Mining and Mine Reclamation in North Central Missouri

Association of Missouri Geologists

42nd Annual Meeting
September 29-30, 1995
Moberly, Missouri
FIELD TRIP GUIDEBOOK
Mining and Mine Reclamation
in
North Central Missouri
near Moberly, Missouri

Association
of
Missouri Geologists

42nd Annual Meeting
September 29-30, 1995
Moberly, Missouri
Association of Missouri Geologists
42nd Annual Meeting and Field Trip
September 29-30, 1995

Executive Committee

RICHARD J. LAUX, FIELD TRIP COORDINATOR

Field Trip Committee

William Bruner
Larry Coen
Mikel Carlson
Albert Copley
Richard J. Laux
Steve Lindley
Tom Watkins

BANQUET AND MEETING HOSTS

Associated Electric Cooperative
Moberly Stone Company
North American Resources
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Trip Schedule</td>
<td>1</td>
</tr>
<tr>
<td>Road Log</td>
<td>2</td>
</tr>
<tr>
<td>Field Trip Itinerary</td>
<td>3</td>
</tr>
<tr>
<td>Introduction</td>
<td>6</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>7</td>
</tr>
<tr>
<td>Field Trip Itinerary - Day 1,</td>
<td></td>
</tr>
<tr>
<td>Friday, September 29</td>
<td>10</td>
</tr>
<tr>
<td>Stop No. 1. Associated Electric Cooperative,</td>
<td></td>
</tr>
<tr>
<td>Prairie Hill Mine</td>
<td>11</td>
</tr>
<tr>
<td>a. Hydrogeologic study at AECI Clifton Hill</td>
<td>12</td>
</tr>
<tr>
<td>b. Cumulative Hydrologic Impact Assessment</td>
<td>32</td>
</tr>
<tr>
<td>Associated Electric Cooperative</td>
<td></td>
</tr>
<tr>
<td>Field Trip Itinerary - Day 2, Saturday, September 30</td>
<td>70</td>
</tr>
<tr>
<td>Stop No. 1. Huntsville Reclamation Project</td>
<td>71</td>
</tr>
<tr>
<td>2. Moberly Stone Company</td>
<td>73</td>
</tr>
<tr>
<td>3. Yates Reclamation Project</td>
<td>74</td>
</tr>
<tr>
<td>4. North American Resources</td>
<td></td>
</tr>
<tr>
<td>Silver Creek Mine</td>
<td>78</td>
</tr>
<tr>
<td>a. Hydrogeologic Study for Silver Creek</td>
<td></td>
</tr>
<tr>
<td>Resources, Inc.</td>
<td>79</td>
</tr>
<tr>
<td>b. Cumulative Hydrologic Impact Assessment</td>
<td></td>
</tr>
<tr>
<td>Silver Creek Resources</td>
<td>103</td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Guide to field trip Stop Day 1</td>
<td>8</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Guide to field trip Stop Day 2</td>
<td>9</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Discharge vs. stream flow, Chariton River</td>
<td>27</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Thomas Hill Energy Center Monitoring location map</td>
<td>31</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Silver Creek Resources, Inc. Monitoring location map</td>
<td>102</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Stratigraphic Succession in Missouri</td>
<td>137</td>
</tr>
<tr>
<td>Figures 7-10</td>
<td>Silver Creek Resources for Watershed maps; monitoring location maps</td>
<td>138-142</td>
</tr>
</tbody>
</table>
ASSOCIATION OF MISSOURI GEOLOGISTS

FALL 1995 FIELD TRIP SEPTEMBER 29-30

FRIDAY AFTERNOON

1:00 pm  Buses leave the Ramada Inn parking lot (wear heavy shoes or boots and bring a safety hat. Our supply of safety hats is limited).

AECI owns approximately 35,000 acres and operates both coal mines and the Thomas Hill Power Plant and the associated cooling lake, Thomas Hill Reservoir. The plant has recently switched to western (Wyoming) coal and the mines are undergoing reclamation. After a presentation regarding AECI, the fuel conversion and a reclamation overview, we will see some reclamation in progress before returning to the Ramada Inn.

4:30 pm  Scheduled return of buses to Ramada Inn.
OFFICERS MEETING 5:00 P.M.
SOCIAL ADJUSTMENT HOUR 6:00 - 7:00 P.M.
BUFFET BANQUET 7:00 P.M.
 SPEAKER: DR. JEFFREY OSBORN,
BUSINESS MEETING

SATURDAY FIELD TRIP - SEPTEMBER 30

8:00 am  Buses leave Ramada Inn (bring your safety hat!)
First stop Huntsville Gob Reclamation Project.
Finished reclamation project which addressed significant environmental and safety issues.

Second Stop: Moberly Stone Company

Large limestone quarry currently mining underground.
Overburden and limestone have been used in nearly reclamation projects as well as for road and other construction uses.

Third Stop: Yates Land Reclamation Project

Reclamation project in process.

12:00 pm  Box lunch
Fourth Stop:  North American Resources, Silver Creek Mine

Active mining operation with open pits, containing reclamation work, and slurry pond operations.

2:30 pm  Scheduled return of buses to Ramada Inn parking lot

Road Log

Friday, September 29, 1995

Miles

0.0  Depart Ramada Inn, proceed west on Highway 24

14.1  Turn right on Highway 3 proceed north through Clifton Hill

21.0  Turn right into AECI Mining Division headquarters

return to Moberly via Highway 3 south and Highway 24 East

Saturday, September 30, 1995

Miles

0.0  Depart Ramada Inn proceed west on Highway 24

1.9  Turn right onto Highway JJ (old Highway 24)

3.1  Huntsville Gob project. Park along Highway. Project is on private property north of railroad tracks. Watch for trains!

4.7  Turn left on Highway C south

5.3  Turn right on Highway 24 west

9.0  Turn left onto Highway 3 south

11.2  Turn right into Moberly Stone Company - afterwards return to Highway 3 and proceed south

18.5  Turn left onto Highway B east

23.5  Yates - turn left onto gravel road - North American Resources Office is trailer on left side of road

24.-24.5  Yates Reclamation Project - exact location dependent upon work progress

Return to Moberly via North American Resources Silver Creek Mine.
Field Trip Itinerary

Day 1

Friday, September 29, 1995

Stop 1  Associated Electric Cooperative Inc.
        Thomas Hill Energy Center - Prairie Hill Mine

25,000 acre coal mine and three unit coal-fired power
plant with a large cooling lake. AECl personnel will
give a presentation regarding fuel conversion and
reclamation activities prior to a field trip to an in-
progress reclamation area.

The following documents were obtained from the Missouri
Department of Natural Resources, Land Reclamation
Program files. They were prepared by Mr. Larry Hendron
and staff of Engineering Surveys and Services, Columbia,
Missouri. Field Trip Itinerary

DAY TWO; SATURDAY, SEPTEMBER 30, 1995

Stop 1  Missouri Department of Natural Resources

        Huntsville Gob Project

Location: The Huntsville Reclamation Project is located near
        Highway JJ in Randolph County, Missouri approximately
        0.5 miles east of Huntsville and 4.2 miles west of
        Moberly.

History: The area was originally mined by the Huntsville-Sinclair
        Mining Company from approximately 1943 until 1950.
        Peabody Coal Company purchased mineral rights in 1950
        and mined until 1955. In addition, numerous reports and
        evidence suggests small mining operations worked
        throughout the valley long before 1943.

Problem Addressed by Reclamation:

- acid mine drainage and sediments from the gob pile
- degraded water quality in Sugar Creek, a main
  tributary of the East Fork of the Chariton River
- clogging of Huntsville Gob branch and Sugar
  Creek by coal waste
- extensive damage to downstream fields due to
  acidic sediment
- areas of burning coal waste

(3)
- areas of steep, unstable banks of coal waste
- construction waste, lumber, tires, steel objects
- minor maintenance needs on the adjacent Huntsville-Colo project

Summary: In the fall of 1992, the Abandoned Mine Land Section of the Land Reclamation Program completed final earthwork on the Huntsville Gob project east of Huntsville, Missouri. The contract was awarded to Slates Construction of Nevada, Missouri. The design was developed by the Abandoned Mine Land Section. The negative impact on water and land resources downstream of the gob pile was a major concern to the state and a headache to landowners. Reclaiming this site included removing coal sediments from a one mile length of Sugar Creek and a major tributary draining the gob pile. The coal waste was hauled back to the gob pile. Prior to reclamation, adjacent farmlands were flooded and contaminated by acidic coal sediments. Coal waste sediment was removed from approximately five acres of prime farmland, and hauled back to the gob pile.

The gob pile was graded to a gentle slope. Two feet of cover material was spread above the coal waste and revegetated. The cover material was excess glacial till overburden from the Moberly Stone limestone quarry, southeast of the reclamation site.

Seeding was completed in the summer of 1993.

Geology: Similar to that described for Prairie Hill Mine.

Other references:

Blevins, Dale W. and Ziegler, Andrew C. Hydrogeology, Water Chemistry and Subsidence of Underground Coal Mines at Huntsville, Missouri July 1987 to December 1988

Blevins, Dale W. Sources of Coal-Mine Drainage and Their Effects on Surface-Water Chemistry in the Claybank Creek Basin and Vicinity North Central Missouri, 1983-84

Gentile, Richard J. Mineral Commodities of Macon and Randolph Counties Work, David M; Summer, Scott and Robertsen, Charles E. Geology of Potential Coal Stripping Areas: Prairie Hill Area, Missouri
Stop 2  
Moberly Stone Company

**Company:**  
Moberly Stone Company  
P.O. Box 582  
Moberly, Missouri  65270

**Location:**  
Moberly Quarry  
Randolph County S-8, 17, T-53N, R-15W  
12 miles SW of Moberly on Highway 3

**Production:**  
400,000 tons/year

**Reserves:**  
30 or 40 years at present production. The limestone deposits more than 420 feet deep.

**Products:**  
Rip-rap, 8" washed stone for Associated, 1 1/2" road stone, 3/4" for driveways, state and county roads. Stonesand, a manufactured sand, which is said to reduce rutting in asphalt paving. Stonesand is more angular than natural sand and therefore bonds better with the asphalt.

**Geologic Formation:**  
Pennsylvania, Desnoinesion Series Marmaton Group with Warsaw and Burlington ledges.

**Overburden:**  
Overburden varies between 10 feet and 50 feet.

**Reclamation:**  
Completion of mining will create a large lake surrounded by wildlife habitat.

Stop 3  
Yates Reclamation Project

On-going reclamation project overseen by the Missouri Department of Natural Resources. The following materials were obtained from the files of the Land Reclamation Program.

Stop 4  
North American Resources  
Silver Creek Mine

300+ acre active coal mining operation near Yates Missouri.

The following documents were obtained from the Missouri Department of Natural Resources, Land Reclamation Program files. They were prepared by Mr. Larry Hendron and staff of Engineering Surveys and Services, Columbia, Missouri.
Introduction

This field trip is designed to give participants exposure to the changing conditions in the North Central Missouri coal mining areas. Coal mining has occurred in the area since before the 1850's. Current production is much reduced even from several years ago. Due to relatively high sulfur content and changing regulatory requirements, many of the mines have or are closing. "Abandoned" mines and closing mines are undergoing reclamation which has led to a large local demand for lime and rock for rip-rap and roads. We will visit a limestone quarry which has supplied lime, rock and soils for near-by mine reclamation projects. We will also visit finished and in-progress reclamation projects as well as one of the few remaining active coal mining operations in the area.
Acknowledgements

The following individuals and organizations have provided the opportunity for members of the Association of Missouri Geologists to visit their facilities or have allowed the committee to use their work in developing the field trip and guidebook. Their cooperation and contributions are gratefully acknowledged: Jerry Bindel, John Newman, Tom Watkins and other staff of Associated Electric Cooperative, Inc.; Mikel Carlson of Midwest Environmental Consultants, P.C.; William Bruner and Moberly Stone Company, Charles Stieffermann and staff of the Missouri Department of Natural Resources' Land Reclamation Program and Steve Lindley of North American Resources.
Field Trip Itinerary

Day 1

Friday, September 29, 1995
Stop 1
Associated Electric Cooperative Inc.
Thomas Hill Energy Center - Prairie Hill Mine

25,000 acre coal mine and three unit coal-fired power plant with a large cooling lake. AECl personnel will give a presentation regarding fuel conversion and reclamation activities prior to a field trip to an in-progress reclamation area.

The following documents were obtained from the Missouri Department of Natural Resources, Land Reclamation Program files. They were prepared by Mr. Larry Hendron and staff of Engineering Surveys and Services, Columbia, Missouri.
HYDROGEOLOGIC STUDY
for
PERMIT NO. 1991-03
at
ASSOCIATED ELECTRIC COOPERATIVE, INC.
CLIFTON HILL, MISSOURI

SUMMARY

Associated Electric Cooperative, Inc. (AECI) intends to permit 2,092 acres in eastern Chariton County for surface mining and reclamation activities. The proposed permit area lies between the Chariton River and Middle Fork of the Little Chariton River and four miles north of US Route 24. The area is contiguous to previously permitted areas 1990-04, 1986-01, and 1989-02.

The study area is in the eastern one-half of the Western Interior Coal Province and is in the Central Lowland Province of the Interior Plains. The land surface is mostly rolling hills with land-surface altitudes ranging from 750 feet in the northeast to 650 feet in the southwest. The bedrock is of Pennsylvanian age and consists of alternating beds of shale, limestone, sandstone, coal, and associated underclay. These rocks dip to the southwest at about one percent. Unconsolidated deposits of silt, clay, sand, and some gravel of Quaternary age occur in stream valleys incised into the older Pennsylvanian bedrock.

The area has continental climate and receives average annual precipitation of about 39 inches. Topographic relief is low, but predominately shale bedrock and soils having slow infiltration rates cause most of the precipitation and snow melt to move as runoff into streams. Regional base stream flow is poorly sustained because the Pennsylvanian aquifers are not capable of providing sufficient water to maintain it. An abandoned underground mine is present near the western limits of the proposed permit area. The extent of the mine works is not known at this time but will be investigated further in 1992 and prior to surface mining activities.

Monitoring wells and baseline stream flow were sampled for water quality and quantity analyses. Low-flow, high-flow, and base flow stream data were collected along with groundwater information in order for the groundwater/surface water relationship to be evaluated.

The domestic and agricultural groundwater needs in the area are generally met with

(Revised March 1992)
mining activities, AECI would install any new wells in the Mississippian aquifer or connect the affected landowner to the public water district system.

The mining and reclamation operations will require handling and disposal of potentially acid- and/or toxic-forming materials. These include the black and dark gray fissile shale overlying the Croweburg, the Bevier-Wheeler coal underclay and parting, and the sometimes present fissile shale overlying the Bevier coal seam. The glacial till has excellent engineering properties to properly seal the potentially acid- and/or toxic-forming materials. To further reduce the environmental impacts of surface mining in the permit area, the glacial till is placed upon the shale during reclamation to fabricate a pre-mining lithology.

The lack of aquifers in the area that are of sufficient size and quantity to be used for water supply that could be impaired by surface coal mining methods is a large consideration in determining the probable hydrogeologic impacts of mining. As the shallow aquifers or their recharge areas are disturbed by surface mining, both the quantity and quality of water yielded will probably decrease. Reclaimed mine soils will function as recharge areas and as new aquifers that will discharge to adjacent streams. However, the recharge will be reduced due to the heterogeneous nature of the spoil and its inability to provide a direct conduit in which groundwater can flow. The principal impact of coal mining will probably be decreased base flow conditions and impaired quality of surface water as a result of very little recharge received from the mine soils until final reclamation has been completed. At that time, base flow and water quality should be very similar to pre-mining conditions.

**BASELINE DATA AND BACKGROUND INFORMATION**

The mine permit area encompasses an area of about 2,000 acres in eastern Chariton County and is adjacent to existing AECI operations. The study design for the proposed mine area included the monitoring of surface water, ground water, and precipitation as well as classification of existing stratum by overburden analyses. The monitoring period to obtain the baseline and background information was from May 1990 to July 1991 for surface water and June 1991 to the present for groundwater. A drilling program to procure overburden samples was performed in the summer of 1990. Monitoring locations and overburden drill holes are depicted on the map included on the following page.

Monthly precipitation in the study area over the past 22 months has ranged from 0.35 inches in June 1991 to 8.03 inches in May 1990. Records indicate the long term average is about 37 inches of precipitation per year. Heaviest precipitation is expected
in the late spring and summer. Normal average daily temperatures range from about 28 degrees in January to 77 degrees Fahrenheit in July. Precipitation data for the past 22 months is included in Appendix VI.

Prevailing winds, as inferred from Weather Bureau data collected at Columbia Regional Airport, are from the north or northwest at speeds from 8 to 11 miles per hour.

**WATER USER SURVEY**

Information acquired from correspondence with residents or acquired directly by the interviewer may be found on the water user survey forms previously submitted to DNR-LRC. Groundwater levels in the wells are considered accurate; however, in most cases, information pertaining to well depth is considered hearsay. None of the deep well depths were physically defined in the field, nor were casing depths established. Therefore, information pertaining to well depths is considered approximate. Due to the lack of clear information from these wells regarding subsurface stratigraphy of this area, it is difficult to correlate the data and accurately determine the areal extent of the confined and unconfined aquifers. Information found in *The Stratigraphic Succession in Missouri* indicates that most of the area’s deep wells terminate in Mississippian strata. These wells reportedly produce water for domestic and agricultural uses.

Upon completion of the water user survey, there were 204 identified sources of water within a one mile radius of the permit area. Of the sources identified, there were 110 wells, 14 cisterns, 3 springs, 74 ponds, and 3 streams. The reliance on wells and cisterns is declining in this area as the Thomas Hill Public Water Supply district expands its water lines.

Within the proposed permit area, there are 4 described wells in the Water User Survey. Two wells, 37WA and 37WB, have reportedly been filled on the Meinhardt tract. On the Williams tract, well 52WB has been abandoned but has not been filled. Well 52WA, on the same Williams tract, is an active agricultural well which is reported to be 30 to 40 feet deep. Although this well is located in the proposed permit area, it will not be disturbed by mining activities due to its location alongside Route W.

**GEOLOGY**

**Study Area Geology**

The study area is in the eastern one-half of the Western Interior Coal Province and is in the Central Lowlands Province of the Interior Plains. The land surface is comprised mostly of rolling hills with land surface altitudes ranging from about 650 feet in the
northwest to 750 feet in the southeast.

The geologic setting classification system describes 1) the hydraulic character of the bedrock units above and below the coal beds in terms of their permeability and 2) the structural features within the bedrock units of the general area. In this mine plan area, the classification would be GS-1 or flat lying coal beds of less than 5 degrees. The permit area is at or above the local drainage level and mining will require only minor consideration of dewatering.

The physiography of eastern Chariton consists of gently rolling hills with reliefs of about 100 feet. Hilltops are flat to gently rounded as the result of Pleistocene glacial activity. The major stream valleys are approaching grade, beginning to widen their channels, and have many youthful V-shaped gullies as tributaries.

The thick mantle of Pleistocene age glacial drift present in the hills and throughout the area is normally about 50 to 100 feet thick. In some areas this glacial till is capped by a veneer of Wisconsin Age wind-blown loess which may be as thick as 10 feet on some hilltops.

Pennsylvanian Age strata underlie the glacial drift which are in turn underlain by Mississippian Age formations. Rocks of the Pennsylvanian age may be found in outcrops in the stream valleys of the area.

Mississippian System. The Mississippian limestones comprise most of this system. It is believed that the Burlington-Keokuk Formation is the uppermost unit for this part of Chariton County. The Mississippian limestones are the nearest significant water bearing stratum below the Croweburg coal seam. According to published reports from the Missouri Geology and Land Survey, the top of the Mississippian limestone is approximately 100 to 120 feet below the Croweburg coal.

Pennsylvanian System. This system is composed primarily of clastic rocks with thin beds of limestone and coal also being present. Pennsylvanian strata have been assigned to five Series; however, only the Missourian Series and Desmoinesian Series are present in Chariton County. Formations of particular interest to this area, and in descending order, are the Lagonda, Bevier, Verdigris, and Croweburg formations.

The Croweburg formation consists chiefly of a soft, pyritized black shale overlain with a hard, sandy gray shale. At the top of the Croweburg formation is the Croweburg coal seam, which averages about 20 inches in thickness, including its associated underclay.
The Verdigris formation primarily consists of gray shales interbedded with black, fissile shales and thin beds of limestone. The Wheeler coal and Ardmore limestone are the important members and lie near the top of the approximately 25 foot formation. The Ardmore limestone measures 14 to 20 inches in thickness while the Wheeler coal is about one foot in thickness.

The Bevier formation is comprised almost entirely by the Bevier coal with the associated underclay being its only other member. The coal varies in thickness from 3 to 4 feet in the proposed permit area and is blocky with the cleats filled with calcite and pyrite.

The Lagonda formation in this area ranges from 40 to over 60 feet in thickness and primarily consists of a hard, silty gray shale. A channel sandstone and the 2 to 3 feet thick Breezy Hill limestone member complete the profile.

Quaternary System. Glacial deposits from the Kansan and Nebraskan glacial episodes are present in this area of eastern Chariton County and are the parent material for the various surficial soil types. The glacial deposits are composed of clays, silts, and sands with some boulder size material. On hilltops, these deposits are capped by up to 10 feet of wind-blown loess.

Structural Geology. The structural geology in the area of eastern Chariton County is relatively simple in comparison with structural geology throughout the rest of Missouri. It is influenced slightly by the Salisbury-Quitman anticline to southwest and the College Mound-Bucklin anticline to the northeast. The regional dip is towards the northwest at about 2 to 3 feet per mile.

Coal and Overburden

AECI plans to mine the Bevier-Wheeler and Croweburg coal seams in the mine permit area; therefore, minesoils down to the shaley underclay beneath the Croweburg seam will be affected by the operations.

The subsurface investigations were performed during the summer of 1990. Samples of the glacial till and the Pennsylvanian strata were procured with conventional coring equipment.

The glacial till soils of similar grain size were composited into one sample for each hole, and consolidated overburden specimens were taken with a format of one sample per stratum and/or one sample every 5 feet. A total of 339 soil and rock samples from Borings 90-2-2,3,4,5&6 and Borings 90-4-1,2,3,4,6&8 were collected and analyzed in
November 1990.

Overburden samples were analyzed by others for the following characteristics: pH, electrical conductivity, maximum and sometimes actual acidity potential, neutralization potential, and buffer pH to calculate the calcium carbonate surplus or deficiency as well as neutralizable acidity. The pyritic sulfur, when determined, was used in the calculation for calcium carbonate equivalent. Results of overburden analyses are included in Appendix V.

