RECLAMATION RESEARCH IN NORTH DAKOTA

PART B

RESEARCH PUBLICATION BRIEFS

GEOLOGY AND HYDROLOGY (GH)

Title: **A GEOLOGIST'S VIEW OF STRIP MINING**

Author: E.A. Noble

Organization: University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Some Environmental Aspects of Strip Mining in North Dakota (M.K. Wali, ed.), pp. 53-60. North Dakota Geological Survey Educational Series 5, 1973

Key Index Words: Geology, Geohydrology, Hydrogeochemistry, Mining Impacts,

Brief Description

This paper presents the geologist's view of surface mining as a unique but relatively minor disturbance of a small portion of the earth's surface with minor changes in topography and regional ground water flow. The author believes that the geochemical and other effects of mining would eventually be mitigated. The needs and problems of surface mining in western North Dakota and the adequacy of the reclamation efforts are discussed.

Analysis of Conclusions

Research conducted subsequent to the publication of this paper has revealed that surface mining can cause several hydrogeochemical and hydrological problems which can be prevented only by careful planning and implementation of mining and reclamation techniques.

Title: **POTENTIAL IMPACT OF LARGE - SCALE STRIP MINING ON GROUNDWATER SUPPLIES IN WESTERN NORTH DAKOTA**

Authors: G.H. Groenewold, S.R. Moran, and C.A. Anderson

Organization: North Dakota Geological Survey and University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 29(1):11, 1975

Key Index Words: Geology, Geohydrology

Brief Description

In this presentation, four potential modifications of groundwater supplies, which may result from large-scale lignite development in western North Dakota, were discussed. An overview of the problems was presented and studies underway in areas of proposed development were explained.

Analysis of Conclusions

These research findings have been greatly elaborated in subsequent work of similar nature.

Title: **GEOLOGY OF THE NORTH BEULAH, CENTER, AND GLENHAROLD LIGNITE MINES IN MERCER AND OLIVER COUNTIES, SOUTHWESTERN NORTH DAKOTA**

Author: R.E. Kulland

Organization: University of North Dakota, Grand Forks, ND

Format: Thesis

Reference: M.S. Thesis, University of North Dakota, Grand Forks, ND, 1975

Key Index Words:

Brief Description

Document was not available for review.

Analysis of Conclusions

Analysis of conclusions was not possible.

Title: **PROBABLE CAUSES OF SURFACE INSTABILITY IN CONTOURED STRIP MINE SPOILS**

Authors: G.H. Groenewold and L.M. Winczewski

Organization: North Dakota Geological Survey and University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 31(1):10, 1976

Key Index Words: Geology, Subsidence, Surface Instability

Brief Description

This presentation dealt with a preliminary reconnaissance of existing graded strip mine spoils in western North Dakota. This was done to identify the various geological and engineering problems which exist within these materials. The problems include differential subsidence of the surface of the spoil, slope instability, and piping features.

Analysis of Conclusions

Research along these lines has been greatly advanced by the subsequent work by the senior author.

Title: **DEVELOPMENT OF A PRE-MINING GEOLOGICAL FRAMEWORK FOR LANDSCAPE DESIGN RECLAMATION IN NORTH DAKOTA**

Authors: S.R. Moran, G.H. Groenewold, L.A. Hemish, and C.A. Anderson

Organization: North Dakota Geological Survey and University of North Dakota, Grand Forks, ND.

Format: Report

Reference: North Dakota Geological Survey Miscellaneous Series No. 55, 1976

Key Index Words: Geology, Geohydrology, Mining Impact

Brief Description

This report discusses the conceptual framework for reclamation in light of the possible impacts of mining on groundwater quality and agricultural productivity. Preliminary data are presented to highlight the implications of mining and reclamation on the hydrologic and hydrogeochemical properties of the reclaimed land and their features of instability.

Analysis of Conclusions

This and subsequent studies along similar lines have advanced our understanding of the geological factors considerably. Continued research in this area is essential.

Title: **CHEMICAL AND BACTERIOLOGICAL ANALYSES OF STREAM SEDIMENTS IN THE KNIFE RIVER BASIN OF NORTH DAKOTA**

Authors: M.C. Bromel and K. Johnson

Organization: NDSU-Department of Microbiology

Format: Report

Reference: Report prepared for Office of Research and Development, US Environmental Protection Agency, Washington, DC 66 p.

Key Index Words: Surface Hydrology, Water Quality, Microbiology

Brief Description

A base line study was conducted of the chemical and bacteriological quality of the stream and mine impoundment waters and sediments in the Knife River Basin of North Dakota. This study, including the impact analyses of present strip mining of coal deposits on water quality, will provide a comparison for future assessments of stream quality under expanded coal production and coal conversion activities.

Analysis of Conclusions

The baseline data obtained on the chemical and bacteriological quality of the stream, mine impoundments, and sediments will be useful for future comparisons.

Title: **WESTERN NORTH DAKOTA LIGNITE STRIP MINING PROCESSES AND RESULTING SUBSURFACE CHARACTERISTICS**

Author: L.M. Winczewski

Organization: Department of Geology, University of North Dakota, Grand Forks, ND

Format: Thesis

Reference: M.S. Thesis, University of North Dakota, 432 p., 1977

Key Index Words: Geology, Geohydrology

Brief Description

The research reported in this thesis was undertaken to study the subsurface geologic characteristics both before and after strip mining using current techniques. The groundwater recharge and flow through mined areas was also studied.

Analysis of Conclusions

This thesis is very useful for understanding some geologic and hydrogeologic impacts of surface mining in North Dakota.

Title: **GEOLOGY, GROUNDWATER HYDROLOGY ANDHYDROGEO-CHEMISTRY OF A PROPOSED SURFACE MINE AND LIGNITE GASIFICATION PLANT SITE NEAR DUNN CENTER, NORTH DAKOTA**

Authors: S.R. Moran, J.A. Cherry, P. Fritz, W.M. Peterson, M.H. Sommerville, S.A. Stancel, and J.H. Ulmer

Organization: North Dakota Geological Survey; Department of Earth Sciences, University of Waterloo, Waterloo, Ontario; and Engineering Experiment Station, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Geological Survey Report of Investigation No. 61, 1978

Key Index Words: Geohydrology, Hydrogeochemistry, Coal Gasification

Brief Description

The objective of this study was to describe the subsurface hydrological and hydrochemical regime in the area of a proposed coal mining area near Dunn Center, North Dakota. Several geologic test holes were drilled and logged, and core samples were taken from selected holes. Nests of observation wells were installed for water level monitoring, water sampling and permeability testing. Laboratory analyses were conducted on the core samples. This study resulted in a detailed description of geological and hydrogeochemical properties of the study area.

Analysis of Conclusions

Should mining be proposed for the area included in this study, this report contains ample information to allow a detailed analysis of possible effects on the groundwater supplies of the area.

Title: **GEOLOGIC, HYDROLOGIC, AND GEOCHEMICAL CONCEPTS AND TECHNIQUES IN OVERBURDEN CHARACTERIZATION FOR MINED LAND RECLAMATION**

Authors: S.R. Moran, G.H. Groenewold, and J.A. Cherry

Organization: Alberta Research Council, Edmonton, Alberta, Canada; North Dakota Geological Survey, Grand Forks, ND; Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, Canada

Format: Report

Reference: North Dakota Geological Survey Report of Investigation, No. 63, 1978

Key Index Words: Geology, Geohydrology, Hydrogeochemistry, Mining Impacts

Brief Description

The objective of this study was to evolve techniques for the identification of materials which would be beneficial or deleterious to revegetation if replaced near the post-mining land surface during reclamation. In addition, an attempt was made to identify the physical and chemical interactions which control subsurface water chemistry. Field studies consisting of drill hole sampling and analyses were conducted at five (5) sites in western North Dakota. The results of this study include the development of an interpretative framework which relates pore fluid chemistry to a number of hydrogeochemical factors. In addition, the authors conclude that saturation extract tests do not provide an adequate assessment of overburden chemistry for reclamation purposes.

Analysis of Conclusions

This study was the first to propose an interpretive hydrogeochemical explanation (conceptual model) for the chemistry of post-mining groundwater which develops in surface mined landscapes. A precise quantitative relationship between overburden chemical parameters and post-mining groundwater quality remains to be developed.

Title: **HYDROLOGY OF A WATERSHED WITH SUBIRRIGATED ALLUVIAL MATERIALS IN CROP PRODUCTION**

Authors: D.J. Dollhopf, G.W. Wende, J.D. Doering, and D.W. Hadberg

Organization: Montana Agricultural Experimental Station, Montana State University, Bozeman, MT

Format: Report

Reference: Peabody Coal Contract No. 055 (1975-1979), 1979

Key Index Words: Alluvial Valley Floors, Subirrigation, Groundwater

Brief Description

This report documents the investigation of a subirrigated alluvial valley floor that is located downstream from a surface coal mining operation near Coal Strip, Montana. The major source of recharge to the alluvium was located below the coal but mining did intercept secondary sources of recharge to the alluvium. The baseline water quality in the alluvium is hard and high in TDS, but suitable for irrigation water.

