
Kansas Geological Survey

The FY90 Annual Report of the Dakota Aquifer Program Executive Summary

by

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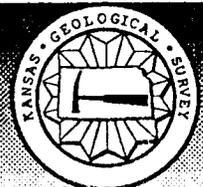
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GEOHYDROLOGY

DAKOTA AQUIFER PROGRAM



THE FY90 ANNUAL REPORT OF THE DAKOTA AQUIFER PROGRAM

Executive Summary

The Dakota aquifer system is an integral part of the water-resources planning for central and western Kansas. This aquifer system underlies approximately the western half of Kansas (Figure 1), adjacent portions of Colorado and Nebraska, and much of the rest of the interior continental region of North America. A lack of water due to local depletion of shallower freshwater aquifers in central and western parts of Kansas will create a demand for water supplies from the underlying Dakota aquifer in the future. In addition, those areas of the Dakota aquifer currently undergoing development are managed with little or no technical guidance for policy decisions because of a lack of data. In central Kansas oil-brine disposal in shallow zones beneath the Dakota aquifer may impact water quality in the Dakota, overlying aquifers, and surface waters by increasing the potential for upward migration of natural and disposed brines. At present insufficient data on water quality and availability preclude a thorough evaluation of the aquifer's ability to support the long-term development that will occur as shallower sources of water are depleted or of the effects of shallow oil-brine disposal practices. In response to the need for an integrated program of research, the Kansas Geological Survey has been carrying out and coordinating a long-term multi-agency program to assess the water-resources potential of this aquifer since FY89.

During FY90 the Dakota aquifer program conducted subregional investigations of the Dakota aquifer in areas currently undergoing development in Kansas and in adjacent areas in southeastern Colorado (Figure 1). Three major subarea projects have been defined within this developed region. The FY90 research program effort contributed up-to-date information on the Dakota aquifer geologic framework, geohydrology, and groundwater geochemistry in these three subareas for users, including state and local regulatory and planning agencies.