A comparison of the strata encountered the during actual drilling conducted within the mine plan area indicates there is little lateral variation of the stratigraphic units. Written in general terms, about 80 to 100 feet of loess and glacial till are penetrated on the hills and side slopes before shales, sandstones, limestones, clays and coal seams of the Pennsylvanian Age are encountered. In the vicinity of the proposed permit area, the Pennsylvanian rocks which are to be affected by mining are generally found between elevations 690 feet and 700 feet. Underlying the Pennsylvanian age strata, and about 100 feet below the Croweburg coal seam, is the Mississippian Age limestone. The lateral variation of this unit has not been determined by this study.

Overburden analyses conducted on samples secured from the borings indicate the trend of increasing pH and neutralization potential with depth until the Bevier coal seam is reached where both parameters decrease. Past experience has indicated that this is a common occurrence in overburden analyses in Northern Missouri. Generally, the highest neutralization potentials exist in the Breezy Hill and Ardmore limestones. Since the glacial till soils exhibited a total calcium carbonate surplus and good compaction potential, they should be adequate sealants and cover for burial of potentially toxic- and/or acid-forming materials.

The maximum acidity potential for the overburden and coal was determined using the total sulfur analysis and correlation. Pyritic sulfur analyses were also performed when required on coal, underclays, gray shales, and black shales to determine actual acidity potential. The mathematical difference between the neutralization potential and maximum acidity potential (or in some cases the actual acidity potential) gives the net calcium carbonate equivalent. Department of Natural Resources guidelines, along with other published information define an acid-forming material as that with a deficiency greater than minus 5 tons of CaCO₃ equivalent (or a pH less than 4.0). The materials requiring special considerations in the reclamation operation are given in the Coal and Overburden Analysis Results in the Appendix of this report. Generally, the fissile black and dark shales above the coal seams, the coal seams, and associated underclays have been identified as potential acid- and/or toxic- forming materials.
To obtain an overall assessment of the toxic and/or acidic nature of the overburden, a weighted average of the tons of calcium carbonate equivalent per 1,000 tons of material was calculated. In computing the weighted average, the coal seams and Croweburg underclay were not taken into consideration. The calcium carbonate equivalent ranged from a high of 136.5 tons at Boring 90-2-6-COB to a low of 53.1 tons at Boring 90-4-8COB. The composited weighted average for all 11 holes is 83.4 tons of calcium carbonate surplus. The logs of the borings are included in Appendix V.

**HYDROLOGY**

**Groundwater**

The aquifers of Northern Missouri may be classified into two groups: 1) the unconsolidated aquifers in glacial drift and alluvium, and 2) the consolidated or bedrock aquifers. The unconsolidated aquifers are an important source of groundwater in the area, while shallow consolidated aquifers yield small supplies of moderately mineralized water and may be derived in part from underlying Pennsylvanian formations. Sources of water in the surficial material are 1) perched above the modern clay subsoils, 2) perched above the paleosols, 3) in the glacial drift, and 4) in the buried glacial drift channel deposits. Because of the fine-grained nature of the surficial materials in northeastern Missouri, well yields are low in unconsolidated aquifers except where there are extensive layers of permeable materials or buried channel deposits.

The hydrologic setting classification system describes the occurrence of groundwater within or adjacent to the coal seam to be mined. Factors considered in the classification system include 1) the position of the coal bed to be mined with respect to aquifers, 2) the geologic materials above and below the coal bed and they serve as confining beds or as aquifers, and 3) the type of aquifer - confined for unconfined. In the mine plan area, the classification would be considered as HS (B2) in which the confined aquifer lies below the coal bed, and shales provide a low permeability barrier between the coal and underlying aquifers.

Five groundwater monitoring wells were installed by Engineering Surveys and Services in June 1991 to develop background quality and quantity information for 1) the perched water in the glacial till (MW30, MW31, and MW32), 2) the Pennsylvanian confined aquifer (MW33), and 3) the spoil unconfined aquifer (MW34). The holes were drilled and logged under the supervision of a geological engineer, and the wells were designed and constructed as per DNR-LRC guidelines. The well development was preformed by AECI personnel. The locations for all wells are depicted on the Monitoring Location Map. The drill logs and well installation diagrams are included in Appendix I.
performed by AECI personnel. The locations for all wells are depicted on the Monitoring Location Map. The drill logs and well installation diagrams are included in Appendix I.

Slug test methods for single-well installations were used to determine the aquifer transmissivity of the soil and rock materials near well-bore. The Bouwer and Rice method was used to determine the hydraulic conductivity of the aquifers with completely or partially penetrating wells. Well tests were performed by a qualified engineering technician of this firm experienced in groundwater sampling and field testing.

The thickness of the aquifer at Well MW30 was based upon an interpolated bedrock (impermeable) elevation of 660± and a saturated zone from elevation 660 to 700. The thickness of the aquifer at Wells MW31 and MW32 was based upon an interpolated bedrock (impermeable) elevation of 612± and a saturated zone from elevation 612 to 652. The thickness of the aquifer at Well MW33 was based upon an impermeable stratum encountered at elevation 649 and a saturated zone from elevation 649 to 697. The thickness of the aquifer at well MW34 was based upon an impermeable stratum encountered at elevation 647 and a saturated zone from elevation 647 to 649. Wells MW30, MW31, and MW32 were not installed the entire length of the aquifer - in this case to the bedrock surface; therefore, only partial penetration of the aquifer was captured. Wells MW33 and MW34 pierced the entire length of the aquifer.

The piezometric surface in wells MW30, MW31, and MW32 has generally increased during the baseline monitoring period and also follows the trend in increased precipitation. Slug tests revealed low hydraulic conductivity values of 0.94, 0.45, and 1.37 feet per day for the three respective wells using the partial penetration formulas. Transmissivity values of 38, 18, & 55 square feet per day were also calculated for the wells. The specific yields cannot be determined from slug test data but are estimated at 0.003 times the hydraulic conductivity. The specific yields are therefore estimated to be 0.003, 0.001, and 0.004, respectively.

The piezometric surface in well MW33 and spoil well MW34 has generally increased during the baseline monitoring period and follows the trend in increased precipitation. Slug tests revealed low hydraulic conductivity values of 0.06 and 0.12 feet per day for the two respective wells using the full penetration formulas. Transmissivity values of 3.14 and 0.27 square feet per day were also calculated for the wells. The specific yields are estimated to be less than 0.001 for both of the wells using the correlation described above. Although possible, but not probable, the aquifer thickness in the spoil could be 74.3 feet at Well MW34. If this were the case, the hydraulic conductivity would only increase to 0.28 feet per day, and the transmissivity would increase to 20.48 square feet per day. The estimated specific yield would remain less than 0.001. The calculations from well tests are provided in Appendix III.

The baseline water quality data for Wells MW30, MW31, and MW32 is relatively consistent for perched water encountered in the glacial till. The pH is neutral to slightly basic, the sulfate is less than 100 milligrams per liter (mg/l), the dissolved iron is less than 0.5 mg/l and the dissolved manganese is less than 2.0 mg/l. Groundwater samples from wells MW31 and MW32 have higher concentrations of dissolved iron than well MW33. This correlates well to the visual description of the encountered soil materials in which iron staining was noted. Some of the dissolved manganese concentrations are above the EPA secondary drinking water standards of 0.05 mg/l and range from 0.01 to 1.8 mg/l. As expected, the higher concentrations of manganese were found in the wells with higher iron concentrations - wells MW31 and MW32. The 1979 USGS report 954-E titled Geochemical Survey of Waters of Missouri states the groundwater in northern Missouri has an average manganese concentration of 0.47 mg/l with a range of 0.06 to 2.9 mg/l from eight samples. Over all, only minor seasonal fluctuations in groundwater

(Revised April 1992)
well is a sandstone stratum of the Croweburg formation. The groundwater in this stratum is very alkaline having a pH of 12 to 12.5. The total dissolved solids are high and in the range of 1,300 to 2,100 mg/l; thus indicating a long residence time in the subsurface. The dissolved iron and dissolved manganese levels are low and are less than 0.05 and 0.10 mg/l, respectively. The sulfate concentrations are typically high in Pennsylvanian strata, and this well is measuring 96 to 136 mg/l. These values fall within the expected range of 100 to 150 mg/l most often found in background samples in northern Missouri. Since the monitoring began, the sulfate has generally decreased and dissolved iron concentrations have increased by a factor of 10. The remaining parameters have shown very little variance over time.

The baseline groundwater quality data for the minesoil unconfined aquifer has been acquired using well MW34. The screened hydrologic unit being monitored in this well is the glacial till (with minor amounts of shale and limestone) spoil. The groundwater is positioned at the interface of the spoil and the Ardmore limestone bedrock. Other than the sulfate concentrations, the groundwater quality found in this well is similar to that found in well MW33. The pH is about 12 and is most likely influenced by the buffering from the underlying limestone and long residence time. The total dissolved solids ranges from 1,500 to 2,300 mg/l, the dissolved iron is less than 0.12 mg/l and the dissolved manganese is less than 0.1 mg/l. Sulfate values ranging from 400 to 1,050 mg/l have been reported. The primary mineral sources of sulfate include the evaporite sediments in the mine soils such as gypsum and anhydrite as well as sulfates of magnesium and sodium.

In summary, the Pleistocene soils and Verdigris formation contain relatively few aquifers capable of satisfying water-use requirements. The glacial till has a very high clay content (usually greater than 35 percent) and a very low sand content (usually less than 15 percent). The rocks are mostly fine-grained marine shales which are poor aquifers. In addition, the continuous underclays beneath the coal seams impede the vertical movement of groundwater. Laboratory summaries and graphical correlations are presented in Appendix III.

The Mississippian bedrock aquifer lies beneath the entire region and is a significant aquifer in the mine area. According to the *Hydrology of area 38, Western Region, Interior Coal Province - Iowa and Missouri*, "The Mississippian aquifer has the best potential for development where it forms the bedrock surface or where the overlying Pennsylvanian rocks are relatively thin. Wells completed in or near these areas of recharge usually have greater yields and less mineralized water. Generally, yields are greater in carbonate rocks where the fissure system is well developed whether near the surface or at depth."
The publication continues to read: "Concentrations of dissolved solids averaged 3,140 mg/l in water from wells completed in the Mississippian aquifer. The median pH was 7.2, and average alkalinity was 345 mg/l. Sulfate concentrations ranged from 6.8 to 2,660 mg/l. Sulfate and sodium are the dominant ionic species as they comprise 27 to 40 percent of the total solute concentration in water from a typical well."

**Surface Water**

The modern drainage system of Northern Missouri more or less parallels the buried preglacial channels. Surface water infiltrating into upland soils tends to percolate on clay-rich subsoils, where most seeps move laterally until reaching shallow upland modern drainages in the form of springs. The buried preglacial channels are in turn recharged by the infiltration from modern drainages as well as ascension from underlying consolidated aquifers.

The surface water hydrologic monitoring network consists of data collection stations and are depicted on the Monitoring Location Map. A total of six stream monitoring stations have been established downstream of the proposed permit area and include stations 20, 21, 22, 23, 24, and 25. Stations 21, 22, and 25 will not receive drainage from the mine plan area; however, the water quality flow data has been used to evaluate the baseline conditions. Stream data were collected from May 1990 through July 1991 and included flow measurements and procuring grab samples for laboratory analyses. Stream stations were used primarily to monitor base flow, low flow, and high flow conditions. The primary receiving streams in the proposed permit area are two unnamed tributaries to the Chariton River (Stations 23 and 24) as well as Bee Creek (Station 20) which is a tributary to the Middle Fork of the Little Chariton River.

The Chariton River has two USGS stream gaging stations situated upstream from the proposed permit area. One is station 06905500 near Prairie Hill having a drainage area of 1,870 square miles, and the other is station 0924114 near Novinger in Northern Missouri which has a drainage area of 1,370 square miles. The 7-day low flow for the Chariton River at Prairie Hill is 21 cubic feet per second (cfs) for recurrence intervals of 2 years and less. Therefore, it is probable the Stations 20 and 23 which have drainage areas of only 5.5 square miles will not have flowing water for periods of 7 or more days during years of normal or below normal precipitation.

Flood flows for 2, 5, 10, 25, 50, and 100 year frequencies have been calculated for Stations 20, 23, and 24 and are included on the following three pages. The equations used for these calculations are provided in Appendix VII. The flood flows at Stations 20 and 23 are about 2.1 times the flows at Station 24 due to the increased size of the drainage area.
ASSOCIATED ELECTRIC COOPERATIVE, INC.

Station BL-20

<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td>Drainage Area</td>
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<tr>
<td>Stream Length</td>
<td>4.26 miles</td>
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<tr>
<td>Elevation at 10% of Stream Length</td>
<td>653 feet</td>
</tr>
<tr>
<td>Elevation at 85% of Stream Length</td>
<td>718 feet</td>
</tr>
<tr>
<td>Distance from 10% to 85% Length</td>
<td>3.2 miles</td>
</tr>
<tr>
<td>Change in Elevation</td>
<td>65 feet</td>
</tr>
<tr>
<td>Gradient</td>
<td>20 feet per mile</td>
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</tbody>
</table>

Q2  626 cfs  
Q5  1052 cfs  
Q10 1332 cfs  
Q25 1700 cfs  
Q50 1950 cfs  
Q100 2211 cfs
Station BL-23

Drainage Area 5.5 square miles
Stream Length 2.31 miles
Elevation at 10% of Stream Length 653 feet
Elevation at 85% of Stream Length 687 feet
Distance from 10% to 85% Length 1.73 miles
Change in Elevation 34 feet
Gradient 20 feet per mile

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<tr>
<th>Q2</th>
<th>628 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5</td>
<td>1052 cfs</td>
</tr>
<tr>
<td>Q10</td>
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<tr>
<td>Q25</td>
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<tr>
<td>Q50</td>
<td>1945 cfs</td>
</tr>
<tr>
<td>Q100</td>
<td>2204 cfs</td>
</tr>
</tbody>
</table>
ASSOCIATED ELECTRIC COOPERATIVE, INC.

Station BL-24

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<th>Description</th>
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<tbody>
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<td>Drainage Area</td>
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</tr>
<tr>
<td>Stream Length</td>
<td>3.78</td>
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<tr>
<td>Elevation at 10% of Stream Length</td>
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<tr>
<td>Elevation at 85% of Stream Length</td>
<td>704</td>
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<tr>
<td>Distance from 10% to 85% Length</td>
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<tr>
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<tr>
<td>Gradient</td>
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</tr>
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<td>Q2</td>
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<tr>
<td>Q50</td>
<td>889</td>
</tr>
<tr>
<td>Q100</td>
<td>1001</td>
</tr>
</tbody>
</table>
for Stations 20, 23, and 24 and are included on the following three pages. The equations used for these calculations are provided in Appendix VII. The flood flows at Stations 20 and 23 are about 2.1 times the flows at Station 24 due to the increased size of the drainage area.

The interaction of surface water with groundwater can be interpreted by examining the base flow parts of the flow duration curves, which indicate the percentage of time stream flow was equaled or exceeded. The flow duration curves represent low and base flow duration at both USGS gaging stations on the Chariton River. To compensate for differences in drainage area size, unit discharge was calculated for each of the USGS station using DNR-GLS Water Resources Report 20 titled Low Flow Characteristics of Missouri Streams. Unit discharge is the stream flow divided by the drainage area. Base flow at 90% flow duration is 0.007 cfs/mi² and 0.013 cfs/mi² for the Novinger and Prairie Hill gaging stations, respectively. The steep slopes of the unit discharge curves for both stations indicate little base flow, and that the streams respond mainly to storm runoff.

Dr. Wayne Pettyjohn with Oklahoma State University has recently developed a model that uses stream hydrograph separation techniques to estimate the effective groundwater recharge rates. For the study area, the effective recharge rate is defined as the total quantity of water that originates from downward infiltration to the water table and eventually finds its way to a nearby stream. Effective recharge is less than the total annual recharge due primarily to evapotranspiration. The program plots a stream hydrograph, separates it by three different methods, and produces flow-duration curves and a variety of tables.

The daily discharge measurements for water years 1985 through 1990 were obtained for both USGS gaging stations on the Chariton River. The three hydrograph separation methods - fixed interval, sliding interval, and local minima generally produce two calculations that are similar while the third may be substantially different. The two similar methods were used for each station and in each year to calculate and average the groundwater discharge, the groundwater recharge, and the percent of groundwater contribution to the stream discharge. A table showing these values is included on the following page. The table indicates that the watershed characteristics for both stations are quite similar. Also, the table shows that in the Chariton River Basin, 44% of the stream flow is derived from groundwater while 56% is derived by direct surface runoff. The average effective groundwater recharge to the Chariton River is calculated, using this model, to be about 0.20 gpm per acre in the watershed. Using the 0.36 gpm per acre total average runoff, the average discharge for each watershed can be calculated. For BL20, BL23, and BL24 the average stream discharge is 2.77 cfs, 2.82 cfs and 1.13 cfs respectively.

The eight baseline stream stations have monitored high, low, and average flows, and the stations are situated in large, medium, and small watersheds. In general, the

(Revised March 1992)
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The eight baseline stream stations have monitored high, low, and average flows, and the stations are situated in large, medium, and small watersheds. In general, the surface water quality is dependent upon seasonal, drainage area, and flow variations. Laboratory summaries and graphical correlations are presented in Appendix IV. A discussion of these variances is as follows:

1. **pH.** The pH varied between 7 and 8.3 at all of the stream stations indicating a slightly basic condition. Generally, the pH remains constant but then decreases during the winter months.
2. **Total Dissolved Solids.** The concentration of TDS generally varied between 100 to 500 mg/l with the exception of stream station 24 where it reached a level of 2,200 mg/l. As the flows increased at each of the stations, the TDS generally decreased.

3. **Total Suspended Solids.** The concentration of TSS generally varied from 0 to 1,800 mg/l with the exception of stream stations 23 and 26, which are in the Chariton River flood plain, where it reached levels between 3,000 and 4,000 mg/l. As expected, the TSS escalated as the stream flow increased and accelerated erosion in the watershed.

4. **Sulfate.** The concentration of sulfate generally varied from 0 to 150 mg/l with the exception of stream station 27 where it is ranged from 100 to 250 mg/l. As the flow increased, generally the sulfate level decreased. Station 27 is located in a watershed that has had extensive previous surface mining activities.

5. **Acidity*.** The acidity level varied from -20 to -250 with the exception of stream station 24 where a low of -1,200 was reported. Generally, the acidity increased at all stations in the winter months.

6. **Alkalinity*.** The alkalinity level varied from 50 to 300 with exception of stream station 24 where it peaked at 1,600. Generally, the alkalinity decreased during the summer months in the smaller watersheds, and the alkalinity increased with a decreased in flow in the larger watersheds.

7. **Dissolved iron.** The concentration of dissolved iron was less than 1.0 mg/l with the exception of stream station 24 where it reached a level of 1.6 mg/l. In the small watersheds, the dissolved iron level decreased with an increase in flow. In the larger watersheds, the dissolved iron increased with an increase in flow.

8. **Dissolved manganese.** The concentration of dissolved manganese was less than 1 mg/l with the exception of stream station 24 where it reached a level of 1.8 mg/l. The correlation between concentration and watershed size for dissolved iron also holds true for dissolved manganese.

Closer examination of the watershed above stream station 24 reveals approximately 90 percent of the flow is derived from alluvial runoff of cropland to provide a very alkaline condition with higher dissolved iron and manganese concentrations.

* Units are milligrams calcium carbonate per liter
IDENTIFICATION OF PROBABLE HYDROLOGIC CONSEQUENCES

The baseline conditions have been assessed to identify the probable hydrologic consequences that mining and reclamation activities will have upon the hyrological regime. The abandoned underground mine works are most likely in the Bevier-Wheeler seam, and no adverse environmental affects should occur when the mine is uncovered by AECI.

Surface Water

Based upon the results of baseline stream data as well as watershed characteristics, it is our prediction that if NPDES limitations are met at the source discharge points as required by the present statutes, the following effects will occur prior to reclamation bond release.

1. The 7-day low flows for recurrence intervals of 2 years will be zero at stream stations 20, 21, 22, 23 and 24. During periods of low flows, the receiving streams will be impacted with higher concentrations of sulfate, manganese, and iron. However, the quality should remain well below the "maximum allowable" for the metals and sulfate, and the total suspended solids should actually decrease as AECI constructs surface water control structures in the permit area.

2. Base flows are not expected to exceed, but may decrease from, the present 0.007 cfs/mi² during mining and reclamations activities due the construction of diversion and detention structures for storm water management. Base flows will decrease somewhat during mining and reclamation activities since the contributions from groundwater sources will decrease from the present 40%; however, the base flows should return to their original values soon after final reclamation. The estimated peak flows at the stream stations are not expected to change significantly for similar reasons.

3. To predict the surface water quality values, previously acquired pre-mining and post-mining data for nearby watersheds are used. The average monthly quality data obtained at stream stations 16 & 27 provide the best indication of the predicted water quality values since they are now monitoring post-mining conditions. Based upon the historical and present water quality values for stations 16 & 27, we predict the pH values at stations 20, 23, and 24 should show a slight decrease to the 7.0 to 7.5 range; the total suspended and dissolved solids should remain about the same; the dissolved iron and manganese concentrations should increase slightly but remain less than 100 ug/l with the exception of station 23 where it should remain unchanged; the sulfates should increase to about the 100 to 250 mg/l range. The alkalinity and acidity of the surface waters should somewhat decrease and increase, respectively, but prevail as alkaline. Trends for seasonal variation in water quality should not differ from baseline conditions.
4. The cumulative impact on the Chariton River (stream station BL-26) is based on the average baseline water quality data from BL-26 in 1990-91 and comparing it to premining and postmining water quality data acquired from the Middle Fork of the Chariton River in 1981 and again in 1990-91. The cumulative impact on the Middle Fork of the Chariton River (stream station BL-27) is based on average water quality data for station 7 (1981), station 16 (1989-1990) and station BL-27 (1990-1991). The predicted surface water quality impacts on stations BL-26 and BL-27 are estimated as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BL-27</th>
<th>BL-26</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.6 (same)</td>
<td>7.6 (same)</td>
</tr>
<tr>
<td>TDS</td>
<td>400 mg/l (slight increase)</td>
<td>250 mg/l (slight increase)</td>
</tr>
<tr>
<td>TSS</td>
<td>100 mg/l (increase)</td>
<td>600 mg/l (slight increase)</td>
</tr>
<tr>
<td>Acidity</td>
<td>-60 (slight degradation)</td>
<td>-70 (same)</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>80 (slight degradation)</td>
<td>100 (same)</td>
</tr>
<tr>
<td>Sulfate</td>
<td>150 (increase)</td>
<td>100 (increase)</td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>&lt;0.1 mg/l (same)</td>
<td>&lt;0.1 mg/l (slight decrease)</td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>0.2 mg/l (same)</td>
<td>&lt;0.1 (same)</td>
</tr>
</tbody>
</table>

5. Runoff from the mine area will remain relatively consistent with what presently drains from the site. A slight increase in runoff will result from the newly reclaimed area prior to establishing a good vegetative cover, but the increase is not expected to noticeably affect the hydrologic regime of the entire site.

