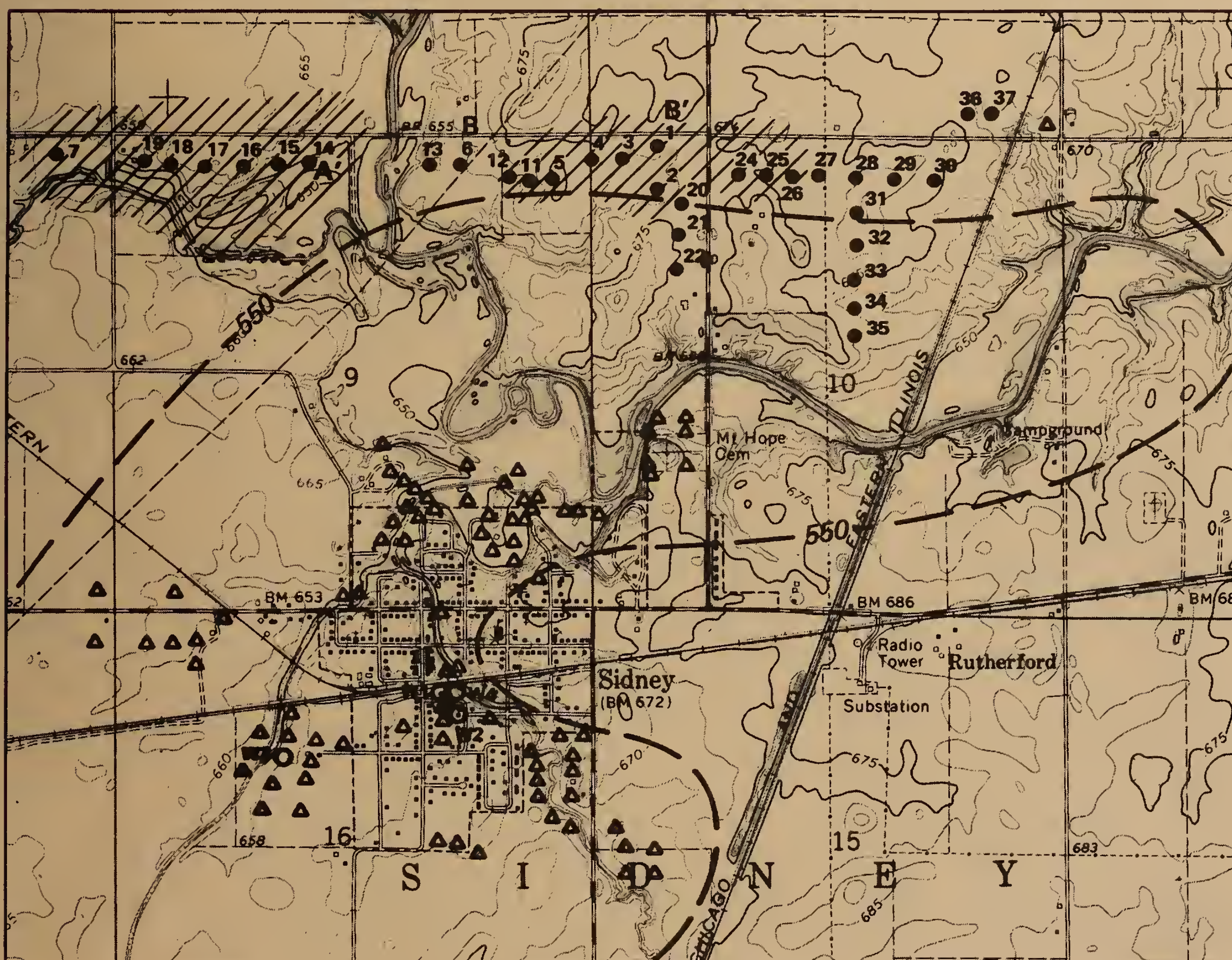
# Supplemental groundwater supplies for six small communities in Illinois

Vickie Poole    Robert Vaiden

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STATE GEOLOGICAL SURVEY DIVISION

