Kansas Geological Survey

EQUUS BEDS AQUIFER MINERAL INTRUSION STUDY: MAP PRODUCTS

by

Jeffrey Schloss
Donald Whittemore
David Young
Richard Sleezer
Robert Buddemeier

In cooperation with:
Kansas Water Office
Equus Beds Groundwater Management District No. 2
U.S. Bureau of Reclamation

Kansas Geological Survey Open-File Report 97-28

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CONTENTS

INTRODUCTION

The Equus Beds Aquifer Mineral Intrusion (EBMI) Study is investigating the saltwater intrusion problem in western Equus Beds Groundwater Management District No. 2 (GMD2) to help implement the water supply subsection of the Lower Arkansas Basin plan of the Kansas Water Plan. An appraisal study was prepared by KGS in FY 1995 for the U.S. Bureau of Reclamation in cooperation with GMD2 (Whittemore and Sophocleous, 1995). Previous investigations and water-quality data indicate that aquifer waters are saline along the south side of the Arkansas River between Hutchinson and Wichita. However, immediately north of the river, water quality is good and suitable for most uses including municipal, industrial, and irrigation, with chloride concentrations well below the recommended public water-supply standard. In addition to its role as an important regional source of water for agricultural and domestic uses, the Equus Beds aquifer is the sole source of water for the cities of Hutchinson and Nickerson, which withdraw over two billion gallons annually. The main concern is the possible impact of continued ground-water development which might cause migration of the saline water to the north and contamination of the fresh ground-water resources of the aquifer.

The present study is being conducted as a cooperative effort of state and federal agencies with GMD2. Additional funding and direct participation together with the cooperating agencies under a cost-sharing program is being planned with the U.S. Bureau of Reclamation (USBR). The USBR has funded installation of a monitoring well network in the study area (Young et al. 1997).

The objectives of the overall study, including the contributions of all participating agencies, are to:

a) Determine the sources, distribution, and variation of saline water, including saltwater-freshwater interfaces, in the aquifer between Nickerson and Hutchinson;
b) Determine the control of geology, hydrology, and climate on the salinity distribution;
c) Develop a management-oriented computer model to simulate water and salt movement under a variety of scenarios;
d) Assess the current impact of land and water use on the salinity distribution and predict the effect of changing human and environmental factors on salinity migration into freshwater areas;
e) Recommend best management, protection, and remediation strategies, including well-head protection practices, to mitigate contamination of freshwaters by salinity.

LOCATION AND DESCRIPTION OF STUDY AREA

The general study area includes the 16 townships from T21S to T24 S and R5W to R8W in Reno, Rice, and McPherson counties; this area encloses 576 square miles. The main portion of concern within the general study area is the Arkansas River corridor in north-central Reno County; this area is within the northwest part of the western extension of GMD2. The study area lies within the eastern portion of the High Plains aquifer in the Great Bend Prairie and Equus Beds regions.

The Arkansas River valley is the main geomorphic feature. The Arkansas River flows from northwest to southeast through the study area. Tributaries to the Arkansas River within the general study area are Cow Creek, which flows from the north and joins the Arkansas River in Hutchinson, and Salt Creek, which flows from the south and joins the river just west of Hutchinson.

MAP PRODUCTS

Maps were compiled to display characteristics important to the study. The regional maps include both the EBMI Study area and the surrounding Great Bend Prairie and Equus Beds region. The regional maps are valuable to the study in that they display characteristics in adjoining areas, parts of which have been investigated in more detail than in the current study and which can affect the study area in terms of water and salt budgets. Where the density of data is appropriate or there are specific project requirements, more detailed maps of the study area were also produced. Most of the source data used in the map compositions can be obtained through the Data Access and Support Center (DASC) at the Kansas Geological Survey. Some of the text in the section below has been obtained from the DASC core metadata catalog, which can be viewed online at the URL http://gisdasc.kg.ukans.edu/dasc/coredata.html.