6. The reclamation activities, which include storm water management, are expected to decrease the erosion of surficial soils. Applying the Universal Soil Loss equation to the present topography and composition of the proposed permit area leads to an expected yield of about 23 tons per acre per year. Upon reclamation - with flatter slopes, energy absorbing ground cover, and storm water management - the expected yield should reduce to about 16 tons per acre per year.

**Groundwater**

Based upon the results of overburden analyses, the local geology, and groundwater information produced during the baseline monitoring period, it is our prediction that if generally accepted mining and reclamation practices for the State of Missouri are followed, these effects on the groundwater will occur:

1. Generally, the quality and quantity of groundwater in the Pennsylvanian and Quaternary aquifers will be influenced more by the seasonal variations in precipitation than mining and reclamation operations. The well tests indicate the disturbed aquifers in the mine area will first experience an increase in transmissivity and storativity due to the random particle size distribution. With time, the flow of subsurface water carrying fine clays and silts will have a tendency to fill the flow paths, thus reducing all of the original coefficients by a factor of about 10.

2. Infiltration into the groundwater regime will be slow during the early plant production stages because the new vegetative cover will not be sufficient to impede surface runoff. However, as the vegetative cover matures and land conservation measures such as diversions, grass waterways, and sediment ponds impede the surface runoff, the shallow aquifers should be recharged to pre-mining availabilities.

3. The projected variations in groundwater quality for the consolidated aquifer is based on the baseline data obtained from wells MW33 in the unmined area and MW34 in the reclaimed area. These variations include: a very slight decrease in pH to around 12; a slight increase in total dissolved solids

(30)
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

ASSOCIATED ELECTRIC COOPERATIVE, INC. - 1991-03 PERMIT APPLICATION

GEOGRAPHIC AND GEOLeGIC SETTING

CLIMATE

The total annual precipitation is approximately 37.4 inches. Of this, 24 inches, or 65%, usually falls in April through September. Rainfall in April through September is less than 19 inches. The average seasonal snowfall is 27 inches. The greatest snow depth at any one time was 19 inches. In winter, the average temperature is 28 degrees F; and the average daily minimum is 20 degrees. In the summer, the average temperature is 74 degrees; and the average daily maximum temperature is 85 degrees. The prevailing wind is from the south/southwest. Average wind speed is highest, 12 miles per hour, in the spring.

TOPOGRAPHY AND DRAINAGE

Generally, Randolph and Chariton Counties are located physiographically in the dissected till plains (which are composed of loess-covered hills and glacial till). Regionally, elevation ranges from about 650 feet to about 800 feet. Hilltops are flat to gently rounded as the result of Pleistocene glacial activity. The major stream valleys are approaching grade, beginning to widen their channels, and have many youthful V-shaped gullies as tributaries. The mine plan area is located in two watersheds just inside of that area outlined in Hydrology of Area 38, Western Region, Interior Coal Province Iowa and Missouri and is drained by the Middle Fork of the Little Chariton which flows south and west into the Chariton River. The Chariton River flows south into the Missouri River.

SOILS CHARACTERISTICS, VEGETATION

Soils in the permit area include 344.3 acres of the Lagonda Silt Loam (5-9% slopes eroded), 255 acres of the Bevier Silty Clay Loam (2-5% slopes), 21.4 acres of the Dockery Silt Loam (1-5% slopes), 32.2 acres of the Colo Silty Clay Loam (1-5% slopes), 156.8 acres of the Edina Silt Loam (1-5% slopes), 5.9 acres of the Chariton Silt Loam (1-5%), 50.4 acres of the Vesser Silt Loam (1-5% slopes), 2.6 acres of the Lagonda Silty Clay Loam (5-9% slopes), 754.1 acres of the Armstrong Loam (5-9% slopes eroded), 4.6 acres of Armstrong Loam (9-14% slopes, eroded), 323.7 acres of the Armstrong Clay Loam (5-9% slopes severely eroded), Armstrong Clay Loam, (9-14% slopes severely eroded), and 25 acres of the Grundy Silt Loam (2-5% slopes). Prime farmland soils include Lagonda Silt Loam, Bevier Silty Clay Loam, Grundy Silt Loam, Dockery Silt Loam, Colo Silty Clay Loam, Edina Silt Loam, Chariton Silt Loam, and Vesser Silt Loam. These soils make up about 43% of the soils in the mine plan area. The vegetation of the mine plan area in the premine state consists of approximately 240.3 acres of wildlife habitat, 144.8 acres of pasture, 859.1 acres of non prime cropland, 215.6 acres of bottom prime farmland, 574 acres of upland prime farmland, 14.2 acres of water, and 44 acres of roads.
GEOLOGY

Structurally, western Randolph and eastern Chariton Counties are bounded by the College Mound-Bucklin anticline to the northeast and the Salisbury-Quitman anticline to the south and west. The College Mound-Bucklin anticline is terminated at its southern end in the headwaters of the Elk Fork River and at its northern end at Bucklin, Missouri. This has a gentle northeast limb and a slightly steeper southwest limb. The strike is northwest with a gentle northwest plunge. The Salisbury anticline is located between the Chariton River and the East Fork of the Chariton River, underlaying the town of Salisbury. This structure is present only in the Pennsylvanian strata. Regionally, as a result of the Ozark Uplift, the dip is north to northwest (slightly affected by the Forest City Basin). According to the permittee, locally, the dip is to the southwest and is approximately 1 degree.

Quaternary System

Unconsolidated sediments present in the general stratigraphic section include Holocene (alluvium) and Pleistocene (glacial drift and buried channel deposits) aged strata. Alluvial fill consists of clay, sand, and gravel, grading from fine to coarse grained with increasing depth and are from 0-150 feet. The yields of this unit increase with percent increase of gravel and sand in deposits. There are large yields along the Missouri and Mississippi Rivers. Tributaries supply sufficient water for domestic and farm use of 10 to 3,000 gallons per minute. These are recharged by precipitation and by infiltration from the streams. Aquifers are thinnest near the edges of the valley and thicker near the center of the valley. The well yields are sufficient to supply cities and irrigation water in some areas and domestic users elsewhere. Glacial drift deposits consist of clay, silt, sand, and gravel and are the most widespread of the Quaternary aquifers. Glacial deposits range in thickness from zero in the southease prege erosion has removed the deposits to 400 feet in the northwest part of the State. Maximum thicknesses of these deposits are located where preglaciated valleys are filled with glacial debris. These units yield water in sufficient quantities (on an average 0-10 gallons per minute, but has been noted as high as 25 gallons per minute) for domestic and farm use. Buried channel deposits occur near or below alluvial aquifers. Sand and gravel are the major deposits in this type of aquifer and are as much as 50 feet thick. Wells completed in the buried channel aquifer yield as much as 1,000 gallons per minute to individual wells and, in some places, can yield sufficient water to supply small cities and domestic needs in most areas and are primarily from buried river valleys. The potentiometric surface in this aquifer (which can be either water table or artesian) is affected by the regional topography. Recharge is by direct precipitation and discharge is into the major river systems in northern Missouri.

Pennsylvanian System

Generally, the consolidated stratigraphic section regionally consists of (in descending order) Pennsylvanian (Virgilian, Missourian, and Des Moinesian Series). Marmaton and Cherokee Groups of the Des Moinesian Series are the

(33)
principal coal-bearing units. The deposits which form the limestone, shale, sandstone, siltstone, claystone, and coal are marine and non-marine and result from cyclic changes in ancient sea shorelines. The entire Pennsylvanian System ranges in thickness from 0-1800 feet.

Specifically, though, this area has no water seeps on the high wall. There are water users in the area which use the shallow water for domestic use. However, this is rare. Water is excessively mineralized and yields from 0-10 gallons per minute. The large shale content of most Pennsylvanian rocks greatly impedes the flow of ground water vertically; thus, the Pennsylvanian probably is a confining bed atop the relatively permeable Mississippian aquifer. Well yields from the areas other than the permit area, in the thicker parts of the aquifer, or where the aquifer occurs near the surface, yields greater (20 - 100 gallons per minute) have been noted. Recharge to the aquifer is from precipitation that falls on the areas of outcrop, as well as percolation of water through overlying sediment. The Pennsylvanian rocks lie unconformably on the Mississippian rocks.

Mississippian, Devonian and Silurian Systems

Mississippian age rocks (Meramecian, Osagean, and Kinderhookian Series) are the primary bedrock formations in the permit area. Meramecian aged rocks range in thickness from 0-350 feet. The Meramecian Series generally contains sufficient interbedded shale to make the series incapable of yielding water in large quantities. Osagean aged rocks and the upper two limestone formations from the Kinderhookian Series (Sedalia and Chouteau) are from 0 to 310 feet thick and yield adequate water (5 to 15 gallons per minute) for domestic and farm use. This strata is considered to be the Mississippian aquifer. Upper Devonian strata, including the Louisiana Limestone, Grass Creek Shale, and Snyder Creek Formation (composed of shale and limestone), along with the lower Kinderhookian Series strata (Hannibal Shale and Kinderhook Shale (composed of shale), are considered to be one hydrologic unit (that is, the upper confining bed) in that they have the same water bearing properties. They are considered to be a confining layer throughout much of northern Missouri, thinning to the south. They range in thickness from 0-260 feet. The middle and lower undifferentiated geologic units of the Devonian, as well as the Silurian, are composed of limestone and dolomite are not considered to be important as an aquifer. These are also considered to be part of the upper confining bed, as is the Maquoketa Shale. The Mississippian aquifer, generally, is confined above and below by shales and clays. The approximate thickness of the aquifer is between 150 and 600 feet. Some gypsum and anhydrite beds occur locally in upper parts of the Mississippian aquifer above the shale zone. Dissolution of these minerals affect the quality of the water. Wells completed in or near areas of recharge usually have greater yields and less mineralized water. Generally, yields are greater in carbonate rocks where the fissure system is well developed.
Ordovician and Cambrian Systems

The Maquoketa Shale, which is considered to be within the upper Ordovician strata, ranges in thickness from 0 to 150 feet. It is composed of shale and is considered to be the confining layer in the extreme east along the Mississippi River. The Kimmswick Limestone, a dolomite and limestone yields water generally sufficient for domestic supplies, approximately 5-10 gallons per minute. The Decorah Formation, Plattin Limestone, Joachim Dolomite, all considered to be possessing similar waterbearing properties, consist of dolomite and shale. They contain limited sources of water. Locally, they may be confining layers. The St. Peter Sandstone and Everton Formations are considered to possess similar water bearing properties. These strata are composed of sandstone and dolomite.

Yields from these aquifers range from 25-75 gallons per minute. The water is excessively mineralized in the north. Most of the uses for this water is for domestic, farm, and small industry. The Lower Ordovician strata is represented by the Powell, Cotter, and Jefferson City Dolomite. This strata is composed of dolomite and is considered unimportant as an aquifer, but may produce sufficient water locally for domestic and farm use. Yields range from 0 to 25 gallons per minute. The Roubidoux Formation, Gasconade, and Gunter Sandstone Member are considered to possess similar water bearing properties. These strata are composed of sandstone. Yields range from 50 to 500 gallons per minute. These strata provide water for municipal, industrial, and irrigation uses. The Eminence Dolomite and Potosi Dolomite (contained within the upper Cambrian System) are considered to possess similar water bearing properties. These strata are composed of dolomite. Yields from these strata range from 440 to 1,100 gallons per minute and are capable of providing water for large cities, industry, and irrigation. The middle and lower Ordovician Series and the upper Cambrian strata are considered to be the Cambrian-Ordovician aquifer and range in thickness from 0-1300 feet. The Derby-Doe Run Dolomite and the Davis Formation range in thickness from 20 to 300 feet. They are composed of shale and dolomite. Transmissivity of this aquifer in the generally permit and adjacent areas range from 0.010 to 0.008 ft² per second. Recharge to the Cambrian-Ordovician aquifer system in this region is almost always from percolation of water through overlying rocks. Most of the surficial recharge to this aquifer system occurs in Iowa, Minnesota, and Missouri (along the Missouri River in Boone County where this aquifer crops out). The direction of ground water flow for the Cambrian-Ordovician aquifer generally would be to the north and west. The Derby-Doe Run is considered to be a limited source of water, whereas, the Davis Formation is considered to be a confining layer in northern Missouri. The Bonneterre Dolomite and the Lamotte Sandstone range in thickness from 0 to 700 feet. They are composed of sandstone and dolomite. Little information is available regarding the hydrologic capabilities of these strata. There may be some production from the Lamotte sandstone.

The Precambrian is composed solely of igneous rocks and is considered to be an unimportant source of water.
Local Geology

In the permit area, the Quaternary System is present in the form of glacial till deposits from the Kansan and Nebraskan glacial episodes. It generally consists of one or more distinct layers of sandy or silty clay containing random, unconnected sand and gravel lenses that range in thickness from 26 feet to approximately 103 feet. In addition, the Pennsylvanian System is present. The Little Osage formation is present in thicknesses ranging from about 3 to 25 feet thick. In some drill holes, either the Summit coal or the Summit coal underclay is present. Beneath this is the Blackjack Creek formation which is not present in all drill holes. It ranges in thickness from 0 to about 5 feet. The Blackjack Creek formation has an erosional unconformity at its upper surface. Beneath this is the Excello formation. Again, it is not present in all drill holes. It ranges in thickness from 0 to about 7 feet. The underlying Mulky coal seam present to the east several miles is absent in the permit area. The Lagonda formation underlies the Excello formation in the permit area as sandstones and shales and has a consistent thickness of about 40 feet across the permit area. The Bevier formation is present as the Bevier coal seam and a shale parting at the base. The coal seam averages 2.3 feet thick. Beneath the coal seam is a shale parting that averages about 1.4 inches thick. Underlying this is the Verdigris formation. The Wheeler coal seam (part of the Verdigris formation) is located at the top and is mined in tandem with the Bevier coal seam.

The Wheeler is 1.6 feet thickness. The Bevier-Wheeler coal seam is present across the entire permit area. Underlying the Wheeler is an underclay (.5 feet thick and is present across the entire permit area), a gray shale, the Ardmore limestone member, and a lower black shale. Beneath this is the Croweburg formation which is present in the area. Based on the depths of the core holes, it consists of the Croweburg coal seam (1.5 feet thick), an underclay, and a lower shale member. This coal seam will be mined where possible.

SURFACE COAL MINING

Coal in the Chariton River Basin is extracted by surface mining methods and, in some instances, different auger mining methods. Topsoil is removed from areas in advance of overburden removal and stockpiled for later use in reclamation. After removal of topsoil, overburden is blasted and removed in a long trench by a dragline or front-end loaders down to the coal. The coal is then ripped and removed by front-end loaders. Thickness of the coal at the existing mine for the Bevier-Wheeler coal seam is about 3.8 feet thick. The overburden ranges in thickness from about 77 to 160 feet. After removal of the coal, a second trench is dug adjacent to, and parallel with, the first trench. The overburden removed from the second trench is placed in the first trench. This continues across the area to be mined until the last trench is dug. The final trench is usually filled with water, forming a final cut lake. Mined areas are backfilled with overburden material from areas being mined, recontoured to the approximate original contour, and revegetated.

(36)
ANTICIPATED MINING

There are no other surface coal mine operators planning to mine in the adjacent areas to the proposed mine plan area located in the Chariton River Basin. AECI currently has no permits located within the Middle Fork Little Chariton River Basin in the office for review.

EXISTING MINES AND CURRENTLY PROPOSED MINING

Currently (1992), there are 4 active permits operating both in the Chariton River watershed and the Middle Fork of the Little Chariton River Basin amounting to approximately 4,684 acres held by Associated Electric (1981-02, 1986-01, 1989-02 and 1990-04). In addition, there are 11 other AECI support permits located in Middle Fork Basin. Associated Electric Cooperative has mined approximately 28,837,250 tons of coal from the areas currently permitted and will mine approximately 10,075,320 tons of coal from the Bevier, Wheeler, and Crowburg coal seams in the proposed permit. The proposed permit amounts to approximately 2,092 acres, of which approximately 982 acres of this will actually be mined. This current permit is located in two major watersheds. The first is a 174.6 square mile watershed (of which 425 acres are to be permitted) in the Middle Fork Little Chariton River Basin (down to Site BL-27). There is approximately 1,172 acres of prelaw disturbance upstream from the proposed permit area in this particular watershed. The balance of this permit, 1,667 acres, is located in the 1,961 square mile Chariton River watershed (down to Site BL-26). No known upstream prelaw disturbance exists in this watershed. The projected completion date of the existing surface mines is approximately the year 2005. Projected completion dates may change due to fluctuations in market conditions and the demand for high sulfur coal. The projected maximum area to be disturbed by existing surface coal mines is approximately 2,050 acres.

CUMULATIVE IMPACT AREA

The Cumulative Impact Area (CIA) was determined using the procedures outlined in the OSMRE draft document, Guidelines for Preparation of a CHIA.

The proposed total area to be permitted by AECI is located in Sections 4,5,6,7,8, and 18 in Township 54 N, Range 16 W, and Section 1, Township 54 N, Range 17 West, Chariton county, Missouri. As indicated above, the permit area is located in two watersheds. Since the proposed permit contains two watersheds and because preliminary evaluations of Cumulative Impact Areas showed the need for two CIA determinations, this CHIA will be organized in this manner.

Surface Water Cumulative Impact Area for Middle Fork Chariton

Criteria

The Draft CHIA Guidelines suggest that spatially remote mining operations can be excluded from a surface cumulative impact area using criteria specifically defined for that purpose.

(37)
The Surface Water Cumulative Impact Area has been determined to be that area which drains above and below the permit area, as identified on the accompanying map. The entire affected watershed encompasses approximately 174.6 square miles. The first cumulative impact boundary determination was placed at the confluence of the East Fork Chariton and Middle Fork Chariton Rivers. An assumption was made that a discharge value of 7 mg/l of iron from the mine site would be used to evaluate the CIA boundary. The mass balance equation (using the regression equation for low flow for northern Missouri) was used to determine the impact. A value of .71 mg/l was obtained. This number is well below the material damage criteria of 1 mg/l. The second cumulative impact boundary determination was placed at the confluence of Muncas Creek with the Middle Fork Chariton River.

Again, an assumption was made that a discharge value of 7 mg/l of iron discharged from the mine site. The mass balance equation was used to determine the impact. A value of .73 mg/l was obtained. Again, this value is well below the material damage criteria of 1 mg/l. The third cumulative impact boundary determination was placed BL-27. Again, an assumption was made that a discharge value of 7 mg/l of iron discharged from the mine site. The mass balance equation was used to determine the impact. A value of .83 mg/l was obtained. A fourth cumulative impact boundary determination was placed at BL-20. An assumption was made that a discharge value of 7 mg/l of iron discharged from the mine site. The mass balance equation was used to determine the impact. A value of 1.73 mg/l was obtained. Obviously, this value is well above the material damage criteria of 1 mg/l. Since the evaluation at BL-20 showed that an impact will result from the proposed mining operations and that all the other evaluations showed negligible impact well below the material damage criteria of 1 mg/l, and since there currently is a surface water site at this point (BL-27) to better able to evaluate potential impacts, the downstream limits of the surface water Cumulative Impact Area were placed downstream from where the permit tributary empties into the Middle Fork Little Chariton River at BL-27. The surface water CIA was delineated to include the total drainage area of these streams.

**Surface Water Cumulative Impact Area for Chariton River**

**Criteria**

The Draft CHIA Guidelines suggest that spacially remote mining operations can be excluded from a surface cumulative impact area using criteria specifically defined for that purpose.

The Surface Water Cumulative Impact Area has been determined to be that area which drains above and below the permit area, as identified on the accompanying map. The entire affected watershed encompasses approximately 1,961 square miles. The first cumulative impact boundary determination was placed at the mouth of the Chariton River at the Missouri River. An assumption was made that a discharge value of 7 mg/l of iron from the mine site would be used to evaluate the CIA boundary. The mass balance equation (using the regression equation for low flow for northern Missouri) was used to determine the impact. A value of .39 mg/l was obtained. This number
is well below the material damage criteria of 1 mg/l. The second cumulative impact boundary determination was placed at BL-26 just below the mine disturbance along the Chariton River.

Again, an assumption was made that a discharge value of 7 mg/l of iron discharged from the mine site. The mass balance equation was used to determine the impact. A value of 0.41 mg/l was obtained. Again, this value is well below the material damage criteria of 1 mg/l. The third cumulative impact boundary determination was placed BL-21. Again, an assumption was made that a discharge value of 7 mg/l of iron discharged from the mine site. The mass balance equation was used to determine the impact. A value of 1.6 mg/l was obtained. This value is well above the material damage criteria of 1 mg/l. Since the evaluation at BL-20 showed an impact would result from operations and that the other two evaluations showed that negligible impact will result from the proposed mining operations and since there currently is a surface water site at this point (BL-26), to be better able to evaluate potential impacts, the downstream limits of the surface water Cumulative Impact Area were placed downstream from where the permit tributaries empty into the Chariton River at BL-26. The surface water CIA was delineated to include the total drainage area of these streams.

A hydrologic impact, as defined by the Draft CHIA Guidelines, is defined as a "measurable change in hydrologic parameters...." A "measurable change" for surface water in this CHIA is defined in terms of total iron concentration.

Ground Water Cumulative Impact Area for Middle Fork Chariton and Chariton Rivers

Criteria

The impact of mining and associated activities on the aquifers has been identified as a very minor concern in this assessment as a result of the findings of the water user survey study and the hydrogeologic baseline information as provided below. The Cambrian-Ordovician and Mississippian aquifers are hydrologically separated from the strata being impacted by mining according to Imes (1985). Imes states that the large shale content of most Pennsylvanian rocks greatly impedes the flow of ground water; thus, the Pennsylvanian probably is confining bed atop the relatively permeable Mississippian aquifer. Therefore, the regional CIA boundary will not be evaluated. The accompanying maps delineate the outline of the Ground Water Cumulative Impact Area and the general flow direction of the ground water. As the geology in this region, generally speaking, has little or no dip, the affected strata crop out in a predicted pattern coincident with the topographic lines, along stream valleys. One assumption made in this evaluation is that the outcrops of the affected strata are considered to be the locations where the ground water would be discharging, thus, contributing to the surface water flow. The potentiometric ridge of the Ground Water Impact Area is also considered to be the surface watershed boundary. As a rule in this region, those water bearing strata close to the ground surface causing localized shallow subsurface flow follow the surface topography.
BASELINE HYDROLOGIC CONDITIONS

Ground Water

Baseline hydrologic conditions within the CIA were determined in accordance with OSMRE's Draft Guidelines For Preparation of a Cumulative Hydrologic Impact Assessment. "Baseline conditions" here refer to the state of the hydrologic balance of the proposed permit area prior to the proposed mining. The baseline year for (ground water and surface water) this CHIA was April of 1990 to December of 1991.

