ASSESSMENT OF POSSIBLE GROUNDWATER CONTAMINANT FLOW PATHS IN TWO UPPER COASTAL PLAIN HYDROGEOLOGIC SETTINGS

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INTRODUCTION

The Upper Coastal Plain geologic province of Georgia and South Carolina has abundant groundwater in sand aquifers of Cretaceous- and Tertiary-age geologic formations. This groundwater, a primary source for agricultural, municipal, industrial, and domestic water supply, is generally neutral to acid in pH, very low in dissolved solids, and below 100 μS/cm in specific conductance. Because of regional soil and sediment types, this groundwater is also vulnerable to contamination from surface activities.

The purpose of this presentation is to demonstrate how we predicted and evaluated groundwater flow paths at a proposed waste site in the Upper Coastal Plain region of Crawford County, Georgia, based on patterns of groundwater flow shown by Upper Coastal Plain flow models at the Savannah River Site (SRS). SRS is located in the Upper Coastal Plain of western South Carolina; groundwater flow at SRS has been studied extensively for over 30 years.

BACKGROUND

In February of 1992, the Macon-Bibb County, Georgia, Water and Sewerage Authority submitted a permit application to the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources to develop a 4,400-acre sewage sludge land application facility in neighboring Crawford County, 20 miles west of Macon. The Crawford County Commission retained Exploration Resources, Inc., to evaluate the permit application independently and to provide the county government with technical counsel in solid waste and environmental land-use issues in Crawford County.

The stratigraphy and hydrogeologic characteristics of sediments and soils at the proposed sludge application site in Crawford County are similar to the setting of SRS. Numerous studies of groundwater contaminant transport at SRS using modeling (Geotrans, Inc., 1992) and contaminant plume studies (Westinghouse, 1992a, b) have helped geologists conceptualize the interrelationships among local stratigraphic variations, depth of stream incision, and groundwater flow paths in this region of the Upper Coastal Plain.

Modeling and tracer investigations at SRS have confirmed that through studying stream basin morphology, regional stratigraphy, and local sediment type, geologists can make valuable inferences about general groundwater flow patterns, even in the absence of detailed local subsurface data. For geologists and consultants with constantly changing client needs and locations, this is a cost-effective approach to hydrogeological work in Coastal Plain settings. Such understanding is needed to design and install effective monitoring well networks in multiple-aquifer settings or to assess the effectiveness of existing networks.

Faced with limited time and a small budget, Crawford County was unable to commission a full independent hydrogeological study of the proposed sludge application site. In order to meet budget and time requirements, Exploration Resources focused on integrating these concepts of groundwater flow at SRS with field studies of the proposed sludge application site, state-wide hydrogeologic data, and regional stratigraphic studies (Davis et al., 1989; Davis and Trent, 1987; Hetrick, 1990; Huddlestun and Hetrick, 1991). Using these tools, we were then able to evaluate potential pathways for groundwater contamination at the proposed sludge application site.

Pathway Studies at SRS

Groundwater flow path investigations at SRS have incorporated computer modeling (Geotrans, Inc., 1992) and the use of known contaminants such as tritium and

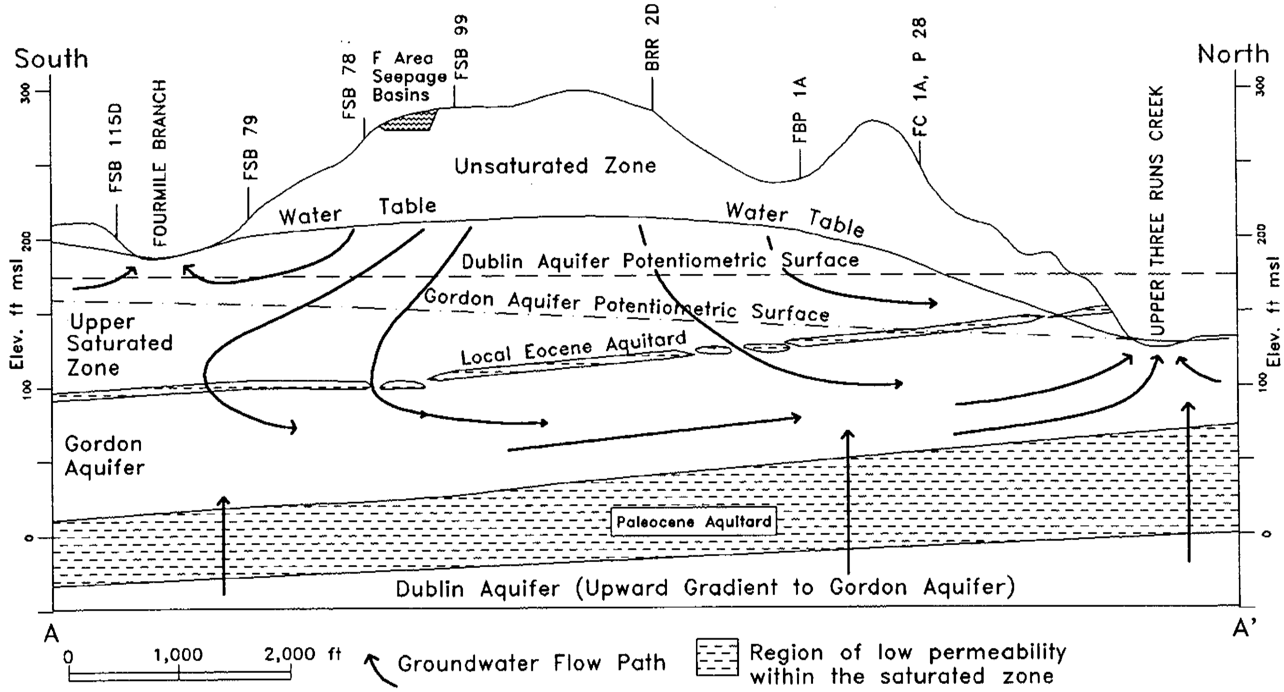

Figure 1. Generalized hydrostratigraphic cross section from south to north across the General Separations Area at SRS (after Westinghouse, 1992c).