Maps prepared to date for the project address the following topical areas: Geology, Plates D and H; Hydrology, Plates F and G; Soils, Plates B and C; Land Cover, Plate A; and Water Rights, Plate E. The specifications and descriptions of the maps (plates A-H) included in this report are as follows:

Plate A: Land Cover Classification in the Great Bend Prairie and Equus Beds Regions

Map theme: Land Use Land Cover
Map scale: 1:500,000
Source scale: 1:100,000 (approximately)
Data source: Kansas Applied Remote Sensing, 1993
This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, by Fritz Kessler, Graduate Research Assistant and by Lee Bissinger, Graduate Research Assistant, under the supervision of Jeff Schloss, Research Assistant.

The Land cover database depicts 10 general land cover classes for the State of Kansas. The database was compiled from a digital classification of Landsat Thematic Mapper (TM) imagery by the Kansas Applied Remote Sensing (KARS) Program. These data are suited for county-level and watershed-level analyses that involve land use and land cover.

Landcover classifications in the 13 county region are residential, commercial and industrial, grassland, urban grassland, woodland, urban woodland, cropland, water, and other. In

terms of acreage, cropland and grassland are the dominant land uses within the study area. The term cropland is generic and refers to all land which is used to grow agricultural crops. A distinction can be made between the two major categories of cropland (dryland and irrigated) by comparing Plate A with Plate E which shows the locations of water rights within the study area. In general, where the predominant land use is cropland and there are dense clusters of water rights, a large percentage of croplands are being irrigated. Where cropland is predominant and water rights are sparse or non-existent, dryland farming techniques are being used to grow crops. A large supply of good quality water is required for effective irrigation. Cropland is generally irrigated except where the quantity and/or quality of ground water limits or precludes its use for irrigation.

The largest areas which are being used for grasslands are those in which the topography restricts land use or where the soils are too wet, too salty, or too sandy to be used effectively for cropland. The best examples of this are the dune field north of Hutchinson where topography (steeply sloping sand dunes) and sandy soils (excessively well-drained, low natural fertility, and large risk for wind erosion) present severe limitations on land use, and the areas along Rattlesnake Creek and near the Quivira Salt Marshes which have poorly drained (wet) and/or saline soils.

Plate B: Surface Soils Classified by Texture in the Great Bend Prairie and Equus Beds Regions

Map theme:	Surface Soils
Map scale:	1:500,000
Source scale:	variable
Data source:	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1994

Scientific authors: Donald Whittemore and Richard Sleezer.
This dataset was compiled into map form by Lee Bissinger, Graduate Research Assistant and by Fritz Kessler, Graduate Research Assistant, under the supervision of Jeff Schloss, Research Assistant.

This plate was constructed using the STATSGO database. STATSGO is a digital soils map and database developed by the National Resource Conservation Service as a part of the National Cooperative Soil Survey. The STATSGO soil maps are compiled by generalizing more detailed soil survey maps which were originally constructed at scales of 1:24,000 or 1:20,000. Map unit composition for a STATSGO map is determined by transecting or sampling areas on more detailed maps and expanding the data statistically to characterize the whole map unit. The map data are compiled in 1-by 2-degree topographic quadrangle units and merged and distributed as statewide coverages. The soil map units are linked to attributes in the Map Unit Interpretations Record relational database which gives the proportionate extent of the component soils and their properties for each soil map unit.

Soil map units for the 13 county area being studied were grouped on the basis of the surface soil texture of the three most prevalent soil series within each STATSGO soil map unit.

The STATSGO map units were then ranked using the surface soil texture information as an indication of the expected infiltration capacity of each map unit. The principal assumption was that soils with fine textured surface horizons (i.e. clay, silty clay, etc.) would have slower infiltration rates than soils with coarse textured surface horizons (i.e. sand, loamy sand, loamy fine sand, etc.). The ranking scheme was developed at the Kansas Geological Survey, Geohydrology Section, by Don Whittemore, Senior Scientist and Section Chief, and by Rich Sleezer, Graduate Research Assistant.

The general patterns of STATSGO map units in the Arkansas River valley and north of the valley in the EBMI Study area parallel the river. Patterns to the west of the study area tend to parallel tributary streams to the Arkansas River. The change from map units which are dominated by the silt loam to fine sandy loam Hoard-Canadian-Platte soil in the Arkansas River valley in Rice County, to those dominated by the fine sandy loam to sand loam Canadian-Kaski-Platte soil in the valley in Reno County, may have some relation to the mapping history in the different counties. A current project of the National Resources Conservation Service (formerly Soil Conservation Service) to remap and characterize soils in Reno County may address the inconsistency at the county border. The prominent zone of sand dunes north of the Arkansas River in southeastern Rice and northeastern Reno County is shown as the loamy fine sand soil of the Dillwyn-Dillwyn-Tivoli association.