There were a total of five wells which were used for PHC and CHIA purposes. The information from Wells MW30A, MW31A, and MW32A were used in order to determine the aquifer characteristics for the till aquifer. These wells are 33 feet, 30 feet, and 25 feet deep and have approximate transmissivities of 38 sq. ft/day, 18 sq ft/day, and 57 sq ft/day, respectively. Well MW 33, 95.2 feet deep with a transmissivity of 3.14 sq feet/day, was installed in order to monitor deeper water bearing zones. Well MW34 was installed in order to determine spoil aquifer characteristics; its transmissivity is 20.48 sq. ft/day and is 74.3 feet deep.

As indicated above, five wells were installed to establish ground water quality and static water level for Permit 1991-03. The following describes the water quality from these wells:

The water quality from Well #30 Till is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Average (7 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.1 to 8.5</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>428</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>no data</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.05</td>
<td></td>
</tr>
</tbody>
</table>

The water quality from Well #31 Till is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Average (7 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 6.6 to 7.1</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>
The water quality from Well #32 Till is as follows:

Average
(7 samples)
mg/l

pH range 6.9 to 7.8
Total Dissolved Solids 284
Dissolved Iron .32
Dissolved Manganese 1.24
Sulfate 20

The water quality from Well #33 Above Coal is as follows:

Average
(7 samples)
mg/l

pH range 12.2 to 12.4
Total Dissolved Solids 1723
Total Iron .034
Total Manganese no data
Sulfate 107.8

The water quality from Well #34 Spoil is as follows:

Average
(7 samples)
mg/l

pH range 11.8 to 12.1
Total Dissolved Solids 1712.5
Sulfate 673.5
Total Iron .086
Total Manganese .01

**Surface Water**

**Middle Fork Chariton River Watershed**

The lack of aquifers capable of storing large volumes of water result in no appreciable base flow in the small tributaries to the Middle Fork Chariton. As a result, stream flow reflects the rainfall events, with the storm runoff providing the majority of the stream flow to the ephemeral reaches. The base flow from Middle Fork Little Chariton River is low from November through April. During the period from May to October, the flow is greater as a result to heavy rainfall. The seven-day Q10 is zero for the tributary from the permit area. The seven-day Q 10 for the Middle Fork Chariton is approximately .78 cfs.

For the Middle Fork Chariton River watershed, there were no surface water monitoring sites set up for watersheds which will not be impacted by surface
mining; thus, no information is available from these watersheds. An assumption was made that this water quality was equivalent to or no worse than that water from the watershed monitored by BL-20. As discussed earlier, the tributaries to the north (along the upper reaches of Middle Fork Little Chariton) receive abandoned mine drainage.

Three sampling points were selected by Associated Electric to establish baseline water quality for Permit 1991-03. Site BL-16 was chosen to sample runoff and assess the baseline water quality located upstream of the mining activity. Sites BL-27 and BL-20 were chosen to assess impacts of mining through the life of the mining operation.

**Middle Fork Chariton watershed**

The water quality from site BL-16 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (21 samples) mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.4 to 8</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>40</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>454</td>
</tr>
<tr>
<td>Sulfate</td>
<td>265</td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>0.089</td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>0.17</td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>168</td>
</tr>
</tbody>
</table>

The water quality from site BL-20 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (15 samples) mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7 to 8</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>355</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>319</td>
</tr>
<tr>
<td>Sulfate</td>
<td>77</td>
</tr>
<tr>
<td>Dissolved Iron (11)</td>
<td>0.29</td>
</tr>
<tr>
<td>Dissolved Manganese (13)</td>
<td>0.49</td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>51</td>
</tr>
</tbody>
</table>

The water quality from site BL-27 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (14 samples) mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.3 to 7.9</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>122</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>297</td>
</tr>
<tr>
<td>Sulfate</td>
<td>155</td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>0.08</td>
</tr>
<tr>
<td>Dissolved Manganese (13)</td>
<td>0.1</td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>206</td>
</tr>
</tbody>
</table>

(42)
Chariton River Watershed

The majority of the flow from the Chariton River is considered to be base flow. The balance of the flow is attributed to runoff from rainfall events. During the period from May to October, the flow is greater as a result of heavy rainfall. Tributaries to the stream are ephemeral and show no base flow during the better part of the year. The seven-day Q10 is 0 for the tributaries flowing into the Chariton River. However, the year seven-day Q10 for the Chariton River is 8.4 cfs.

For the Chariton River watershed, there were no surface water monitoring sites set up for watersheds which will not be impacted by surface mining; thus, no information is available for these watersheds. An assumption was made that this water quality was equivalent to or no worse than that water from the watershed monitored by BL-21.

Three sampling points were selected by Associated Electric to establish baseline water quality for Permit 1991-03. Site BL-25 was chosen to sample runoff and assess the baseline water quality located upstream of the mining activity. Sites BL-26, 24, 23, 22, and 21 were chosen to assess impacts of mining through the life of the mining operation.

The water quality from site BL-21 is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Average (15 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.2 to 8.2</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>497</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.18</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

The water quality from site BL-22 is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Average (15 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.2 to 8.2</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>23.75</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.2</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>1.75</td>
<td></td>
</tr>
</tbody>
</table>
The water quality from site BL-23 is as follows:

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<table>
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<th>Parameter</th>
<th>Average (14 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7.2 to 8.1</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>876</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>191</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese (13)</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>73.5</td>
<td></td>
</tr>
</tbody>
</table>
```

The water quality from site BL-24 is as follows:

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (10 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 6.7 to 8.3</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>290</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>580</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.655</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.507</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>73.6</td>
<td></td>
</tr>
</tbody>
</table>
```

The water quality from site BL-25 is as follows:

