INTRODUCTION

Ground water in the area of the Borough of Lansdale has been withdrawn since the early 20th century for use as drinking water and for industrial supply. In 1979, water from public-supply wells in the area was found to be contaminated with trichloroethylene (TCE), tetrachloroethylene (PCE), and other synthetic organic compounds (CH2MHill, 1991). Through additional sampling, an area of ground-water contamination was identified, and the site, known as North Penn Area 6, was placed on the National Priority List (NPL) by the U.S. Environmental Protection Agency (USEPA). The North Penn Area 6 site encompasses about 3 mi^2 (2.6 km^2) and includes at least six sources of contamination on separately-owned properties largely within the borough of Lansdale (CH2M Hill, 1991). The site is located on the U.S. Geological Survey (USGS) Lansdale and Telford 7.5-minute topographic quadrangle maps (fig. 1, pl. 1).

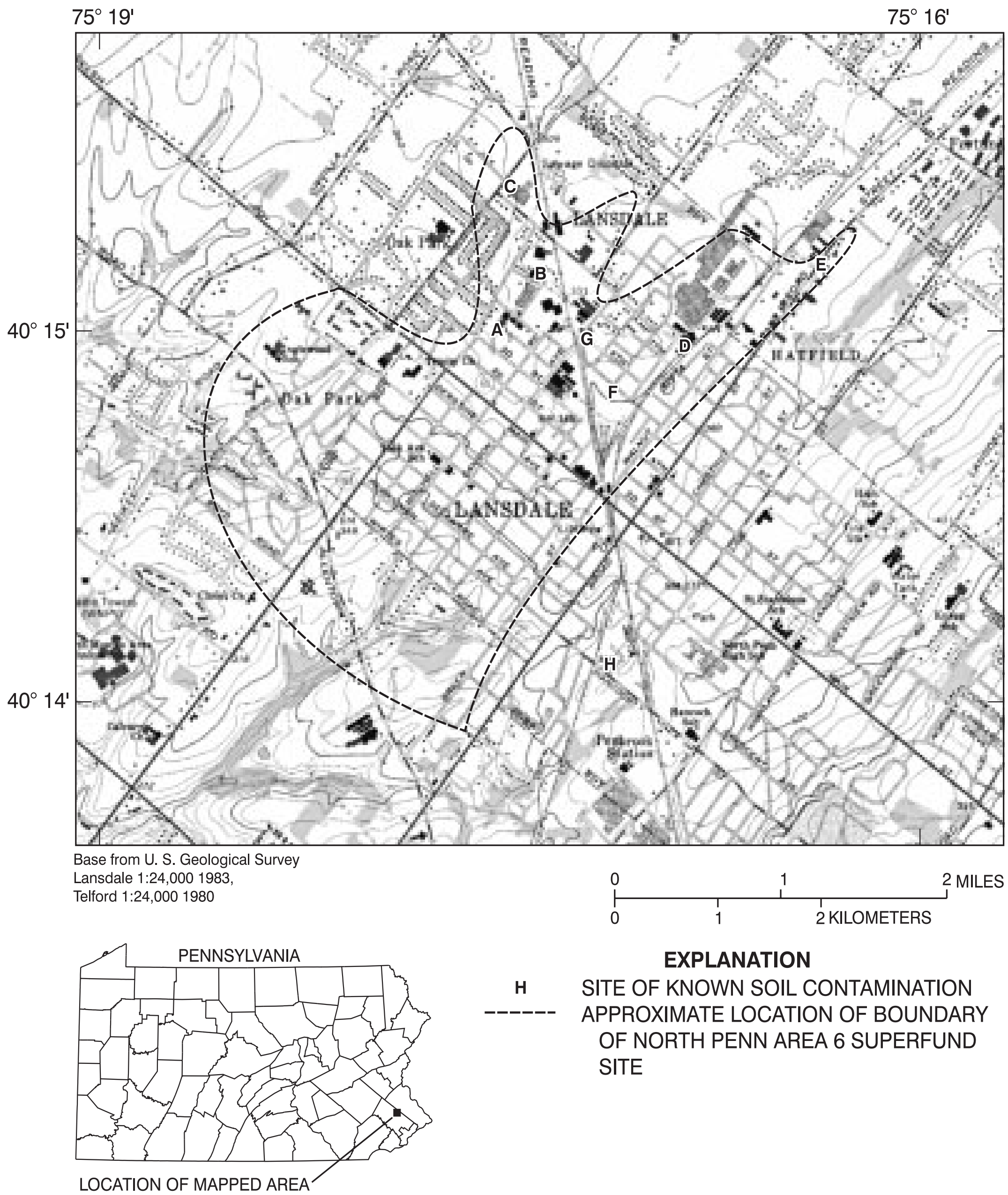

Figure 1. Location of North Penn Area 6 site, Lansdale, Pa.