Plate C: Surface Soils Classified by Texture in the South-Central Kansas study area

Map theme:	Surface Soils
Map scale:	1:100,000
Source scale:	1:24,000
Data source:	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1996

Scientific authors: Donald Whittemore and Richard Sleezer
This dataset was compiled into map form by Lee Bissinger, Graduate Research Assistant and by Fritz Kessler, Graduate Research Assistant, under the supervision of Jeff Schloss, Research Assistant.

This plate was constructed using the SSURGO database. SSURGO is a digital soil map and database developed by the National Resource Conservation Service as a part of the National Cooperative Soil Survey. Soils maps in SSURGO are digital versions of maps published in county level soil surveys. In Kansas, it is common for these maps to have been originally drawn at scales of 1:20,000 or 1:24,000. Soil map units are linked to the Map Unit Interpretations Record relational data base, which gives the proportionate extent of the component soils in each map unit and their physical, chemical, and engineering properties. It also contains interpretive information regarding landuse and natural resource planning and management. This dataset is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey.

Soils in the sixteen township area which is the focus of this study were grouped on the basis of the surface soil texture of the most prevalent soil series within each SSURGO soil map unit. The SSURGO map units were then ranked using the surface soil texture information as an indication of the expected infiltration capacity of each map unit. The principal assumption was that soils with fine textured surface horizons (i.e. clay, silty clay, etc.) would have slower infiltration rates than soils with coarse textured surface horizons (i.e. sand, loamy sand, loamy fine sand, etc.). The ranking scheme was developed at the Kansas Geological Survey, Geohydrology Section, by Don Whittemore, Senior Scientist and Section Chief, and by Rich Sleezer, Graduate Research Assistant.

There are 80 different soil series or complexes in the study area; these fall into 21 different groups of texture types ranging from clay to fine sand. The general pattern of the surface textures of SSURGO map units in the Arkansas River valley and north of the valley in the study area parallel the river similarly to the patterns for the STATSGO map units. There is no overall pattern for the series to the south of the river. More detailed patterns occur as groups of textures, such as to the south of the Arkansas River, and elongated trends, such as the generally north-south strips of soils in the prominent sand dune field in southeastern Rice County, southwestern McPherson County, and northeastern Reno County.

Plate D: Surface Geology in the Great Bend Prairie and Equus Beds Regions

Map theme:	Surface Geology
Map scale:	1:500,000
Source scale:	variable
Data source:	Kansas Geological Survey, Automated Cartography, 1992

This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, by Fritz Kessler, Graduate Research Assistant and Lee Bissinger, Graduate Research Assistant, under the supervision of Jeff Schloss, Research Assistant.

The source database is an Arc/Info implementation of the 1:500,000 scale Geology Map of Kansas, M-23, 1991. This work was performed by the Automated Cartography section of the Kansas Geological Survey, under contract to the Kansas Water Office. The goal of this project was to capture, in Arc/Info structures, the spatial and attribute information portrayed on this map. The data for Map M-23 was digitized from an original paper copy publication of the Geology Map of Kansas, Map M-1, 1964. That map incorporated a 1:500,000 scale, USGS base map. Because of this source and scale, there were some edge matching problems with the state boundary as maintained by the Kansas Cartographic Database (KCD). Two classes of spatial features are represented in the Arc/Info version of the geology map: polygons depicting major geologic units and lines demarking the bases of key geologic formations within the units.

Information on the surficial geology of the study area is needed for delineating aquifer boundaries and assessing the character of earth materials which would affect land use and infiltration of rainfall at the land surface. The general correlation of surface geology with the

distribution of the soil map units is apparent by comparison of this plate with Plates B and C. However, the soils maps display more detail for the surface characteristics. For example, in the study area there are four different soil map units within the corridor of post-Kansas alluvium on the surficial geology map. The prominent areas of sand dunes in the geology map also have a variety of soil textures; the major dune zone to the north of the Arkansas River valley in the northeastern part of the study area has a coarser surface texture than the dune area to the south of the river in the western portion of the study area.