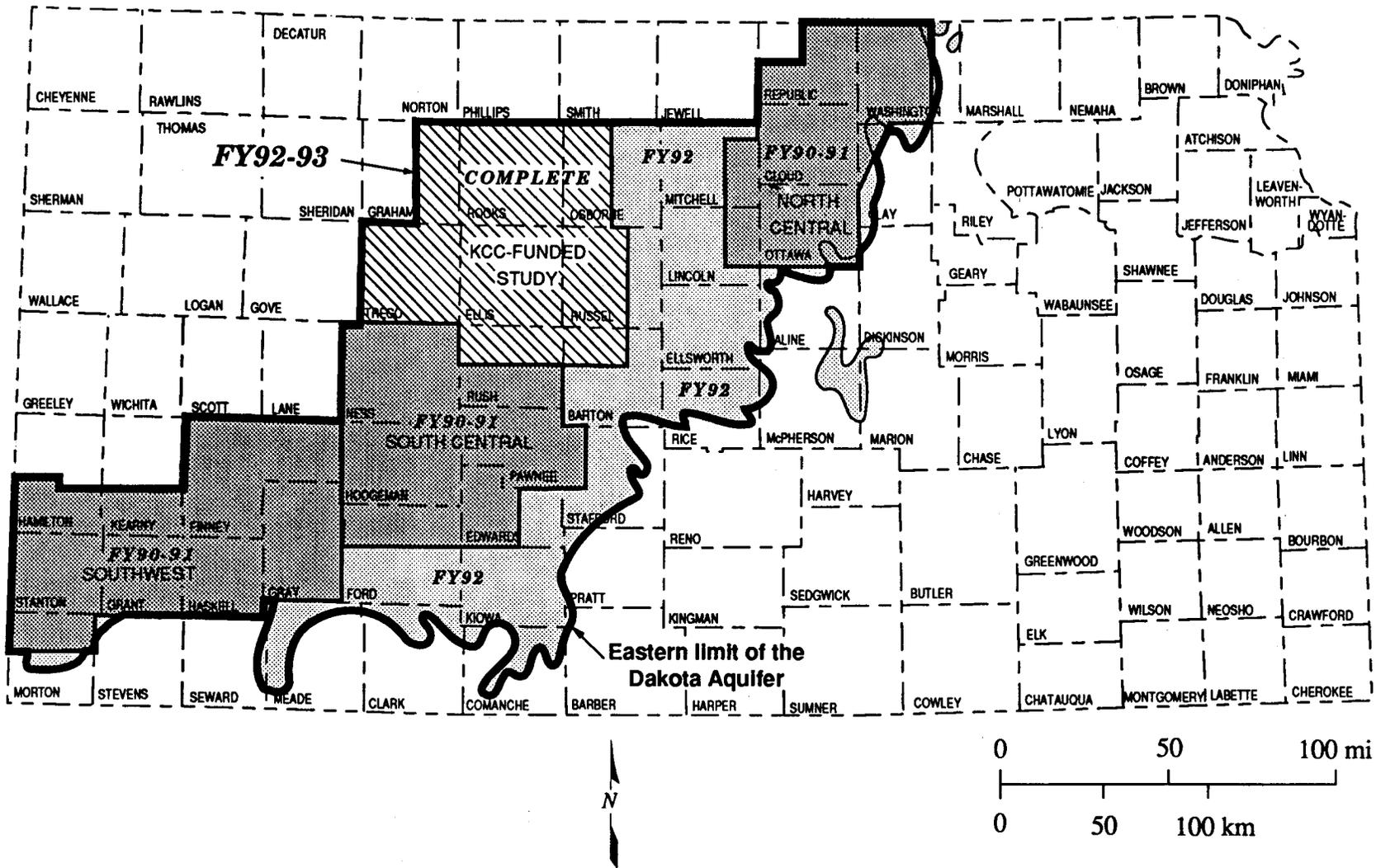


Figure 1. Extent of the Dakota aquifer in Kansas and subareas of investigation.

Geologic Framework

The Dakota aquifer is made up of interbedded sandstones and shales that were deposited in river valleys, in deltas, and in nearshore marine environments that with time, shifted laterally over much of the North American continental interior approximately 94–108 million years ago. Figure 2 shows the geography of Kansas and adjacent states at the time that the middle portion of the Dakota aquifer framework was being deposited approximately 97 million years ago. An understanding of the sedimentary architecture is essential to predicting the location of freshwater-bearing sandstones and pathways of upward saltwater migration from sources in underlying aquifers. Further, the geologic processes responsible for the laterally shifting sites of sandstone deposition through time must be known in order to make these predictions.

Considerable effort was spent to define the sedimentary architecture of the Dakota aquifer in central and southwestern Kansas in more detail than was possible at the regional scale. The additional detail was developed from test-hole drilling in central Kansas by the Kansas Geological Survey and from the addition of subsurface information from south-central and south-western Kansas and southeastern Colorado to the geologic data base. All test-hole drilling was done in areas lacking reliable subsurface geologic information. With the expanded geologic data base it will be possible continue the work already begun on (1) mapping the trend and distribution of sandstone aquifers in the Dakota aquifer and (2) developing an understanding of the past geologic processes responsible for their distribution.

Geohydrology

In the FY90 program a hydrologic properties data base on the Dakota aquifer framework was expanded with laboratory and field data. Hydrologic properties data are used to define the aquifers and those units that retard the movement of water in the ground-water flow system. A sandstone permeability data base was generated from laboratory measurements on cores of the Dakota aquifer framework collected from test-hole drilling in north-central Kansas. Research was also conducted to develop methodologies to analyze pumping test results in aquifers like the Dakota