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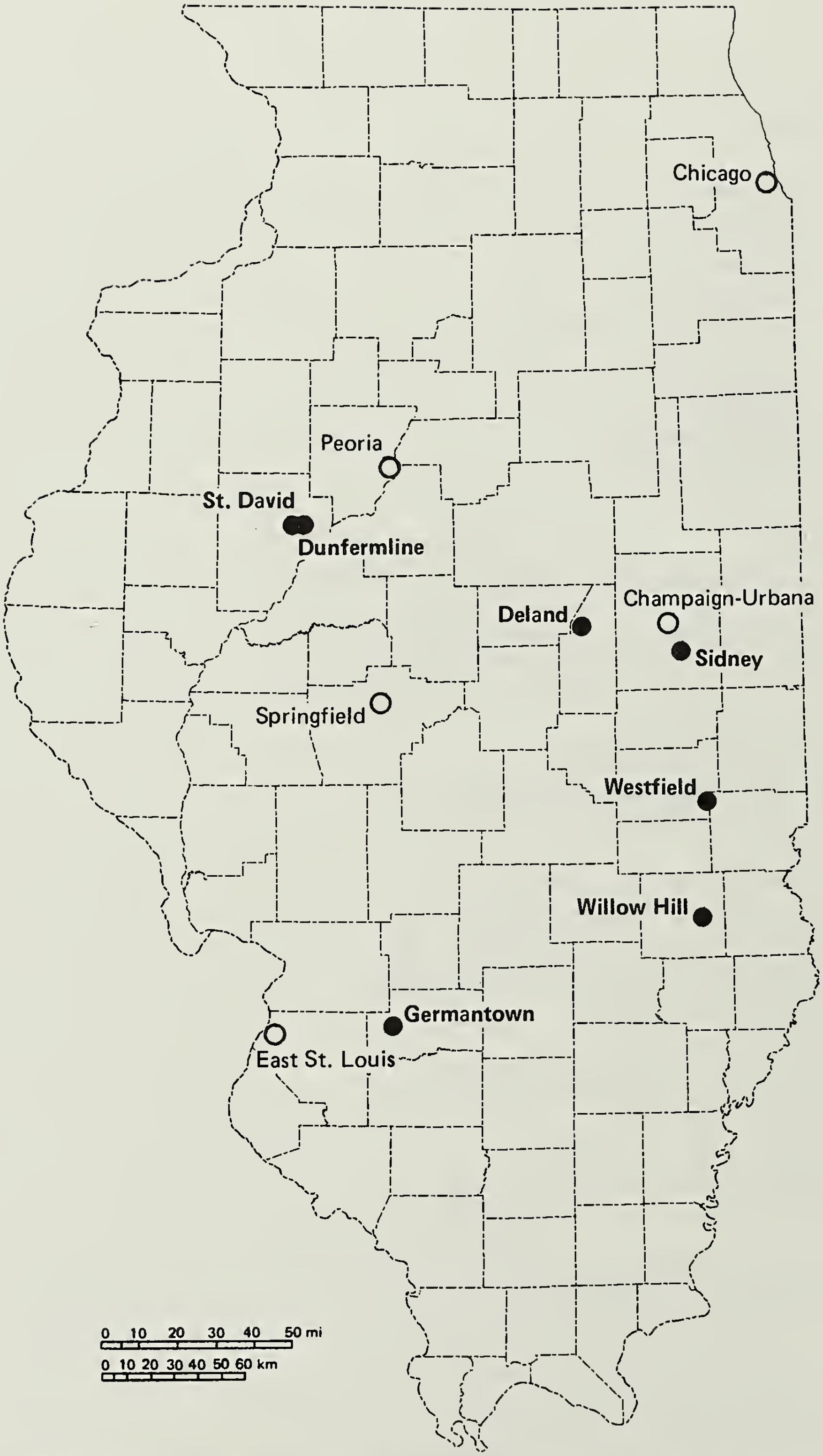



**Figure 1.** Communities (dots) studied for this report, and reference cities (circles).

## Abstract

*Many small Illinois communities that depend on groundwater to supply their municipal water systems experienced water shortages during the drought of 1976-77. In this supplemental geophysical assessment of the aquifers supplying groundwater to these towns, six communities were selected (on the basis of past shortages and projected needs) as sites for exploration programs to locate sites for new municipal wells. Electrical earth resistivity surveys were used extensively to evaluate the water-producing capacities of the glacial deposits and to provide a basis for recommendations for test-drilling locations.*

## Introduction

Water shortages occur periodically in many Illinois communities that depend on groundwater for their municipal water supply. In 1980 the Illinois Division of Water Resources, the Illinois State Geological Survey (ISGS), and the Illinois State Water Survey (Wehrmann et al., 1980) assessed the adequacy of groundwater supplies in 18 small communities that had experienced water shortages as a result of the drought of 1976-1977. We selected six of these communities (on the basis of past shortages and potential needs) as sites for supplemental studies that might be helpful in locating new municipal wells (fig. 1).

The electrical earth resistivity (EER) procedure used in this study is a quick, relatively reliable method of locating sand and gravel deposits; it is based on the fact that when fresh water is present, the resistivities of coarse-grained sands and gravels are higher than those of finer grained sediments such as silts and clays (fig. 2a). In this procedure, an electric current is applied into the ground through two current electrodes, and the potential difference is measured across a pair of potential electrodes. Apparent resistivity is calculated on the basis of the measured potential drop, applied current, and electrode spacing (Freeze and Cherry, 1979). The apparent resistivity is a weighted average of the resistivities of the earth materials that exist in the region between the potential surfaces ($P_1$ and $P_2$) that intersect the surface of the earth at the potential electrodes (fig. 2b). As the distance of the electrode pairs from the center stake is systematically increased, changes in apparent resistivity can be related to variation in resistivity of earth materials with depth. Values of resistivity are recorded in ohm-meters.