Analysis of Conclusions

Since the major source of recharge is stratigraphically below the coal most of the cropland is expected to stay subirrigated during mining. But a drop in the water table level could occur which would cause a temporary decrease in crop production. In general, no definite trends or major changes were observed for either surface runoff or groundwater chemistry within the study area.

Title: **GEOLOGY AND GEOHYDROLOGY OF THE KNIFE RIVER BASIN AND ADJACENT AREAS OF WEST CENTRAL NORTH DAKOTA**

Authors: G.H. Groenewold, L.A. Hemish, J.A. Cherry, B.W. Rehm, G.N. Meyer, and L.M. Winczewski

Organization: North Dakota Geological Survey, Grand Forks, ND; Oklahoma Geological Survey, Norman, OK; Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, Canada; Minnesota Geological Survey, St. Paul, MN; and Engineering Experiment Station and Department of Geology, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Geological Survey Report of Investigation No. 64, 1979

Key Index Words: Geohydrology, Hydrogeochemistry, Stratigraphy

Brief Description

This study discusses the surface and subsurface geology, regional groundwater flow systems, chemistry and chemical evolution of groundwater in the near surface units of the Knife River Basin in west central North Dakota. Two sites outside of the Knife River Basin, the Center and Falkirk sites, are also discussed. The regional stratigraphic framework of the units overlying the Pierce Formation has been worked out based on extensive test drilling. In addition a geochemical model which attempts to account for the groundwater chemistry of the various units is proposed.

Analysis of Conclusions

The geochemical model first presented in NDGS Report of Investigation No. 63 is further refined and expanded in this study. The information presented here on the regional and local hydrogeology of the study sites provides the background information necessary to evaluate the possible hydrologic consequences of mining.

Title: **HYDROLOGIC MODELING OF COAL LANDS**

Authors: B.P. Van Haveren and G.H. Leavesley

Organization: Bureau of Land Management and USGS-Water Resources Division

Format: Report

Reference: BLM and USGS-Water Resources Division (Central Region) Report, May 1979

Key Index Words: Hydrologic Modeling, Mining Impacts

Brief Description

This report discusses development of a digital model for determining hydrologic consequences of surface mining. It describes various inputs including climate, physical characteristics, overburden, vegetation, etc. This model can apply to watersheds with limited data to assess hydrological impacts.

Analysis of Conclusions

It is our understanding that funding for this program has been discontinued. Continued funding is necessary to complete calibration of the model. This program would be extremely useful to the PSC if it were available. This is the only sophisticated technique that can be used to anticipate surface water hydrologic impacts from surface coal mining operations.

Title: **INSTABILITY OF CONTOURED SURFACE MINED LANDSCAPES IN THE NORTHERN GREAT PLAINS: CAUSES AND IMPLICATIONS**

Authors: G.H. Groenewold and B.W. Rehm

Organization: North Dakota Geological Survey and UND-Engineering Experiment Station, Grand Forks, ND

Format: Paper

Reference: Adequate Reclamation of Mined Lands? - A Symposium, pp. 2-1 to 2-15, Soil Conservation Society of America and WRCC-21, Billings, MT, March 1980

Key Index Words: Subsidence, Piping

Brief Description

The design of a stable post-mining landscape requires the knowledge of the distribution of overburden materials, proper equipment selection, and a consideration of climatic factors. There are three common forms of instability encountered in mined lands: area wide settling, localized collapse, and piping.

Analysis of Conclusions

Area wide settling is less in scraper contoured areas than in bulldozer contoured areas, particularly if contouring occurred in mid-winter. Area wide settling generally occurs during the first year after completion of contouring. Dozer contouring of frozen spoils concentrates large blocky fragments in valley areas. Settlement and thawing in areas where the frozen blocky materials have been concentrated is the cause of localized collapse. This type of instability may be avoided if dozer contouring is restricted during the winter months. Piping is controlled by a combination of physical and chemical conditions in the spoils. Piping begins as a crack that is located in areas of near surface highly dispersive sodic materials. Piping then will develop if an avenue for water is available in the subsurface such as a fracture zone. Fracturing in the subsurface is related to differential settling between areas of stable scraper contouring and unstable dozer contouring.

Title: **POTENTIAL EFFECTS ON GROUNDWATER OF FLY ASH AND FGD WASTE DISPOSAL IN LIGNITE SURFACE MINE PITS IN NORTH DAKOTA**

Authors: G.H. Groenewold, J.A. Cherry, O.E. Manz, H.A. Gullicks, D.J. Hassett, and B.W. Rehm

Organization: North Dakota Geological Survey, Grand Forks, ND; University of Waterloo, Waterloo, Ontario; University of North Dakota, Grand Forks, ND; Soil Testing Service of Minnesota, Minneapolis, MN

Format: **Report**

Reference: Symposium on Flue Gas Desulfurization, Houston, TX, October 1980

Key Index Words: Waste Disposal, Fly Ash, FGD, Groundwater

Brief Description

This paper presents a summary of the results from an investigation of the effects of fly ash and FGD waste disposal on groundwater quality at the Center Mine

Analysis of Conclusions

North Dakota lignite fly ash produces leach waters that have high pH and high concentrations of arsenic, molybdenum, and selenium. FGD waste from North Dakota lignite produces a leach water that has pH values from 7.0 to 8.5 and is high in concentrations of sulfate, magnesium, and sodium. Piezometers installed near the fly ash disposal area as well as piezometers installed in buried fly ash yield contaminated waters with high pH and high concentrations of arsenic, selenium, and molybdenum. Water from piezometers in spoil with FGD waste contained high sulfate concentrations and showed no significant concentrations of arsenic, selenium, or molybdenum. The areal extent of groundwater contaminated by FGD waste or fly ash is small but is expected to increase gradually as a result of groundwater flow and continued waste disposal.

Title: **DEPOSITIONAL SETTING AND GROUNDWATER QUALITY IN COAL BEARING SEDIMENTS AND SPOILS IN WESTERN NORTH DAKOTA**

Authors: G.H. Groenewold, B. Rehm, and J.A. Cherry

Organization: North Dakota Geological Survey; UND-Engineering Experiment Station, Grand Forks, ND; University of Waterloo, Waterloo, Ontario, Canada

Format: Report

Reference: Recent and Ancient Nonmarine Depositional Environments: Models for Exploration (F.G. Ethridge and R.M. Flores, eds.), SEPM Special Publication No. 31, 1981

Key Index Words: Groundwater, Overburden Analysis, Hydrogeochemistry

Brief Description

This report includes hydrogeochemical studies conducted at five surface mines in North Dakota. Hydrogeochemical processes include pyrite oxidation, carbonate dissolution, gypsum precipitation and dissolution, cation exchange and sulfate reduction. The key components (mineralogical variables in the sediments) are largely dependent upon fluctuations in the fluvial depositional settings of the sediments. Degradation of groundwater quality in spoils settings is dependent on mineralogical variables and the degree of weathering, dissolution, and ion exchange that takes place in the post-mine settings.

Analysis of Conclusions

The potential for weathering and the generation of elevated salinities in post-mining landscapes can be decreased by the selective emplacement of overburden materials during mining and post-mining operations. Unweathered materials should be placed at the base of the spoils (below the post-mining water table) where sulfide oxidation will be minimum. The differences in mineralogy, which is related to the depositional environments, will dictate the direction of chemical evolution the groundwater will take after disturbance. For example, the overburden at the Indian Head Mine is primarily clayey sediments deposited in a flood basin environment. The overburden at the Center Mine is predominantly sandy sediments deposited in point bar and natural levee environments. Finely disseminated pyrite is common in the reduced (flood basin) setting. Pyrite is uncommon in the coarse textured sediments. TDS values at Indian Head range as high as 15,880 mg/l which is nearly three times as high as the maximum TDS value for spoils water at Center.

Title: **PROGRESS REPORT ON THE EFFECTS OF SURFACE MINING ON THE SURFACE WATER HYDROLOGY OF THE SELECTED BASINS IN THE FORT UNION COAL REGION, NORTH DAKOTA AND MONTANA.**

Author: D.G. Emerson

Organization: United States Geological Survey (In Cooperation with U.S. Bureau of Land Management), Bismarck, ND

Format: Report

Reference: USGS Open File Report 81-678, 1981

Key Index Words: Hydrologic Modeling, Mining Impacts, Surface Water

Brief Description

This report discusses the development of a means (model) to assess the impacts on surface water hydrology due to changes in land use resulting from surface mining in North Dakota and Montana. The data collected to date and the additional information needed to complete the study are given. Data were collected from West Branch Antelope Creek study area in North Dakota since October 1976, and from Hay Creek study area in Eastern Montana since March 1978.

