solids	OUTFALL 001	20-Nov-07	L66410	ACZ	440
Total Dissolved Solids	OUTFALL 001	27-Nov-07	L66501	ACZ	460
Total Dissolved Solids	OUTFALL 001	13-Dec-07	L66776	ACZ	430
Total Dissolved Solids	OUTFALL 001	18-Dec-07	L66834	ACZ	420
Total Dissolved Solids	OUTFALL 001	27-Dec-07	L66969	ACZ	410
Total Dissolved Solids	OUTFALL 001	03-Jan-08	L67032	ACZ	410
Total Dissolved Solids	OUTFALL 001	09-Jan-08	L67142	ACZ	430
Total Dissolved Solids	OUTFALL 001	16-Jan-08	L67276	ACZ	410
Total Dissolved Solids	OUTFALL 001	24-Jan-08	L67395	ACZ	430
Total Dissolved Solids	OUTFALL 001	30-Jan-08	L67465	ACZ	430
Total Dissolved Solids	OUTFALL 001	06-Feb-08	L67580	ACZ	420
Total Dissolved Solids	OUTFALL 001	14-Feb-08	L67686	ACZ	410
Total Dissolved Solids	OUTFALL 001	20-Feb-08	L67791	ACZ	370
Total Dissolved Solids	OUTFALL 001	27-Feb-08	L67892	ACZ	340
Total Dissolved Solids	OUTFALL 001	05-Mar-08	L68026	ACZ	260
Total Dissolved Solids	OUTFALL 001	11-Mar-08	L68119	ACZ	280
Total Dissolved Solids	OUTFALL 001	19-Mar-08	L68271	ACZ	250
Total Dissolved Solids	OUTFALL 001	26-Mar-08	L68373	ACZ	240
Total Dissolved Solids	OUTFALL 001	01-Apr-08	L68453	ACZ	250

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Total Dissolved Solids	OUTFALL 001	09-Apr-08	L68617	ACZ	200
Total Dissolved Solids	OUTFALL 001	16-Apr-08	L68742	ACZ	220
Total Dissolved Solids	OUTFALL 001	22-Apr-08	L68812	ACZ	240
Total Dissolved Solids	OUTFALL 001	01-May-08	L69011	ACZ	260
Total Dissolved Solids	OUTFALL 001	07-May-08	L69103	ACZ	300
Total Dissolved Solids	OUTFALL 001	13-May-08	L69194	ACZ	340
Total Dissolved Solids	OUTFALL 001	20-May-08	L69324	ACZ	370
Total Dissolved Solids	OUTFALL 001	16-Sep-08	L71861	ACZ	350
Total Dissolved Solids	OUTFALL 001	06-Oct-08	L72251	ACZ	380
Total Dissolved Solids	OUTFALL 001	13-Oct-08	L72442	ACZ	370
Total Dissolved Solids	OUTFALL 001	20-Oct-08	L72583	ACZ	380
Total Dissolved Solids	OUTFALL 001	27-Oct-08	L72704	ACZ	390
Total Dissolved Solids	OUTFALL 001	03-Nov-08	L72821	ACZ	380
Total Dissolved Solids	OUTFALL 001	11-Nov-08	L73002	ACZ	400
Total Dissolved Solids	OUTFALL 001	17-Nov-08	L73100	ACZ	850
Total Dissolved Solids	OUTFALL 001	24-Nov-08	L73238	ACZ	400
Total Dissolved Solids	OUTFALL 001	01-Dec-08	L73293	ACZ	400
Total Dissolved Solids	OUTFALL 001	06-Jan-09	L73828	ACZ	400
Total Dissolved Solids	OUTFALL 001	12-Jan-09	L73916	ACZ	420
Total Dissolved Solids	OUTFALL 001	19-Jan-09	L74021	ACZ	410
Total Dissolved Solids	OUTFALL 001	26-Jan-09	L74159	ACZ	400
Total Dissolved Solids	OUTFALL 001	02-Feb-09	L74227	ACZ	420
Total Dissolved Solids	OUTFALL 001	10-Feb-09	L74377	ACZ	400
Total Dissolved Solids	OUTFALL 001	16-Feb-09	L74450	ACZ	400
Total Dissolved Solids	OUTFALL 001	23-Feb-09	L74543	ACZ	390
Total Dissolved Solids	OUTFALL 001	02-Mar-09	L74651	ACZ	360
Total Dissolved Solids	OUTFALL 001	09-Mar-09	L74775	ACZ	360
Total Dissolved Solids	OUTFALL 001	16-Mar-09	L74860	ACZ	370
Total Dissolved Solids	OUTFALL 001	23-Mar-09	L74957	ACZ	380
Total Dissolved Solids	OUTFALL 001	30-Mar-09	L75055	ACZ	360
Total Dissolved Solids	OUTFALL 001	09-Apr-09	L75238	ACZ	300
Total Dissolved Solids	OUTFALL 001	14-Apr-09	L75293	ACZ	270
Total Dissolved Solids	OUTFALL 001	20-Apr-09	L75373	ACZ	260
Total Dissolved Solids	OUTFALL 001	28-Apr-09	L75502	ACZ	280
Total Dissolved Solids	OUTFALL 001	05-May-09	L75628	ACZ	260
Total Dissolved Solids	OUTFALL 001	05-May-09	L75628	ACZ	260
Total Dissolved Solids	OUTFALL 001	11-May-09	L75727	ACZ	260
Total Dissolved Solids	OUTFALL 001	19-May-09	L75900	ACZ	250
Total Dissolved Solids	OUTFALL 001	27-May-09	L76078	ACZ	280
Total Dissolved Solids	OUTFALL 001	01-Jun-09	L76150	ACZ	290
Total Dissolved Solids	WIL-6	19-Apr-07	L62148	ACZ	570