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (14 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>range 7 to 7.9</td>
<td></td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>479</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>206</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>2798</td>
<td></td>
</tr>
</tbody>
</table>
```

The water quality from site BL-26 is as follows:
Average
(14 samples)
mg/l

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.9-7.9</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>557</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>196</td>
</tr>
<tr>
<td>Sulfate</td>
<td>48.9</td>
</tr>
<tr>
<td>Dissolved Iron</td>
<td>.13</td>
</tr>
<tr>
<td>Dissolved Manganese</td>
<td>.06</td>
</tr>
<tr>
<td>Flow (cfs)</td>
<td>3447</td>
</tr>
</tbody>
</table>

Charts in Appendix A have been included showing the relationship between flow and the parameters listed above. As can be seen from the comparison between water quality and flow, some cases, lower total dissolved solids and lower sulfate concentrations occur during high flow periods. In contrast, higher total suspended solids in some cases occur during high flow periods.

IDENTIFICATION OF HYDROLOGIC CONCERNS

OSMRE's Draft CHIA Guidelines require identification of the hydrologic concerns that will be addressed by the assessment, the specific indicator parameters that will be used to measure and evaluate the concerns (with respect to water uses), and the sites at which the parameters will be evaluated. The hydrologic concerns for this assessment were identified from the permit application, from the USGS publications Hydrology of Area 38, Western Region, Interior Coal Province Iowa and Missouri, and the Missouri Water Quality Standards. The receiving streams, the Chariton River and the Middle Fork Little Chariton, are classified as Type P streams. (Class P streams mean that they maintain permanent flow in drought periods.) The primary uses for the Chariton River are irrigation, livestock and wildlife watering, aquatic life, whole body contact and drinking water supply. The primary uses for the Middle Fork Little Chariton are drinking water supply, livestock, wildlife watering, and protection of aquatic life. The water quality standards used below were designed to ensure that discharge of water from the permit areas will not degrade the quality of receiving waters downstream, with particular parameters being noted. This is the rationale behind the use of some of the NPDES, EPA, and Water Pollution Control Program regulation criteria.

Concerns Related to Surface Water Hydrology

The following surface water concerns have been raised and will be addressed in this assessment:

1. Potential impacts to surface water quality due to changes in dissolved iron, dissolved manganese, and sulfate.

The hydrologic concerns for the Chariton River and the Middle Fork Little Chariton primarily involve the 1) changes in the chemical composition of stream flow due to the addition of acid mine drainage (iron, manganese),
and 2) disturbances of overburden due to mine excavation may increase the availability of some chemical constituents that cause deleterious effects in water (iron, manganese, and sulfate, possibly causing deleterious effects in water used for livestock and wildlife watering, the protection of aquatic life, drinking water supply).

2. Potential impacts to surface water quantity especially flooding risk due to increased peak flows from the mining area during storm events at site BL-26 and BL-27.

Concerns Related to Ground Water Hydrology

The impact of mining and associated activities on the aquifers has been identified as a very minor concern in this assessment as a result of the findings of the water user survey study and the hydrogeologic baseline information provided in the PHC and this CHIA.

1. Potential impacts to the ground water quantity due to the proximity of mining to nearby active water wells will be negligible based on the lack of water users surrounding the permit area, the fact that the ground water flow direction is similar to the contour of the topography (the ground water wells of concern are located in a different ground water recharge area than that of the permit area), in addition to the fact that the transmissivity of the aquifers is very small.

2. Potential impacts to ground water quality (dissolved iron, dissolved manganese, and sulfate) due to the infiltration of potentially impacted ground water into active water wells nearby will be negligible based on the lack of water users surrounding the permit area, the ground water wells of concern are located in a different ground water recharge area than that of the permit area, in addition to the fact that the transmissivity of the aquifers is very small.

MATERIAL DAMAGE CRITERIA

Regulation 10 CSR 40-6.050(9) requires the Missouri Land Reclamation Program authority to assess cumulative hydrologic impacts in order to determine whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area. This is done by estimating impact magnitudes and comparing them to the appropriate threshold levels that indicate the occurrence of material damage to the hydrologic balance. These threshold values which indicate the impact level at which material damage to the hydrologic balance may occur are called material damage criteria.

The Draft CHIA Guidelines give the following definition for material damage: "Material damage to the hydrologic balance means, with respect to CHIA, the changes to the hydrologic balance caused by surface mining and reclamation operations to the extent that these changes would significantly affect present and potential uses as designated by the regulatory authority." Hydrologic balance is defined by 30 CFR 701.5 as "the relationship between
the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as drainage basin, aquifer, soil zone, lake, or reservoir. It encompasses the dynamic relationship among precipitation, run-off, evaporation and change in ground and surface water storage." For purposes of this CHIA, the above definition will be used. The protection of present and potential water uses will be incorporated into this CHIA.

The CHIA is based on the best currently available data and is a prediction of mining related impacts on the hydrologic balance. To assure that the predictions in the CHIA are consistent with the actual on-the-ground conditions, AECI is required to monitor water quality and quantity as part of the permit requirements.

The material damage criteria were established at magnitudes above which damage to the hydrologic balance would be indicative of an economic loss to the current and potential water users or would result in significant reduction of the capability of an area to support aquatic life, drinking water supply, wildlife communities, and livestock, irrigation and whole body contact.

Rationale for Material Damage Criteria

Parameters for surface water quantity and quality

The material damage criteria in this CHIA concentrates on changes of surface flow rates and their chemical composition that would physically affect the off-permit hydrologic balance as it presently affects irrigation, livestock and wildlife watering, drinking water supply, protection of warm water aquatic life, and recreation. Therefore, the criteria are designed to limit changes in the present discharge regime to magnitudes which would not cause economic loss to existing livestock businesses, which would not cause significant alteration to the channel size or gradient, would remain adequate capacity for irrigation, recreation-whole body contact, existing aquatic life and wildlife communities, and would provide satisfactory water quality for drinking water supplies. In order to assess the material damage potential of changes to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site:

The following are brief rationale for the selection of each parameter and its limiting values and descriptions for selection of the criteria used for each parameter:

Annual Flow Volumes:

The mean annual volume of flow was selected as the most meaningful indicator parameter for water quantity.
Dissolved Iron

Dissolved iron has been found to be toxic to fish at concentrations of 0.9 mg/l, as well as smothering fish eggs and bottom dwelling fish food organisms. Missouri Water Commission standards for the protection of aquatic life is 1 mg/l and is .3 mg/l for drinking water standards (secondary esthetic standards). (There are no standards for wildlife and livestock watering.) The Missouri Water Commission standard of 1 mg/l will be used for the material damage criteria for both watersheds.

Dissolved Manganese

Dissolved manganese is not considered to be a problem for aquatic life (in fresh waters) and livestock. Tolerance values range from 1.5 mg/l to over 1000 mg/l. Missouri Water Commission has no standards for aquatic life, livestock and wildlife watering, irrigation, or recreation for this parameter. However, there is a secondary water quality standard for drinking water supply of .05 mg/l, for esthetic reasons (rather than health reasons). This baseline information shows that the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of manganese that are above the water standards. Because of the above data results, the largest average value of manganese, or .55 mg/l, will be used for the standard for this CHIA for both watersheds.

Sulfate

Sulfate ion occurrences are common in streams which receive drainage from surface coal mined areas. This parameter is highly indicative of the quality of water running off these disturbed areas. Once pyritic materials are oxidized, one of the end products is the sulfate ion. Missouri's standards for this parameter (this standard is for sulfate and chloride combined; typically chloride occurs in very minor amounts) for the protection of aquatic life is 1000 mg/l. According to 10 CSR 20-7.031(4)(L), "Class P1, L1, L2 and L3 waters and streams with seven (7)-day Q10 low flow of more than one (1) cubic foot per second. The total chloride plus sulfate concentration shall not exceed the estimated natural background concentration by more than twenty percent (20%) at the sixty (60)-day Q2 low flow. This limit will be used. For the Chariton River, the 60-day Q2 is 53 cfs. The sulfate/chloride concentration for the Middle Fork of the Chariton will be 1000 mg/l.

Total Dissolved Solids

Total dissolved solids are common in streams which receive drainage from surface coal mined area. This parameter is highly indicative of the quality
of water running off these disturbed areas. The Missouri Water Commission has no standards for total dissolved solids for livestock and wildlife watering, aquatic life, or for drinking water, irrigation, or recreation. Based on the background baseline information, this data indicates that the preexisting baseline concentration of total dissolved solids upstream from the proposed permit area on Middle Fork Little Chariton River is 657 mg/l. For streams of this character, the limit to be used will be 1000 mg/l.

**pH**

The parameter pH, the negative log of the hydrogen ion concentration, when present, will result in acid mine drainage and fish kills under certain conditions. The Missouri Water Commission's standards are 6.5-9.0. The NPDES limits allow pH values of 6.0-9.0. EPA's 1976 Water Quality Criteria limits suggests pH values of 6.5-9.0. The standard 6.0-9.0 for pH will be used for the material damage criteria for this CHIA.

**Parameters for Ground Water Quantity and Quality**

The material damage criteria in this CHIA concentrates on any changes of ground water flow rates and their chemical composition that would physically affect the off-permit hydrologic balance as it presently affects livestock and wildlife watering, and protection of aquatic life as well as drinking water supply. Therefore, material damage criteria can be designed to limit changes in the present discharge regime to magnitudes which would not cause economic loss to existing livestock businesses, which would not cause significant alteration to the channel size or gradient, and would remain adequate capacity for existing fish and wildlife communities and protect the water users who draw from these aquifers. It must also be considered in determining whether or not material damage will take place given the fact that there are no water users based on the water user survey that will potentially be impacted (water quality or water quantity) from the proposed mining operation. It is the determination here that potential water quality contamination is extremely unlikely at this proposed permit site. Because of this, no parameters for ground water quantity and quality are proposed.

**MATERIAL DAMAGE CRITERIA**

As discussed earlier, surface water concerns have been identified as topics for CHIA evaluation. The surface water concerns will be evaluated at Site BL-27 on the Middle Fork Little Chariton River approximately 4500 feet downstream from where the permit tributary empties into the Middle Fork at the Highway 24 crossing. In addition, the surface water concerns will be evaluated at Site BL-26 on the Chariton River at a county road crossing between Section 36, T54N, R18W, and Section 31, T54N, R17W.
Material Damage Criteria for Surface Water

<table>
<thead>
<tr>
<th>Concerns</th>
<th>Parameters for Criteria</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>aquatic life</td>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td></td>
<td>iron</td>
<td>1 mg/l</td>
</tr>
<tr>
<td></td>
<td>sulfate</td>
<td>calculation/1000 mg/l</td>
</tr>
<tr>
<td>livestock/watering</td>
<td>pH</td>
<td>6-9 mg/l</td>
</tr>
<tr>
<td></td>
<td>iron</td>
<td>1 mg/l</td>
</tr>
<tr>
<td></td>
<td>sulfate</td>
<td>calculation/1000 mg/l</td>
</tr>
<tr>
<td>drinking water</td>
<td>iron</td>
<td>1 mg/l</td>
</tr>
<tr>
<td>supply</td>
<td>manganese</td>
<td>.55 mg/l</td>
</tr>
<tr>
<td>irrigation</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>recreation</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

ANALYSIS OF CUMULATIVE HYDROLOGIC IMPACTS

Surface Water Impacts - Quality - Middle Fork Chariton River

The greatest impact to water based on the results below, would be expected to occur during low flow periods generally for all parameters. At these times the amount of dilution will be at a minimum.

IMPACTS ON WATER QUALITY PARAMETERS AT WATER STATION BL-27
AT DIFFERENT FLOW CONDITIONS

<table>
<thead>
<tr>
<th>Total Dissolved</th>
<th>Dissolved pH</th>
<th>Sulfate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Iron</td>
<td>Manganese</td>
<td></td>
</tr>
<tr>
<td>Solids mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
</tr>
</tbody>
</table>

Low Flow

The seven day Q10 low flow on the proposed permit area on the tributaries to the Middle Fork Chariton is .78. In using the Mass Balance equation, the use of this value would yield the following results. However, in consideration of the existing low flow data, the following conditions may result:
| Prevailing | 736.81 | .451 | .55 | 6.4 | 465.23 |
| Predicted  | 741.03 | .449 | .55 | 7.4 | 464.86 |
| Mean Flow   |        |      |     |     |       |
| Prevailing  | 30.06  | .105 | .196| 7.2 | 249.35 |
| Predicted   | 30.10  | .105 | .196| 7.2 | 249.36 |
| High Flow   |        |      |     |     |       |
| Prevailing  | 239.96 | .013 | .047| 8.7 | 72.91 |
| Predicted   | 239.96 | .013 | .047| 8.7 | 75.91 |

As demonstrated above, the anticipated water quality (as a result of the surface coal mining of Associated Electric, 1991-03 proposed permit) has not exceeded the material damage criteria standards.

Surface Water Impacts - Quantity - Middle Fork Chariton River

In order to assess the effects of mining on flows at the CIA, synthetic hydrographs were developed for three different watershed configurations. First, to represent a pre mining condition, the entire watershed is assumed to have a CN of 75. Second, to represent the maximum effect of mining, the entire permit area is assumed to be disturbed and no sediment ponds in place with a curve number of 90. Third, to represent the minimum effect of mining the entire permit area is assumed to be controlled by a vegetation that controls runoff with a curve number of 80. The actual effects of mining would be between the extremes of the second and third case. Finally, the peak flows for the three cases were completed for approximately 2 year - 24 hour event. Based upon the following, it has been determined (after seeing that the maximum deviation (9%) is within acceptable limits without showing an impact) that there will be no impact to the quantity of the surface water as a result of the mining.

<table>
<thead>
<tr>
<th>RAINFALL EVENT</th>
<th>PREMINE PEAKFLOW</th>
<th>MAX-MINING NO SED POND</th>
<th>MIN-MINING CN=80</th>
<th>MAXIMUM DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>cfs</td>
<td>cfs</td>
<td>cfs</td>
<td>%</td>
</tr>
<tr>
<td>2.9</td>
<td>4311</td>
<td>390</td>
<td>180</td>
<td>9%</td>
</tr>
</tbody>
</table>
ANALYSIS OF CUMULATIVE HYDROLOGIC IMPACTS

Surface Water Impacts- Quality-Chariton River

The greatest impact to water based on the results below, would be expected to occur during low flow periods generally for all parameters. At these times the amount of dilution will be at a minimum.

<table>
<thead>
<tr>
<th>IMPACTS ON WATER QUALITY PARAMETERS AT WATER STATION BL-26</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT DIFFERENT FLOW CONDITIONS</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/l)</td>
</tr>
<tr>
<td>Dissolved Iron (mg/l)</td>
</tr>
<tr>
<td>Dissolved Manganese (mg/l)</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Sulfate (mg/l)</td>
</tr>
</tbody>
</table>

| Low Flow | Prevailing | 320.18 | .321 | .28 | 7.28 | 95.42 |
| Mean Flow | Predicted | 320.24 | .321 | .28 | 7.09 | 95.44 |
| High Flow | Prevailing | 207.9 | .103 | .06 | 7.66 | 46.08 |
|           | Predicted | 208.0 | .103 | .06 | 7.66 | 46.08 |
|           | Prevailing | 117.5 | .046 | .01 | 8.04 | 12.03 |
|           | Predicted | 117.55 | .046 | .01 | 8.04 | 12.03 |

As demonstrated above, the anticipated water quality (as a result of the surface coal mining of Associated Electric, 1991-03 proposed permit) has not exceeded the material damage criteria standards.

Surface Water Impacts- Quantity

In order to assess the effects of mining on flows at the CIA, synthetic hydrographs were developed for three different watershed configurations.
First, to represent a pre-mining condition, the entire watershed is assumed to have a CN of 75. Second, to represent the maximum effect of mining, the entire permit area is assumed to be disturbed and no sediment ponds in place with a curve number of 90. Third, to represent the minimum effect of mining the entire permit area is assumed to be controlled by a vegetation controlling runoff leaving the area with a curve number of 80. The actual effects of mining would be between the extremes of the second and third case. Finally, the peak flows for the three cases were completed for approximately 2 year - 24 hour event. Based upon the following, it has been determined (after seeing that the maximum deviation (7%) is within acceptable limits without showing an impact) that there will be no impact to the quantity of the surface water as a result of the mining.

<table>
<thead>
<tr>
<th>RAINFALL EVENT</th>
<th>PREMINE PEAKFLOW</th>
<th>MAX-MINING NO SED POND</th>
<th>MIN-MINING CN=80</th>
<th>MAXIMUM DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>cfs</td>
<td>cfs</td>
<td>cfs</td>
<td>%</td>
</tr>
<tr>
<td>2.89</td>
<td>339</td>
<td>1147</td>
<td>517</td>
<td>7%</td>
</tr>
</tbody>
</table>
FINDINGS

Based upon the findings contained within this CHIA, it is the recommendation of the Missouri Land Reclamation Program that the probable cumulative hydrologic impacts of all anticipated coal mining in the general area on the hydrologic balance has been designed to prevent damage to the hydrologic balance outside the proposed mine plan area.
BIBLIOGRAPHY

Hydrologic Unit Map, State of Missouri, 1977, U.S.G.S.,


Appendices to PHC and CHIA Guideline Documents, 1985, Office of Surface Mining.


White, D., et. al, 1963, Data of Geochemistry, Chapter G., Chemical Composition of Subsurface Waters, U.S.G.S. Prof. Paper 440-F.

Feder, G., 1979, Geochemical Survey of Waters of Missouri, U.S.G.S., Prof. Paper 954-E.


Land Reclamation Program Regulations, Division 40, Missouri Dept. Nat. Res.
Freeze, A., Cherry, J., 1979, Groundwater.


Potter, Dennis, 1989, Soil Survey of Randolph County, Missouri, U.S.D.A., Missouri Agricultural Experimental Station.
Field Trip Itinerary

Day 2

Saturday, September 30, 1995
Stop 1  Missouri Department of Natural Resources

Huntsville Gob Project

Location: The Huntsville Reclamation Project is located near Highway JJ in Randolph County, Missouri approximately 0.5 miles east of Huntsville and 4.2 miles west of Moberly.

History: The area was originally mined by the Huntsville-Sinclair Mining Company from approximately 1943 until 1950. Peabody Coal Company purchased mineral rights in 1950 and mined until 1955. In addition, numerous reports and evidence suggests small mining operations worked throughout the valley long before 1943.

Problem Addressed by Reclamation:
- acid mine drainage and sediments from the gob pile
- degraded water quality in Sugar Creek, a main tributary of the East Fork of the Chariton River
- clogging of Huntsville Gob branch and Sugar Creek by coal waste
- extensive damage to downstream fields due to acidic sediment
- areas of burning coal waste
- areas of steep, unstable banks of coal waste
- construction waste, lumber, tires, steel objects
- minor maintenance needs on the adjacent Huntsville-Colo project

Summary: In the fall of 1992, the Abandoned Mine Land Section of the Land Reclamation Program completed final earthwork on the Huntsville Gob project east of Huntsville, Missouri. The contract was awarded to Slates Construction of Nevada, Missouri. The design was developed by the Abandoned Mine Land Section. The negative impact on water and land resources downstream of the gob pile was a major concern to the state and a headache to landowners. Reclaiming this site included removing coal sediments from a one mile length of Sugar Creek and a major tributary draining the gob pile. The coal waste was hauled back to the gob pile. Prior to reclamation, adjacent farmlands were flooded and contaminated by acidic coal sediments. Coal waste sediment was removed from approximately five acres of prime farmland, and hauled back to the gob pile.

The gob pile was graded to a gentle slope. Two feet of cover material was spread above the coal waste and revegetated. The cover material was excess glacial till overburden from the Moberly Stone limestone quarry, southeast of the reclamation site.

Seeding was completed in the summer of 1993.
Geology: Similar to that described for Prairie Hill Mine.

Other references:

Blevins, Dale W. and Ziegler, Andrew C.
Hydrogeology, Water Chemistry and Subsidence of Underground Coal Mines at Huntsville, Missouri
July 1987 to December 1988

Blevins, Dale W.
Sources of Coal-Mine Drainage and Their Effects on Surface-Water Chemistry in the Claybank Creek Basin and Vicinity North Central Missouri, 1983-84

Gentile, Richard J.
Mineral Commodities of Macon and Randolph Counties
Work, David M; Summer, Scott and Roberts, Charles E.
Geology of Potential Coal Stripping Areas: Prairie Hill Area, Missouri
Stop 2  Moberly Stone Company

Company: Moberly Stone Company  
P.O. Box 582  
Moberly, Missouri 65270

Location: Moberly Quarry  
Randolph County S-8, 17, T-53N, R-15W  
12 miles SW of Moberly on Highway 3

Production: 400,000 tons/year

Reserves: 30 or 40 years at present production. The limestone deposits more than 420 feet deep.

Products: Rip-rap, 8" washed stone for Associated, 1 1/2" road stone, 3/4" for driveways, state and county roads. Stonesand, a manufactured sand, which is said to reduce rutting in asphalt paving. Stonesand is more angular than natural sand and therefore bonds better with the asphalt.

Geologic Formation: Pennsylvania, Desmoinesion Series Marmaton Group with Warsaw and Burlington ledges.

Overburden: Overburden varies between 10 feet and 50 feet.

Reclamation: Completion of mining will create a large lake surrounded by wildlife habitat.
Stop 3  

Yates Reclamation Project

On-going reclamation project overseen by the Missouri Department of Natural Resources. The following materials were obtained from the files of the Land Reclamation Program.
DNR AWARDS CONTRACT FOR LAND RECLAMATION IN RANDOLPH COUNTY

JEFFERSON CITY, MO, JANUARY 30, 1995 -- Nearly 300 acres of coal mined lands will be reclaimed to correct safety and environmental problems near Yates in Randolph County. The Missouri Department of Natural Resources (DNR) and the Land Reclamation Commission have awarded a $1.5 million contract for reclamation work to Nationwide Mining Inc. of Pleasanton, Kansas.

The project covers lands located from one to three miles north of Yates that were disturbed during coal mining by the Yates Energy Corporation. The company abandoned the mine sites without completing the reclamation required by Missouri law. DNR and the Land Reclamation Commission forfeited bond money put up for the site by the Yates Energy Corporation. The forfeited bond money and funds from a state surcharge on coal mined in Missouri will pay for the reclamation.

The plans for reclamation were a joint design effort of the Land Reclamation Program and the Office of Surface Mining-Technical Assistance Program located in Denver, Colorado. Computer technologies available to the federal agency helped speed up design activities in this unique state and federal cooperative agreement.

The reclamation project will dispose of an estimated 30,000 cubic yards of coal wastes in open pits located in project limits and providing proper cover of soil. Other areas where exposed coal wastes are producing acid drainage from the site will be cleaned up, and those coal wastes will be disposed of in a similar manner. Open pits with steep highwalls that pose safety hazards will be filled in, and the highwalls will be altered to safe slopes. Water impoundments will be constructed throughout the project limits and all other areas will be top soiled and revegetated.

For more information, contact DNR's Land Reclamation Program at (314) 751-4041 or 1 (800) 361-4827.
YATES PERMIT AND BONDING SUMMARY
OCTOBER 4, 1994

The following is a summary of the permits issued and areas bonded for the Yates Energy Bond Forfeiture Project. This summary will assist in establishing the scope of reclamation related to this bond forfeiture project.

There were six permits issued to the Yates Energy Corporation between the years of 1982 through 1984. Permits issued by the Land Reclamation Program are listed below.

<table>
<thead>
<tr>
<th>PERMIT NUMBER</th>
<th>ACREAGE PERMITTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982-16</td>
<td>201 acres</td>
</tr>
<tr>
<td>1982-31</td>
<td>299 acres</td>
</tr>
<tr>
<td>1984-1</td>
<td>185 acres</td>
</tr>
<tr>
<td>1984-6</td>
<td>34 acres</td>
</tr>
<tr>
<td>1984-7</td>
<td>47 acres</td>
</tr>
<tr>
<td>1984-13</td>
<td>225 acres</td>
</tr>
</tbody>
</table>

TOTAL 991 acres

Of these six permits only Permit 1984-6 was not partially or fully bonded by the coal company. 17 increments of bonding were provided for the other five permits as follows:

<table>
<thead>
<tr>
<th>PERMIT NUMBER</th>
<th>INCREMENT</th>
<th>ACREAGE BONDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982-16</td>
<td>1</td>
<td>80 acres</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10 acres</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>44 acres</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1 acre</td>
</tr>
<tr>
<td>1982-31</td>
<td>1</td>
<td>42 acres</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5 acres</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3 acres</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17 acres</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>55 acres</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>41 acres</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>79 acres</td>
</tr>
<tr>
<td>1984-1</td>
<td>1</td>
<td>64 acres</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>37 acres</td>
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<tr>
<td></td>
<td>3</td>
<td>66 acres</td>
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<tr>
<td>1984-7</td>
<td>ALL</td>
<td>47 acres</td>
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<tr>
<td>1984-13</td>
<td>1</td>
<td>93 acres</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 acre</td>
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BONDED TOTAL 685 acres

The 94 acres bonded under Permit 1984-13 and 42 acres under Permit 1982-31 Increment No. 1 have been repermitted by North American Resources, Silver Creek Mine. The total repermitted acreage is 136

(76)
The permitted bonded area associated with Permit 1984-7 does not appear to have been mined therefore it will not be considered as an area to be reclaimed in bond forfeiture work. This area consists of 47 acres.

The total area for which is considered to be in need of land use revision and reclamation liability release is approximately 502 acres.
300+ acre active coal mining operation near Yates Missouri.

The following documents were obtained from the Missouri Department of Natural Resources, Land Reclamation Program files. They were prepared by Mr. Larry Hendron and staff of Engineering Surveys and Services, Columbia, Missouri.
SUMMARY

Silver Creek Resources, Inc. intends to permit about 384 acres in southern Randolph County for surface mining and reclamation activities. The proposed permit area lies immediately south of Silver Creek, west of Coal Creek, and north of Missouri State Route B. This area is contiguous to two previously surface mined areas that are now considered unreclaimed abandoned mine lands.

The study area is located in the eastern half of the Western Interior Coal Province and is in the Central Lowlands Province of the Interior Plains. The land surface is comprised of mostly rolling hills with land surface altitudes ranging from about elevation 685 feet in the north to 815 feet in the south. The bedrock is of Pennsylvanian age and consists of alternating beds of shale, limestone, sandstone, coal, and associated underclay. The rock dips gently towards the northwest. Unconsolidated deposits of silt, clay, sand, and some gravel of Quaternary age occur in stream valleys that are, at times, incised into the older Pennsylvanian bedrock.

The area has a continental climate and receives average annual precipitation of about 36 inches. Topographic relief is low, but bedrock comprised predominantly of shale and soils having slow infiltration rates cause most of the precipitation and snow melt to move as runoff into streams. Regional base stream flow is poorly sustained because the Pennsylvanian aquifers are not capable of providing sufficient water to maintain it. Nine mine shafts are known to exist in the vicinity of the mine plan area with two of the mines being present in the mine permit area. The extent of the mine works is not known at this time but will be investigated further prior to the start of surface mining activities.

Monitoring well and baseline stream flow were sampled for water quality and quantity analyses. Low flow, high flow, and base flow stream data were collected along with groundwater information in order for the groundwater/surface water relationship to be evaluated.

The domestic and agricultural groundwater needs in the area are generally met with cisterns and shallow wells into the Quaternary soils. Should it become necessary to find an alternate source of groundwater due to disruption by mining activities, Silver Creek Resources, Inc. would install new wells or connect the affected landowner to the public water district system.

The mining and reclamation operations will require handling and disposal of potentially acid- and/or toxic- forming materials. These include the Bevier-Wheeler coal underclay and parting, and the sometimes present fissile shale overlying the Bevier coal seam. The glacial till has excellent engineering properties to properly seal the potentially acid- and/or toxic- forming materials. To further reduce the environmental impacts of surface mining in the permit area, the glacial till is placed upon the shale during reclamation to fabricate pre-mining lithology. This sequence of reclamation is used to approximate the original topographic profile of the mined area and to minimize disturbance to the hydrologic balance.

The proposed mine operation should not result in contamination, diminution, interruption of groundwater or surface water within the proposed permit or adjacent areas for domestic,