Analysis of Conclusions

No conclusions are drawn. Report summarizes progress made thus far on model development and data collection efforts.

Title: **WATER RESOURCES INVESTIGATIONS IN NORTH DAKOTA, 1981**

Compiled by: C.R. Martin and L.L. Albright

Organization: USGS, Water Resources Division, Bismarck, ND

Format: Report

Reference: USGS Open File Report 81-923, 1981

Key Index Words: Water Resources, Surface Water, Groundwater

Brief Description

Describes surface and groundwater investigations being conducted by the USGS. Includes county groundwater studies, aquifer evaluations, snow surveys, hydrologic changes resulting from lignite mining, hydrologic effects of strip mining at Gascoyne, etc.

Analysis of Conclusions

No conclusions have been drawn; report summaries specify progress made to date.

Title: **HYDROLOGIC CHARACTERISTICS AND POSSIBLE EFFECTS OF SURFACE MINING IN THE NORTHWESTERN PART OF WEST BRANCH ANTELOPE CREEK BASIN MERCER COUNTY, NORTH DAKOTA**

Authors: M.E. Crawley and D.G. Emerson

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: Water Resources Investigations 79-81, 1981

Key Index Words: Groundwater, Surface Water, Hydrogeochemistry, Runoff, Mine Drainage

Brief Description

The study area is the northwestern part of the West Branch Antelope Creek basin located in north central Mercer County, North Dakota. The study area encompasses 28 sq. miles. The area was selected for study because of the near future development of the lignite deposits. This document established the pre-mining conditions as a standard to evaluate any future changes to the hydrologic regime as a result of surface mining.

Analysis of Conclusions

Data available indicate that small local plumes of water rich in sodium and sulfate could result from mining along the edge of the West Branch Antelope Creek tributary. In some locations there will be movement of this enriched water toward the Antelope Creek aquifer. The potential for contamination of ground waters by toxic concentrations of trace metals for people would be small. Transport would be greatly retarded by adsorption and cation exchange and the large bicarbonate concentration in the water would produce rapid precipitation of most trace metals. The impact of the mining on the quantity and timing of runoff will probably be minor and will be dependent on mining practices. There would be major changes on small areas for short periods of time but the overall flow regime would be altered only slightly. Sediment yields will change depending on mining practices. Runoff from spoils, reclaimed areas, or both, will have increased salinity.

Title: **HYDROGEOLOGICAL AND GEOTECHNICAL PROCEDURES MANUAL FOR THE DISPOSAL OF FLY ASH AND FGD WASTE FROM LOW RANK COALS IN WESTERN STRIP MINES**

Authors: D. Daly, G. Groenewold, O. Manz

Organization: Engineering Experiment Station and MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: US DOE, Grand Forks Energy Technology Center, Bulletin No. 83-04-EES-03, 1982

Key Index Words: Fly Ash, FGD, Waste Disposal, Groundwater, Trace Elements

Brief Description

The purpose of this manual is to provide a summary of the current regulatory framework, FGD equipped power plant characteristics, and surface coal mine FGD waste disposal site operations within the western states. A set of guidelines based on geologic and hydrologic criteria is presented for use in establishing waste disposal sites within surface mines.

Analysis of Conclusions

In order to evaluate a future FGD waste disposal site, the geology and hydrogeology must be understood. Geologic characterization should consist of lithologic samples and logs accompanied by geophysical logs. This data will enable the geologist to characterize the stratigraphy, lithology, structure, and geochemical properties in the pre-mine setting. Hydrogeologic characterization should consist of gathering hydrogeologic and hydrogeochemical data for the saturated and unsaturated zones. Hydrogeological data synthesis should consist of determining groundwater flow directions, hydraulic characteristics of shallow aquifers and aquitards, position of the water table, and background water quality. Disposal site candidates are then chosen on the basis of projected post-closure water table, hydrogeologic and hydrogeochemical character of the materials below the elevation of the pit bottom, and projected character of the spoil material. The ideal natural setting would have the following characteristics: 1) semiarid to arid climate 2) low permeability spoil materials 3) significant acid/base buffering capacity in the surrounding materials

Title: **HYDROGEOCHEMICAL CONSEQUENCES OF STRIP MINING IN THE FORT UNION GROUP OF SOUTHWESTERN NORTH DAKOTA**

Author: R. Houghton

Organization: U.S. Geological Survey, Bismarck, ND

Format: Paper

Reference: Symposium on Surface Mining Hydrology Sedimentology and Reclamation, pp. 79-86; Lexington, KY, 1982

Key Index Words: Hydrogeochemistry, Water Quality, Mining Impacts

Brief Description

Since 1973 the USGS has been conducting hydrogeochemical investigations at the Gascoyne Mine in southwestern North Dakota. An increase in lignite production between 1974 and 1976 has caused degradation in quality and quantity of shallow groundwater systems. This increase in lignite production has prompted concern about the effects of mining on the quality and quantity of shallow groundwater in this semiarid part of the country.

Analysis of Conclusions

Mining increases the quantity of soluble salts available to infiltrating waters by exposing the overburden to sufficient air to oxidize all reactable forms of reduced sulfur. Also, overburden with large contents of soluble salts is placed below the water table where dissolution can occur. The water quality deterioration that is observed in saturated spoils is characterized by a 5 fold increase in dissolved solids. The deterioration in water quality may be reduced by retaining the salt rich horizons above the post-mining water table. Expanded mining along the lignite outcrop could result in a major decrease in recharge to the aquifer as a whole.

Title: **TRACE ELEMENT ENRICHMENTS IN WATERS ASSOCIATED WITH STRIP MINING OF LIGNITE IN THE FORT UNION GROUP OF SOUTHWESTERN NORTH DAKOTA**

Author: R.L. Houghton

Organization: USGS-Water Resources Division, Bismarck, ND

Format: Paper

Reference: Proceedings of Symposium on "Trace Element Mobilization in Western Energy Regions (L.P. Gough and R.C. Severson, eds.), p. 46, Colorado School of Mines Research Institute, Denver, CO, November 1982

Key Index Words: Trace Elements, Surface Water, Groundwater

Brief Description

Weathering of outcropping lignite and spoil near Gascoyne Mine have resulted in enrichment of several trace elements in local ground and surface waters. Cadmium, copper, lead, and selenium concentrations exceed recommended domestic water criteria in many parts of the lignite aquifer. Concentrations do not, however, exceed recommended levels for stockwatering.

Analysis of Conclusions

This report is the only one that indicates that concentrations of some heavy metals in ground water may be of concern in some surface mined areas in North Dakota. This report indicated the need for additional research.

Title: **THE MINERALOGY OF LOW RANK COAL FLY ASH**

Authors: G.J. McCarthy and S.J. Steinwand

Organization: Department of Chemistry, NDSU, Fargo, ND

Format: Paper

Reference: Materials Research Society, 1982

Key Index Words: Fly Ash, Mineralogy, X-ray Diffraction

Brief Description

X-ray diffraction analysis of seventy-seven specimens of fly ash have been performed at NDSU. Most of the specimen originated at low rank coal-fired power plants.

Analysis of Conclusions

The results of these analysis along with results obtained by workers at Iowa State, Penn State, Purdue and UND gives better understanding of low rank coal mineralogy.

Title: **MECHANISMS, DISTRIBUTION AND FREQUENCY OF GROUNDWATER RECHARGE IN AN UPLAND AREA OF WESTERN NORTH DAKOTA**

Authors: B.W. Rehm, G.H. Groenewold, and W.M. Peterson

Organization: North Dakota Geological Survey, Grand Forks, ND

Format: Report

Reference: North Dakota Geological Survey Report of Investigation No. 75, 1982

Key Index Words: Groundwater, Recharge, Mining Impacts

Brief Description

This study focuses on the area surrounding the Falkirk Mine near Underwood in McLean County, North Dakota. Estimates of groundwater recharge rates for 1979 were obtained using a network of piezometers and water table wells, these data were supplemented with observations on evapotranspiration rates, soil moisture changes, and stable isotope concentrations. The average rate of groundwater recharge for the year was determined along with its spatial and temporal distribution.

Analysis of Conclusions

The methods and conclusions presented herein are applicable to determining possible differences in recharge capacity between the pre- and post-mining settings.