Basic equipment for this study included an AC current instrument (a Bison Model 2350B), insulated single-conductor electrical cable, two steel stakes that were implanted a few inches in the ground to introduce the current, two copper stakes that were implanted a few inches in the ground to measure the potential differences, and four short lengths of insulated wire, with alligator clips on both ends, which were used to connect the electrical cables to the electrodes (Gilkeson, 1984). In the Schlumberger electrode configuration used in this study, the electrodes were laid out in a line with the current electrodes positioned at the outside ends and the potential electrodes forming the inner pair (fig. 2b). A fixed ratio of 10:1 was maintained between the distance separating the current electrodes and the potential electrodes. The method of expanding the electrode configuration systematically about a center stake, measuring the potential differences, and calculating apparent resistivity values of the earth materials below the center stake is termed vertical electrical sounding (VES). A plot of apparent resistivity values verses electrode spacings is a VES curve (Heigold et al., 1984).

Qualitative and quantitative analyses were made of the VES data obtained during this study. Qualitative interpretation was based on examination of the maxima, minima, inflection points, and apparent resistivity values of the VES curves. The purpose of the quantitative analysis was to convert the weighted average apparent resistivity values used to construct the VES curves into a sequence of layers representing types of earth materials of varying thickness and calculated "true" resistivity. These "true" resistivities and thicknesses are referred to as layering parameters. The quantitative interpretation (inversion technique) used in this study was developed by Zohdy (1973), and used the method of convolution (Ghosh, 1971) and modified DarZarrouk functions (Zohdy, 1973, 1975). This technique provides only one of many geoelectrically equivalent layering parameters solutions for a given VES curve (Heigold et al., 1984). Information available on the geologic framework of the study area was used in conjunction with the EER data to delineate portions of each study area that exhibit the most favorable VES data. Cross-sections through these "most favorable areas" illustrate the layering parameters or "true" resistivities (in ohm-meters) and "true" thicknesses determined by quantitative analyses for the earth materials below the center stake of each VES profile. Discussions of these cross-sections and recommendations for future test drilling sites are provided for each community studied.

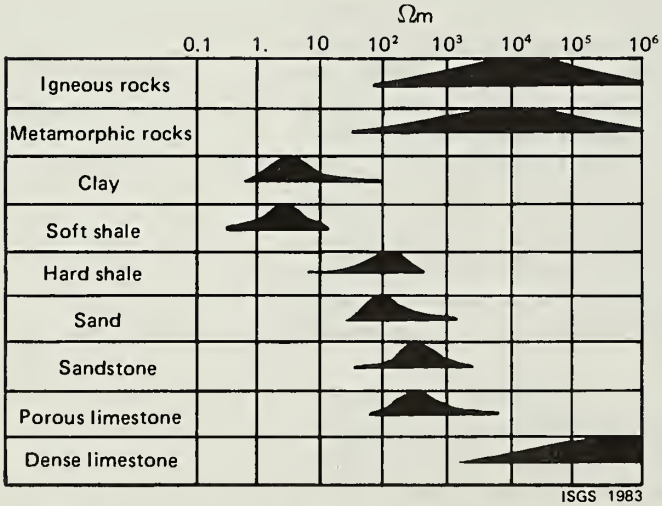



**Figure 2a.** Approximate resistivity ranges of some rock types (adapted from Griffiths and King, 1965).

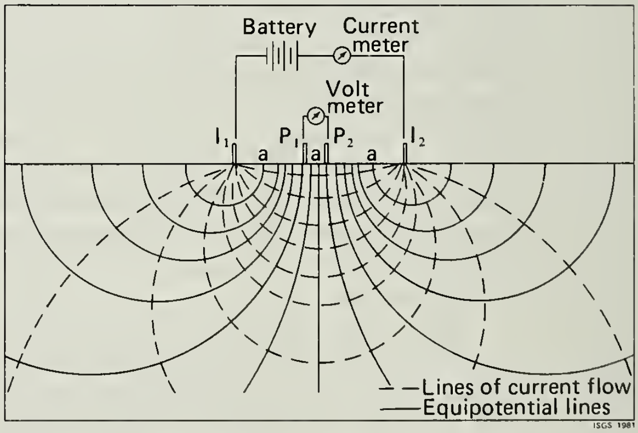



**Figure 2b.** Basic elements of an earth resistivity meter and the Schlumberger electrode configuration.

## DeLand

The community of DeLand (population 509) is located in northwestern Piatt County, in Section 9, T. 19N., R. 5E. (fig. 3). The population of DeLand is not projected to increase significantly by the year 2000, but according to the State Water Survey (Wehrmann et al., 1980), the well field was being pumped at or near its practical sustained yield in 1980.

