

Water Resources Investigation 2017-1a

THE UPPER PIERRE AQUIFER OF THE CHEYENNE BASIN, NORTHEASTERN COLORADO, GEOLOGIC CROSS SECTIONS



by

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Introduction

To facilitate the review of past and ongoing well permit applications and water court applications, the Colorado Division of Water Resources (DWR) initiated a hydrogeologic study of the Upper Pierre aquifer within the Cheyenne Basin of northeastern Colorado. The results and products produced from this study are published herein as Water Resource Investigation 2017-1a and 2017-1b.

This report (WRI 2017-1a) is a compilation of ten regional geologic cross sections created from interpretation of geophysical logs from 200 oil and gas wells. WRI 2017-1b comprises several structure and isopach maps important to the hydrogeology of the Upper Pierre aquifer, whose data were also derived from geophysical log interpretation.

Previous Work

A few authors have addressed the presence of water-bearing strata within the upper portion of the Pierre Shale in northeastern Colorado previous to this work. The "Upper Transition Member of Pierre Shale" is mapped and described by Scott (1978) as "dark-gray marine calcareous silty shale or claystone, shaly sandstone, and sandy shale." The Upper Transition Member is thicker than, and encompasses, the Upper Pierre aquifer as defined in the present report. Kiteley (1978) created cross sections of Cretaceous rocks including the Pierre Shale. She correlated several sandstone and siltstone intervals in the upper portion of the Pierre Shale. The presently defined Upper Pierre aquifer includes Kiteley's "Member C", "Member D", and "Unnamed" sandstones. Kirkham and others (1980) and Kirkham and Rold (1986) recognized the presence of water-bearing siltstone and silty-sandstone in the upper part of the Pierre Shale within the Cheyenne Basin and named these lithologies as the "Upper Pierre Aquifer." In the early 1990s, DWR staff mapped the base of the Laramie-Fox Hills aquifer in the Cheyenne Basin, and initiated work on the Upper Pierre but never completed it (DWR, 1991). These previous works have informed the present investigation and have proved extremely valuable in extending the correlations of the Upper Pierre aquifer across the Cheyenne Basin.

Data Compilation

The regional cross sections extend from the Wyoming border on the north to just south of the South Platte River valley, and from the interstate highway I-25 corridor on the west to approximately six miles east of Sterling, Colorado. These cross sections depict the structure and stratigraphy of the geologic formations from the surface down to the upper part of the Pierre Shale. Interpretations of the tops and bases of geologic formations and Upper Pierre aquifer intervals were made utilizing images of the spontaneous potential and resistivity logs available from the Colorado Oil & Gas Conservation Commission online database. Well location, elevation, and interpreted geologic information were compiled in a master database managed by DWR. Geophysical log image files were outsourced for digitization into Log ASCII Standard (LAS) files for analysis and insertion at the well control points on the geologic cross sections.

Plate 1 displays the locations of the ten regional geologic cross sections on both a geographic feature map and geologic map of the Cheyenne Basin area. Five east-west (A through E) and five north-south (F through J) cross sections were produced with a vertical scale of one inch equals 400 feet and a horizontal scale of one inch equals 16,000 feet resulting in a vertical exaggeration of 40:1. For each cross section a surface elevation profile, along the line of section, was generated from the U.S. Geological Survey 10-meter Digital Elevation Model. The geometry of the alluvium associated with the South Platte River was derived from the alluvial aquifer GIS data layer produced for the South Platte Decision Support System (<http://cdss.state.co.us/GIS/Pages/Division1SouthPlatte.aspx>) managed by the Colorado Water Conservation Board.

The cross sections were produced in Golden Software's Strater® v.3. Below each cross section are index maps showing the location of the cross section well control points on both geographic and geologic maps. Surface hydrologic features are labeled above the elevation profile where they intersect the cross section. The oil and gas well control points are labeled at the top of the cross section in alphanumeric sequence from west to east and south to north. This labeling protocol corresponds to the labels on the geographic and geologic location maps. In addition to an alphanumeric label, the well's API number and Public Land Survey System information are also displayed.

In utilizing oil & gas well geophysical log information, it is assumed that the reported location and elevation of both ground surface and kelly bushing are correct. Errors in either location or elevation could produce vertical offsets in the interpreted contacts.