Title: **EARTH RESISTIVITY INVESTIGATIONS IN RECLAIMED SURFACE LIGNITE MINE SPOILS**

Authors: A.E. Kehew and G.H. Groenewold

Organization: North Dakota Geological Survey, Grand Forks, ND

Format: Report

Reference: North Dakota Geological Survey Report of Investigation No. 77, 1983

Key Index Words: Resistivity, Hydrogeochemistry, Hydrology, Groundwater

Brief Description

This report describes the results of an investigation in which earth resistivity techniques were used to evaluate hydrochemical and hydrogeologic conditions on reclaimed and undisturbed sites at Falkirk, Center, and Indian Head mines in North Dakota. Resistivity can be used as a tool for evaluating groundwater degradation following mining and reclamation. Resistivity surveys show an inverse correlation between measured resistivity values and total dissolved solids content of groundwater. The higher the resistivity of the overburden materials, the better the quality of groundwater below reclaimed spoils that can be expected.

Analysis of Conclusions

This is the only study of its kind in North Dakota, which uses basic concepts to study fundamental aspects of post-reclamation groundwater quality. This study demonstrates usefulness of "remote-sensing" techniques to study groundwater.

Title: **GEOLOGICAL AND GEOCHEMICAL CONTROLS ON THE CHEMICAL EVOLUTION OF SUBSURFACE WATER IN UNDISTURBED AND SURFACE MINED LANDSCAPES IN WESTERN NORTH DAKOTA**

Authors: G.H. Groenewold, R.D. Koob, G.J. McCarthy, B.W. Rehm, and W.M. Peterson

Organization: North Dakota Geological Survey, Grand Forks, ND

Format: Report

Reference: North Dakota Geological Survey Report of Investigation No. 79, 1983

Key Index Words: Hydrogeochemistry, Groundwater, Overburden Analysis

Brief Description

The major purposes of this study were to refine the previously developed hydrogeochemical model and to determine its applicability to spoils settings. Field activities included detailed instrumentation of undisturbed and spoils settings at two mines, and laboratory work included overburden analyses, leaching, weathering, and acid-base neutralization studies. The researchers concluded that the mineralization of subsurface water in spoils settings is typically two to three times greater than in the undisturbed settings and that this highly mineralized water has the potential to impact local surface water bodies.

Analysis of Conclusions

The previously developed geochemical model to explain post-mining groundwater quality is further refined in this report. In addition several aspects of the relationship between hydrogeochemical processes and properties and various aspects of reclamation success are discussed.

Title: **DETECTION OF UNDERGROUND LIGNITE MINES BY GRAVITY SURVEYS - FINAL REPORT TO PUBLIC SERVICE COMMISSION**

Authors: W.D. Gosnold, Jr., C. Quinn, and M. Luther

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota MMRRI Bulletin No. 83-10-MMRRI-01, 1983

Key Index Words: Microgravity Surveys, AML, Underground Mines

Brief Description

This report describes the results of an investigation conducted at four abandoned mine land sites in western North Dakota to locate and map underground mine tunnels and voids using microgravity surveys

Analysis of Conclusions

Conclusions of this project indicate that gravity surveys are effective in locating underground mine tunnels. However, from a practical viewpoint, gravity surveys are best suited for areas with individual mine tunnels rather than closely-spaced mine rooms. The investigators recommended that gravity surveys be cross-checked with available drill hole data to validate interpretations of anomalies.

Title: **HYDROGEOLOGICAL AND HYDROGEOCHEMICAL DATA BASE FOR ABANDONED SURFACE MINED LANDS - PHASE I**

Authors: G.H. Groenewold, E.C. Murphy, R.D. Koob, and C.R. Schmidt

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota MMRRI Bulletin No. 83-10-MMRRI-02, October 1983

Key Index Words: Groundwater, Geohydrology, Hydrogeochemistry

Brief Description

This report describes the results of hydrogeological and hydrogeochemical investigations conducted at four abandoned lignite mined sites in western North Dakota. No significant differences in the groundwater levels and groundwater quality were observed between the disturbed and the adjoining undisturbed locations at each of the four sites.

Analysis of Conclusions

It was concluded that the lack of difference in the quality of groundwaters at disturbed and undisturbed sites was due to either attenuation caused by infiltrating waters or due to lack of leaching. It was purported that to determine the exact mechanism involved would help make proper decisions about regrading.

Title: **WATER RESOURCES DATA, NORTH DAKOTA, WATER YEARS 1982**

Authors: R.E. Harkness and N.D. Haffield

Organization: USGS Water Resources Division, Bismarck, ND

Format: Report

Reference: USGS-Water Data Report ND-82-1, 1983

Key Index Words: Water Resources, Water Quality

Brief Description

These reports provide water quality and quantity data for USGS gaging stations throughout North Dakota.

Analysis of Conclusions

Information provided is utilized by mining companies for determining hydrologic balance of streams within and adjacent to mining areas. Several monitoring stations are important to the mining companies' data collection effort.

Title: **WATER RESOURCES INVESTIGATIONS IN NORTH DAKOTA**

Compiled by: N.K. Laukford and L.L. Albright

Organization: USGS, Water Resources Division, Bismarck, ND

Format: Report

Reference: USGS Open File Report 83-220, 1983

Key Index Words: Water Resources, Surface Water, Groundwater

Brief Description

Describes surface and groundwater investigations being conducted by the Water Resources Division of USGS in North Dakota. Status reports are provided for each of the thirty-five (35) projects included in this report.

Analysis of Conclusions

No conclusions have been drawn; report summaries specify progress made to date.

Title: **DATA FROM THE SURFACE WATER HYDROLOGIC INVESTIGATIONS OF THE HAY CREEK STUDY AREA, MONTANA, AND THE WEST BRANCH ANTELOPE CREEK STUDY AREA, NORTH DAKOTA, OCTOBER 1976 THROUGH APRIL 1982**

Authors: D.G. Emerson, S.W. Norbeck, and K.L. Boespflug

Organization: US Geological Survey, Bismarck, ND (in cooperation with US Bureau of Land Management)

Format: Report

Reference: USGS Open File Report 83-136, 1983

Key Index Words: Surface Water, Hydrology

Brief Description

The report contains data on air temperature, relative humidity, wind direction, wind run, solar radiation, precipitation, soil temperature, snowpack density and water content, streamflow, water quality, soil moisture, land use, and basin characteristics of Haycreek Study Area in Montana and the west Branch Antelope Creek Study area in North Dakota.

Analysis of Conclusions

The purpose of this study was to collect and analyze hydrologic and other environmental data for selected coal deposit areas in Montana and North Dakota in response to the leasing nomination of federal coal. The study areas have high leasing potential; thus the watersheds were selected to determine the pre-mining hydrologic characteristics and provide the necessary baseline data to assess the effects of surface mining.

Title: **GROUND-WATER DATA FOR SELECTED COAL AREAS IN WESTERN NORTH DAKOTA**

Authors: J.D. Wold and S.W. Norbeck

Organization: U.S. Geological Survey in cooperation with Bureau of Land Management

Format: Report

Reference: USGS Open-file Report 83-219, 1983

Key Index Words: Ground-Water Data

Brief Description

Groundwater data is provided for the Sand Creek, Hanks, New England, Mott, Dickinson and Bowman-Gascoyne coal area, North Dakota. The report contains the following: 1) Maps showing the location of wells, springs and test holes; the location of wells and test holes where driller logs are available; the location of wells with chemical analysis; and 2) tables showing well, spring and test-hole records; logs; and chemical analysis of water. Descriptions of the location of data collection sites and methods used to collect data are included.

Analysis of Conclusions

The U.S. Geological Survey conducted a groundwater inventory in selected areas of the Fort Union coal region of Western North Dakota to provide information to the BLM as an aid in making leasing decisions. Knowledge of the pre-mining hydrologic conditions is necessary to evaluate probable impacts should mining occur in these areas of probable development.

Title: HYDROGEOCHEMICAL CHARACTERISTICS OF ABANDONED SURFACE MINES IN NORTH DAKOTA - IMPLICATIONS WITH RESPECT TO RECLAMATION

Authors: G.H. Groenewold, R.D. Koob, and E.C. Murphy

Organization North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of the National Symposium and Workshops on Reclamation of Abandoned Mine Lands, Bismarck, North Dakota, 1984

Key Index Word: AML, Groundwater, Vegetation

Brief Description

Fifty one abandoned surface mine sites were field evaluated and grouped into four generic categories based upon geological and vegetative variables. One study site was chosen as representative of each of the four generic categories. This characterization was undertaken to determine whether reclamation is appropriate or not at each type of abandoned mine site.

Analysis of Conclusions

An objective evaluation of the suitability of each generic type of abandoned mine land for reclamation will require continued research focused on the distribution of salts in the spoils and infiltration/recharge characteristics of each setting.