The DeLand area is physiographically situated in the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province. It lies approximately 6 miles northwest of the Cerro Gordo Moraine and 10 miles southwest of the Champaign Moraine, both of the Wisconsinan glaciation (Woodfordian Age). The nearly flat to gently rolling topography in the DeLand study area is typical of a glacial ground moraine. Drainage of the area is principally south and southeast, via Goose Creek and its tributaries, to the Sangamon River, approximately 6 miles southeast of DeLand.

The uppermost bedrock in the DeLand area consists mostly of shale, and some siltstone, limestone, sandstone, and coal of the Pennsylvanian Bond and Modesto Formations. Elevation of the bedrock surface ranges from slightly less than 500 feet above mean sea level.(m.s.l.) in a small tributary of the Mahomet Bedrock Valley approximately 1 mile southwest of town to slightly more than 550 feet above mean sea level approximately 1 mile north of town. The uppermost bedrock is generally considered to be non-wateryielding, and no water wells in the DeLand study area are finished in it.

The unconsolidated Pleistocene glacial drift in the DeLand area consists of a complex of icelaid till, waterlaid clay, silt, sand and gravel outwash and alluvium, and windblown silt (loess) of pre-Illinoian, Illinoian, and Wisconsinan age (Wehrmann et al., 1980, Kempton et al., 1982). Drift thickness ranges from 160 to 170 feet in the study area, and increases to 200 feet in all directions outside the study area. Thickness of the blanketing loess varies from approximately 4 to 6 feet. A widespread sand and gravel deposit 1 to 5 feet thick is known to occur within the glacial drift at a depth of 70 to 100 feet below the surface. DeLand's municipal wells and several wells furnishing domestic supplies tap this deposit within the study area. Some test holes drilled by the village during the period from 1933 to 1935 indicate that a sand and gravel deposit of similar thickness occurs at a depth of approximately 140 to 160 feet, just above the bedrock surface. No information is available concerning the continuity of this deposit or its possible wateryielding capabilities.

DeLand currently operates six municipal wells on the southwest edge of town (SW¼, Sec. 9, T. 19N., R. 5E.) numbered 1, 3, 4, 5, 6, and 7. (These are not shown on fig. 2; but the location of the well field is indicated.) The wells are finished at depths of 79 to 83 feet and screened intervals are located in the bottom 3.25 to 9.5 feet of the wells (Wehrmann et al., 1980).