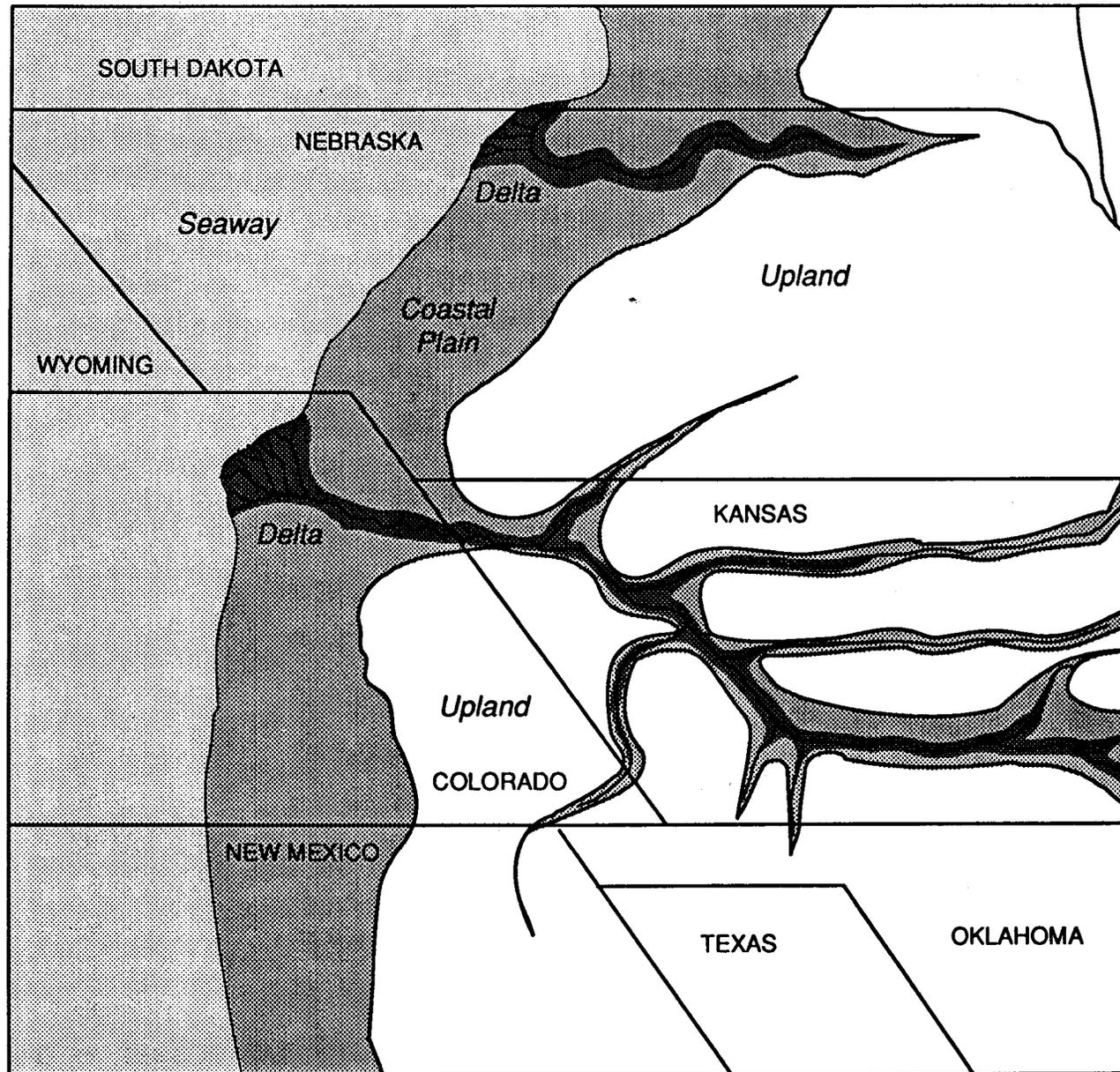


Figure 2. Midcontinent geography during deposition of the middle portion of the Dakota aquifer approximately 97 million years ago.

that contain buried stream channels, and a pumping test was conducted in southwestern Washington County in a major ancient river channel. Little is known about the Dakota aquifer in north-central Kansas, although it is used quite extensively as a source of water for irrigation and public water supply.

Several field surveys of water wells were made to collect updated information on the Dakota aquifer ground-water flow system. The updated water-level information is being used to determine the directions of ground-water movement and the effects of pumpage from the aquifer. One survey of water levels in wells screened in the Dakota aquifer was conducted in southeastern Colorado by the U.S. Geological Survey while another was being conducted in southwestern and central Kansas by the Kansas Geological Survey and the Division of Water Resources, Kansas Board of Agriculture. A total of 250 water-level measurements were made during the surveys in Kansas and in southeastern Colorado. Processing of the survey results is continuing in FY91.

Ground-Water Geochemistry

In the developed area of the Dakota aquifer ground-water samples were collected and analyzed from 14 sites. The FY90 analytical results and previously collected data are being used to determine the factors that influence the water chemistry of the Dakota aquifer. The factors that control the water chemistry relate to the flow paths through the aquifer and the chemistry of waters in the recharge and discharge areas of the aquifer. Water-quality characteristics important for use considerations were assessed for samples collected in 1990 and analyzed at the KGS and compared to the preliminary water-quality assessment in the FY89 report. In addition to salinity problems, similar patterns or distributions were observed for fluoride and nitrate concentrations exceeding drinking-water standards. The percentage of samples exceeding the iron and manganese standards are smaller than before because particulates contribute to these elements for some of the earlier values in the data base. As in the preliminary assessment, no samples exceeded the standard for the heavy metals cadmium, chromium, copper, lead, silver, and zinc, and the alkaline earth element barium. A few samples contained levels of selenium or mercury above the drinking-water criteria,

similar to the percentages found in the preliminary assessment. Arsenic concentrations near or above the drinking-water standard were found in many samples in contrast with previous data. These results are being verified to make sure the arsenic is from the ground water and not some other source. Waters range widely in radon contents; whether the higher concentrations exceed a standard cannot be determined until the federal government establishes a maximum level for radon in water supplies.