Title: **WATER RESOURCES DATA - NORTH DAKOTA WATER YEAR 1984**

Authors: N.D. Haffield and G.L. Ryan

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: USGS Water-Data Report ND-84-1, 1984

Key Index Words: Surface Water, Groundwater, Water Quality, Water Data

Brief Description

Water-resources data for North Dakota consists of stage, discharge, and water quality of streams; stage, contents, and water quality of lakes and reservoirs; and water levels and water quality of ground-water wells. This report contains discharge records for 108 gaging stations; stage only records for 21 gaging stations; stage and contents for 13 lakes and reservoirs; water quality for 108 gaging stations, 8 lakes, 33 wells, 2 precipitation stations; and water levels for 31 observation wells. These data represent that part of the National Water Data System operated by the U.S. Geological Survey and cooperating State, Federal, and local agencies in North Dakota.

Analysis of Conclusions

No conclusions. This is a listing of data compiled by US Geological Survey.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1984**

Authors: G.H. Groenewold

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Bulletin No. 84-10-MMRRI-01, 1984

Key Index Words: AML, Hydrology, Waste Disposal, Fly Ash, FGD Waste, Lignite Resources

Brief Description

This report summarizes the objectives and results of eleven ongoing research projects conducted at the MMRRI during July 1, 1983 to June 30, 1984. The projects include: 1) evaluation of lignite and geothermal resources, 2) reclamation of abandoned mined lands, 3) characterization, use, and disposal of power industry generated wastes, 4) overburden characterization, etc. Educational and training activities of the Institute, and a list of reports, papers, and presentations made during the report period are also included.

Analysis of Conclusions

The information contained in this report covers a wide range of research topics of practical value to the mining and power industry. However, because of the ongoing nature of most of these investigations, no final conclusions of recommendations have been given. Continued research on these projects is necessary.

Title: **HYDROGEOCHEMISTRY OF THE UPPER PART OF THE FORT UNION GROUP IN THE GASCOYNE LIGNITE STRIP-MINING AREA, ND**

Authors: R.L. Houghton, D.C. Thorstenson, D.W. Fisher, G.H. Groenewold

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: USGS Open File Report 84-131, 1984

Key Index Words: Hydrogeochemistry, Water Quality, Fort Union Group

Brief Description

This report is a continuation of studies that have been conducted by the U.S. Geological Survey at the Gascoyne Lignite Mine since 1973. This report addresses the effects on groundwater quality that will be caused by exposing the reduced sediments from below the water table to oxidating conditions in the spoils.

Analysis of Conclusions

The undisturbed aquifers within the Gascoyne Mine area are a sodium sulfate/bicarbonate type with dissolved solid concentrations ranging from 575 mg/l to 8740 mg/l. The base of the spoils resaturate quite rapidly and the ground water is degraded as compared to the pre-mine setting. Dissolved solids in aquifers reestablished in spoils range from 4,400 to 11,000 mg/l. The researches estimate that one pore volume must leach the spoils in order to return the salt levels to their premine geochemical salt balance. They estimate that the time involved to complete such leaching would approximate 120 years based on the average hydraulic conductivity and water storage of the spoils.

Title: **MINERALOGY AND LEACHING BEHAVIOR OF FIXED BED GASIFICATION ASH DERIVED FROM NORTH DAKOTA LIGNITE**

Authors: G.J. McCarthy, R.J. Stevenson and G.H. Groenewold, D.J. Hassett, R.R. Honke

Organization: Dept of Chemistry, NDSU, Fargo, ND, MMRRI, Engineering Experiment Station, Energy Research Center, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Gas Research Institute Contract, 1984

Key Index Words: Ash Mineralogy, Coal Gasification, Lignite

Brief Description

The objective of this study was to provide a detailed understanding of the chemistry, mineralogy and leaching behavior of ash from coal gasification plants. Three gasifiers were used including Great Plains Gasificiation Associates commercial facility near Beulah, ND. The gasifier had similar maximum temperatures but incorporated several differences in operating and ash handling conditions. Lignite from the same seam was gasified in all tests.

Analysis of Conclusions

None of the gasification ashes would be classified as a "hazardous waste" according to EPA standards. Several elements are present in the leaching solutions at levels above drinking and irrigation water standards, but this is not a concern for ash placed in a properly engineered disposal area.

Title: **QUALITY OF WATER FOR LIVESTOCK IN MAN-MADE IMPOUNDMENTS IN THE NORTHERN HIGH PLAINS**

Authors: M.A. Rumble

Organization: USFS - Rocky Mountain Forest and Range Experiment Station, Rapid City, SD

Format: Paper

Reference: Journal of Range Management 38(1): 74-77, 1985

Key Index Words: Impoundments, Water Quality

Brief Description

This paper discusses water quality problems of surface mine impoundments for livestock watering based on a study of twenty-seven parameters. Age of the impoundments was included for interpretive purposes. Statistical analysis was used to determine where differences among impoundment types existed.

Analysis of Conclusions

An excellent study with very useful data, as well as a recommendation to use TDS as a primary indicator of water quality for livestock.

Title: **RECONNAISSANCE MAPS TO ASSIST IN IDENTIFYING ALLUVIAL VALLEY FLOORS, WEST-CENTRAL, NORTH DAKOTA, DRAFT**

Authors: D. Nimck, R. Rasmussen, B. Rusmore, and J. Schmidt

Organization: Earth Resource Associates, Helena, Montana

Format: Draft Report

Reference: Department of the Interior, Office of Surface Mining, OSM/TM - 3/85, 1985

Key Index Words: Alluvial Valley Floors

Brief Description

The objective of this study was to identify surface irrigated and subirrigated sites in west central North Dakota. In addition, sites which meet the geomorphic criteria and have the potential to be surface irrigable were identified on the basis of regional agricultural practices. The authors emphasize that these maps represent a reconnaissance-level efforts.

Analysis of Conclusions

All irrigated and subirrigated valleys underlain by unconsolidated deposits were identified as potential alluvial valley floors. More detailed site specific data collection may indicate the lack of an alluvial valley floor due to unsuitable soils, topography, or water supply. These maps as well as the "Alluvial Valley Floor Identification and Study Guidelines" should be used when determining the presence or absence of an alluvial valley floor.

Title: **SNOWMELT TRACT-ELEMENT ENRICHMENTS IN PRAIRIE POTHOLES AND SOILS OF CENTRAL NORTH DAKOTA**

Authors: R.L. Houghton and J.E. Foss

Organization: U.S. Geological Survey, Bismarck, ND, NDSU - Soils Department, Fargo, ND

Format: Paper

Reference: National Atmospheric Deposition Program Technical Committee Meeting, October 8-11, 1985

Key Index Word: Trace Elements, Buffering Capacity, Prairie Potholes, Soil Properties

Brief Description

A discussion of the chemical consequences of a snowmelt event under both field and laboratory conditions, evaluating pH and trace element concentrations.

Analysis of Conclusions

A technical paper providing some insight into the buffering capacity of ferromagnesian minerals, removal of volatile trace-elements via adsorption, and a discussion of acidity based on rate of snowmelt and soil conditions (frozen or unfrozen).

Title: **MINERALOGY OF FIXED-BED GASIFICATION ASH DERIVED FROM NORTH DAKOTA LIGNITE**

Authors: R.J. Stevenson and G.J. McCarthy

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND, and NDSU- Department of Chemistry and Geology, Fargo, ND

Format: Paper

Reference: Presented at Materials Research Society of Boston, Dec. 1-7, 1985

Key Index Words: Coal Gasification, Fly Ash, Ash Mineralogy

Brief Description

The mineralogy of ash samples derived from North Dakota lignite and gasified in three different fixed bed producers was determined by X-ray diffraction and scanning electron microscopy. The lignite that was gasified came from the same formation but from 2 different mines separated by about 20 km. This paper presents a summary of the mineralogy of the ash samples.

Analysis of Conclusions

This and other studies have advanced our understanding of the impacts of ash disposal. Continued research in this area is necessary to evaluate the design of future ash disposal sites.

Title: **PALEOENVIRONMENTS OF THE PALEOCENE-SENTINEL BUTTE FORMATION, KNIFE RIVER AREA, WEST CENTRAL NORTH DAKOTA**

Authors: D.J. Daly, G.H. Groenewold, C.R. Schmit

Organization: North Dakota MMRRI, Univeristy of North Dakota, Grand Forks, ND

Format: Paper

Reference: Rocky Mountain Section, S.E.P.M., Denver, CO., 1985

Key Index Words: Lignite, Depositional Model

Brief Description

This paper utilizes subsurface litholoic and geophysical information to identify and study four sedimentation intervals in the Paleocene Sentinel Butte Formation of the upper Fort Union Group in West Central North Dakota. The lower Sentinel Butte is interpreted as a record of swamp (lignite components) and Pluvio-lacustrine (clastic components) conditions that alternatively dominated a broad, flat alluvial plain with drainage to the East-South-East.

Analysis of Conclusions

This paper describes the four sedimentation intervals in the lower Sentinel Butte Formation and out lines areas where further investigation is needed to develop a comprehensive depositional model for the upper Fort Union Group in the Williston Basin.