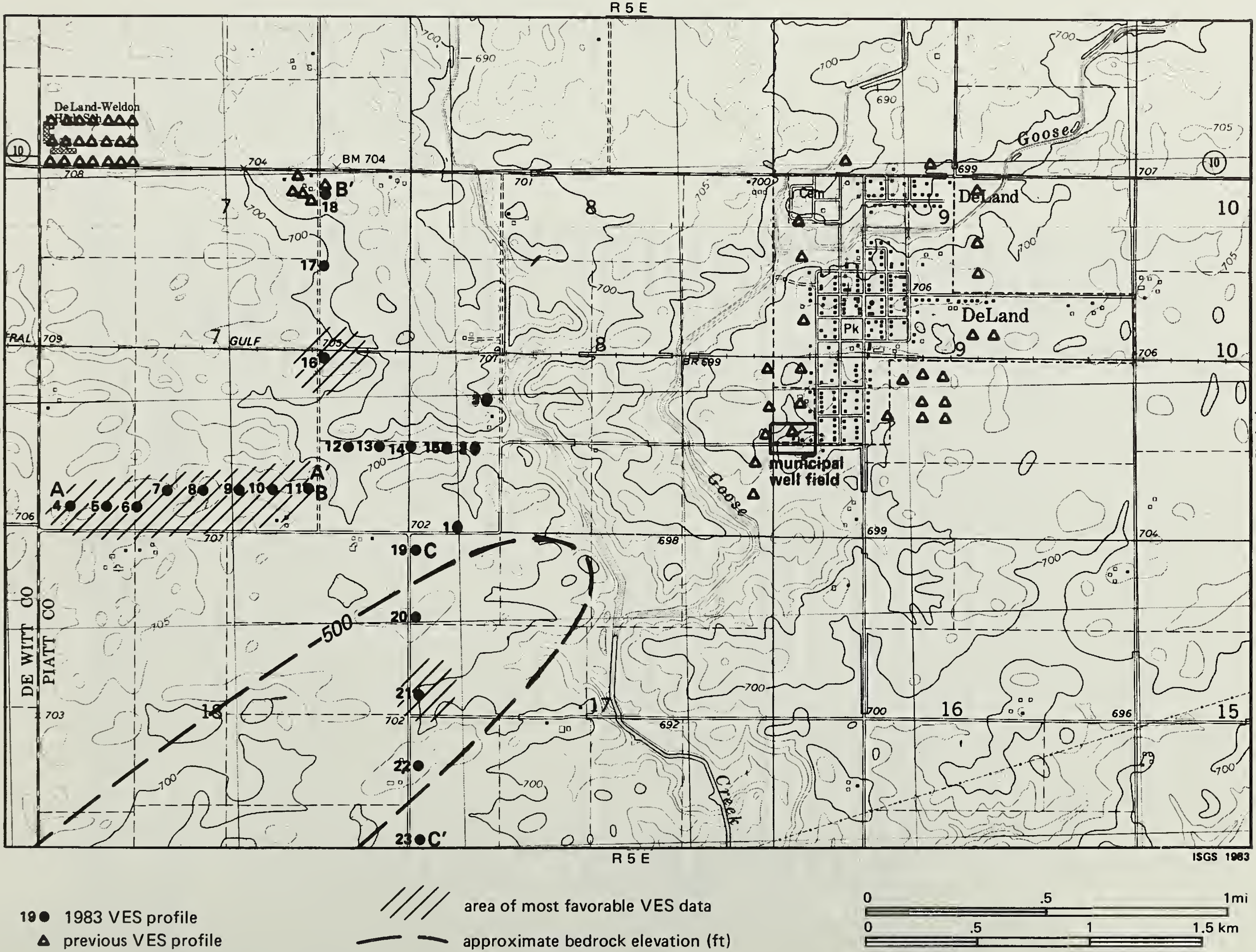



Figure 3. DeLand study area.

Yields from municipal wells 1, 3, 4, and 5 were reported to be 10 to 17 gallons per minute in November, 1978. Illinois State Water Survey data (Robert Olson, personal communication, 1980) indicate that total pumpage from each well in 1982 averaged 2,643,340 gallons (approximately 7,260 gal/day or 5 gal/min) for wells 1, 3, 4, and 5. Municipal wells 6 and 7 were completed in May and June of 1982. The August 1983 Illinois Environmental Protection Agency (IEPA) inspection report indicated that wells 6 and 7 were in use, but no pumpage data were available. As noted by Wehrmann et al. (1980) the addition of these wells in the same aquifer tapped by the other municipal wells is not expected to increase the sustained yield of the well system. Current demand is at or near the 43,000 gallons per day average sustained yield of the field. Water shortages occur during periods of drought when the sustained yield falls and demand is high.

In the 1980 report, Wehrmann et al. recommended that a supplemental electrical earth resistivity survey be made in the large, relatively undeveloped areas just outside the village limits in N½ of Section 17, T. 19N., R. 5E., and southwest, south, and southeast of town near the ancient Mahomet Bedrock Valley and its tributaries. On the basis of those recommendations, VES profiles were located west of the village limits and approximately 1 to 1½ miles southwest of the village, where a possible extension of a tributary of the Mahomet Bedrock Valley is in alignment with the current municipal well field.

VES data were evaluated both qualitatively and quantitatively. Interpretation of the resistivity data consisted of construction, examination, and inversion (using the inversion technique of Zohdy, 1973) of VES curves for all VES profiles. Inversion of a VES curve provides layering parameters ("true" resistivities and thickness) for the sediments below the center stake of the corresponding VES profile. Three lines of VES profiles, AA′, BB′, and CC′ (fig. 3) were selected to illustrate the layering parameters associated with the areas of most favorable VES profiles.

AA′, an east-west line of VES profiles (fig. 4a), is located just north of the south line of Section 7, T. 19N., R. 5E., approximately 1½ miles southwest of DeLand. All VES profiles along this line indicate a layer of higher resistivity at one or two general depths, one relatively shallow and one ranging from the depth of the current municipal wells to just above the bedrock surface. VES profiles 7 and 10 show high "true" resistivity layers at depths ranging from approximately 80 feet to the bedrock surface and are considered the most favorable sites for test drilling.

Line BB′ of VES profiles (fig. 4b), beginning at VES profile 11, extends 1 mile north along the center of the east half of Section 7, T. 19N., R. 5E., approximately 1¼ miles west of DeLand. All VES curves indicate possible coarse-grained layers in the unconsolidated sediments at various depths above the estimated bedrock surface. The VES curve of profile 16 exhibits higher amplitude and more curvature than other VES profiles along line BB′ and is considered the most favorable site along this line for future test drilling.

Line CC′ of VES profiles (fig. 4c) is oriented north-south along the east line of Section 18, T. 19N., R. 5E., about 1 to 1½ miles southwest of DeLand. The line traverses a possible tributary of the ancient Mahomet Bedrock Valley, oriented northeast-southwest and roughly aligned with the current municipal well field. VES profiles along this line may indicate the


**Figure 4a.** Layering parameters ("true" resistivities and thicknesses) along line A-A′, DeLand study area. "True" resistivity values are in ohm-meters.

presence of a coarse-grained layer directly above the bedrock surface. On the basis of our evaluation of apparent resistivity curves and computed layering parameters, VES profile 21 is the most favorable site for test drilling along this line.