Geologic Cross Section Explanation

Graphically represented in these cross sections are the following geologic formations and the Upper Pierre aquifer hydrogeologic interval:

- Quaternary age unconsolidated alluvial deposits associated with the South Platte River alluvial aquifer
- Neogene through Late Cretaceous geologic formations (from youngest to oldest)
 - Ogallala Formation
 - White River Formation
 - Laramie Formation
 - Fox Hills Sandstone
- Upper Pierre Shale transition zone intervals
 - the upper confining layer (Pierre Shale 1),
 - Upper Pierre aquifer,
 - Pierre Ash (where identified), and
 - lower confining layer (Pierre Shale 2)

The objective of this investigation was to understand the structural and stratigraphic relationships of the Upper Pierre aquifer as they relate to groundwater resources administration. The Upper Pierre aquifer is a transitional geologic deposit between offshore marine shale of the Pierre Shale and the nearshore marine sandstone deposits of the overlying Fox Hills Sandstone. The Upper Pierre aquifer interval has a distinct geophysical log signature and is composed of interlayered shale, siltstone, and fine-grained sandstone. Specific characteristics and details of the Upper Pierre aquifer are documented in the text accompanying the mapping products produced for this investigation (WRI 2017-1b). The Upper Pierre aquifer, represented by the stippled salmon-colored layer on the cross sections, is the interval in which various water-bearing productive silts and fine-grained sands occur. It does not imply that the entire interval is composed of water producing materials. It is important to understand that the Upper Pierre aquifer is the only unit depicted as a hydrogeologic unit in these cross sections; all other units on the cross sections are depicted as geologic formation contacts, not as aquifer intervals.