agricultural, or industrial uses. In addition, due to the regulated mining methods and procedures anticipated to be used for the mine plan area, flooding stream flow alteration should not occur.

The lack of aquifers in the mine plan area that are of sufficient size and quantity to be used for water supply and that could also be impaired by surface coal mining methods is an important consideration in determining the probable hydrogeologic impacts of mining. Because of the lack of aquifers of sufficient size and quantity, the probable hydrologic impacts of mining should be minimal. Once mining begins, the expected hydrogeologic impact on the shallow aquifers (located above the Mississippian aged formation) or their recharge areas includes a decrease the quantity and quality of the water yielded while the expected hydrogeologic impact on the surface water corridors includes in decreased base flow conditions of neighboring streams and impaired surface water quality due to the small amount of recharge expected to be received from the mine soils. Once final reclamation of the mine area has been completed, base stream flow and water quality should be similar to pre-mining conditions. The reclaimed mine soils are expected to function as recharge areas and as new aquifers that will discharge into adjacent streams. The anticipated recharge of the mine spoil is expected to be reduced somewhat from the pre-mining conditions due to the heterogeneous nature of the spoil and its inability to provide a direct conduit through which groundwater can flow; however, base stream flow and water quality should be very similar to pre-mining conditions.

**BASELINE DATA AND BACKGROUND INFORMATION**

The proposed mine permit site is located in Randolph County about 25 miles northwest of Columbia, Missouri and 15 miles southwest of Moberly, Missouri. The small town of Yates, Missouri is located approximately 3/4 miles south of the southernmost extent of the proposed mine permit area. The mine permit area encompasses about 384 acres in southern Randolph County, Missouri while the total watershed area encompasses approximately 15,200 acres, including all or part of Sections 3, 4, 9, and 10 of Township 52 North, Range 15 West and Sections 28, 33, and 34 of Township 53 North, Range 15 West. The primary surface water corridors in the total watershed area included Silver Creek, Turner Fork, Coal Creek, and an unnamed tributary to Silver Creek.

The study and analysis performed for the proposed mine area included the monitoring of surface water, groundwater, and climatological data as well as classification of existing stratum by overburden analysis. The monitoring period to obtain the baseline data and background information occurred in two phases. The first phase was performed in 1982 when the property was first being evaluated and the second phase occurred in 1992 and 1993. A drilling program to obtain overburden samples was performed in April 1982. Monitoring locations and overburden drill holes are depicted on the map included in the Appendix.

It should be noted that five surface coal mines are located within 1.0 mile of the mine plan area. All of these mine are located in the same major watershed as the proposed mine permit area. One of the mines was made operational after the 1982 baseline study. Nine mine shafts are known to exist in the vicinity of the mine plan area with two of the mines being present in the mine permit area.
Annual precipitation in the study area ranges from extremes of about 24 to 50 inches with an average annual precipitation of about 36 inches. The heaviest precipitation tends to occur from April to September. May is usually the wettest month with an average rainfall of about 4.7 inches. The average seasonal snowfall is nearly 19 inches. On the average, 14 days per year have at least 1 inch of snow on the ground.

The consistent pattern of climate for the area is one of cold winters and long hot summers. Normal average daily temperatures (as recorded at Fayette, Missouri) range from 30 degrees Fahrenheit in January to 77.9 degrees Fahrenheit in July. Average daily maximums range from 84.5, 89.7, and 82.2 degrees Fahrenheit in June, July and September, respectively. Average daily minimums are below freezing from December to March with a minimum of 20.1 degrees Fahrenheit occurring in January. Last frost usually occurs between mid April and early May.

Prevailing wind data was collected at the Columbia Regional Airport. This data, as inferred by the Weather Bureau, indicates that the prevailing winds are predominantly from the north or northwest at speeds ranging from 8 to 11 miles per hour.

WATER USER SURVEY

Information acquired from correspondence with residents or acquired directly by the interviewer may be found on the water user survey forms included with this document. Groundwater levels found in wells are considered to be accurate; however, in most cases, information pertaining to well depth is considered to be hearsay. Due to the general lack of clear information from these wells regarding the subsurface stratigraphy of this area, it is difficult to correlate the data and accurately determine the areal extent of the confined and unconfined aquifers.

Information found in The Stratigraphic Succession of Missouri indicates that deep wells drilled in southern Randolph County usually terminate in Mississippian aged strata. These wells reportedly produce water for domestic and agricultural uses.

Upon completion of the water user survey, there were 44 identifiable sources of water within a 1.0 mile radius of the proposed mine permit area. Of the sources identified, there were 5 wells, 13 cisterns, 1 surface water impoundment, and 25 users of rural or county water. The reliance on wells and cisterns is declining as the rural water district expands its water lines. No deep wells were noted to be present within 1 mile of the proposed mine permit area.

GEOLOGY

Geology of the Study Area

The study area is located in the eastern half of the Western Interior Coal Province. More specifically, the study area is located in the Central Lowlands Province of the Interior Plains. The land surface is comprised of mostly rolling hills with land surface altitudes ranging from about elevation 685 feet in the north to 815 feet in the south.
The geologic setting classification system describes the hydraulic character of the bedrock units above and below the coal beds in terms of their permeability and the structural features within the bedrock units and influencing the general area. In this mine plan area, the classification would be GS-1, or flat lying coal beds of less than 5 degrees dip. The permit area is at or above the local drainage level with only minor amounts of dewatering considered to be necessary for mining.

The physiography of southern Randolph County consists of gently sloping to strongly sloping uplands with a maximum relief of about 200 feet and an average relief of about 100 feet. The ridge-tops are rounded with most of the area’s main roads following the divides. The major stream channels are at or near grade and are in the process of widening their channels. The major stream channels have many youthful V-shaped tributaries.

A mantle of Pleistocene age glacial drift is present in the area. The glacial drift is of sufficient thickness, normally 50 to 100 feet, that good exposures of bedrock are uncommon in the upland areas even though a significant amount of dissection has occurred. In some areas the glacial drift is capped with a veneer of Wisconsin aged, wind-blown loess which may be as thick as 10 feet on some hilltops. Pennsylvanian aged strata underlie the glacial drift and represent a period of oscillating seas and cyclic deposition in a near-shore type environment. Recent alluvial sediment is present in the major stream valleys.

Silver Creek is the major surface water corridor for the study area with it and its tributaries, Coal Creek and an unnamed tributary to Silver Creek, draining in a westerly direction, into the East Fork Chariton River drainage system. Other surface water corridors that border the study area, but do not drain it include Salt Fork and Bonne Femme, which drain in a southerly direction towards the Moniteau and Missouri Rivers, respectively, and Turner Fork which drains into Silver Creek about 1 mile downstream from the proposed mine permit area.

Mississippian System. Mississippian aged limestones comprise most of this system. Outcrops of Mississippian aged rocks have not been reported in Randolph County but are known to be present in the subsurface. Published reports from the Missouri Geology and Land Survey division of the Missouri Department of Natural Resources (MDNR) indicate that the top of the Mississippian aged limestone is approximately 100 to 120 feet below the Croweburg coal seam.

The Mississippian aged limestones are the nearest significant water bearing stratum below the Croweburg coal seam. Many of the areas deep wells (however, none exist in the immediate mine plan area) have been drilled into or through it to Ordovician aged rocks, primarily to the St. Peter formation with some being as deep as the Roubidoux formation.

Pennsylvanian System. This system is comprised primarily of clastic rocks with thin beds of limestone and coal being present. Pennsylvanian aged strata have been assigned to five series; however, only the Marmaton and Cherokee groups of the Desmonian Series are present. Data obtained from borings into the Pennsylvanian system and field work performed by this firm indicate the following formations are present in the study area, listed in ascending order:

(82)
1) Croweburg formation
2) Verdigris formation
3) Bevier formation
4) Lagonda formation
5) Mulky formation
6) Excello formation
7) Blackjack Creek formation
8) Little Osage formation

The total thickness of the Croweburg formation in this area was not determined. The Croweburg coal seam, penetrated by one boring in the mine plan area, was on the order of 0.3 feet in thickness and was underlain by about 2.0 feet of underclay. Outcroppings of the Croweburg coal seam exhibit a thin bedded "boney" coal with iron and sulfur stains.

The Verdigris formation consists of a gray shale member overlain by the Ardmore member which is, in turn, overlain by the Wheeler coal and associated underclay. The gray shale is usually around 20 feet in thickness and may grade upwards into a black shale that is about 2 feet in thickness. The Ardmore member is usually about 5 to 8 feet thick and consists of alternating beds of limestones and shales. The Wheeler underclay ranges from a few inches to over one foot in thickness and is gray in color. The Wheeler coal seam is usually about 1 foot in thickness, is medium bright, hard, and contains frequent thin bands of vertical pyrite and calcite on cleat faces and with occasional thin pyrite bands on the order of 1/2 inch in thickness.

The Bevier formation is separated from the Wheeler coal by a thin parting of dark gray mottled shale. This parting is normally about 2 or 3 inches in thickness but occasionally achieves thicknesses as great as 8 inches. The Bevier coal seam is usually between 2.5 to 3 feet in thickness and is medium bright, banded, and contains frequent thin vertical bands of pyrite and calcite on cleat faces. The pyrite bands, as in the underlying Wheeler coal seam, occasionally are as thick as 1/4 inch.

The Lagonda formation is the thickest and most prominent formation of the Pennsylvanian aged material found in the study area. The total thickness of this unit is normally around 40 feet. The Lagonda formation, as encountered by borings in the mine plan area, primarily consists of a calcareous gray shale mixed with thinly bedded limestone.

The Mulky formation is poorly represented in this area. This formation consists of a thin gray shale and an irregularly bedded spotty limestone and coal smut. The total thickness of this formation is estimated to be on the order of 5 feet.

The Excello formation is also poorly represented in this area and consists of a very dark gray shale overlying traces of the characteristic black fissile shale found at the base of the formation. The total thickness of this formation in the study area is estimated to be on the order of 5 feet.

The Blackjack Creek formation is principally comprised of limestone in the study area. This formation, as encountered in the study area, is described as being thick bedded,
fossiliferous, massive limestone that ranged in thickness from 2 to 4 feet.

The Little Osage formation is at least partially represented in the study area by the Summit coal seam and the Houx member, but is very inconsistent laterally. The upper part of the formation appears to be missing. The lower part is represented by the Summit coal seam, the overlying gray shale, and the Houx limestone member or by a coal smut with irregular traces of the limestone member. This formation, when encountered, ranged from 3 to 12 feet in thickness.

**Quaternary System.** Glacial deposits from the Kansan and Nebraskan glacial episodes are present in southern Randolph County and are the parent material for the various surficial soil types. The glacial deposits are primarily comprised of clays, silts, and sands. Gravel, cobble and boulder size material are sometimes encountered in the glacial drift. Windblown loess overlies the glacial drift on hilltops. The loess may be up to 10 feet in thickness at undissected hilltop locations.

**Structural Geology.** The structural geology of the southern part of Randolph County is neither complex nor unusual in comparison with structures throughout the rest of Missouri. The regional dip in the mine plan area is about 20 feet per mile in the direction of the Forest City Basin, located towards the northwest, and is a result of the Ozark uplift.

Information published by McCracken in 1971 indicates that the areal geologic structure is apparently influenced by several principal structural features. These features include the Browns Station anticline located southeast of the study area, the Howard County syncline located southwest of the study area, the Salisbury-Quitman anticline located to the northwest of the study area, and the College Mound-Bucklin anticline located to the northeast of the study area.

Local structures include minor undulations of the Pennsylvanian strata and may be a result of differential compaction. A structural high is present in the mine area and trends towards the north-northwest.

**Coal and Overburden**

Silver Creek Resources, Inc. plans to mine the Bevier and Wheeler coal seams in the proposed mine permit area. Because of this mining plan, the mine soils extending from the unconsolidated surficial material down to the shaley underclay lying beneath the Wheeler coal seam will be affected by the mining operations.

The subsurface investigations for the mine plan area were performed during the spring of 1982 and during the fall of 1992. Borings for both the 1982 and 1992 investigations were drilled with a truck-mounted Failing Holemaster 1250 drilling rig equipped with a rotary head. A tri-cone roller bit was used to advance the boreholes. During the 1982 subsurface investigation, the air expelled cuttings were collected for each change in material type and placed in sealed containers. The Bevier and Wheeler coal seams along with their associated underclay were cored in an effort to maintain maximum sampling control over these softer strata.
A total of 44 samples were collected from borings W1 and W3 (1982 investigation) with a sampling format of at least one sample per stratum and/or one sample per every 5 feet of boring. Whenever possible, at least 2 pounds of sample were collected. At the time of sample collection, a visual description and geologic log was compiled and recorded by a geologist from this firm.

Overburden samples were analyzed for the following parameters: pH, percent total sulfur, maximum acidity potential, neutralization potential, and calcium carbonate (CaCO₃) surplus or deficiency. If the pH was found to be greater than 8.2 the total sodium, magnesium, and calcium was measured to calculate the sodium absorption ratio. The results of these analysis are included in the Appendix.

A comparison of the strata encountered during actual drilling conducted within the mine plan area indicates that there is some lateral variation of the stratigraphic units. Written in general terms, a mantle of loess and glacial till are penetrated on the hills and side slopes before shales, sandstones, limestones, clays, and coal seams of the Pennsylvanian age are encountered. Underlying the Pennsylvanian age strata, and about 100 feet below the Croweburg coal seam, is Mississippian age limestone. The lateral variation of the Mississippian limestone was not determined in this study.

The overburden analysis results demonstrated trends in two of the parameters that are worthy of mention here. Both the pH and neutralization potential showed an increase with depth until just above the coal or coal smut horizon. At this point the trends reversed and the pH and neutralization potential showed a decrease from the strata above the coal. Below the coal horizon the pH and neutralization potential again showed an increase with depth until just above the next coal horizon, at which point it would decrease again. This trend occurred in both borings and have been recognized in other overburden analysis of coal bearing strata that this firm has performed in other areas.

The maximum acidity potential for the overburden and the coal was determined using the total sulfur analysis and correlation. (Pyritic sulfur analyses were also performed when required on coal, underclays, gray shales, and black shales to determine the actual acidity potential.) The mathematical difference between the neutralization potential and the maximum acidity potential (or in some cases the actual acidity potential) gives the net calcium carbonate equivalent. MDNR guidelines, along with other published information define an acid forming material as that with a deficiency greater than minus 5 tons of calcium carbonate equivalent or a pH less than 4.0. The materials requiring special considerations in the reclamation operation are given in the Coal and Overburden Analysis Results in the Appendix of this report. Generally, the fissile black and dark shales above the coal seams, the coal seams, and the associated underclays have been identified as potential acid and/or toxic forming materials.

To obtain an overall assessment of the toxic and/or acidic nature of the overburden, a weighted average of the tons of calcium carbonate equivalent per 1,000 tons of material was calculated. In computing the weighted average, the coals seams were taken into consideration; however, the coal seams will be mined and the actual calcium carbonate equivalent is expected to be greater than the what has been estimated for this study. The calcium carbonate equivalent
ranged from a high of 130 tons at boring W3 (1982 location) to a low of 85 tons at boring W1. The logs of the borings are included in the Appendix of this report.

GROUNDWATER HYDROLOGY

General

The groundwater aquifers of north-central Missouri may be classified into two general groups:

1) Unconsolidated aquifers in glacial drift and alluvium
2) Consolidated, or bedrock aquifers

The unconsolidated aquifers are a moderately important source of groundwater in the area while shallow consolidated aquifers yield small supplies of moderately mineralized water and may be derived in part from the underlying Pennsylvanian age formations. Sources of water in the surficial (unconsolidated) material are as follows:

1) Perched above the modern clay subsoils
2) Perched above the paleosoils
3) Located within the glacial drift
4) Located in the buried glacial drift channel deposits
5) Located in modern alluvial channel deposits

Because of the fine grained nature of the surficial materials in northern Missouri, well yields are low in unconsolidated aquifers except where there are significant deposits of permeable materials or in buried channel deposits. In addition, the highly dissected nature of the surface topography coupled with the relatively low hydraulic conductivity and transmissivity characteristics of the glacial soils make the shallow unconsolidated aquifers highly dependent on precipitation to maintain usable quantities of water.

The hydrologic setting classification system describes the occurrence of groundwater within or adjacent to the coal seam to be mined. Factors considered in the classification system include:

1) The position of the coal bed to be mined with respect to the aquifers.
2) The geologic materials above and below the coal bed and whether they serve as aquifers or aquitards (ie. confining beds).
3) The type of aquifer, whether confined or unconfined.

In the mine plan area, the classification would be considered as HS (B2) in which the confined aquifer lies below the coal bed, and shales provide a low permeability barrier (aquitard) between the coal and the underlying aquifers (David B. Richards, U.S. Department of the Interior, 1985, "Groundwater Information Manual: Coal Mine Permit Applications -- Volume I," page 24).
Several monitoring wells were developed in each of the two watersheds located in the proposed mining area. Since the movement of groundwater is generally down dip and downstream, the wells were placed for the purpose of monitoring water as it passed through the watershed. One well was installed at the ridge-top of each watershed (wells W1 and W3) and down gradient wells were developed in the valley, below the proposed mining area (wells W2, W4, and W6). All well locations were accurately surveyed with subsequently recorded groundwater elevations being measured from ground level.

1992/1993 Data

A total of two groundwater monitoring wells, W3 and W6, were installed for the 1992/1993 baseline study to develop background quality and quantity information for the perched water in the glacial till, unconfined alluvial aquifers, and the Pennsylvanian age confined aquifer(s). All water quality analyses were performed in accordance with standard methods. The holes were drilled and logged by others and the wells were developed by others. The locations for the groundwater monitoring wells are shown on the Monitoring Location Map included in the Appendix of this report. The drill logs and well installation diagrams are included in the Appendix.

It should be noted that well W3, installed for the 1982 baseline study, was replaced for the 1992/1993 baseline study at the request of the Missouri Department of Natural Resources. This well was moved only a few feet from its original (1982) location and retained its W3 well identification number. Well W1 (1982) was destroyed and was not sampled for the 1992/1993 baseline study. Wells W2 and W4, installed in 1982, and wells W3 and W6, installed in 1992, were evaluated during the 1992/1993 baseline monitoring period.

Slug tests were used to determine the aquifer transmissivity of the soil and rock materials near the well-bore for wells W3 and W6. The Bower and Rice method was used to determine the hydraulic conductivity of the aquifers with completely or partially penetrating wells. The well development and testing was performed by a qualified engineering technician from Silver Creek Resources, Inc. that was experienced in groundwater sampling and testing.

The thickness of the aquifer at well W3 was based upon an interpolated bedrock permeable elevation of about 723 and a saturated zone from elevation 723 to 726. The thickness of the aquifer at well W6 was based upon an interpolated bedrock permeable elevation of about 769 and a saturated zone from elevation 769 to 772. Both of these wells are believed to have fully penetrated the aquifer. Slug tests revealed transmissivity values of 12.2 gallons per day per foot (gpd/ft) for well W3 and 45.6 gpd/ft for well W6. The slug tests also revealed low hydraulic conductivity values of 0.54 feet per day for well W3 and 2.03 feet per day for well W6. The specific yields cannot be determined from slug test data but are estimated at 0.003 times the hydraulic conductivity. The specific yield for well W3 is estimated to be at 0.002 for well W3 and 0.006 for well W6.

The piezometric surface of well W3 has generally increased during the 1992/1993 baseline monitoring period and follows a trend of increased precipitation and/or adjacent stream discharge. This trend agrees well with the results for the 1982 baseline study for well W3.
The piezometric surface of wells W2, and W4 remained fairly constant during both the 1982 and 1992/1993 baseline monitoring period and did not appear to be greatly influenced by increases in precipitation and adjacent stream discharge. The piezometric surface of wells W6 also remained fairly constant during the 1992/1993 baseline monitoring period. The nearly constant piezometric surface encountered in these wells reflects the minor changes in surface water levels for various flows.

The 1992/1993 baseline groundwater quality for well W2 is relatively consistent for an alluvial aquifer with relatively high hydraulic conductivities moving through alluvial silts, sands, and gravel and underlain with coal or coal smut. The pH is slightly basic, the sulfate ranges from 61 mg/l to 340 mg/l, the total dissolved solids range from 164 mg/l to 618 mg/l, the dissolved iron ranged from 0.03 mg/l to 0.43 mg/l, the dissolved manganese ranged from a low of below detection limits to 0.142 mg/l.

The 1992/1993 baseline groundwater quality for well W3 is relatively consistent for confined Pennsylvanian aquifers found in or adjacent to coal seams. The pH is slightly basic, the sulfate ranges from 404 mg/l to 625 mg/l, the total dissolved solids range from 722 mg/l to 2,030 mg/l, the dissolved iron ranged from 0.01 mg/l to 0.15 mg/l, the dissolved manganese ranged from a low of 0.004 mg/l to 0.319 mg/l.

The 1992/1993 baseline groundwater quality for well W4 is relatively consistent for an alluvial aquifer with relatively high hydraulic conductivities moving through alluvial silts, sands, and gravel. The pH is slightly basic to acidic, the sulfate ranges from 100 mg/l to 250 mg/l, the total dissolved solids range from 458 mg/l to 519 mg/l, the dissolved iron ranged from 0.01 mg/l to 0.03 mg/l, the dissolved manganese ranged from a low of 0.016 mg/l to 2.125 mg/l. The elevated manganese level was encountered only once in this well. All other manganese levels measured in this well during the 1992/1993 baseline period remained fairly constant. The single elevated manganese reading is believed to be an anomaly and not representative of the levels normally encountered in this aquifer.

The 1992/1993 baseline groundwater quality for well W6 is relatively consistent for confined Pennsylvanian aquifers found in or adjacent to coal seams. The pH is slightly basic, the sulfate ranges from 210 mg/l to 775 mg/l, the total dissolved solids range from 405 mg/l to 1,952 mg/l, the dissolved iron ranged from a low of below detection limits to 0.73 mg/l, the dissolved manganese ranged from a low of below detection limits to 0.277 mg/l.

1982 Data

A total of four groundwater monitoring wells, W1, W2, W3, and W4, were installed to develop background quality and quantity information for the perched water in the glacial till, unconfined alluvial aquifers, and the Pennsylvanian age confined aquifer(s). The holes were drilled and logged under the supervision of personnel from this firm. The wells were developed by others. The locations for the groundwater monitoring wells are shown on the Groundwater Monitoring Well Map included in the Appendix of this report. The drill logs and well installation diagrams are included in the Appendix.
Slug tests were used to determine the aquifer transmissivity of the soil and rock materials near the well-bore. The Bower and Rice method was used to determine the hydraulic conductivity of the aquifers with completely or partially penetrating wells. This method requires estimation of the aquifer thickness and an impermeable level or location of an underlying aquitard. The well development and testing was performed by a qualified engineering technician from this firm that was experienced in groundwater sampling and testing.

The thickness of the aquifer at well W1 was based upon an interpolated bedrock impermeable elevation of about 775 and a saturated zone from elevation 775 to 782. The thickness of the aquifer at well W2 was based upon an interpolated bedrock impermeable elevation of about 726 and a saturated zone from elevation 726 to 729. The thickness of the aquifer at well W3 was based upon an interpolated bedrock impermeable elevation of about 723 and a saturated zone from elevation 723 to 727. Well W4 was not installed the entire length of the aquifer - in this case, to the bedrock surface; therefore, only partial penetration of the aquifer was achieved. Wells W1, W2, and W3 pierced the entire length of the aquifer.

The piezometric surface of wells W1 and W3 has generally increased during the 1982 baseline monitoring period and follows a trend of increased precipitation and/or adjacent stream discharge. Slug tests revealed transmissivity values of 9.1 gallons per day per foot (gpd/ft) for well W1 and was not calculated due to the wells slow recovery in W3. The slug tests also revealed low hydraulic conductivity values of 1.53 feet per day for well W1 and was not calculated for well W3 due to its low transmissivity. The specific yields cannot be determined from slug test data but are estimated at 0.003 times the hydraulic conductivity. The specific yield for well W1 is estimated to be at 0.005 for well W1 and was not calculated for well W3.

The piezometric surface of wells W2 and W4 remained fairly constant during the 1982 baseline monitoring period and did not appear to be influenced by increases in precipitation and/or adjacent stream discharge. Slug tests revealed transmissivity values of 19.6 gpd/ft for well W2 and 101.8 gpd/ft for well W4. The slug tests also revealed high hydraulic conductivity values of 3.85 feet per day for well W2 and 21.5 feet per day for well W4. The specific yield cannot be determined from slug test data but are estimated at 0.003 times the hydraulic conductivity. The specific yield for well W2 is estimated to be at 0.012 and 0.065 for wells W2 and W4, respectively.

The baseline groundwater quality for well W1 is relatively consistent for perched water found in glacial soils and near the soil/bedrock interface where the bedrock is comprised of a mixture of shale and limestone. The pH is near neutral and ranges from slightly acidic to slightly basic, the sulfate ranges from 1,666 mg/l to 2,437 mg/l, and the total dissolved solids range from 3,748 mg/l to 4,307 mg/l. The total dissolved solids decreased when the neighboring stream discharge increased over the 1982 baseline monitoring period. The sulfate levels tended to decrease over the 1982 baseline monitoring period. The dissolved iron ranged from a low of 0.05 mg/l to 1.29 mg/l.

The baseline groundwater quality for well W2 is relatively consistent for an alluvial aquifer with relatively high hydraulic conductivities moving through alluvial silts, sands, and gravel and underlain with coal or coal smut. The pH is neutral to slightly acidic, the sulfate
ranges from 106 mg/l to 414 mg/l, and the total dissolved solids range from 353 mg/l to 969 mg/l. The total dissolved solids and sulfate levels when neighboring stream discharge increased over the 1982 baseline monitoring period. The dissolved iron ranged from a low of 0.05 mg/l to 1.38 mg/l.

The baseline groundwater quality for well W3 (1982) is relatively consistent for confined Pennsylvanian aquifers found in or adjacent to coal seams. The pH is slightly basic, the sulfate ranges from 493 mg/l to 722 mg/l, and the total dissolved solids range from 1,287 mg/l to 1,519 mg/l. The total dissolved solids, sulfate, and dissolved iron remained fairly constant throughout the 1982 baseline monitoring period.

The baseline groundwater quality for well W4 is relatively consistent for an alluvial aquifer with relatively high hydraulic conductivities moving through alluvial silts, sands, and gravel. The pH is slightly neutral to basic, the sulfate ranges from 119 mg/l to 231 mg/l, the total dissolved solids range from 384 mg/l to 510 mg/l. The total dissolved solids and sulfate levels remained fairly constant throughout the 1982 baseline monitoring period. The dissolved iron ranged from a low of 0.10 mg/l to 0.62 mg/l.

Summary