Table A.1. Chloride, sulfate, and TDS data used to derive site-specific criteria (continued).

Analyte	Location Code	Date	Lab Number	Lab Code	Result (mg/L)
Total Dissolved Solids	WIL-6	26-Apr-07	L62246	ACZ	450
Total Dissolved Solids	WIL-6	03-May-07	L62384	ACZ	490
Total Dissolved Solids	WIL-6	10-May-07	L62546	ACZ	460
Total Dissolved Solids	WILL	23-May-07	L62821	ACZ	340
Total Dissolved Solids	WILL	06-Dec-07	L66678	ACZ	530
Total Dissolved Solids	WILL	31-Dec-07	L67005	ACZ	410
Total Dissolved Solids	WILL	08-Jan-08	L67099	ACZ	430
Total Dissolved Solids	WILL	30-Jan-08	L67467	ACZ	440
Total Dissolved Solids	WILL	20-Feb-08	L67784	ACZ	370
Total Dissolved Solids	WILL	11-Mar-08	L68140	ACZ	280
Total Dissolved Solids	WILL	01-Apr-08	L68444	ACZ	260
Total Dissolved Solids	WILL	12-May-08	L69164	ACZ	400
Total Dissolved Solids	WILL	24-Jun-08	L70082	ACZ	550
Total Dissolved Solids	WILL	02-Jul-08	L70264	ACZ	630
Total Dissolved Solids	WILL	08-Jul-08	L70373	ACZ	470
Total Dissolved Solids	WILL	04-Aug-08	L70935	ACZ	590
Total Dissolved Solids	WILL	08-Sep-08	L71684	ACZ	390
Total Dissolved Solids	WILL	01-Oct-08	L72179	ACZ	380
Total Dissolved Solids	WILL	17-Nov-08	L73094	ACZ	420
Total Dissolved Solids	WILL	08-Jan-09	L73875	ACZ	420
Total Dissolved Solids	WILL	12-Jan-09	L73905	ACZ	420
Total Dissolved Solids	WILL	02-Feb-09	L74235	ACZ	440
Total Dissolved Solids	WILL	02-Mar-09	L74659	ACZ	370
Total Dissolved Solids	WILL	02-Apr-09	L75102	ACZ	360
Total Dissolved Solids	WILL	05-May-09	L75627	ACZ	310
Total Dissolved Solids	WILL	01-Jun-09	L76149	ACZ	300