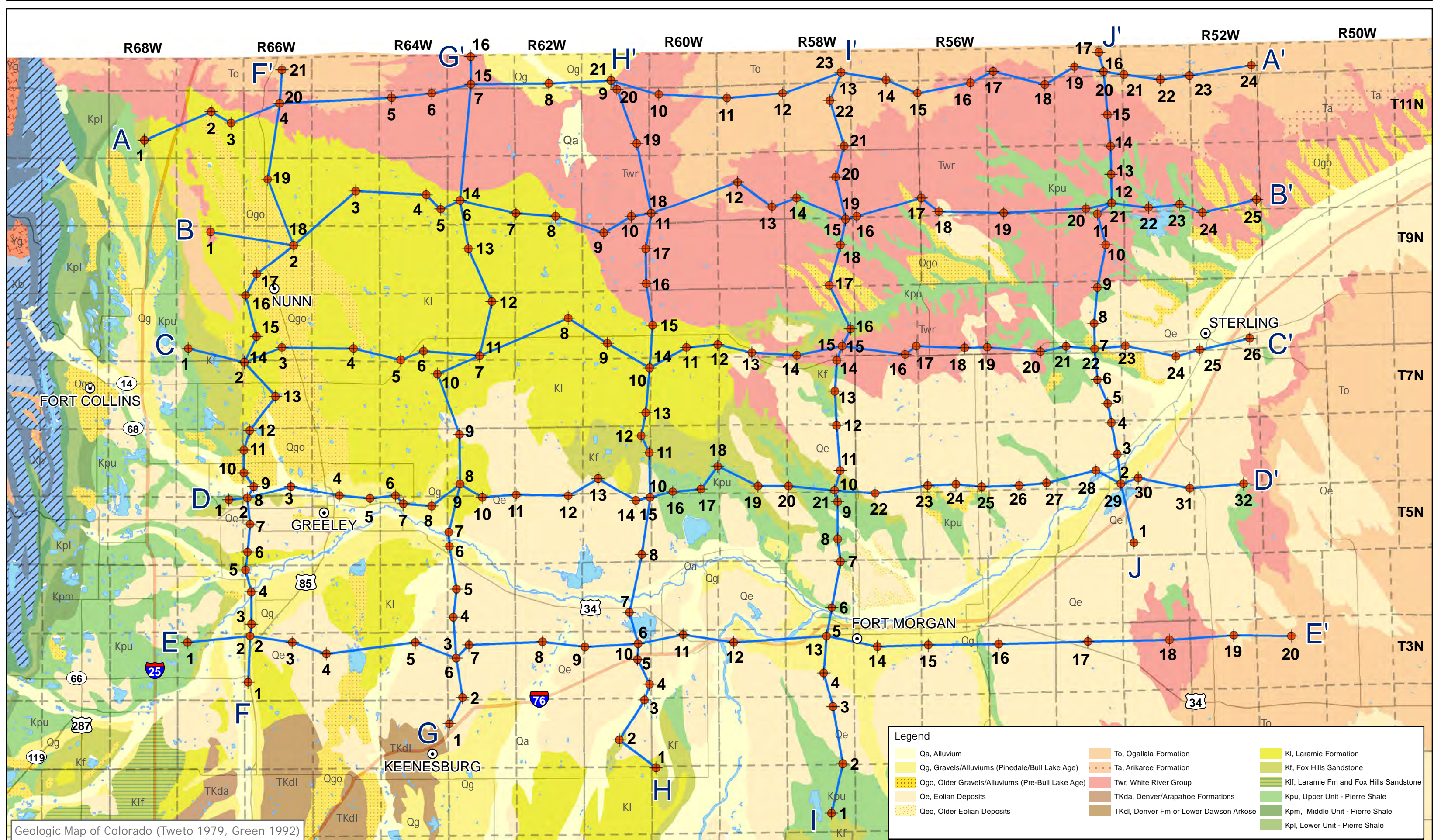
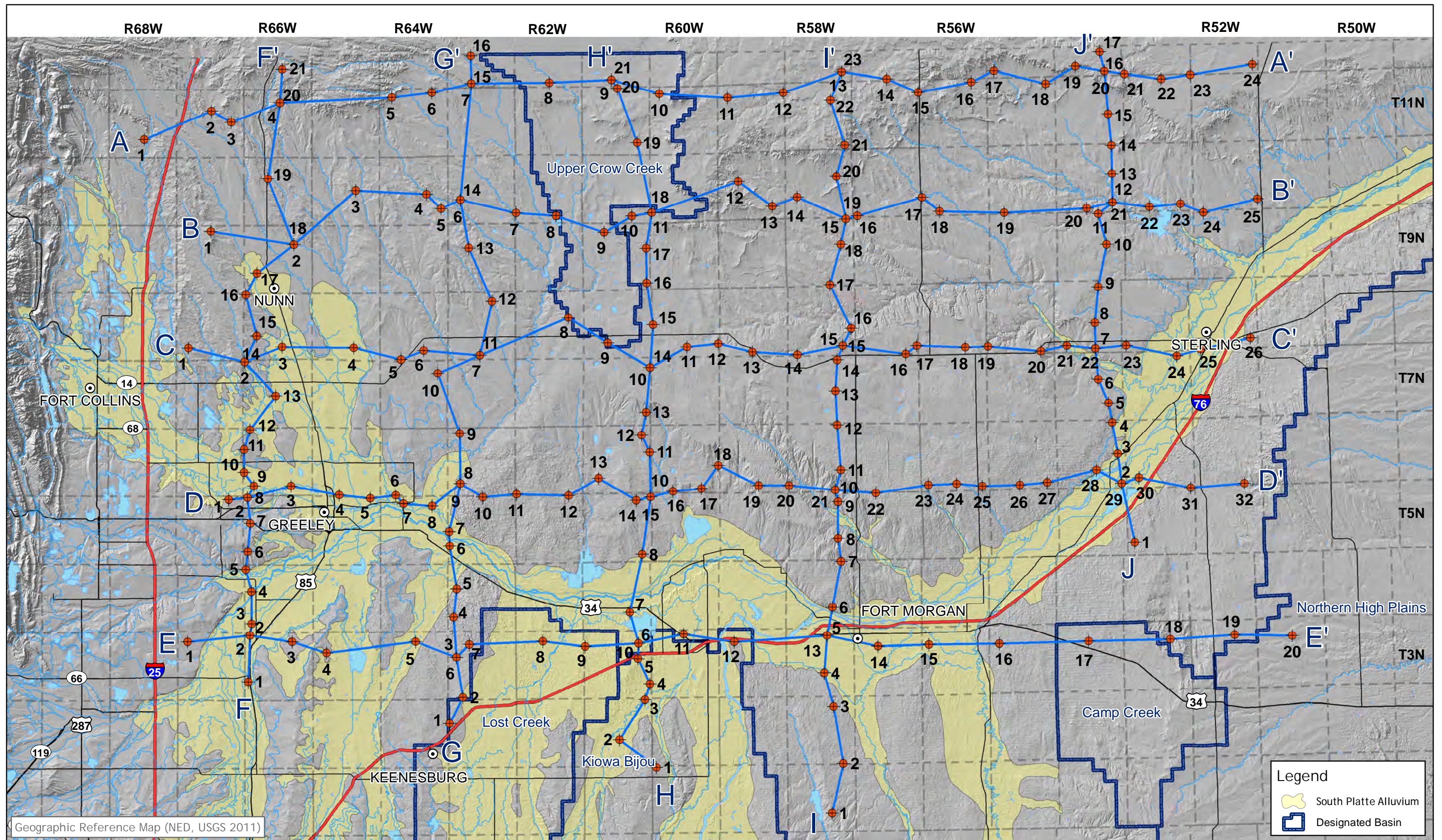
The geology is portrayed as structural cross sections with contacts and interfaces measured relative to mean sea level. Oil and gas well operators rarely log the shallow portions of the borehole. Consequently, the geologic units at or near the surface were interpolated from depth to generally correspond to the statewide geologic mapping of Tweto (1979) which is available as a GIS shapefile (Green, 1992). The contact or interface is dashed where inferred. This is the case for much of the Ogallala/White River contact. A linear interpolation is portrayed for the contact or interface between units from one well control point to another. It should also be noted that while geologic units are depicted as coming to the surface, much of the area is overlain by a veneer of Quaternary eolian deposits, which are not displayed on the cross sections. The structural cross sections are useful in understanding where certain geologic units or the Upper Pierre aquifer outcrop or subcrop beneath surficial geologic deposits. In addition, structural features such as faulting or folding (Greeley Arch) may be inferred from these sections. Geologic formation lithologic descriptions for the units within the cross sections are found in the description of map units of Tweto (1979) and Scott (1985).