Since 1995, abandonment of public-supply wells in favor of an alternative surface-water supply and closure of industrial facilities has changed the location and rate of ground-water withdrawals in Lansdale. The USEPA, concerned about contaminant migration, requested that the USGS determine the effects of these changes in water use on the direction of ground-water flow. In 1996, the USGS began a study to describe the ground-water system and simulate ground-water flow on a regional scale by use of a numerical model. This work was done to assist the USEPA in preparing a remedial investigation and feasibility study (RI/FS) of the North Penn Area 6 site.

The North Penn Area 6 site initially included about 26 industrial properties. Some industries in the area have operated since the 1940’s, whereas others began operating as recently as the 1980’s. Various solvents, degreasers, and other types of organic compounds were used by these industries and most commonly include PCE, TCE, and 1,1,1-trichloroethane (1,1,1-TCA). The organic compounds PCE and TCE may break down in microbially mediated reactions to form various additional compounds, including cis-1,2-dichloroethylene (cis-1,2-DCE) and vinyl chloride (VC) (Bouwer and others, 1981; Vogel and McCarty, 1985). The break-down compounds cis-1,2-DCE and VC also have been detected in ground water in Lansdale. Although most ground-water contamination in the Lansdale area is due to organic compounds, metals were used in some industrial processes, and chromium has been detected in ground water beneath at least one property.

In 1979, TCE was measured in concentrations greater than 4.5 μg/L in eight North Penn Water Authority (NPWA) public-supply wells in and near Lansdale. The USEPA maximum contaminant level to minimize health risks in drinking water is 5 μg/L for TCE. After the discovery of TCE in water from the public-supply wells, ground-water sampling and site assessments were conducted by USEPA and others. In 1986, the USEPA requested information about solvent use from 17 industries in the area, and in 1989, residential wells were sampled by CH2MHill (CH2MHill, 1991). The North Penn Area 6 site was placed on the NPL (commonly referred to as a Superfund site) in 1989. Environmental investigations by property owners, the Pennsylvania Department of Environmental Protection (PADEP) and by USEPA and its contractors indicate ground water beneath the Borough of Lansdale is contaminated with volatile organic compounds (VOC’s). Concentrations of TCE as great as 9,240 μg/L were measured in water samples from public-supply wells (CH2MHill, 1991). VOC’s also were detected in ground-water samples from industrial and domestic wells and in surface-water samples from a tributary to West Branch Neshaminy Creek (fig. 1). A RI/FS was initiated by the USEPA and its contractor, CH2MHill, in 1991. Since 1994, the USEPA through its contractor, Black & Veatch Waste Science, Inc. (B&V), and individual property owners have conducted soil sampling to determine the extent of contaminant sources (Black & Veatch Waste Science, Inc. 1994; Gregory Ham, U.S. Environmental Protection Agency, written commun., 1997); the USEPA also coordinated ground-water sampling in spring 1995, winter 1996, and fall 1997 to determine the extent of ground-water contamination. In consultation with USGS, 26 additional monitor wells were drilled by USEPA’s contractor (B&V) in Lansdale during the summer of 1997; these and other wells were sampled in fall 1997. Concentrations of TCE as high as 13,000 μg/L were measured in shallow monitor wells during fall 1997 (Black & Veatch Waste Science, Inc., 1998).

Purpose and Scope

This report describes the ground-water system and presents results of numerical simulation of ground-water flow in the area of the North Penn Area 6 site, Lansdale, Pa. All hydrologic and geologic data collected by USGS during the 3-year (1996-99) investigation in and near Lansdale are summarized in this report; these data include geophysical logs and measurements of stream base flow, water levels in wells, chemical and physical properties of ground-water samples, and responses of water levels in wells to aquifer tests. Aquifer characteristics are defined. Ground-water flow directions, capture zones for streams and wells, and flowpaths from known sources of contamination in soil are presented for simulations under three different pumping conditions.