Title: **SINKHOLE DEVELOPMENT IN RECLAIMED SMECTITIC SPOIL**

Authors: M.B. Dusseault, J.D. Scott and S.R. Moran

Organization: University of Alberta and Alberta Geological Survey, Edmonton, Alta.

Format: Paper

Reference: Proceedings of the Frist Multidisciplinary Conference on Sinkholes, Orlando, FL, 1985

Key Index Words: Sinkhole, Stopping Mechanism, Subsidence, Smectitic Spoil

Brief Description

Discussion of sinkhole development on reclaimed strip mine spoil several years after leveling. Differential subsidence is described as well as mechanisms for sinkhole development. Possible mitigating procedures are also addressed.

Analysis of Conclusions

Elimination of sinkholes by filling is not difficult but the general problem of differential subsidence is the root cause and has a deleterious effect on agriculture, not only for safety concerns, but also because of ponding water with the potential for soil salinization. It is desirable to eliminate the cause rather than correct the symptoms.

Title: **ATTENUATION CAPACITY OF WESTERN NORTH DAKOTA OVERBURDEN SEDIMENTS**

Authors: D.J. Hassett and G.H. Groenewold

Organization: UND - Mining and Minerals Resource Research Laboratory, Grand Forks, ND

Format: Report

Reference: DOE Contract DE-AB18-80FC10120, 105 p, 1985

Key Index Words: Fly Ash, Waste Disposal

Brief Description

The objective of this project was to determine the cation and anion attenuation capacity of typical overburden materials from these surface mines. The sediments were evaluated in both oxidized and reduced states. The experiments were performed in which these sediments were treated with solutions of selected cations and anions at known concentrations.

Analysis of Conclusions

This and ongoing studies have advanced our understanding of the impacts of ash disposal. Continued research in this area is necessary to evaluate the design of future ash disposal sites.

Title: **HYDROLOGY OF THE WIBAUX-BEACH LIGNITE DEPOSIT AREA, EASTERN MONTANA AND WESTERN NORTH DAKOTA**

Authors: W.F. Horak

Organization: U.S. Geolgical Survey, Bismarck, ND

Format: Report

Reference: USGS Water-Resources Investigators Report 83-4157, 1985

Key Index Words: Hydrology, Wibaux-Beach Lignite Deposit, Water Resources

Brief Description

The study area encompasses the entire mineable portion of the Wibaux-Beach deposit. This area includes the Beaver Creek water course that would receive runoff from the potential mine area. Concerns for the water resources in the area prompted the study. This document established the pre-mine conditions as a standard to evaluate any changes to the system as a result of surface mining.

Analysis of Conclusions

The researchers conclude that streamflow and stream water-quality impacts can be mitigated by applying appropriate mining and reclamation techniques. Post-mining water quality within the base of the spoils is expected to increase. Potentiometric declines in the lignite aquifer is projected to be several feet up to 2 or 3 miles from the mining activity. Mining impacts on aquifers beneath the lignite are expected to be minor.

Title: **TECHNICAL BASIS FOR CODISPOSAL OF GASIFICATION AND COMBUSTION AS FROM THE PLANTS AT BEULAH, NORTH DAKOTA**

Authors: G.J. McCarthy, D.J. Hassett, O.E. Manz, G.H. Groenewold, R.J. Stevenson, K.R. Henke, and P. Kumarathasan

Organization: NDSU - Department of Chemistry, Fargo, ND, Engineering Experiment Station, MMRRI, Energy Research Center, Grand Forks, ND

Format: Paper

Reference: Materials Research Society Symposium Volume GS, 1985

Key Index Words: Fly Ash, Coal Gasification

Brief Description

The technical basis for codisposal of gasification ash from the Great Plains Gasification Associates plan, combined with cementitious "scrubber ash" and bottom ash from the adjoining Antelope Valley generating station, both located in Beulah, North Dakota, has been explored. Nine blends containing only the ashes and tap water were fabricated into cylinders and tested for compressive strength and other physical properties. A blend having the ash proportions of the two plants was tested for leachability with respect to several regulated and minor elements. Mineralogical characterization by XRD and SEM was performed on the individual waste solids and the cured mixes. Most of the blends had compressive strengths greater than 400 psi after 7-day/38°C and 28-day/21°C curing. Leaching behavior, evaluated by the EPA-EP and ASTM tests, was determined for As, Se, B, V, Mo, Ba, Sr, and K.

Analysis of Conclusions

In addition to ash proportions, curing conditions (T, pH_2O, time) and water to solid ratio appear to be key parameters in obtaining well-consolidated and lower leachability products.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1985**

Authors: North Dakota MMRRI staff

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Annual Report, 1985

Key Index Words: AML, Hydrology, Waste Disposal, Fly Ash, FGD waste, Lignite Resources

Brief Description

This report summarizes the objectives and results of fifteen ongoing research projects conducted at the MMRRI during July 1, 1983 to June 30, 1984. The projects include: 1) evaluation of lignite and geothermal resources, 2) reclamation of abandoned mined lands, 3) characterization, use, and disposal of power industry generated wastes, 4) overburden characterization, etc. Educational and training activities of the Institute, and a list of reports, papers, and presentations made during the report period are also included.

Analysis of Conclusions

The information contained in this report covers a wide range of research topics of practical value to the mining and power industry. However, because of the ongoing nature of most of these investigations, no final conclusions of recommendations have been given. Continued research on these projects is necessary.

Title: **DATA USES AND FINDINGS OF STREAM FLOW-GAGING PROGRAM IN NORTH DAKOTA**

Authors: G.L. Ryan

Organization: USGS Water Resources Division, Bismarck, ND

Format: Report

Reference: USGS Open-File Report 85-349, 1985

Key Index Words: Stream Flow, Surface Water, Hydrology

Brief Description

This report documents the uses, funding and availability of the stream flow data currently collected in North Dakota. As of 1984, 94 stream flow gaging stations are operated in North Dakota. Station type, data uses, and funding sources are identified for each station.

Analysis of Conclusions

Data from all stations have multiple uses. All stations have sufficient justification for continuation, but five stations primarily were used for short term research studies and were scheduled to be discontinued at the end of 1985.

Title: **TYPES, CAUSES AND EFFECTS OF INSTABILITY PHENOMENA IN RECLAIMED SPOILS AT TWO SURFACE COAL MINES IN WESTERN NORTH DAKOTA - APPENDICES**

Authors: ND Geological Survey Staff

Organization: North Dakota Geological Survey, Grand Forks, ND

Format: Report - Appendices

Reference: Bureau of Mines Contract J0275010, 1985

Key Index Words: Groundwater, Lignite

Brief Description

These data are the result of studies done by the North Dakota Geological Survey under a U.S. Bureau of Mines contract. The data were collected at Baukol-Noonan's Center Mine and North American Coal Corporation's Indian Head Mine. It consists of elevation and histories which are a measurement of vertical and horizontal movement of groundwater in reclaimed spoils.

Analysis of Conclusions

The data presented in these appendices are useful for assessing ground water recharge and movement in reclaimed spoils.

Title: **DEVELOPMENT OF A HYDROGEOLOGICAL AND HYDROGEOCHEMICAL DATA BASE FOR ABANDONED MINE LANDS - PHASE II**

Authors: G.H. Groenewold, E.C. Murphy, and R.D. Koob

Organization: North Dakota MMRRI - University of North Dakota, Grand Forks, ND, North Dakota Geological Survey, Grand Forks, ND, North Dakota State University, Fargo, ND

Format: Report

Reference: MMRRI Bulletin No. 86-02, MMRRI - 01, 1986

Key Index Word: AML, Hydrology, Hydrogeochemistry

Brief Description

This report represents the results of hydrogeological and hydrogeochemical work done at the Noonan abandoned mine site that was one of the four sites investigated in the Phase I portion of this study.

Analysis of Conclusions

Unlike recently reclaimed surface mines, this site showed only a slight increase in mineralization of subsurface waters. The conclusion was that reclamation was inappropriate in this setting.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1986**

Authors: North Dakota MMRRI staff

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Annual Report, 1986

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology

Brief Description

This report contains information on thirteen ongoing research projects conducted by the MMRRI staff during July 1, 1985 to June 30, 1986. Most of the projects were the same as listed in the 1985 annual report. New projects include studies on ash disposal, soil liners for fly ash disposal sites, effects of fly ash and FGD wastes on groundwater quality and environmental impacts of underground coal gasification. Educational, training and other activities and accomplishments of the MMRRI are also included.

Analysis of Conclusions

This is a valuable source of information about the research activities of the MMRRI. It covers a wide range of research topics of practical value to the mining and power industry. Continuation of these studies is strongly recommended until each study is successfully concluded.