trichloroethylene (Westinghouse, 1992 a, b) as tracers. This research has been facilitated by the immense amount of core data available on site, including both petrographic and hydraulic characterizations of sediments (Fallaw et al., 1992; Harris et al., 1992). Geotrans, Inc. (1992) has simulated groundwater flow in the central region of SRS using a program called FTWORK, similar in design to the well-known MODFLOW used by the U.S. Geological Survey (McDonald and Harbaugh, 1988). FTWORK provides multidimensional simulation for fully saturated media using a relatively simple flow equation based on hydraulic head.

At SRS, the program has been applied to the hydrostratigraphic system beneath the General Separations Areas (GSA, near the center of SRS), consisting of three aquifers (one unconfined and two semiconfined) separated by two aquitards. Flow paths beneath the GSA as simulated by FTWORK are depicted in a simplified two-dimensional fashion in Figure 1. The relationship between the depth of stream incision (and the resultant breaching of aquitards) and groundwater flow direction and discharge location are shown by the reversal in horizontal flow direction between the southern portion of the upper saturated zone and the subjacent Gordon Aquifer (Aadland et al., 1992; at SRS, this aquifer corresponds to the Congaree Formation of Siple, 1967). Shallow, local water-bearing zones discharge into local perennial streams (Fourmile Branch, Figure 1), or into deeper regional aquifers, where vertical hydraulic gradients and stratigraphy permit. Intermediate (Gordon Aquifer) and basal aquifers (Dublin-Midville Aquifer System) drain toward more deeply incised major tributaries (Upper Three Runs Creek, Figure 1) and large rivers (Savannah River), respectively.

Vertical flow directions are also varied and complex at SRS. The breaching of the local Eocene aquitard (known at SRS as the "green clay," a basal bed of Siple's [1967] McBean Formation) allows groundwater discharge from the underlying Gordon Aquifer into Upper Three Runs Creek at the northern (right) edge of the Figure 1 cross section. Discontinuities in this aquitard and downward vertical gradients from the water table to the Gordon Aquifer allow the downward migration of groundwater from the water table into the Gordon Aquifer.

Figure 2. Hydrogeological cross section, northwest to southeast, through the proposed sludge application site in Crawford County, Georgia.

Stratigraphy and Hydrogeology of the Proposed Crawford County Sludge Application Site

Two factors were considered to be of critical importance in assessing the validity the hydrogeologic site characterization proposed by Macon-Bibb County in the site permit application: the presence or absence of clay-rich confining units and hydraulic gradients, which might retard or prevent the downward transport of surface contaminants into aquifers used for local or regional water supply, and the adsorptive capacity of soils and sediments at the site for metals and nitrate from applied sludge.

Because time and access to the property was limited, our field work was confined to the study of surficial geology and to the location of springs and wetlands, as controlled by clay-rich confining units. Recent extensive clearcutting of much of the property allowed easier mapping of surface geology.

During the field study, we found springs and small wetlands at the relatively clay-rich contact between the Cretaceous-age Pio Nono and Gaillard formations (approximately 500 ft msl; Figure 2), indicating that this contact constitutes a local confining bed, probably supporting a perched water table. Limited outcrop and topography also indicated the possibility of a clay-layer near the elevation of Deep Creek, the major spring-fed perennial stream on the site. Interviews with local drillers have confirmed this observation and verified that thick clay-rich layers are not common or widespread.

Topographic relations and the locations of springs and wetlands indicated horizontal components of shallow groundwater flow to be controlled by local stream incision. Regional hydrogeologic studies (Pollard and Vorhis, 1980) showed regional groundwater flow to the southeast in Cretaceous-age formations. Local water well drillers provided information on the locations and depths of flowing wells, as well as the approximate depths to clay-rich strata (confining units) and sandy, high yielding strata. Field study and research on regional geology provided additional information on subsurface hydrogeologic characteristics of the site.

Based on these observations, we concluded that the site is probably underlain by a two-aquifer system (one unconfined and one semiconfined) and numerous perched zones. Highly permeable sands and irregular local confining units prevent the simple characterization of groundwater flow paths at the site. Vertical and horizontal reversals in flow directions may exist, similar to conditions at SRS. Where hydraulic gradients are favorable, discontinuous clay beds (Huddlestun and Hetrick, 1991) probably allow for vertical groundwater transport from the water table to basal zones (Figure 2).

CONCLUSIONS

A preliminary hydrogeological study submitted to EPD in November of 1992 by Macon-Bibb County contains potentiometric data and drillers logs that appear to verify our multiple aquifer hypothesis. Additional data are expected to be submitted to EPD by April of 1993. There is evidence for multiple water-bearing zones, but the degree of hydraulic communication between zones is not clear. More detailed hydrologic characterization is necessary to determine aquifer connectivity and detailed local gradient relationships. Thus far, however, core and potentiometric data validate our initial characterization of the site based on field relations, regional studies, and comparisons with SRS hydrostratigraphy. We view this method of initial site characterization as an expedient and cost-effective approach to hydrogeologic study in upper Coastal Plain settings.

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