In another part of the geochemistry research an improved method of displaying water types was developed based on color information theory and the ARC/INFO system. In the present application of this method, gradations between water types defined by their constituent concentrations and total-dissolved-solids concentrations are represented by different hues in a color cube. The axis assignments along the edges of the front face of the cube were selected to produce color conventions appropriate for water types, i.e, most freshwaters equate to blues and greens, most saltwaters equate to red and orange hues. The third axis of the cube represents changes in total-dissolved-solids concentrations from fresh to saltwater. A representation of only the front face or water-type part of the color cube is shown in this report as Figure 3. The colored area of Figure 3 is the western 2/3 of Kansas with the eastern limit of the bottom of the Dakota aquifer as shown in Figure 1. The black line within the colored area is the eastern limit of the top of the Dakota aquifer outcrop/subcrop. The two white lines are shallow subsurface faults. Note the change in the color patterns that indicate an appreciable change in water chemistry from the areas where the Dakota aquifer is at the surface to those areas where the aquifer is hydraulically connected to the High Plains aquifer (Ogallala and associated alluvial aquifers).

A regionalized classification of ground waters from the Dakota aquifer has been developed based on a statistical analysis of the major ion chemistry. The regionalized classification is generated from a multivariate statistical analysis of the calcium, magnesium, sodium, bicarbonate, sulfate, and chloride concentrations of Dakota aquifer waters reported in the ground-water geochemistry data base. The analysis shows that a four-group classification of the data preserves the distinction among waters associated with the outcrop region, the subcrop region, areas of



Figure 3. Distribution of water-types in the Dakota aquifer of Kansas displayed using a color pattern representation based on hue, lightness, and color saturation system.

northwest and west-central Kansas where the aquifer is more isolated from sources of recharge, and areas where saline waters from underlying saltwater-bearing aquifers have recharged the Dakota aquifer in central Kansas. Other statistical examination showed correlation between chloride concentration and depth in the area where the Dakota aquifer underlies other freshwater aquifers, but no correlation where the aquifer is at the surface.

Publication of the FY89 Annual Report

During FY90 the FY89 annual report of the Dakota aquifer program was published as part of the Kansas Geological Survey Open-File Report series. This report (1) discusses the geologic framework, geohydrology, and ground-water geochemistry of the Dakota aquifer in Kansas from a regional perspective on the basis of existing information; (2) provides an outline of the major research direction that the Kansas Geological Survey intends to follow in the Dakota aquifer program; and (3) contains documentation for the geologic, geophysical log, geohydrologic, and ground-water geochemistry data bases that were developed in the FY89 program.

A significant part of this report is the 11 map plates which contain information at 1:1,000,000 scale on aspects of the Kansas Dakota aquifer geologic framework, geohydrology, and ground-water geochemistry. The map plates that portray the geologic aspects of the Dakota aquifer framework and adjacent units were developed from the geologic and geophysical log data bases. These data bases are discussed further in the FY89 Annual Report of the Dakota aquifer program. The maps portrayed in Plate 1 and Plates 3 through 11 were produced by the computer-aided cartographic system GIMMAP (Geodata Interactive Management Map Analysis and Production) developed by the Kansas Geological Survey. Plate 2 was produced with the ARC/INFO geographic information system. The chloride concentration contour lines were generated using SURFACE III and the geologic information was digitized using GIMMAP.

Relationship of the FY90 Dakota Aquifer Program to Future Research Directions

During FY90-93 the overall objective of the Dakota aquifer program is to characterize subregionally the water-resources potential of the areas where the Dakota aquifer is shallowest and is undergoing development in central and southwestern Kansas. In FY91-92, Kansas Geological Survey in cooperation with the U.S. Geological Survey is installing five monitoring sites within the Dakota aquifer and conducting hydrologic tests in order to gain insight into the relationship of the Dakota aquifer with the overlying High Plains (Ogallala and associated alluvial aquifers) and underlying saltwater-bearing aquifers. In FY91 the expanded geologic data base for southwestern and south-central Kansas is being used to determine sandstone body trend and distribution using the geologic data base. In the ground-water geochemistry part of the program, work will continue to (1) add more information to the ground-water quality data base from sampling the installed monitoring sites and other water wells screened in the Dakota aquifer, (2) continue work on evaluating the factors that control salinity and the concentrations of major, minor, and trace constituents in ground water, and (3) continue work on the assessment of ground-water for various uses on the basis of ground-water quality. Under 3, the marked difference between previous and current arsenic data is being examined. In FY91 an effort will also be made to translate the Dakota aquifer program data bases into INFO format so that they can be input into the geographic information system for display and dissemination to other state agencies. In addition, interfaces with the data bases managed by other state agencies and the U.S. Geological Survey will be developed in order to facilitate the transfer of data to potential users. In FY92-93, the results of the sub-area investigations will be combined and used to characterize the Dakota aquifer in central and southwestern Kansas. The results of this integration will be used to develop three-dimensional computer simulations of the aquifer that eventually can be used to assess various water-management scenarios.