Previous Work

Ground-water studies in the Lansdale area have been prompted by concern about limited ground-water availability during periods of drought, by discovery of contaminated drinking water from public-supply wells, and by interest in commercial and industrial uses of the ground water. Rima (1955), Longwill and Wood (1965), and Newport (1971) provide well-characteristic and ground-water-quality data and a description of ground-water resources in Montgomery County, Pa., including the Lansdale area. Longwill and Wood (1965) compiled a geologic map, that in the Lansdale area, was based almost entirely on unpublished manuscripts by Dean B. McLaughlin. Lyttle and Epstein (1987) compiled a geologic map of the Newark 1° × 2° quadrangle that updates and revises the geologic nomenclature for the area. Biesecker and others (1968) described the water resources of the Schuylkill River Basin, which drains part of the Lansdale area.

Investigations of ground-water contamination after 1979 by NPWA, USEPA, and others are summarized in a report to the USEPA by CH2MHill (1991). Sources of ground-water contamination in North Penn Area 6 site are identified additionally in another report to the USEPA by B&V (1994). Results of aquifer-interval isolation (packer) tests of two NPWA wells for hydraulic properties and water quality are given in Sutton (1983; 1984). Goode and Senior (1998) present a review of aquifer tests done in the Lansdale area from 1980 through 1995, including tests done in industrial-supply wells at manufacturing facilities, in public-supply wells, and in monitor wells at sites of known or suspected ground-water contamination.

Acknowledgments

The cooperation of well owners who made their wells accessible for water sampling, water-level measurements, and geophysical logging is greatly appreciated, especially those owners that allowed repeated sampling or continued monitoring of their wells. The well owners include North Penn Water Authority; J.W. Rex Company; John Evans & Sons Company; Philadelphia Toboggan Company; Rogers Mechanical; American Olean Tile; Dal Tile; North Penn Feed; Lehigh Valley Dairy; Merck, Sharpe and Dohme; Angelo Brugnoli; and residents in areas in and near Lansdale. Steve Siegfried, Craig Forwood, and Terry Gable of NPWA, Austin Race of Lehigh Valley Dairy, and Jason Szefcak of Merck are recognized for providing information about aquifer tests and other hydrologic data, as well as assistance in conducting field work. The technical guidance and coordination by Gregory Ham and Kathy Davies of USEPA was essential to the study. The cooperation of USEPA's contractor, B&V, also was integral to geophysical logging of new monitor wells, disposal of wastewater from aquifer tests, and other aspects of the study. The cooperation of J.W. Rex's consultant, QSI, Inc., is also appreciated.

Roger Morin of USGS provided analyses of acoustic televiewer and other geophysical data for selected wells. Other USGS staff contributing to the project include Randall Conger, Kenneth Eden, Phillip Bird, Kevin Grazul, Robert Rossman, Nicholas Smith, and Cynthia Lesitsky. The assistance of student interns and volunteers at the USGS, including David Prieto, Valerie Holliday, Ben Skupp, and Carrie Stevenson, also is appreciated.

GEOLOGIC SETTING

The study area in and near Lansdale is in the Gettysburg-Newark Lowlands Section of the Piedmont Physiographic Province. The North Penn Area 6 site and surrounding area are underlain by sedimentary rocks of the Lockatong Formation and lower beds of the Brunswick Group of the Newark Supergroup (Lyttle and Epstein, 1987) (fig. 2). Sediments of the Newark Supergroup were deposited in a rift basin during the Triassic age (260 million years ago). Following deposition, sediments in the Newark Basin were buried, compacted, and faulted. The Lockatong Formation commonly is relatively resistant to erosion and tends to form ridges that rise above flat or rolling topography underlain by rocks of the Brunswick Group. Lansdale and the North Penn Area 6 site are underlain mostly by rocks of the Brunswick Group and are on relatively flat upland terrain that is a surface-water divide between the Wissahickon Creek to the southwest, Towamencin Creek to the west, and tributaries to the West Branch Neshaminy Creek to the north and northeast (figs. 1 and 2).

Lithology

The Lockatong Formation consists of detrital sequences (cycles) of gray to black calcareous shale and siltstone, with some pyrite, and chemical sequences (cycles) of gray to black dolomitic siltstone and marlstone with lenses of pyritic limestone, overlain by massive gray to red siltstone with analcime (Lyttle and Epstein, 1987). Interbeds of reddish-brown, sandy siltstone have been mapped in the Lockatong Formation south of Lansdale (Lyttle and Epstein, 1987). The Lockatong Formation overlies the Stockton Formation, which consists of gray to reddish-brown sandstones, shales, and siltstones. Contacts between the Lockatong Formation and the overlying Brunswick Group are conformable and gradational, and the two formations may interfinger (Lyttle and Epstein, 1987). The lower beds of the Brunswick Group consist predominantly of homogeneous, soft, red to reddish-brown and gray to greenish-gray mudstones and clay- and mud-shales, with some fine-grained sandstones and siltstones. Bedding is irregular and wavy. Some beds are micaceous. Interbedded silt-shales and siltstones are moderately well sorted. Mudcracks, ripple marks, crossbeds, and burrows are common in all of the beds. The Brunswick Group rocks contain