Title: **EVAPORITE MINERALOGY ASSOCIATED WITH SALINE SEEPS IN SOUTHWESTERN NORTH DAKOTA**

Authors: M.E. Timpson, J.L. Richardson, L.P. Keller, and G.J. McCarthy

Organization: NDSU-Soil Science Dept. and Dept of Chemistry and Geology, Fargo, ND

Format: Paper

Reference: Soil Science Society of America Journal 50(2),: 490-493, 1986

Key Index Words: Salinity, Evaporite Mineralogy, Lateral Transport, Efflorescence

Brief Description

This paper discusses the mineralogic changes occurring as saline waters migrate through the soil profile, and the mineralogic composition of the saline efflorescences present at the soil surface of saline seeps.

Analysis of Conclusions

An excellent paper on the mineral crystallization sequence from the water table to the soil surface observed in saline seeps.

Title: **THE EFFECTS OF GROUNDWATER HYDROLOGY ON SALINITY IN A RECHARGE-FLOW THROUGH-DISCHARGE WETLAND SYSTEM IN ND**

Authors: J.L. Arndt and J.L. Richardson

Organization: Soil Science Dept., Fargo, ND

Format: Draft

Reference: Unpublished

Key Index Words: Salinity, Pond Permanence, Geochemistry, Groundwater Recharge, Wetlands

Brief Description

A study conducted to evaluate soil salinization in a topographic series of wetlands within a catchment. Emphasis was placed on salt distribution in the soil profile as related to groundwater movement, recharge-discharge relationships, and number and duration of ponding events. The entire process was then directly related to evapotranspiration and progressive freezing of pondwater and shallow groundwater as mechanisms of concentration.

Analysis of Conclusions

Data presented are preliminary and the study is ongoing; however, research to date indicates both progressive freezing and evapotranspiration play an important role in the evolution and morphology of wetland soils as well as salt distribution within the wetland system.

Title: **HYDROLOGY OF NEW ENGLAND - MOTT COOL AREA, NORTH DAKOTA**

Authors: M.G. Croft

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: Unpublished

Key Index Words: Lignite, Groundwater

Brief Description

The need for this investigation came about as a response to the U.S. Department of Interior request for hydrologic information on federal coal lands leased and eligible for lease within the New England - Mott lignite deposit. Study will concentrate on defining the ground water flow system and chemical characteristics and determination of surface water flow magnitudes, chemical quality, sediment concentration, and sediment load.

Analysis of Conclusions

No technical analysis is possible at this time; however, a study of this magnitude will provide information to serve as a data base for possible future mining in this area.

Title: **COMPOSITION OF ATMOSPHERIC DEPOSITION IN WESTERN NORTH DAKOTA**

Authors: R.L. Houghton

Organization: U.S. Geological Survey, Bismarck, ND

Format: Professional-Communication

Reference: Unpublished

Key Index Words: Atmospheric deposition, Trace Elements, Detection Limits

Brief Description

Study of the composition of atmospheric deposition and its effect on the hydrologic system.

Analysis of Conclusions

Conclusions are that North Dakota is receiving acidic deposition with the major contributor being sulfates from gas-flaring and coal-fired power generation. Long term studies of pH indicate an overall lowering; however, the data base is currently too small to confidently define this trend or to relate it to increased sulfur and nitrogen oxides associated with energy development.

Title: **GEOCHEMISTRY AND MICROBIOLOGY OF SULFUR IN SHALLOW GROUND WATER SYSTEMS ASSOCIATED WITH LIGNITE DEPOSITS, NORTH DAKOTA**

Authors: R.L. Houghton, R.D. Koob, G.H. Groenewold, D. Brekke

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: Unpublished

Key Index Words: Geochemistry, Groundwater

Brief Description

A detailed geochemical investigation to quantitatively describe the sulfur sources that contribute to ground water sulfates in strip mines situated in recharge zones and to determine the hydrogeochemical processes that control the sulfur path to the ground water.

Analysis of Conclusions

No technical analysis is possible at this time; however, because sulfates are the principal cause of ground water deterioration in the vicinity of lignite mines in North Dakota, it is important to define and understand the sulfur cycle so that appropriate mitigation procedures can be implemented.

Title: **PROBABLE AND OBSERVED HYDROLOGIC CONSEQUENCES OF LIGNITE STRIP MINING IN THE FORT UNION GROUP NEAR GASCOYNE IN SOUTHWESTERN NORTH DAKOTA**

Authors: R.L. Houghton

Organization: U.S. Geological Survey, Bismarck, ND

Format: Report

Reference: Unpublished

Key Index Words: Geohydrology, Lignite

Brief Description

The purpose of this investigation is to define the effects of discharge of mine-impacted ground water on the surface water system.

Analysis of Conclusions

No technical analysis is possible at this time; however, based on observed anomalous sulfate concentrations in shallow ground water systems, there appears to be problems and questions that this study will focus in on.

Title: **COAL-BASED STRATIGRAPHY FOR THE UPPER FORT UNION GROUP (PALEOCENE) WEST CENTRAL NORTH DAKOTA**

Authors: G.H. Groenewold, D.J. Daly, C.R. Schmit, and L.A. Hemish

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Paper submitted to SEPM

Reference: Unpublished

Key Index Words: Fort Union Group, Lignite

Brief Description

A detailed stratigraphic framework was constructed for the Paleocene strata of the Sentinel Butte and upper Bullion Creek formations in the Knife River area in West Central North Dakota. The study sequence found to be characterized by at least seven major coals continuous over the 8000 km^2 of the study area instead of locally persistent coals as interpreted by previous investigations. Each major lignite has been named and assigned both type and reference test holes.

Analysis of Conclusions

The resulting framework provides a basis in this portion of the study area for a more accurate evaluation of the magnitude and distribution of coal reserves.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1987**

Authors: North Dakota MMRRI staff

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Annual Report, 1987

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology

Brief Description

This report contains information on fifteen ongoing research projects conducted/initiated by the MMRRI staff during July 1986 to June 30, 1987. Most of the projects were the same as listed in 1985 and 1986 annual reports and concentrated on evaluation of lignite resources and coal-bearing strata in North Dakota, use and disposal of energy industry generated wastes, and groundwater quality. A demonstration project to study the economic feasibility of producing mineral wool fibers from molten slag generated by cyclone boiler at the MDU's power plant at Beulah is also included in this report.

Analysis of Conclusions

Like other annual reports of MMRRI, the information included in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry. Some of these projects require continued investigation.

Title: **PREVENTION OF GROUND-WATER QUALITY DEGRADATION DURING RECLAMATION OF A URANIFEROUS LIGNITE MINE, NORTH DAKOTA**

Authors: R.L. Houghton, G.S. Anderson, S.R. Hill, J.L. Burgess, J.D. Wald, D.P. Patrick, R.L. Hall, and J.D. Unseth

Organization: U.S. Geological Survey, ND Public Service Commission, ND State Department of Health, Bismarck, ND

Format: Paper

Reference: Proceedings of Combined Fourth Biennial Billings Symposium on Mining and Reclamation in the West and the National Meeting of the American Society for Surface Mining and Reclamation, pp. G-4-1 to G-4-19, Billings, MO, March 17-19, 1987

Key Index Words: AML, Uranium, Groundwater, Salinity

Brief Description

A pilot AML reclamation project, conducted at the Palaniuk site, near Belfield, ND, to eliminate radiation hazards due to uranium in the spoil, is discussed. Reclamation plans were developed to control the principal geochemical processes that lead to mobility of uranium and associated constituents. The spoil was buried at a certain depth in the pit which effectively reduced surface radiation and radon gas to background levels. The saline spoil were selectively placed above the water table, and covered by mounded clay cap to prevent dissolution of salts and contamination of ground water. Uranium concentration in the local ground water was reported to have decreased, and the reclaimed site was considered suitable for grazing or haying use..

Analysis of Conclusions

An understanding of the local geochemical processes is crucial for developing and implementing reclamation plans for uraniferous coal mines. The success achieved in reclaiming this uraniferous abandoned mine site testifies to the above observation. However, post-reclamation monitoring of this site for a few more years would seem advisable.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1988**

Authors: North Dakota MMRRI staff

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Annual Report, 1988

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements

Brief Description

This report contains information on sixteen ongoing research projects conducted/initiated by the MMRRI staff during July 1, 1987 to June 30, 1988. Most of the projects were the same as listed in 1987 annual report. Work on lignite resource evaluation, use/disposal technology for fly ash and other energy industry waste products, and characterization of overburden and gasification ashes and phases continued. Information about the educational and training activities, staff, and MMRRI advisory committee is also included.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry. Some of these projects will require continued investigation.