To summarize, the well field currently utilized by DeLand is near its sustained yield. Although new wells may be drilled to replace or augment wells with decreased capacity due to clogging, the State Water Survey (Wehrmann et al., 1980) has determined that additional new wells in the immediate vicinity of the current well field will not increase the total supply by any significant amount. Exploration for additional water resources to increase the practical sustained yield of the present well system is therefore recommended in the following locations: (1) VES profiles 7 and 10, located approximately 1950 feet from each other and approximately 525 feet north of the road along the south line of Section 7, T. 19N., R. 5E.; (2) VES profile 16, located at the center of the west line of Section 8, T. 19N., R. 5E.; and (3) VES profile 21, located approximately 300 feet north and 75 feet east of the center of the west line of Section 17, T. 19N., R. 5E.

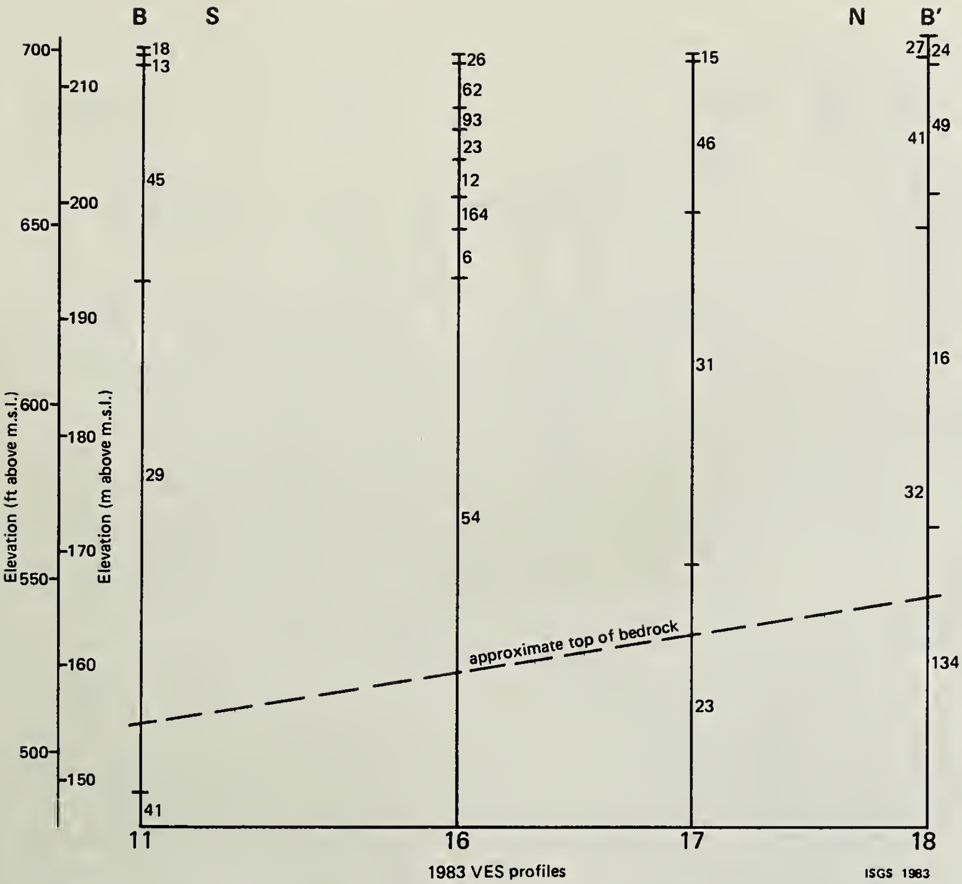



**Figure 4b.** Layering parameters along line B-B′, DeLand study area.

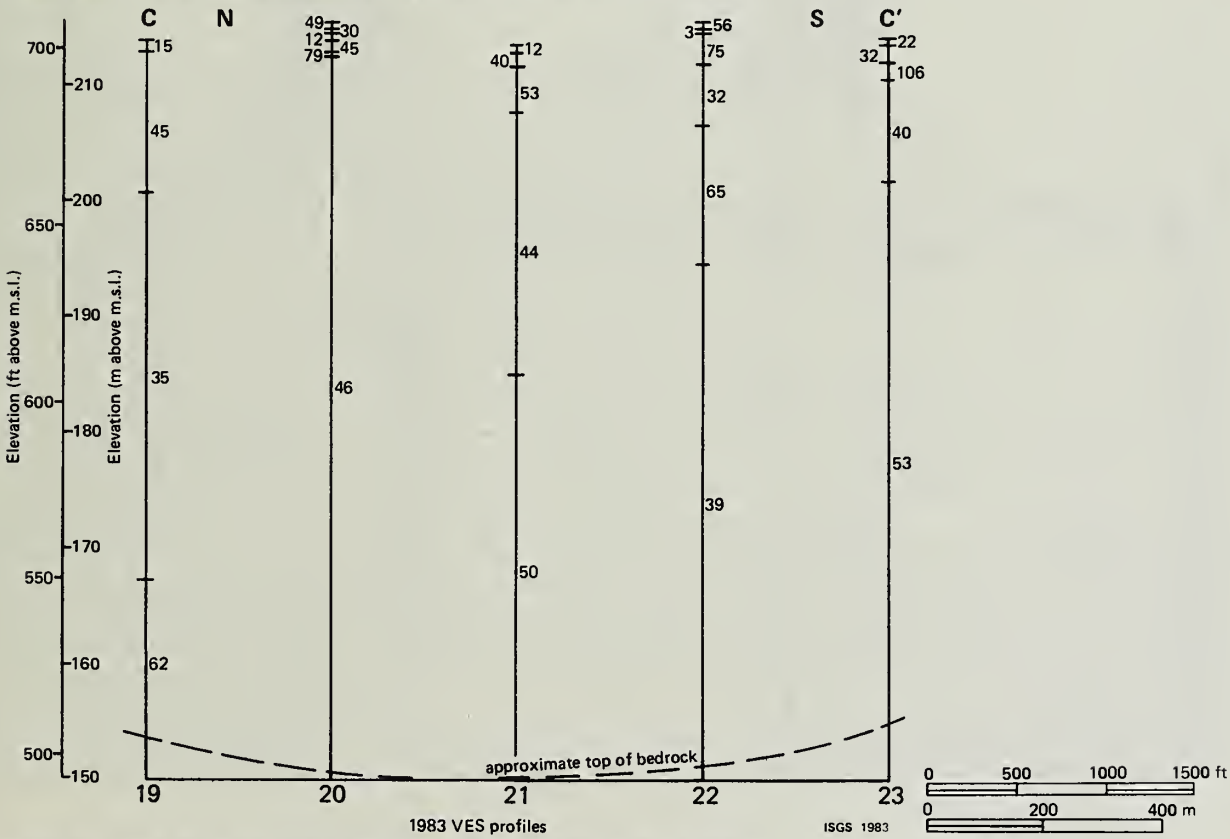



**Figure 4c.** Layering parameters along line C-C′, DeLand study area.

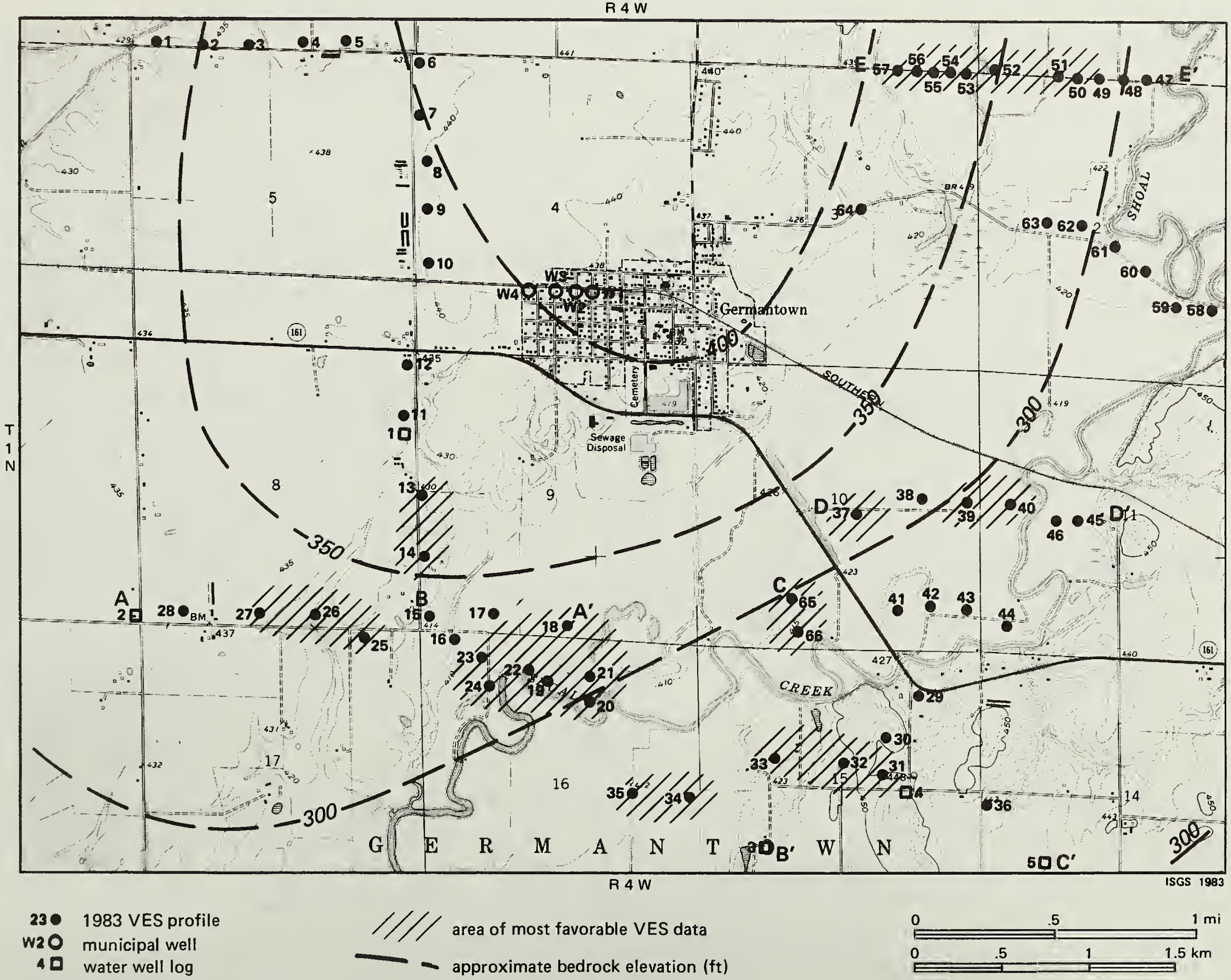



Figure 5. Germantown study area.

## Germantown

The community of Germantown (population 1191) is located in west-central Clinton County in portions of Sections 3, 4, 9, and 10, T. 1N., R. 4W. (fig. 5). The population of Germantown has increased approximately 7.5 percent over the last 10 years and is expected to increase slightly by the year 2000. Average water demand by the year 2000 is expected to remain the same or increase slightly (Wehrmann et al., 1980); however, estimates indicate that during periods of sustained drought aquifer capacity may be reduced by up to 50 percent (Wehrmann et al., 1980).