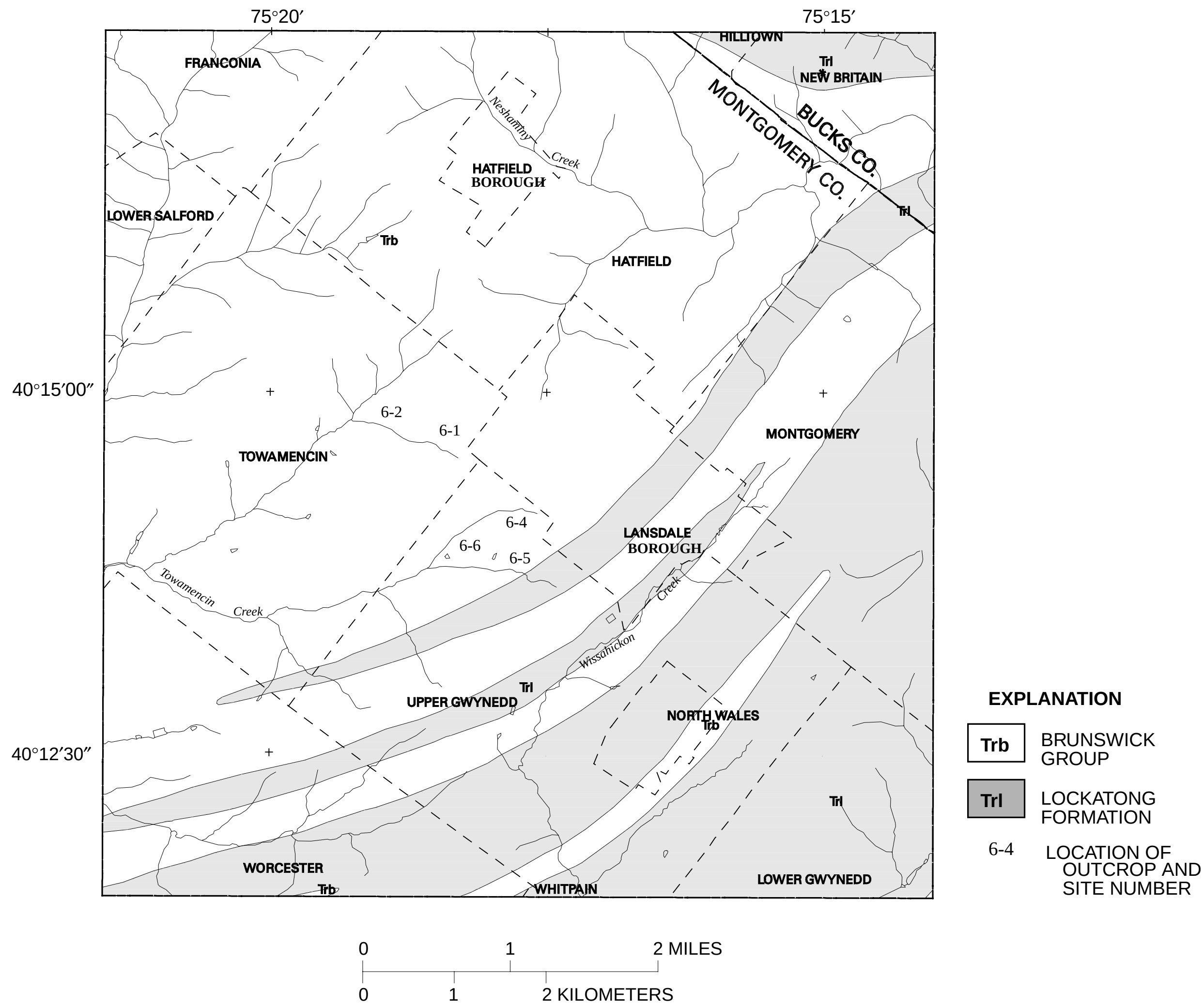

Figure 2. Bedrock geology in area of Lansdale, Pa.

detrital cycles of medium- to dark-gray and olive- to greenish-gray, thin-bedded and evenly bedded shale and siltstone, similar to the underlying Lockatong Formation.