Plate E: Water Rights in the Great Bend Prairie and Equus Beds Regions

Map theme:	Water Rights
Map scale:	1:500,000
Source scale:	variable
Data source:	Kansas Department of Agriculture Water Resources Division, 1993

This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, Lee Bissinger, Graduate Research Assistant, under the supervision of Jeff Schloss, Research Assistant.

The Water Information Management and Analysis System (WIMAS) is a method of visualizing and summarizing water-appropriations and water-use information contained in the Water Resources Information System (WRIS). It provides an overview of all the water rights and pertinent hydrologic information in an area that is available from no other source. The WRIS is the original source database maintained by the Division of Water Resources, Kansas Department of Agriculture for water appropriation and water use information in their mission to manage water appropriations in the State of Kansas. WIMAS consists of a set of Arc Macro Language scripts used with the ArcInfo GIS and a coverage developed from the WRIS database. It also includes numerous other coverages such as land survey lines, roads, and streams to be used in visually relating the water resources information. The basic WIMAS programming was initially developed by the U.S. Geological Survey and has since undergone several revisions to serve further needs. The purpose of the Water Information and Management Analysis System (WIMAS) is to improve the accessibility to and enhance the use of the water appropriations and water use data kept by the Division of Water Resources, Kansas Department of Agriculture. WIMAS allows the user to retrieve information from the Division's Water Rights Information System (WRIS) database by source of water or type of use for any given county, subbasin drainage area, or user-defined area.

The distribution of the water rights in the Great Bend Prairie and Equus Beds region generally indicates the presence of sufficient saturated thickness in the eastern High Plains aquifer for large capacity pumping. Most of the wells with water rights are used for irrigation, although some of the wells supply water for public supplies, industry, and stock yards. However, the areas with few or no well locations may represent either the absence of usable amounts of groundwater, or aquifer areas with water too saline to use. This water-quality effect is evident in northwestern Reno, northeastern Stafford and southwestern Rice counties. The density of the water right

locations along and between the Arkansas River and Cow Creek in north-central Reno and south-central Rice counties is approximately equivalent to the more heavily appropriated areas to the west and southwest in the Great Bend Prairie; groundwater in this region north of the Arkansas River is generally much less saline than the water directly to the south.

Plate F: 1996 Depth To Water Isolines for the High Plains Aquifer in the Great Bend Prairie and Equus Beds Regions

Map theme:	1996 Depth To Water Isolines
Map scale:	1:250,000
Contour interval:	10'
Source scale:	N/A
Data source:	Kansas Geological Survey, Geohydrology Section, 1997

This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, by John Woods, Research Support Specialist, Jeff Schloss, Research Assistant, and Lee Bissinger, Graduate Research Assistant.

Water-level data used to create this map originated with winter measurement data collected by the USGS and the Kansas Board of Agriculture's Water Resources Division. Water-level measurements are generally taken between November 31st and March 1st to allow ground-water to recover to static levels during the winter since most wells measured are used for irrigation. Besides these temporal constraints, the data used was also limited by the types of geologic units that the wells penetrate. These geologic constraints limit the groundwater data so as to be representative of only what is considered to be the High Plains aquifer, and to limit the effects of other aquifers on the contour maps of both the depth to water and the elevation of the water-table above mean sea level. Wells which penetrate any of the following geologic units were excluded from the dataset: KD (Dakota Formation), KN (Niobrara Chalk), KJ (undifferentiated Lower Cretaceous/Upper Jurassic rock) or KU (undifferentiated Lower Cretaceous rocks). These restrictions limited the data to wells which penetrate only the following geologic units: QA (Quaternary Alluvium, QU (Quaternary unifferentiated), and TO (Tertiary Ogallala).

Characterization and quantification of aspects of the hydrology of the study area are necessary for both conceptual and mathematical models of the water flow and budget in the system, including determination of the link between the Arkansas River and ground-water-level changes, and the transport of salinity (Quinodoz and Buddemeier, 1997). Information on inputs to the system include data on precipitation and surface recharge, Arkansas River flow and other stream flow, and subsurface flow of water from the Great Bend Prairie area into the study area. Water outputs comprise evapotranspiration, river flow, and ground-water outflow and discharge.