Germantown is physiographically located in the southern part of the Springfield Plain of the Till Plains Section of the Central Lowland Province; it lies near the southern edge of the Shoal Creek Prairie, approximately 80 miles southwest of the southernmost limit of Wisconsinan glaciation in Illinois. Topographic relief of the prairie is low, generally ranging from 430 to 440 feet above mean sea level. South and east of the Shoal Creek Valley (410 to 420 ft above m.s.l.) the ground surface is ridged; a maximum elevation of approximately 490 feet is reached in Section 15, T. 1N., R. 4W. Drainage is south via small tributary streams to southward-flowing Shoal Creek. Shoal Creek joins the Kaskaskia River approximately 6 miles south of town.

The uppermost bedrock in the Germantown area consists mostly of non-water yielding shales, with some sandstones and limestones of the Pennsylvanian Modesto and Bond Formations. Although some small domestic water supplies are obtained from shallow sandstones and fractured limestone, the shallow bedrock cannot be considered a possible source of moderate to large municipal supplies of groundwater. Elevation of the bedrock surface ranges from a little more than 400 feet above m.s.l. just north of Germantown to a little under 300 feet above m.s.l. in a large bedrock valley approximately 2½ miles west of town. The large bedrock valley southeast of town roughly parallels the present-day Shoal Creek Valley.

The glacial drift in the Germantown area consists mostly of till (pebbly clay) and outwash of pre-Illinoian and Illinoian age, and windblown silt (loess) of Wisconsinan age (Wehrmann et al., 1980; Kempton et al., 1982). Drift thickness ranges from approximately 18 feet, over the shallow bedrock on the nearly flat uplands, to approximately 150 feet, over the large bedrock valley southeast of town. The blanketing loess averages 4 to 6 feet thick. Many