Examples of a driller's log describing lithology of the Triassic-age sedimentary rocks from well cuttings and corresponding geophysical logs are shown for well Mg-1604 in figure 3. Red-brown shale, red-brown sandstone, and gray shale are the most frequently reported rock types in drillers' logs for monitor wells drilled in 1997 (Black & Veatch Waste Science, Inc., written commun., 1997). The large gamma-activity near 80 ft is associated with dark gray shale in well Mg-1604. Increased resistance near 215 ft is associated with red-brown sandstone in the well (fig. 3).

Structure

Bedding in the Newark Basin generally strikes northeast and dips to the northwest. The regional homoclinal dip has been cut by normal and strike-slip faults and warped by transverse folds (Schlische, 1992). Many faults with small displacements have not been mapped. The beds of the Brunswick Group and Lockatong Formation generally strike northeast and dip shallowly to the northwest in the vicinity of the North Penn Area 6 site, with a gradual shift in strike from northeast in central Lansdale to east-northeast in the area south of Lansdale near North Wales (fig. 2) (Longwill and Wood, 1965).

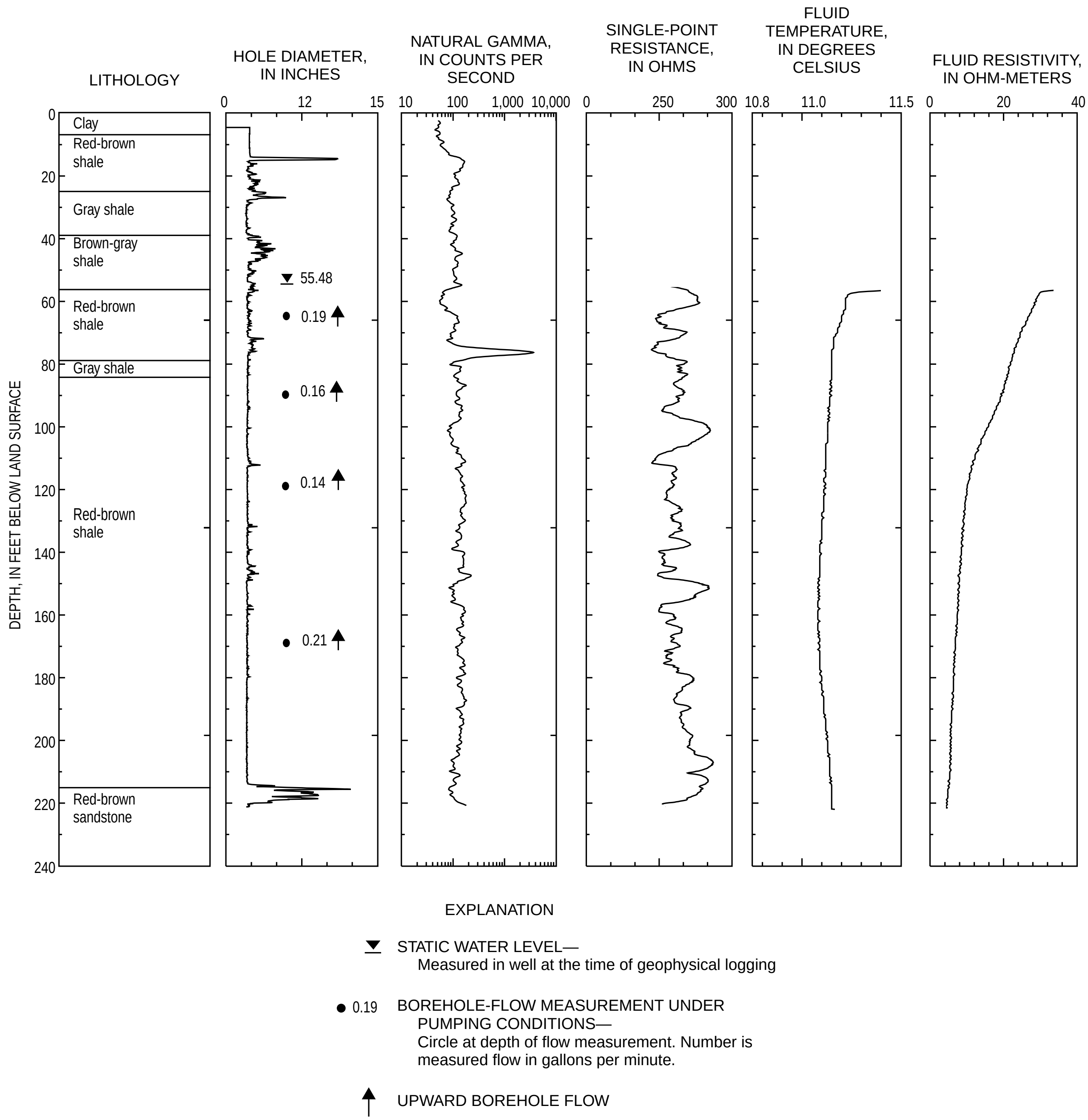

Figure 3. Lithology of well cuttings and geophysical logs for well Mg-1604 in Lansdale, Pa.