Depths to ground water in the EBMI Study area range from less than 10 ft to more than 50 ft. Most of the depths to the north of the Arkansas River are less than 20 ft; depths to the south of the river are generally greater than those to the north.

Plate G: 1996 Water Table Elevation Isolines for the High Plains Aquifer in the Great Bend Prairie and Equus Beds Regions

Map theme: 1996 Water Table Elevation Isolines
Map scale: 1:500,000
Contour interval 20'
Source scale: N/A
Data source: Kansas Geological Survey, Geohydrology Section, 1997
This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, by John Woods, Research Support Specialist, Jeff Schloss, Research Assistant, and Lee Bissinger, Graduate Research Assistant.

Preparation notes, data sources and data constraints are the same as for Plate F. The only additional data incorporated into this map was the land surface elevation above mean sea-level at each well.

The general direction of ground-water flow as indicated by the water-level surface elevation isolines for the winter of 1996 in the Great Bend Prairie and Equus Beds region map is to the east. There is some flexure in the contours in the Arkansas River corridor in the EBMI Study area; flow is towards the northeast to the river in the western part of the study area, and towards the east-southeast between the Arkansas River and Cow Creek in northern part of the study area. The low density of water-level measurement sites is apparent in north-central Reno County. The effects of a single point on the surface is also illustrated by the depression in northwest Harvey County. The monitoring wells drilled for the EBMI study (OFR 97-39) will greatly aid in determining the details of the water-level surface in the study area; a more detailed water table map of the study area will be generated from the measurements obtained during early 1997 from both the state-wide network and project monitoring wells. Depth to water values were subtracted from land surface elevations to derive elevations of the water-table above mean sea-level.

Plate H: Bedrock Elevation Isolines in the South-Central Kansas study area

Map theme: Bedrock Elevation Isolines
Map scale: 1:100,000
Countour interval: 25'
Source scale: N/A
Data source: (See References and Acknowledgements below)
Scientific author: David Young
This dataset was compiled into map form at the Kansas Geological Survey, Geohydrology Section, by Jeff Schloss, Research Assistant and by Lee Bissinger, Graduate Research Assistant.

Depth to bedrock data were compiled from bedrock depth data from the monitoring wells drilled for GMD2 as part of the EBMI project (see OFR 97-39 for data and descriptions), existing measurements, lithologic logs from selected water-well completion records of the Kansas Department of Health and Environment, interpretation of gamma and neutron logs from oil and gas boreholes on file at the KGS data library, and reports of the Kansas Department of Transportation.

The alluvial aquifer of the Arkansas River valley, the eastern portion of the Great Bend Prairie area aquifer, and the western part of the Equus Beds area aquifer are composed primarily of unconsolidated sands and gravels and include lenses and layers of silt and clay. The unconsolidated deposits in the study area include Recent alluvial and eolian deposits, older Pleistocene alluvium, dune sand, and loess. It is also possible that some of the basal gravels are late Pliocene in age. Better characterization of the subsurface geology of the river corridor is required for improving delineation of the surface between the unconsolidated aquifer and the underlying Permian bedrock, and for characterizing the major zones of highly permeable sands and gravels and low permeability clays in the unconsolidated aquifer. The depth to the bedrock surface is also needed for saturated thickness calculations. Because the Permian bedrock may be a source of local brine discharge, and because bedrock channels may serve as conduits for transport of high-salinity water from sources farther to the west, bedrock topography and its relationship to groundwater salinity is an extremely important feature of the study (Young et al. 1997).

This update of earlier bedrock maps adds considerable detail and precision to the bedrock surface in the study area because of the additional data acquired. In particular, there is improved definition of the bedrock channel, associated with the ancestral Arkansas River, that roughly parallels the present Arkansas River on its south side. This channel may be an important transport pathway for saline water.

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Acknowledgments:

Lithologic logs of the new EBMI project monitoring wells were collected by G. D. Hargadine (Kansas Water Office), D. Koci and M. T. Dealy (GMD2). The input of several others in the Geohydrology Section of the Kansas Geological Survey was helpful in producing the bedrock map. The cooperation and assistance of G. Koontz and L. Meyers (Kansas Department of Transportation) are greatly appreciated.

ORDERING INFORMATION

Copies of this report and of individual maps may be ordered from:

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