The geophysical log traces shown on the well control points are vertically scaled to correspond with the scale of the cross section. The log trace amplitude was adjusted to show as much resolution as possible within the constraints of the display and varies between wells. These traces allow the user to see the geophysical log signature variability both vertically between the different geologic units and laterally between wells. The geophysical log traces for certain well control points were intentionally omitted due to cross section spacing constraints. The geophysical logging tool (SP or resistivity) responds differently to different geologic materials and their associated fluids. The lateral variability of permeable units within the Upper Pierre aquifer interval becomes evident when comparing the geophysical log signature at different well locations along the cross section and between cross sections.

The cross sections interpret the geology primarily to identify the top and base of the Upper Pierre aquifer along with other Upper Cretaceous and younger geologic formations. Detailed lithologic or facies changes within these units were not interpreted, but are present as indicated by the geophysical log responses. Site-specific geologic conditions between geophysical log control points within the study area may be different from those depicted in the cross sections.

References

- Colorado Division of Water Resources, Office of the State Engineer, 1991, Structure Contour Map of the Base of the Laramie-Fox Hills Aquifer, Cheyenne Basin, 1:200,000, unpublished.
- Green, G.N., 1992, The Digital Geologic Map of Colorado in ARC/INFO Format, U.S. Geological Survey Open-File Report 92-0507, 9 p.; <http://pubs.usgs.gov/of/1992/ofr-92-0507/>.
- Kirkham, R.M., O'Leary, W., and Warner, J.W. 1980. Hydrogeologic and stratigraphic data pertinent to uranium mining, Cheyenne Basin, Colorado. Colorado Geological Survey Information Series 12.
- Kirkham, R.M. and Rold, J.W., 1986, Water resources of upper Crow Creek, Colorado, Colorado Geological Survey Special Publication 29.
- Kiteley, L.W., 1978, Stratigraphic sections of Cretaceous rocks of the northern Denver Basin, northeastern Colorado and southeastern Wyoming. U.S. Geological Survey Oil and Gas Investigation Chart OC-78.
- Scott, 1978, Map showing geology, structure, and oil and gas fields in the Sterling 1°x 2° quadrangle, Colorado, Nebraska, and Kansas, U.S. Geological Survey Miscellaneous Investigations Series Map I-1092, Sheet 1 of 2.
- Tweto, Ogden, 1979, Geologic Map of Colorado, U.S. Geological Survey, 1:500,000.



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