Thin shale marker beds in the Brunswick Group identified by elevated natural-gamma activity on geophysical logs can be correlated over distances of 1,000 ft or more (300 m or more). High natural-gamma activity typically is associated with thin gray shale beds. Correlation of natural-gamma activity in logs collected by USGS in and near Lansdale show that these shale beds strike 48° to 60° northeast and dip 6° to 30° northwest; the average dip is about 11° (fig. 4) (Conger, 1999). Examples of correlations of natural-gamma logs (fig. 5) from selected wells in central Lansdale Borough (near Third and Main Streets) indicate that bedding strikes about 56° northeast and dips about 7° northwest in that area.

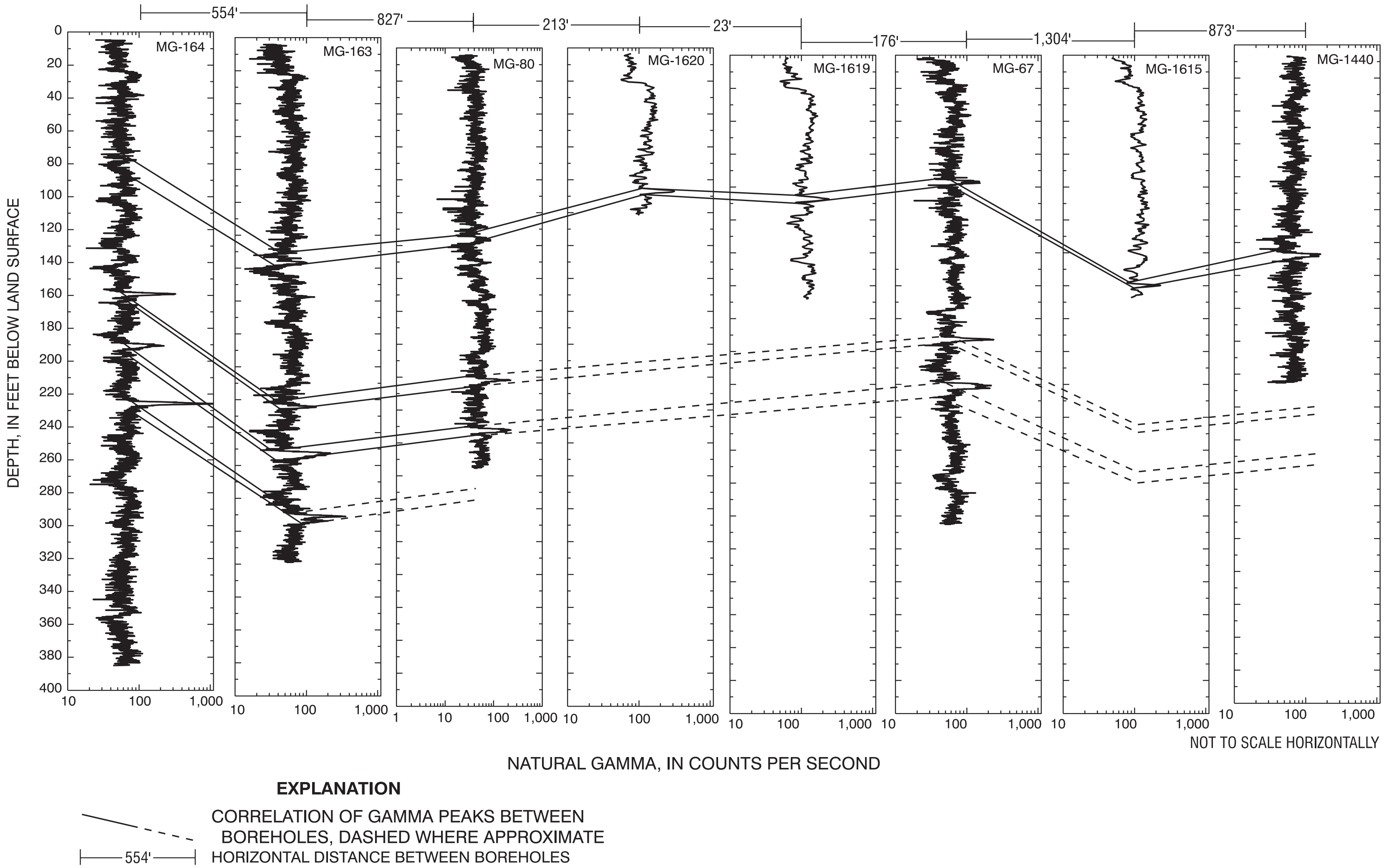

Figure 4. Natural-gamma-log correlations for wells Mg-164, Mg-163, Mg-80, Mg-1620, Mg-1619, Mg-67, Mg-1615, and Mg-1440 in Lansdale, Pa.

Fractures

Longwill and Wood (1965) noted the presence of well-developed fracture systems in many beds of the Brunswick Group. They observed that the strike of the fracture sets appears to be independent of bedding orientation; most fractures are nearly vertical and average about 6 