Wells W2, W3, and W4 were evaluated during both the 1982 and the 1992/1993 baseline study period. The results from these evaluations indicate that the trends noted to occur in the 1982 baseline monitoring period tended to hold true for the 1992/1993 baseline monitoring period. These continued trends indicate, that even though mining has occurred on neighboring property in the same watershed, little or no effect was noted to occur in the groundwater quality.

The Pleistocene soils and Pennsylvanian age bedrock formations contain relatively few aquifers capable of satisfying water use requirements. The glacial till has a relatively high clay content and the underlying rock are primarily comprised of fine grained marine shales, both of which are poor aquifers. In addition, the underclays beneath the coal seams impede the vertical movement of groundwater. The shallow, unconfined, alluvial aquifers may be capable of satisfying water use requirements during periods of normal or heavy precipitation; however, due to the limited size of the watersheds, water quality and availability will decrease in dry periods. Laboratory summaries and graphical correlations are presented in the Appendix.

The Mississippian bedrock aquifer lies beneath the entire region and is a significant aquifer in the entire mine area. According to Hydrology of Area 38, Western Region, Interior Coal Province - Iowa and Missouri, "The Mississippian aquifer has the best potential for development where it forms the bedrock surface or where the overlying Pennsylvanian rocks are relatively thin. Wells completed in or near these areas of recharge typically have greater yields and less mineralized water. Generally, yields are greater in carbonate rocks where the fissure system is well developed whether near the surface or at depth."

The publication continues to read, "Concentrations of dissolved solids average 3,140 mg/l in water from wells completed in the Mississippian aquifer. The median pH was 7.2 and the average alkalinity was 345 mg/l. Sulfate concentrations ranged from 6.8 to 2,660 mg/l. Sulfate
and sodium are the dominant ionic species as they comprise 27 to 40 percent of the total solute concentration from a typical well."

**SURFACE WATER HYDROLOGY**

The modern drainage system of northern Missouri more or less parallels the buried pre-glacial channels. Surface water infiltrating into upland soils tends to perch on clay-rich subsoils, where most seeps move laterally until reaching shallow upland modern drainages in the form of springs. The buried pre-glacial channels are in turn recharged by the infiltration from modern drainages as well as ascension from underlying consolidated aquifers.

The surface water hydrologic monitoring network consists of data collection stations and are depicted on the Monitoring Location Map. A total of six stream monitoring stations were established within, and down-gradient of, the proposed permit area for the 1982 baseline study and include stations S1, S2, S3, S4, S5, and S6. A total of ten stream monitoring stations have been established within, and down-gradient of, the proposed permit area for the 1992/1993 baseline study and include 1982 baseline stations S1, S2, S3, S4, and S5 (note that S6 was excluded) and new stations S7, S8, S9, and S10. Stations S1, S2, S3, and S7 will not receive drainage from the mine plan area. Water quality flow data collected from stations S1, S2, S3, and S7 has been used to evaluate baseline conditions for flow entering the proposed mine permit area. Stream stations S4, S5, S6, S8, S9, and S10 were used to evaluate water quality flow data downstream from, and as the surface water corridors pass through, the mine plan area. the Stream data from the nine data collection points was collected from April 1982 to August 1982 and from October 1992 to the present and included flow measurements and procuring "grab" samples for laboratory analyses. Stream stations were used primarily to monitor base flow, low flow, and high flow conditions. The primary receiving stream in the proposed permit area is Silver Creek, Coal Creek, and an unnamed tributary to Silver Creek.

There are two continuous record and four partial record stream gauging stations north of the Missouri River and relatively near the mine plan area. The two continuous record stations are on the Chariton River near Prairie Hill and on the Elk Fork Salt River near Paris. Drainage areas for these two stations are 1,870 square miles and 262 square miles, respectively. The 7 day low flow for the Elk Fork Salt River is only 0.3 cubic feet per second (cfs) for recurrence intervals of 2 years and zero for large return periods. For the Chariton River near Prairie Hill which has a drainage area about 100 time larger than the study area, the 2 year 7 day flow is only 21 cfs. Therefore, it is probable that all of the baseline stream station sites will not have flowing water for periods of 7 days or more in periods of normal or less than normal precipitation. It is also unlikely that flow rates exceeding 0.5 cfs will occur at stations S6 and S9 on Silver Creek for the same period.

Flood flows for 2, 5, 10, 25, 50, and 100 year frequencies have been calculated for stations S1, S2, S4, S5, S6, S7, and S8. The equations used for these calculations are included in the Appendix. The flood flows at station S6 are about five times the flow at stations S2 and S4 due to the increased size of the drainage area.
The interaction of the surface water of surface water with groundwater can be interpreted by examining the base flow parts of the flow-duration curves, which indicates the percentage of time that stream flow was equaled or exceeded. The flow duration curves represent low and base flow duration at both USGS gaging stations on the Chariton River, the nearest continuous record gaging station to the proposed mine permit area. To compensate for the differences in the drainage area size, unit discharge was calculated for each of the USGS stations using DNR-GLS Water resources Report 20 titled Low Flow Characteristics of Missouri Streams. Unit discharge is the stream flow divided by the drainage area. Base flow at 90 percent flow duration is 0.007 cfs/mi² and 0.013 cfs/mi² for the Novinger and Prairie Hill gaging stations, respectively. The steep slopes of the unit discharge curves for both stations indicate little base flow, and that the stream respond mainly to storm runoff.

Dr. Wayne Pettyjohn with Oklahoma State University has recently developed a model that uses stream hydrograph separation techniques to estimate the effective groundwater recharge rates. For the study area, the effective recharge rate is defined as the total quantity of water that originates from downward infiltration to the groundwater surface and eventually finds its way to a nearby stream. Effective recharge is less than the total annual recharge due primarily to evapotranspiration. The program plots a stream hydrograph, separates it by three different methods, and produces flow-duration curves and a variety of tables.

The daily discharge for water years 1986 through 1991 were obtained for the Huntsville USGS gaging station on the Elk Fork Chariton River. The three hydrograph separation techniques, fixed interval, sliding interval, and local minima, generally produce two calculations that are similar while the third may be substantially different. The two similar methods were used for each year to calculate and average the groundwater discharge, the groundwater recharge, and the percent of groundwater contributing to the stream discharge. A table showing these values is included in the Appendix. The table shows that most of the flow in the Silver Creek basin is derived from groundwater discharge; however, slug tests in the unconfined aquifers exhibited low hydraulic conductivities and transmissivities indicating that the groundwater flow into the creek is negligible as opposed to flow occurring during storm runoff.

The nine baseline stream stations have monitored high, low, and average flows and the stations are situated in large, medium, and small watersheds. In general, the surface water quality is dependent upon seasonal (climatic changes), the drainage area, and flow variations. Laboratory summaries and graphical correlations are presented in the Appendix. A discussion of these variances follows:

1. pH. The pH varied between 6.8 and 8.2 at all of the stream stations indicating a slightly (basic/acidic) condition. The pH appeared to be influenced more by the seasonal weather changes than by the stream flow.

2. Total Dissolved Solids (TDS). The concentrations of TDS generally varied from 100 to 756 mg/l. In general, as the flow increased at each of the stations, the TDS decreased.

3. Total Suspended Solids (TSS). The concentration of TSS generally varied
from 2 to 1,405 mg/l. As expected, the TSS escalated as the stream flow increased and accelerated erosion in the watershed.

4. **Sulfate.** The concentration of sulfate generally varied from 4 to 400 mg/l. In general, as the flow increased the sulfate level decreased.

5. **Acidity.** The acidity level varied from -165 milligrams calcium carbonate per liter (mg CaCO₃/l) to 94 mg CaCO₃/l. Generally, the acidity increased at all stations during the winter months.

6. **Alkalinity.** The alkalinity level varied from 59 mg CaCO₃/l to 224 CaCO₃/l. Generally, the alkalinity decreased during the summer months in the smaller watersheds and the alkalinity increased with decreased flow in the larger watersheds.

7. **Dissolved Iron.** The concentration of dissolved iron was less than 1.68 mg/l. In the small watersheds, the dissolved iron level decreased with an increase in flow. In the larger watersheds, the dissolved iron increased with an increase in flow.

8. **Dissolved Manganese.** The concentration of dissolved manganese was less than 2.080 mg/l. In the small watersheds, the dissolved manganese level decreased with an increase in flow. In the larger watersheds, the dissolved manganese increased with an increase in flow. The source of the elevated manganese measured in samples retrieved from baseline stream station S2 is believed to be from the unreclaimed abandoned mine lands located immediately west of this if this stream station.

Two surface water impoundments identified as the north pit and south pit have been sampled and tested for identical water quality parameters as the previously mentioned stream samples. The two surface water bodies are final pits from Yates Energy and Development, Inc. The results from these analyses are enclosed with this report.

**IDENTIFICATION OF PROBABLE HYDROLOGIC CONSEQUENCES**

The baseline conditions have been assessed to identify the probable hydrologic consequences that mining and reclamation activities will have upon the hydrological regime.

**Surface Water**

Based on the results of baseline stream data as well as the watershed characteristics, it is our prediction that if NPDES limitations are met at the source discharge points as required by the present statutes, the following effects will occur prior to reclamation bond release.

1. The 7 day low flow for recurrence intervals of 2 years will be zero for all of the baseline stream stations monitored during this study. During
periods of low flows, the receiving streams will be impacted with higher concentrations of sulfate, manganese, and iron; however, the quality should remain well below the "maximum allowable levels" for the metals and sulfate, and the total suspended solids should actually decrease as surface water control structures are constructed in the proposed mine permit area.

2. Base flows are not expected to exceed, but may decrease from, the present estimated flow of 0.007 cfs/mi² during mining and reclamation activities due to the construction of diversion and detention structures for storm water management. Base flows will decrease somewhat during mining and reclamation activities since the contributions from groundwater sources will decrease slightly from its present value of 89 percent; however, the base flows should return to their original values soon after final reclamation. The estimated peak flows at the stream stations are not expected to change significantly for similar reasons.

3. The average monthly water quality data obtained at stream station S5 provides the best indication of the predicted water quality since it is monitoring post mining conditions from two previously mined areas. This stream station shows little, if any, change between 1982 baseline data and the 1992/1993 baseline data other than that attributed to stream flow levels and seasonal variations. Based upon an evaluation of the baseline data obtained at stream station S5, it is estimated that the pH values at stream stations S4, S5, and S9 should show a slight decrease to values ranging from about 7.0 to 7.5; the total suspended solids and dissolved solids should remain about the same; the dissolved iron and manganese concentrations should increase slightly during mining, but should return to pre-mining levels after reclamation; the sulfates should increase to about the 100 to 250 mg/l range. The alkalinity should decrease slightly and the acidity should increase slightly, but overall, the water will remain alkaline. Trends for seasonal variations in water quality should not differ from baseline conditions.

4. The cumulative impact on the Silver Creek stream basin is based on average water quality data from stream station S5, located downstream from two existing, but now closed and reclaimed, surface mines (the reclaimed mines are located east of the mine plan area and are, for the most part, topographically down-gradient from the site) and comparing it to water quality data from stream station S7, located upstream from any existing surface mines. The baseline data at stream station S5 was obtained during both the 1982 and the 1992/1993 collection periods and stream station S7 during the 1992/1993 collection period. No appreciable difference was noted when evaluating the 1982 versus 1992/1993 baseline data for stream station S5. Baseline data for stream station S7 is similar to baseline data obtained at stream station S5 over the same baseline
period. The fluctuations noted in the baseline data appears to be related to flow levels and seasonal variations.

5. Runoff from the proposed mine permit area will remain relatively consistent with what presently drains from the site. A slight increase in runoff will result from the newly reclaimed area prior to establishing a good vegetative cover, but the increase is not expected to noticeably affect the hydrologic regime of the entire site.

6. The reclamation activities, which include storm water management, are expected to decrease the erosion of surficial soils. Applying the Universal Soil Loss equation to the present topography and composition of the proposed mine permit area leads to an expected yield of about 23 tons per acre per year. Upon reclamation, with flatter slopes, the energy absorbing ground cover, and storm water management, the expected yield should reduce to about 16 tons per acres per year.

**Groundwater**

Based on the results of overburden analyses, the local geology, and groundwater information produced during the baseline monitoring period, it is our prediction that if generally accepted mining and reclamation practices for the State of Missouri are followed, these effects on the groundwater will occur:

1. Generally, the quality and quantity of groundwater in the Pennsylvanian and Quaternary aquifers will be influenced more by the seasonal variations in precipitation than the mining and reclamation operations. The well tests indicate that the disturbed aquifers in the proposed mine permit area will first experience an increase in transmissivity and storativity due to the random particle size distribution. Past experience with other mines in the vicinity and under similar mining conditions indicate that, with time, the flow of the subsurface water carrying fine clays and silts will have a tendency to fill the flow paths, thus reducing all of the original coefficients by a factor of about 10.

2. Infiltration into the groundwater regime will be slow during early plant production stages because the new vegetative cover will not be sufficient to hinder surface water runoff. As the vegetative cover matures and land conservation measures such as diversions, grass waterways, and surface ponds slow surface runoff, the shallow aquifers should be recharged to present mining availabilities.

3. The projected variations in groundwater quality for the consolidated aquifer is based upon the baseline data obtained from wells W2, W3, and W4. An evaluation of the baseline data shows that the trends noted to occur in the 1982 baseline monitoring period tended to hold true for the
1992/1993 baseline monitoring period. These continued trends indicate, that even though mining has occurred on neighboring property in the same watershed, little or no effect was noted to occur in the groundwater. Based upon this evaluation, minor changes in the groundwater contained in the confined aquifer may occur during mining and reclamation activities but the long-term effects should be minimal, if any.

4. The projected variations in groundwater quality for the unconsolidated aquifer is based upon the baseline data obtained from wells W2, W3, and W4. An evaluation of the baseline data shows that the trends noted to occur in the 1982 baseline monitoring period tended to hold true for the 1992/1993 baseline monitoring period. These continued trends indicate, that even though mining has occurred on neighboring property in the same watershed, little or no effect was noted to occur in the groundwater. Based upon this evaluation, minor changes in the groundwater contained in the unconfined aquifer may occur during mining and reclamation activities but the long-term effects should be minimal, if any.

Water Supply

The water user survey did not reveal any wells drawing water from the Pennsylvanian aquifer near the proposed mine permit area and no wells within the proposed permit area. The majority of the groundwater users are drawing there water from cisterns and shallow wells. The low transmissivity of the Quaternary aquifer and low permeability of the Wheeler and Croweburg underclays give little chance for migration of contaminates to nearby wells.

No groundwater users draw their supply from depths exceeding the Pennsylvanian system. Should mining operations affect groundwater supplies of users, an alternate supply of groundwater could be provided with the Mississippian, or deeper aquifers which mining activities will not affect with their operations. Another alternative would be for Silver Creek Resources, Inc. to furnish potable water service via the local rural water district system.
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CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT
SILVER CREEK RESOURCES - 1993-01 PERMIT APPLICATION

GEOGRAPHIC AND GEOLOGIC SETTING

CLIMATE

The total annual precipitation is approximately 37.4 inches. Of this, 24
inches, or 65%, usually falls from April through September. The average
seasonal snowfall is 27 inches. The greatest snow depth at any one time was 19
inches. In winter, the average temperature is 28 degrees, and the average
daily minimum temperature is 20 degrees. In the summer, the average
temperature is 74 degrees; and the average daily maximum temperature is 85
degrees. The prevailing wind is from the south/southwest. Average wind
speed is highest, 12 miles per hour, in the spring.

TOPOGRAPHY AND DRAINAGE

Randolph county is physiographically located in the Dissected Till Plains.
These flat to gently rounded plains are composed of loess covered hills and
glacial tills deposited during several glacial episodes in the Pleistocene.
Regionally, elevations range from about 650 feet to about 800 feet above mean
sea level. The major stream valleys are approaching grade, beginning to widen
their channels and have many youthful v-shaped gullies as tributaries. The
mine plan area, totalling 392 acres is located just inside the area outlined in
Hydrology of Area 38, Western Region, Interior Coal Province, Iowa and
Missouri, included in this document. The mine plan area is drained by portions
of Silver Creek and Coal Creek watersheds which flow north and northwest.
Turner Fork joins further north from the mine plan area. Silver Creek then
flows west into the East Fork of the Chariton River. The East Fork of the
Chariton River then flows south and slightly west into the Missouri River.

SOILS CHARACTERISTICS AND VEGETATION

Soils in the permit area include the Calwood silt loam (2-5% eroded), Gorlin silt
loam (5-9% eroded), Gosport silt loam (14-30% eroded), Keswick silt loam (9-20%
eroded), Leonard silt loam (2-6% eroded), Mexico silt loam (1-4%), Moniteau silt
loam (0-3%), and Wilbur silt loam (0-1%). The uses for these soils include prime
farmland, cropland, pasture, woods, and wildlife habitat. Prime farmland soils
include Calwood Silt Loam, Mexico Silt Loam, Moniteau Silt Loam, Wilbur Silt
Loam, and Leonard Silt Loam. These soils make up about 25% of the soils in the
mine plan area. The vegetation of the mine plan area in the premine state
consists of approximately 42 acres of cropland and 85 acres of pasture with 223
acres of woodland.

GEOLOGY

Structurally, Randolph county is bounded by the College Mound-Bucklin
anticline to the northeast and the Salisbury-Quitman anticline to the south and
west. The College Mound-Bucklin anticline is terminated at its southern end in
the headwaters of the Elk Fork River. This structure has a gentle northeast
limb and a slightly steeper southwest limb. The strike is northwest with a gentle northwest plunge. The Salisbury-Quitman anticline is located between the Chariton River and the East Fork of the Chariton River, underlying the town of Salisbury. This structure is present only in the Pennsylvanian strata. Regionally, as a result of the Ozark Uplift, the dip is to the northeast and is approximately 2 to 3 feet per mile.

Quaternary System

Unconsolidated sediments present in the general stratigraphic section include Holocene (alluvium) and Pleistocene (glacial drift and buried channel deposits) aged strata. Alluvial fill consists of clay, sand and gravel, grading from fine to course grained with increasing depth and are from 0 to 150 feet. The yields of this unit increase with increasing amounts of gravel and sands in the deposits. Tributaries supply sufficient water for domestic and farm use of 10 to 3000 gallons per minute. These are recharged by precipitation and by infiltration from the streams. Aquifers are thinnest near the edges of the valley and thicker near the center of the valley. The well yields are sufficient to supply cities and irrigation in some areas and domestic users elsewhere in the region. Glacial drift deposits consist of clay, silt, sand and gravel and are the most widespread of the Quaternary aquifers. Glacial deposits range in thickness from zero in the southeast where erosion has removed the deposits to 400 feet in the northwest part of the state.

Maximum thickness of these deposits is located where valleys are filled in with glacial debris. These units yield water in sufficient quantities (on an average 0-10 gallons per minute, but has been noted as high as 25 gallons per minute) for domestic and farm use. Buried channel deposits occur near or below alluvial aquifers. Sand and gravel are the major deposits in this type of aquifer and are as much as 50 feet thick. Wells completed in the buried channel yield as much as 1000 gallons per minute to individual wells and, in some places, can yield sufficient water to supply small cities and domestic needs in most areas and are primarily from buried river valleys. The potentiometric surface in the aquifer (which can be either water table or artesian) is affected by the regional topography. Recharge is by direct precipitation, and discharge is into the major river systems in northern Missouri.

Pennsylvanian System

Generally, the consolidated stratigraphic section regionally consists of (in descending order) Pennsylvanian (Virgilian, Missourian, and Des Moinesian Series). Marmaton and Cherokee Groups of the Des Moinesian Series are principal coal bearing units. The deposits which form the limestone, shale, sandstone, siltstone, claystone and coal are marine and nonmarine and result from cyclic changes in ancient sea shoreline. The entire Pennsylvanian Systems ranges in thickness from 0 to 1800 feet. Visual observations have determined that very little if any water seeps from highwalls. There are water users in the area which use the shallow water to wash cars once per month. Water production from this strata is used mainly for domestic use and is mainly from sandstone formations. However, this is very rare. Water from this strata is excessively mineralized and yields from 0 to 10 gallons per minute. The
large shale content of most Pennsylvanian rocks greatly impedes the flow of
ground water vertically; thus, the Pennsylvanian probably is a confining bed
atop the relatively permeable Mississippian aquifer. Well yields from the area
other than the permit area, in the thicker parts of the aquifer, or where the
aquifer occurs near the surface, greater wells yields (20 to 100 gallons per
minute) have been noted. Recharge to the aquifer is from precipitation that
falls on the areas of the outcrops, as well as percolation of water through
overlying sediment. The Pennsylvanian rocks lie unconformably on the
Mississippian rocks.

Mississippian, Devonian and Silurian Systems

Mississippian age rocks (Meramecian, Osagean, and Kinderhookian Series) are
the primary bedrock formations in the permit area. Meramecian aged rocks
range in thickness from 0 to 350 feet. The Meramecian Series generally
contains sufficient interbedded shale to make the series incapable of yielding
water in large quantities. Osagean aged rocks and the upper two limestone
formations from the Kinderhookian Series (Sedalia and Chouteau) are from 0 to
310 feet thick and yield adequate water (5 to 15 gallons per minute for domestic
and farm use. This strata is considered to be the Mississippian aquifer.
Upper Devonian strata, including the Louisiana Limestone, Grassy Creek Shale
and Snyder Creek Formation (composed of shale and limestone) along with the
lower Kinderhookian Series strata (Hannibal Shale and Kinderhook Shale are
considered to be one hydrologic unit in that they have the same water bearing
properties.) This hydrologic unit is considered to be a confining layer
throughout much of northern Missouri. It eventually thins to the south. This
unit ranges in thickness from 0 to 280 feet. The middle and lower
undifferentiated geologic units of the Devonian, as well as the Silurian are
composed of limestone and dolomite. They are not considered to be important
as an aquifer, but are considered to be part of the upper confining bed as is
the Ordovician aged Maquoketa Shale.

The Mississippian aquifer is generally confined above and below by shales and
cays. The approximate thickness of the aquifer is between 150 and 600 feet.
Some gypsum and anhydrite beds occur locally in upper parts of the
Mississippian aquifer above the shale zone. Dissolution of these minerals affect
the quality of the water. Wells completed in or near areas of recharge usually
have greater yields and less mineralized water. Generally, yields are greater
in carbonate rocks where the fissure system is well developed. Local ground
water flow system direction appears to be coincident with topographic
contours.

Ordovician and Cambrian Systems

The Maquoketa Shale (Upper Ordovician in age) ranges in thickness from 0 to
150 feet. It is composed of shale and is considered to be the confining layer in
the extreme east along the Mississippi River. The Kimmswick Limestone
(composed of dolomite and limestone) yields water generally sufficient for
domestic supplies, approximately 5 to 10 gallons per minute. The Decorah
Formation, Plattin Limestone, Joachim Dolomite (all consisting of dolomite and
shale) all are considered to possess similar water bearing properties. Each
formation contains limited sources of water. Locally, they may be confining layers. The St. Peter Sandstone and Everton Formation are considered to possess similar water bearing properties. These strata are composed of sandstone and dolomite. Yields from these aquifers range from 25 to 75 gallons per minute. The water is excessively mineralized in the north. Most of the uses for this water are for domestic, farm and small industry. The Lower Ordovician strata is represented by the Powell, Cotter and Jefferson City Dolomite. These strata are composed of dolomite and are considered unimportant as an aquifer, but may produce sufficient water locally for domestic and farm use. Yields range from 0 to 25 gallons per minute. The Roubidoux Formation, Gasconade and Gunter Sandstone Member are considered to possess similar water bearing properties. These strata are composed of sandstone. Yields range from 50 to 500 gallons per minute. These strata provide water for municipal, industrial and irrigation uses. The Eminence Dolomite and Potosi Dolomite (within the upper Cambrian system) are considered to possess similar water bearing properties. These strata are composed of dolomite. Yields from these strata range from 440 to 1,100 gallons per minute are capable of providing water for large cities, industry and irrigation. The middle and lower Ordovician Series and the upper Cambrian strata are considered to be the Cambrian-Ordovician aquifer and range in thickness from 0 to 1300 feet. The Derby-Doe Run Dolomite and Davis Formation range in thickness from 20 to 300 feet. They are composed of shale and dolomite. Recharge to the Cambrian-Ordovician aquifer system in this region is almost always from percolation of water through overlying rocks. The direction of ground water flow for the Cambrian-Ordovician aquifer generally would be to the northwest. The Derby-Doe Run is considered to be a confining layer in northern Missouri. The Bonnetteer Dolomite and the Lamotte Sandstone range in thickness from 0 to 700 feet. Little information is available regarding the hydrologic capabilities of these strata. There may be some production from the Lamotte sandstone.

The Precambrian is composed solely of igneous rocks and is considered to be an unimportant source of water.

GEOLOGY OF PERMIT AREA

In the permit area, the Quaternary System is present in the form of glacial till deposits from the Kansas and Nebraskan glacial episodes. It generally consists of one or more distinct layers of sandy or silty clay containing random, unconnected sand and gravel lenses.

The Pennsylvanian System is present as well. Locally, the Little Osage formation is missing. Beneath this, the Blackjack Creek formation is present. It is not present in all drillholes, however, possibly due to an erosional unconformity at its upper surface. Beneath the Blackjack Creek formation is the Excello formation. It is present in only those holes that contain the Blackjack. The Excello formation is an undifferentiated shale in the permit area. The Mulky coal seam present to the east is absent in isolated spots in the permit area. The Lagonda formation is consistent across the permit area. The Bevier formation is present as black shales and the Bevier coal seam at its base. The coal seam averages 1.5 to 2 feet thick. Underlying this is the
Verdigris formation. The Wheeler coal seam is located at the top and is mined in tandem with the Bevier coal seam. The Wheeler coal seam is .75 to 1.25 feet thick. The Bevier-Wheeler coal seam is present across the entire permit area. Underlying the Wheeler is an underclay (.5 feet thick and is present across the entire permit area), the Ardmore limestone member (composed of three limestone stringer beds), a lower black shale, and the Croweburg formation. The Croweburg formation is present occasionally in the area. It consists of the Croweburg coal seam and a lower shale member. None of the strata underlying the Wheeler will be disturbed during the mining process.

SURFACE COAL MINING

Coal in the Chariton River Basin, Randolph County, is extracted by surface mining methods. Topsoil is removed from areas in advance of overburden removal and stockpiled for later use in reclamation. After removal of the topsoil, overburden is blasted and removed in a long trench by a truck and shovel and front end loader operation down to the coal. The coal is then ripped and removed by front end loaders. Thickness of the coal at the existing mine for the Bevier-Wheeler coal seam generally ranges from 2 to 3.25 feet. The overburden ranges in thickness from 66 to 100 feet. After removal of the coal, a second trench is dug adjacent to and parallel with the first trench. The overburden removed from the second trench is placed in the first trench. This continues across the area to be mined until the last trench is dug. The final trench is usually filled with water, forming a final cut lake. Mined areas are backfilled with overburden material from areas being mined, recontoured to the approximate original contour, and revegetated.