Title: **NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1989**

Authors: North Dakota MMRRI staff

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: North Dakota Mining and Mineral Resources Research Institute Annual Report, 1989

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements

Brief Description

This report contains information on thirty four ongoing research projects conducted/initiated by the MMRRI staff during July 1, 1988 to June 30, 1989. Only a few of these projects are related directly to mining and reclamation. A project on bacterial desulfurization of coal has just begun. Work on lignite resource evaluation, use/disposal technology for fly ash and other energy industry waste products, and characterization of overburden and gasification ashes and phases continued. Also projects on technical feasibility of underground gassification are included. Information on two National Mine Land Reclamation supported projects (1. Groundwater movement and chemical evolution from the root zone to water table: and 2. Stabilization of underground mine voids by filling with coal conversion residual materials) is provided. The report includes educational and training activities of the MMRRI, its staff and the advisory committee.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry. Some of these projects will require continued investigation.

Title: **ENERGY & ENVIRONMENTAL RESEARCH CENTER; NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1990**

Authors: Energy & Environmental Research Center Staff

Organization: EERC and MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Energy & Environmental Research Center and North Dakota Mining and Mineral Resources Research Institute Annual Report, 1990

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements, AML, Underground Gasification

Brief Description

This report contains technical information on several lignite mining and reclamation related projects conducted or initiated by the EERC and MMRRI staff during July 1, 1989 to June 30, 1990. Of particular interest are the projects that focus on coal resource evaluation, underground coal gasification, National Mine Land reclamation project, an AML project conducted at the Fritz mine, and some waste disposal and utilization technology.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry. Some of these projects are on-going.

Title: **ENERGY & ENVIRONMENTAL RESEARCH CENTER; NORTH DAKOTA MINING AND MINERAL RESOURCES RESEARCH INSTITUTE ANNUAL REPORT - 1991**

Authors: Energy & Environmental Research Center Staff

Organization: EERC and MMRRI, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Energy & Environmental Research Center and North Dakota Mining and Mineral Resources Research Institute Annual Report, 1991

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements, AML, Underground Gasification

Brief Description

This report contains information on several lignite mining and reclamation related projects conducted or initiated by the EERC and MMRRI staff during July 1, 1990 to June 30, 1991. Of particular interest are the projects that focus on coal resource evaluation, underground coal gasification, National Mine Land reclamation project, an AML project conducted at the Fritz mine, and waste disposal and utilization technology. Most of the projects are the same as summarized in the previous year's annual report, with any additional work accomplished during the current review period.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry.

Title: **STUDIES OF ACIDIC MINE SPOIL AND WATER QUALITY IN AN ABANDONED MINE IN WESTERN NORTH DAKOTA**

Authors: R.D. Butler, J. Solc, and V. Kuhnel

Organization: Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND

Format: Abstract

Reference: Achieving Land use Potential Through Reclamation; Proceedings of the 9th Annual National Meeting of the American Society for Surface Mining and Reclamation, 536p., Duluth, Minnesota, June 1992

Key Index Words: AML, Salinity, Water Quality

Brief Description

This prereclamation study was conducted for the ND Public Service Commission to evaluate radiation hazard and potential to generate acid leachate in the abandoned mine spoils of Fritz Mine in western North Dakota. Laboratory tests on saturated pastes of 3200 spoil samples for vertical profiles of pH and EC indicated a significant potential for acid leachate with high amounts of dissolved solids. However, leachates collected in the field with pressure-vacuum porous cup lysimeters showed a more neutral, fresher water being generated in most locations. The discrepancy between the lab and field observations was explained as being possibly due to the greater amounts of water and mixing that are employed to make the saturated pastes. This would result in increased mineral/water interaction resulting in greater dissolution of solids and acid generation. X-ray diffraction analysis showed pyrite and other iron- and sulfur- bearing minerals in the spoil, with natrojarosite the most abundant and pyrite the least.

Analysis of Conclusions

The technique employed in this study, and the eventual mapping of the area with respect to salinity and other hazards distribution in the spoils, helped develop a reclamation plan for the site that was successfully implemented. This offers a good example of how scientific investigation can be productively coupled with the actual reclamation of an abandoned mine site. This type of study is useful for developing plans for slope stability, revegetation and groundwater protection.

Title: **ENERGY & ENVIRONMENTAL RESEARCH CENTER ANNUAL REPORT - 1992**

Authors: Energy & Environmental Research Center Staff

Organization: Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Energy & Environmental Research Center Annual Report, 1992

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements, AML, Underground Gasification

Brief Description

This report contains information on several mining and reclamation related projects conducted or initiated at the EERC during July 1, 1991 to June 30, 1992. Of particular interest to coal mining and reclamation are the projects that focus on advanced technologies, applied chemistry, energy policy, environmental microbiology, groundwater and waste management, national mineland reclamation, and underground coal gasification. Most of the projects are the same as summarized in the previous year's annual report, with any additional work accomplished during the current review period.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry.

Title: **ENERGY & ENVIRONMENTAL RESEARCH CENTER ANNUAL REPORT - 1993**

Authors: Energy & Environmental Research Center Staff

Organization: Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Energy & Environmental Research Center Annual Report, 1993

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements, AML, Underground Gasification

Brief Description

This report, among many other topics, contains information on several projects related to coal resource development, utilization, reclamation, groundwater, and waste management that were conducted or initiated at the EERC during July 1, 1992 to June 30, 1993.. Most of these projects are the same as summarized in the previous year's annual report, with any additional work accomplished during the current review period. The format of the report is different from that of the previous year.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry.

Title: **ENERGY & ENVIRONMENTAL RESEARCH CENTER BIENNIAL REPORT - 1995**

Authors: Energy & Environmental Research Center Staff

Organization: Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND

Format: Report

Reference: Energy & Environmental Research Center Annual Report, 1993-1995

Key Index Words: Waste Disposal, Fly Ash, FGD Waste, Lignite Resources, Hydrology, Trace Elements, AML, Underground Gasification

Brief Description

This report, among many other topics related to energy and environment, contains information on coal resource development and utilization, reclamation, groundwater, and waste management, that were conducted or initiated at the EERC during July 1, 1993 to June 30, 1995.. Several of these projects are the same as summarized in the previous year's annual report, with any additional work accomplished during the current review period. The format of the report is different from that of the previous year.

Analysis of Conclusions

The information contained in this report covers a wide range of energy and environment related research topics of much practical value to the mining and power industry.

Title: **HYDROLOGIC CHARACTERIZATION OF WETLANDS IN SURFACE COAL MINELANDS OF NORTH DAKOTA**

Authors: P.P. Sharma and R.D. Butler

Organization: NDSU- Land Reclamation Research Center, Mandan, and UND- Energy & Environmental Research Center, Grand Forks, ND

Format: Abstract

Reference: Decades Later: A Time for Reassessment; Proceedings of 12th National ASSMR Meeting, pp. 839, Laramie, Wy, 1995

Key Index Words: Wetlands, Groundwater Recharge, Hydrology

Brief Description

This abstract of a poster presentation provides a brief account of a study on hydrology of various types of wetlands associated with surface coal minelands in North Dakota. The main emphasis was on the types of monitoring instruments used at the six study sites, with some brief discussion of preliminary results.

Analysis of Conclusions

The authors caution that the desirable near- and sub-surface hydroecological attributes of wetlands, associated with surface mines in North Dakota, may not be sustainable in normal and dry years.

Title: **COMPARATIVE ASSESSMENT OF GROUNDWATER CHEMISTRY EVOLUTION AT THREE ABANDONED MINES AND ITS PRACTICAL IMPLICATIONS**

Authors: J. Solc

Organization: UND- Energy & Environmental Research Center, Grand Forks, ND

Format: Abstract

Reference: Successes and Failures: Applying Research Results to Insure Reclamation Success; Proceedings of 13th Annual Meeting of the American Society for Surface Mining and Reclamation, pp. 826, Knoxville, Tennessee, May 1996

Key Index Words: Groundwater, Hydrology, Hydrologic Modeling

Brief Description

Hydro- and geochemical processes involved in pore and groundwater chemistry were investigated at three abandoned mine sites (Fritz, Indian Head, and Velva mines) in North Dakota. Site characteristics and differences were determined by using the geochemical model MINTEQUA2 and statistical analysis. The site differences were mostly related to the gypsum saturation index (Na, Mg, Ca) and Sodium. At the Fritz site about 80-90% soil samples showed saturation paste pH of less than 5.5. At other sites the pH was above 5.5. Fritz site had also higher salinity compared to the others sites. Increases tendency for gypsum saturation within the vadose zone of disturbed sites was noted. This was related to increased concentration of sulfate ions resulting from mineral oxidation.

Analysis of Conclusions

The author claims that geochemical modeling, statistical analysis, and soil extract pH and EC measurements proved to be reliable, fast, and cost-effective for assessing soil acidity, the extent of oxidation zone, and the potential of negative effect on pore and groundwater chemistry of these abandoned sites. The usefulness of these interpretative techniques in assessing pre-mine characteristics is also emphasized.

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