in. (153 mm) apart. The width of fracture openings in individual beds varies. Greenleaf (1996) measured the orientation of more than 150 fractures at outcrops exposed in streams at four sites in the Lansdale area. The strike of fracture sets measured by Greenleaf (1996) commonly ranged from 60° to 70°, 45° to 50°, and 140° to 160°; many fractures are nearly orthogonal to bedding. High-angle fracture sets (vertical or near-vertical fractures) strike northeast to northwest and dip to the southeast and southwest, respectively. Plots of poles to fracture planes determined by Greenleaf (1996) are shown in figure 5. Low-angle fractures (bedding) strike northeast to southeast and dip to northwest and northeast, respectively (fig. 5). The pole of

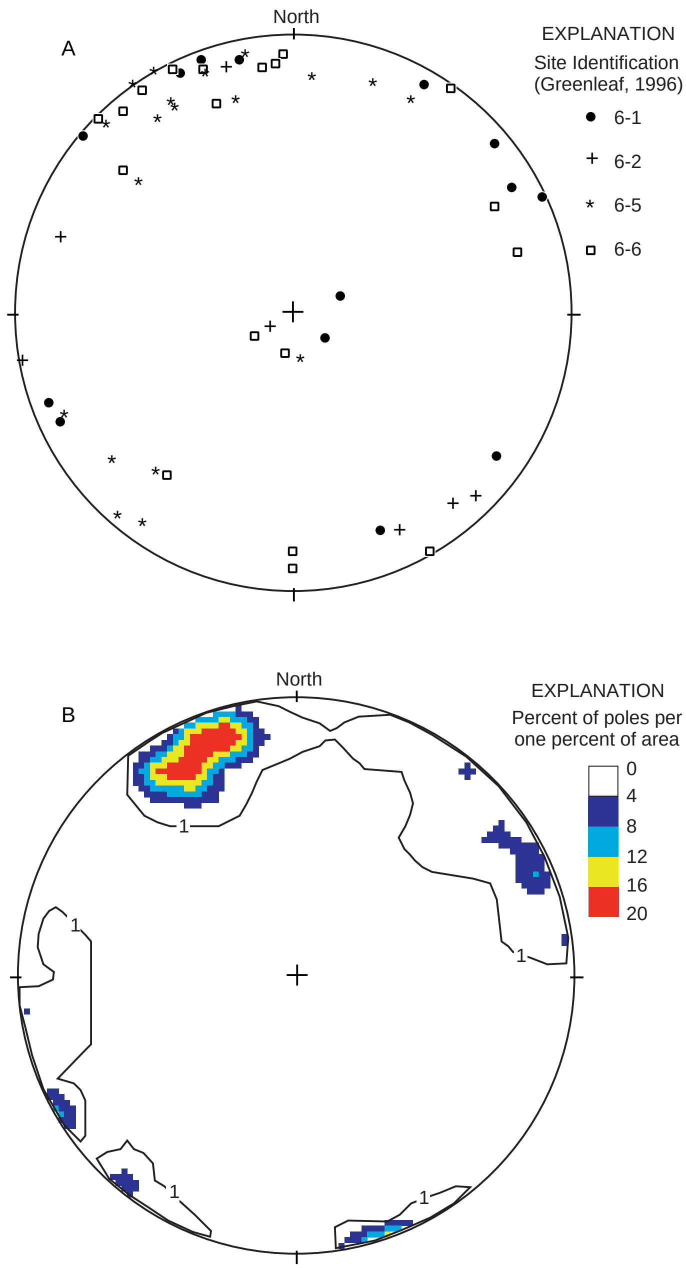

Figure 5. Equal-area, lower-hemisphere plots of poles to fracture planes determined from outcrop measurements at (A) four stream sites in and near Lansdale, Pa., and at (B) one stream site in Whites Road Park, Lansdale, Pa. (Greenleaf, 1996). Individual fracture plane poles are plotted for (A), and 86 fracture plane poles are contoured in (B). See figure 2 for location of stream sites.