ANTICIPATED MINING

There are no other surface coal mine operators planning to mine in the adjacent areas to the proposed mine plan area located in the Silver Creek Basin. Silver Creek Resources currently has no other permits submitted for review.

EXISTING MINES

Currently (1993), there are no active permits operating in the Silver Creek watershed. The proposed permit is located just upstream of the confluence between Silver Creek (composed of a 23 square mile watershed) and the Coal Creek (composed of a 3.1 square mile watershed). There is approximately 493 acres of prelaw disturbance within the Silver Creek watershed. Yates Coal Company mined 398 acres, and Universal Coal Company mined 95 acres of land in Silver Creek Basin. The Abandoned Mined Land (AML) Section of the Land Reclamation Program is presently reclaiming portions of the old Yates permit. The goal is that, once Silver Creek Resources completes mining and reclamation of this area and once the AML Section completes their reclamation, the area will once again be aesthetically pleasing and productive land.

CUMULATIVE IMPACT AREA

The Cumulative Impact Area (CIA) was determined using the procedures outlined in the OSMRE draft document, "Guidelines for Preparation of a CHIA."

(107)
The total area permitted by Silver Creek Resources is approximately 392 acres located in Sections 4 and 9, Township 52 N, Range 15 W, and Sections 33 and 34, Township 53 N, Range 15 W, Randolph county, Missouri. The Bevier and Wheeler coal seams will be mined with approximately 1 million tons of coal being removed during the permit term. The permit area is located in the watershed of Silver Creek, which is a tributary to the Chariton River Basin. The Chariton River constitutes a portion of the Missouri River Basin. The Silver Creek is classified as a Type C stream, meaning it ceases flow during drought periods, but maintains permanent pools which have aquatic life.

SURFACE WATER CUMULATIVE IMPACT AREA

Criteria

The Draft CHIA Guidelines suggest that spatially remote mining operations can be excluded from a surface cumulative impact area using criteria specifically defined for that purpose.

The Surface Water Cumulative Impact Area has been determined to be that area which drains above and below the permit area, as identified on the accompanying map. The entire affected watershed encompasses approximately 47.5 square miles and includes the majority of the Silver Creek watershed. The first cumulative impact boundary determination was placed at the mouth of Silver Creek just before it enters the East Fork of the Chariton River. An assumption was made that a discharge value of 7 mg/L of iron from the mine site would be used to evaluate this CIA boundary. The mass balance equation (using the regression equation for average flow for northern Missouri) was used to determine the impact. A concentration of .48 mg/L was obtained. This number is well below the material damage criteria of 1 mg/L.

The second cumulative impact boundary determination was placed just below the mouth of the Turner Fork tributary along Silver Creek at site S-9. Again an assumption was made that 7 mg/L of iron discharged from the mine site. The mass balance equation was used to determine the impact. A concentration of 1.25 mg/L was obtained. This value exceeds the material damage criteria of 1 mg/L. The initial cumulative impact boundary determination will be utilized, since the end value was below the material damage criteria of 1 mg/L. It is at this point that there will be negligible impact to the downstream water. The downstream limits of the surface water Cumulative Impact Area has been placed at the mouth of Silver Creek (at the point where Silver Creek enters the East Fork of the Chariton River). A monitoring point will be established by the permittee at this site. The surface water CIA was delineated to include the total drainage area of the Silver Creek, Coal Creek, and Turner Fork.

GROUND WATER CUMULATIVE IMPACT AREA

Criteria

The impact of mining and associated activities on any local aquifers has been identified as a very minor concern in this assessment as a result of the findings of the water user survey study, watershed locations, and the hydrogeologic
baseline information as provided below. Some of the water users in the Yates area are in a separate watershed from the proposed permit area. Other users are located within the same watershed as the permit area, but are upgradient from the permit boundary. In all instances, it has been determined that none of the water users will be affected in terms of quantity or quality based on the location and depth of the wells or cisterns.

Regionally, the Cambrian-Ordovician and Mississippian aquifers are hydrologically separated from the strata being impacted by mining according to Imes (1985). Imes stated that the large shale content of most Pennsylvanian rocks greatly impedes the flow of ground water; thus, the Pennsylvanian is probably a partially confining bed atop the Mississippian aquifer. Because of this, the impact of mining and associated activities on regional aquifers has been identified as a minor concern in this assessment.

Because of the above rationale, a Ground Water CIA boundary will not be evaluated. The accompanying maps delineate the outline of a hypothetical Ground Water Cumulative Impact Area if one were to be evaluated and the general flow direction (north) of the ground water. The rationale for the location of the Ground Water CIA boundary is as follows: As the geology of the this region generally speaking has little dip, the affected strata crop out in a predicted pattern coincident with topographic lines. The outcrops of the affected strata are considered or assumed to be the locations where the ground water is "discharging," thus, contributing to the surface water flow. The potentiometric ridge of the Ground Water Impact Area (which forms the boundaries) is also considered to be the surface watershed boundary.

BASELINE HYDROLOGIC CONDITIONS

GROUND WATER

Baseline hydrologic conditions within the CIA were determined in accordance with OSMRE's Draft Guidelines For Preparation of a Cumulative Hydrologic Impact Assessment. "Baseline conditions" here refer to the state of the hydrologic balance of the proposed permit area prior to the proposed mining. Two sets of sample data were used. The baseline years for the CHIA were 1982 and 1992.

There were a total of 4 wells which were used for PHC and CHIA purposes. The information from Well W-6 was used in order to determine alluvial aquifer characteristics. Well W-2 was used in order to determine the aquifer characteristics for glacial till, unconfined alluvial aquifers. Well W-3 was used in order to determine the aquifer characteristics for the Pennsylvanian aquifer. This well is 71.5 feet deep and has an approximate transmissivity of 12.2 gpd/ft for unconfined conditions. The potentiometric map shows the water head of the local aquifers for the most part. This map is based mainly on water levels in wells open in the local aquifers.

As indicated above, 4 wells were installed to establish ground water quality and static water level for Permit 1993-01. The following describes the water quality from these wells.
<table>
<thead>
<tr>
<th>Well #1</th>
<th>Average</th>
<th>(5 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static water level</td>
<td>25.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total dissolved solids</td>
<td>4031.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td>2243</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved iron</td>
<td>.344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved manganese</td>
<td>N.A.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well #2</th>
<th>Average</th>
<th>(8 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static water level</td>
<td>8.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total dissolved solids</td>
<td>660.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td>272.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved iron</td>
<td>.624</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved manganese</td>
<td>.074</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well #3</th>
<th>Average</th>
<th>(18 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static water level</td>
<td>61.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total dissolved solids</td>
<td>1225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td>550.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved iron</td>
<td>.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved manganese</td>
<td>.088</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well #4</th>
<th>Average</th>
<th>(5 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static water level</td>
<td>7.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total dissolved solids</td>
<td>465.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td>161.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved iron</td>
<td>.136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved manganese</td>
<td>.456</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SURFACE WATER

The lack of aquifers capable of storing large volumes of water result in no appreciable baseflow in the local streams. As a result, stream flow reflects the rainfall events, with the storm runoff providing the majority of the stream flow. The base flow from Silver Creek is low from October through March. During the period from April to September, the flow is greater as a result of heavy rainfall. The 7 day Q 10 is zero for the tributaries within and outside of the permit area as well as for Silver Creek.

There were no surface water monitoring sites set up for the watersheds which will not be impacted by surface mining, and no information is available for these watersheds. For purposes of the Cumulative Hydrologic Impact Assessment and mass balance equation, an assumption was made that this water quality was equivalent to, or no worse than, that water from the watershed monitored by surface water monitoring station #9.

Six sampling points were selected by Silver Creek to establish baseline water quality for this permit. Site 8 was chosen to sample runoff and assess the baseline water quality located upstream of the mining activity. Sites 2, 4, 8, 9, and 10 (as well as additional locations not listed here) were chosen to assess impacts of mining through the life of the mining operation. Site 11 will be established immediately downstream in order to monitor water quality or quantity impact downstream from the mine site. This is to be located at the mouth of Silver Creek.

The water quality from site #8 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(5 samples)</td>
</tr>
<tr>
<td></td>
<td>mg/l</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>1.2 cfs</td>
</tr>
<tr>
<td>pH</td>
<td>7.11</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>343.2</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>44</td>
</tr>
<tr>
<td>Sulfate</td>
<td>155.2</td>
</tr>
<tr>
<td>Dissolved iron</td>
<td>.114</td>
</tr>
<tr>
<td>Dissolved manganese</td>
<td>.348</td>
</tr>
</tbody>
</table>

As can be seen by this data, the water is below the Clean Water Commission limits for all the parameters listed. This baseline information also shows that
the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of dissolved iron and manganese that are below water standards.

The water has a good pH, possibly due to the dilution effect and the natural alkalinity of the water. The water from this point flows north along Silver Creek.

The water quality from site #2 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (12 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>4.77 cfs</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.14</td>
<td></td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>471.6</td>
<td></td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>69.8</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>204.5</td>
<td></td>
</tr>
<tr>
<td>Dissolved iron</td>
<td>.148</td>
<td></td>
</tr>
<tr>
<td>Dissolved manganese</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen by this data, the water is below the Clean Water Commission limits for all the parameters listed. This baseline information also shows that the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of dissolved iron and manganese that are below water standards.

The water has a good pH, possibly due to the dilution effect and the natural alkalinity of the water. The water from this point flows north along Coal Creek. It then enters Silver Creek.

The water quality from site #4 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average (6 samples)</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>2.7 cfs</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.38</td>
<td></td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>403.9</td>
<td></td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>76.35</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>165.9</td>
<td></td>
</tr>
<tr>
<td>Dissolved iron</td>
<td>.245</td>
<td></td>
</tr>
<tr>
<td>Dissolved manganese</td>
<td>.17</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen by this data, the water is below the Clean Water Commission limits for all the parameters listed. This baseline information also shows that the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of dissolved iron and manganese that are below water standards.
The water has a good pH, possibly due to the dilution effect and the natural alkalinity of the water. The water from this point flows north and east through the proposed permit area along an unnamed tributary to Silver Creek.

Both this watershed and the watershed being monitored by Site #2 (Coal Creek) contain abandoned mine spoil. The surface water quality is surprisingly good, knowing there are abandoned mine lands here.

The water quality from site #10 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>0.6 cfs</td>
</tr>
<tr>
<td>pH</td>
<td>7.3</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>368.8</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>97.6</td>
</tr>
<tr>
<td>Sulfate</td>
<td>141.36</td>
</tr>
<tr>
<td>Dissolved iron</td>
<td>.086</td>
</tr>
<tr>
<td>Dissolved manganese</td>
<td>.211</td>
</tr>
</tbody>
</table>

As can be seen by this data, the water is below the Clean Water Commission limits for all the parameters listed. This baseline information also shows that the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of dissolved iron and manganese that are below water standards.

The water has a good pH, possibly due to the dilution effect and the natural alkalinity of the water. The water from this point flows southwest along Turner Fork. It then enters Silver Creek.

The water quality from site #9 is as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>2.09 cfs</td>
</tr>
<tr>
<td>pH</td>
<td>7.22</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>376.8</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>77.2</td>
</tr>
<tr>
<td>Sulfate</td>
<td>162.2</td>
</tr>
<tr>
<td>Dissolved iron</td>
<td>.098</td>
</tr>
<tr>
<td>Dissolved manganese</td>
<td>.306</td>
</tr>
</tbody>
</table>

As can be seen by this data, the water is below the Clean Water Commission limits for all the parameters listed. This baseline information also shows that the waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of dissolved iron and manganese that are below water standards.
The water has a good pH, possibly due to the dilution effect and the natural alkalinity of the water. The water from this point flows west along Silver Creek.

Charts in Appendix A have been included showing the relationship between flow and the parameters listed above. As can be seen from the comparison between water quantity and flow, in some instances, lower total dissolved solids and lower sulfate concentrations occur during high flow periods. In contrast, higher total suspended solids, in some cases, occur during high flow periods.

IDENTIFICATION OF HYDROLOGIC CONCERNS

OSMRE's Draft CHIA Guidelines require identification of the hydrologic concerns that will be addressed by the assessment, the specific indicator parameters that will be used to measure and evaluate the concerns (with respect to water uses and the sites at which the parameters will be evaluated). The hydrologic concerns for this assessment were identified from the permit application, from the U.S.G.S. publications Hydrology of Area 38, Western Region, Interior Coal Province, Kansas and Missouri, and the Missouri Water Quality Standards. The receiving stream, Silver Creek, is classified as a Type C stream. (A Class C stream is a classification which means that the streams may cease flow in dry periods, but maintain permanent pools which support aquatic life.) The primary uses for Silver Creek are for livestock and wildlife watering and protection of aquatic life. The water quality standards used below were designed to ensure that discharge of water from the permit areas will not degrade the quality of receiving waters downstream. This is the rationale behind the use of some of the NPDES, EPA, and Water Pollution Control Program regulation criteria.

CONCERNS RELATED TO SURFACE WATER HYDROLOGY

The following surface water concerns have been raised and will be addressed in this assessment:

1. Potential impacts to surface water quality due to changes in dissolved iron and dissolved manganese.

2. The hydrologic concerns for Silver Creek primarily involve the 1) changes in the chemical composition of stream flow due to the addition of acid mine drainage (iron, manganese), and 2) disturbances of overburden due to mine excavation may increase the availability of some chemical constituents that cause deleterious effects in water (iron, manganese, possibly causing deleterious effects in water used for livestock and wildlife watering and aquatic life water uses).

3. Potential impacts to surface water quantity, especially flooding risk due to increased peak flows from the mining area during storm events at site CIA boundary.
CONCERNS RELATED TO GROUND WATER HYDROLOGY

The impact of mining and associated activities on the aquifers have been identified as a very minor concern in this assessment as a result of the findings of the water user survey study and the hydrogeologic baseline information provided in the PHC and this CHIA.

1. Potential impacts to the ground water quantity due to the proximity of mining to nearby active water wells will be negligible based on the fact that the transmissivity of the aquifers is very small, plus there are no water users locally or regionally that could be impacted as a result of the water user survey.

2. Potential impacts to ground water quality (dissolved iron, dissolved manganese) due to the infiltration of potentially impacted ground water into active water wells nearby will be negligible based on the lack of water users surrounding the permit area, plus the fact that there are no active wells nearby that could potentially be impacted as a result of the water user survey.

MATERIAL DAMAGE CRITERIA

Regulation 10 CSR 40 6.050(9) requires the Missouri Land Reclamation Program authority to assess cumulative hydrologic impacts in order to determine whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area. This is done by estimating impact magnitudes and comparing them to the appropriate threshold levels that indicate the occurrence of material damage to the hydrologic balance. These threshold values, which indicate the impact level at which material damage to the hydrogeologic balance may occur, are called material damage criteria.

The Draft CHIA Guidelines give the following definition for material damage: "Material damage to the hydrologic balance means, with respect to the CHIA, the changes to the hydrologic balance caused by surface mining and reclamation operations to the extent that these changes would significantly affect present and potential uses as designated by the regulatory authority." Hydrologic balance is defined by 30 CFR 701.5 as the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as drainage basin, aquifer, soil zone, lake or reservoir. It encompasses the dynamic relationship among precipitation, run-off, evaporation and change in ground and surface water storage." For purposes of the CHIA, the above definition will be used. The protection of present and potential water uses will be incorporated into this CHIA.

The CHIA is based on the best currently available data and is a prediction of mining related impacts on the hydrologic balance. To assure that the predictions in the CHIA are consistent with the actual on-the-ground conditions, Silver Creek Resources is required to monitor water quality and quantity as part of the permit requirements.

The material damage criteria were established at magnitudes above which damage to the hydrologic balance would be indicative of an economic loss to the
current and potential water users or would result in significant reduction of the capability of an area to support aquatic life, livestock, and wildlife communities.

RATIONALE FOR MATERIAL DAMAGE CRITERIA

PARAMETERS FOR SURFACE WATER QUALITY AND QUANTITY

The material damage criteria in this CHIA concentrates on changes of surface flow rates and their chemical composition that would physically affect the off-permit hydrologic balance as it presently affects livestock and wildlife watering and protection of aquatic life. In order to assess the material damage potential of changes to these elements of the hydrologic system, some of the following indicator parameters were selected for evaluation at each evaluation site. Further, the following are brief rationale for the selection of each parameter and its limiting values and descriptions for selection of the criteria used for each parameter:

Annual Flow Volumes:

The mean annual flow volume of flow was selected as the most meaningful indicator parameter for water quantity.

Sediment Load

Sediment is a common constituent of stream flow. The quantity of sediment in the flows affects the identified uses of the streams in this watershed and especially to existing aquatic and wildlife communities. Missouri Clean Water Commission has no standards for aquatic life, livestock, and wildlife watering for this parameter. However, based on the background baseline information, this data indicates that preexisting baseline concentration of suspended solids upstream from the proposed permit area on Silver Creek could get as high as 220 mg/l during peak flow. For streams of this character, the limit to be used will be the 220 ± 10%.

Dissolved Iron

Dissolved iron has been found to be toxic to fish at concentrations of 0.9 mg/l as well as smothering fish eggs and bottom dwelling fish food organisms. Missouri Clean Water Commission standards for the protection of aquatic life is 1 mg/l. There are no standards for wildlife and livestock watering. The standards of 1 mg/l ± 10% will be used for the material damage criteria.

Dissolved Manganese

Dissolved Manganese is not considered to be a problem for aquatic life (in fresh waters) and livestock and wildlife watering. Tolerance values range from 1.5 mg/l to over 1000 mg/l. The Missouri Clean Water Commission has no primary standards for aquatic life, livestock, and wildlife watering for this analyte. However, there is a secondary water quality standard for drinking water supply of .05 mg/l for aesthetic reasons (rather than health reasons). Baseline information shows that waters from unaffected watersheds of this permit area and adjacent areas have natural occurrences of manganese that are above the secondary drinking water standards. After discussions with the
Clean Water Commission, it was determined that the largest value of manganese, or 2.15 mg/l ± 10%, will be used for the standard for this CHIA.

**Sulfate**

Sulfate ion occurrences are common in streams which receive drainage from surface coal mined areas. This parameter is highly indicative of the quality of water running off these disturbed areas. Once pyritic materials are oxidized, one of the end products is the sulfate ion. Missouri's standards for this parameter (this standard is for sulfate and chloride combined; typically chloride occurs in very minor amounts) for the protection of aquatic life is 1000 mg/l. According to 10 CSR 20.7.031(4)(L)1, "Streams with seven (7) day Q10 low flow of less than (1) cubic foot per second...The concentration of chloride plus sulfate shall not exceed 1000 mg/l at this flow." This limit will be used.

**Total Dissolved Solids**

Total dissolved solids are common in streams which receive drainage from surface coal mined areas. This parameter is highly indicative of the quality of water running off these disturbed areas. The Missouri Clean Water Commission has no standards for total dissolved solids for livestock and wildlife watering or for the protection of aquatic life. Based on the background baseline information, this data indicates that the preexisting baseline concentration of total dissolved solids downstream from the proposed permit area on Silver Creek could get as high as 1070 mg/l during low flow. For streams of this character, the limit to be used will be 1070 mg/l. Since this parameter is not included as a parameter for any water use, this will not be used to determine hydrologic impact from this proposed permit.

**pH**

The parameter pH, the negative log of the hydrogen ion concentration, when present in large concentrations, will result in acid mine drainage and fish kills under certain conditions. The Missouri Clean Water Commission's standards are 6.5 to 9.0. The NPDES limits allow pH values of 6.0 to 9.0. EPA's 1976 Water Quality Criteria limits suggest pH values of 6.5 to 9.0. The standard of 6.0 to 9.0 for pH will be used for the materia damage criteria for this CHIA.

**Parameters for Ground Water Quantity and Quality**

The material damage criteria in this CHIA concentrates on any changes of ground water flow rates and their chemical composition that would physically affect the off-permit hydrologic balance as it presently affects livestock and wildlife watering and protection of aquatic life. As discussed earlier, concerns related to ground water hydrology, as well as material damage criteria for ground water, is a very minor concern as a result of the water user survey findings and the hydrogeologic baseline information. Therefore, material damage criteria can be designed to limit changes in the present discharge regime to magnitudes which would not cause economic loss to existing livestock, wildlife, or aquatic life. It is the determination here that potential
water quality contamination is extremely unlikely at this proposed permit site. Because of this, no parameters for ground water quantity and quality are proposed.

MATERIAL DAMAGE CRITERIA

As discussed earlier, surface water concerns have been identified as topics for CHIA evaluation. The surface water concerns will be evaluated at the mouth of Silver Creek just before it enters the East Fork of the Chariton River.

MATERIAL DAMAGE CRITERIA FOR SURFACE WATER

<table>
<thead>
<tr>
<th>Concerns</th>
<th>Parameters for Criteria</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>aquatic life</td>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td></td>
<td>iron</td>
<td>1 mg/l + 10%</td>
</tr>
<tr>
<td></td>
<td>sulfate</td>
<td>1000 mg/l</td>
</tr>
<tr>
<td>livestock/wildlife/watering</td>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td></td>
<td>iron</td>
<td>1 mg/l + 10%</td>
</tr>
<tr>
<td></td>
<td>sulfate</td>
<td>1000 mg/l</td>
</tr>
<tr>
<td></td>
<td>manganese</td>
<td>2.15 mg/l + 10%</td>
</tr>
<tr>
<td></td>
<td>total suspended solids</td>
<td>220 ± 10%</td>
</tr>
</tbody>
</table>

ANALYSIS OF CUMULATIVE HYDROLOGIC IMPACTS

SURFACE WATER IMPACTS - QUALITY

The greatest impact to water based on the results below would be expected to occur during low flow periods, generally for all parameters (except total suspended solids). At these times, the amount of dilution will be at a minimum.

IMPACTS ON WATER QUALITY PARAMETERS AT WATER STATION SW-05 AT DIFFERENT FLOW CONDITIONS

<table>
<thead>
<tr>
<th>Total Dissolved Solids</th>
<th>Dissolved Iron</th>
<th>Dissolved Manganese</th>
<th>pH</th>
<th>Sulfate</th>
<th>Total Suspended Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
</tr>
</tbody>
</table>

Low Flow

The seven day Q10 low flow on the proposed permit area on Silver Creek is zero (0). In using the Mass Balance Equation, the use of zero (0) would yield the

(118)
same or an undefined meaningless number. Because of this, the calculations below represent a ballpark figure only. However, in consideration of the existing low flow data, the following conditions may result:

<table>
<thead>
<tr>
<th></th>
<th>Prevailing</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>544</td>
<td>1067</td>
</tr>
<tr>
<td></td>
<td>0.48</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>1.09</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>7.12</td>
<td>7.44</td>
</tr>
<tr>
<td></td>
<td>286.4</td>
<td>721.3</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>5.96</td>
</tr>
</tbody>
</table>

Mean Flow

<table>
<thead>
<tr>
<th></th>
<th>Prevailing</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>377.4</td>
<td>377.6</td>
</tr>
<tr>
<td></td>
<td>.111</td>
<td>.110</td>
</tr>
<tr>
<td></td>
<td>.338</td>
<td>.336</td>
</tr>
<tr>
<td></td>
<td>7.21</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td>70.86</td>
<td>161.5</td>
</tr>
<tr>
<td></td>
<td>72.9</td>
<td>72.9</td>
</tr>
</tbody>
</table>

High Flow

<table>
<thead>
<tr>
<th></th>
<th>Prevailing</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>245.5</td>
<td>245.5</td>
</tr>
<tr>
<td></td>
<td>.0239</td>
<td>.0239</td>
</tr>
<tr>
<td></td>
<td>.078</td>
<td>.065</td>
</tr>
<tr>
<td></td>
<td>7.99</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>65.15</td>
<td>65.24</td>
</tr>
<tr>
<td></td>
<td>219.9</td>
<td>205.4</td>
</tr>
</tbody>
</table>

As demonstrated above, the anticipated water quality (as a result of the surface coal mining of Silver Creek Resources) has not exceeded the material damage criteria standards.

SURFACE WATER IMPACTS - QUANTITY

In order to assess the effects of mining on flows at the CIA, synthetic hydrographs were developed for three different watershed configurations. First, to represent a premining condition, the entire watershed of 30,400 acres is assumed to have a Runoff Curve Number (CN) of 74 and an average land slope of 6%. Second, to represent the absolute maximum effects of unregulated mining, the entire permit area is assumed to be disturbed (CN = 100) and there are no sediments ponds. Third, to represent the minimum effects of super regulated mining, the runoff from the permit area is assumed to be confined by an impoundment that allows no runoff (CN = 0) and there are no sediment ponds. The actual effects of mining would be between the extremes of the second and third case. The peak flows for the three cases were calculated for a 2 year - 24 hour type II storm of 3.5 inches. As seen on the following table, the maximum change in peak flow is only about 7%. This difference is not significant in hydrologic modeling routines. Even if it were considered significant, it would only result in a 0.3 foot lowering of the crest at the CIA boundary. The 2.4% increase would only result in a 0.09 foot raising of the crest at the CIA boundary. There is no significant change to surface water quantity at the CIA boundary due to surface mining on this permit.

<table>
<thead>
<tr>
<th>RAINFALL EVENT</th>
<th>PREMINE PEAKFLOW</th>
<th>MAX-MINING NO SED POND</th>
<th>MIN-MINING 100% SED POND</th>
<th>MAXIMUM DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>cfs</td>
<td>cfs</td>
<td>cfs</td>
<td>%</td>
</tr>
<tr>
<td>3.5</td>
<td>3137</td>
<td>3211</td>
<td>2903</td>
<td>7.5</td>
</tr>
</tbody>
</table>
FINDINGS

Based upon the findings contained within this CHIA, it is the recommendation of the Missouri Land Reclamation Commission that the probable hydrologic impacts of all anticipated coal mining in the general area on the hydrologic balance has been designed to prevent damage to the hydrologic balance outside of the proposed mine plan area.
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SILVER CREEK RESOURCES
SURFACE WATER LOCATION S-6

FLOW
PH
TDS
TSS
SO4

DATE
04/28/82
06/09/82
07/12/82
09/01/82
28/09/82
26/09/82
07/09/82
05/09/82
03/09/82
01/09/82

1000 100 10 1 0.1 0.01