each fracture plane is a line perpendicular to the fracture plane. The intersection of the fracture poles with an equal-area projection of a lower hemisphere (Ramsey, 1967) is shown in figure 5; horizontal and subhorizontal fractures are represented by points near the center of the circle, and near-vertical fractures plot near the perimeter of the circle.

Acoustic televiewer logs run in seven boreholes in and near Lansdale indicate many of the features identified appear to be bedding-plane partings that strike about 48° northeast and dip about 11° northwest (R. Morin, U.S. Geological Survey, written commun., 1998). Other features appear to be high-angle fractures that also strike to the northeast but dip to the southeast (fig. 6).

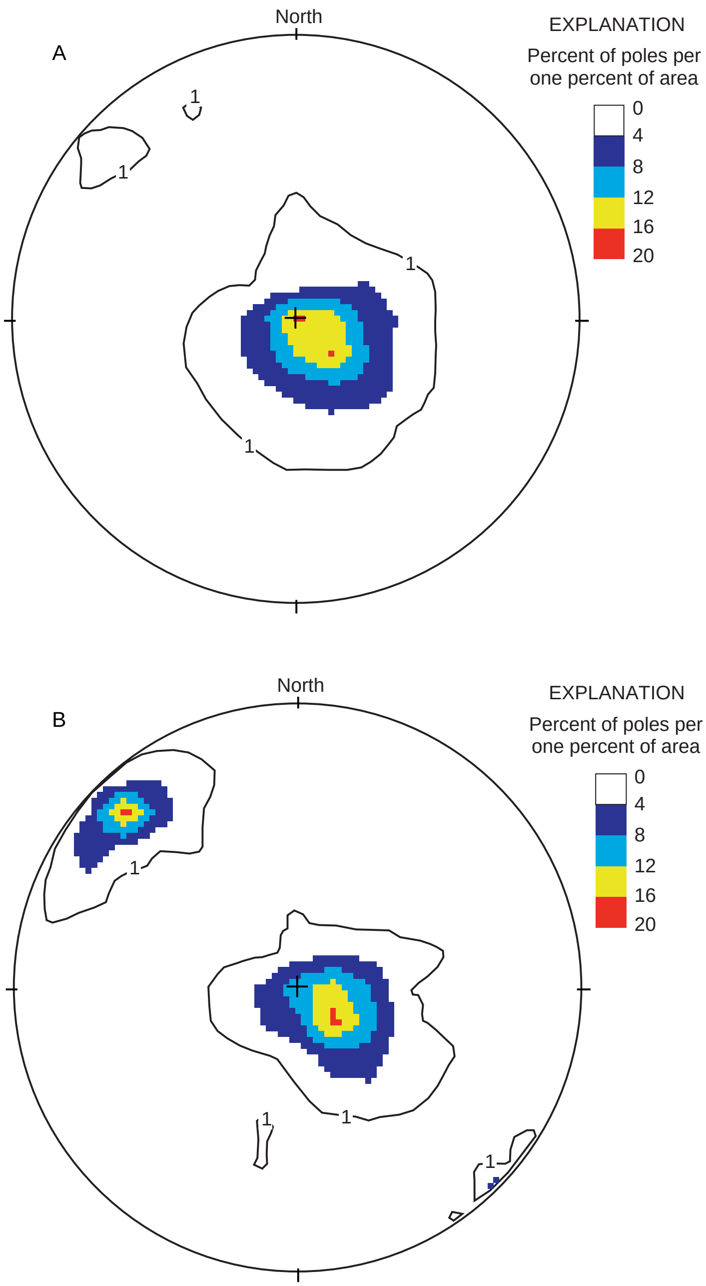

Figure 6. Equal-area, lower-hemisphere contours of poles to fracture planes measured by acoustic televiewer in wells in Lansdale, Pa., for (A) 698 fractures above 400 feet, and (B) 181 fractures below 400 feet below land surface.