domestic wells, in addition to the Germantown municipal wells, obtain water from a widespread sand and gravel deposit 10 to 35 feet deep that ranges between 3 and 15 feet thick (Wehrmann et al., 1980). Oil well logs indicate a potential aquifer of thick ($>$ 50 ft) sand and gravel near the base of the drift in the large bedrock valley; however, oil well log data on glacial drift are often unreliable.

Germantown operates four municipal wells on the north-northwest edge of town in the center of the south half of Section 4, T. 1N., R. 4W.

Wells 1, 2, and 3 were drilled to depths of 25 feet, and well 4 was drilled to 25½ feet. The bottom 5 feet of all four wells is screened, and the thickness of the aquifer tapped is 8½ to 9 feet (Wehrmann et al., 1980). Wells 1 through 4 averaged 8335, 17,988, 26,375, and 18,396 gallons per day, respectively, for a total average pumpage of 71,000 gallons in 1983 (Robert Olson, personal communication, 1983). Although Wehrmann et al. (1980), estimated that the total sustained yield of the current municipal well field was about 93,000 gallons per day, they also noted that because of the shallow depth of the municipal wells, the sustained yield during periods of drought is frequently cut by half. Water demand in Germantown by the year 2000 is estimated to be 82,700 gallons per day (Wehrmann et al., 1980) and it is apparent that additional water resources are necessary during dry periods.

Wehrmann et al. (1980) recommended two areas for future groundwater exploration: (1) northwest and southwest of town (Secs. 4, 5, and 9, T. 1N., R. 4W.) in the same aquifer tapped by the current municipal wells, and (2) east and south in or near the Shoal Creek bottomlands in the eastern half of Section 10, in Section 11, and in Sections 14 through 16, T. 1N., R. 4W., where several drilling logs indicate thick sand and gravel deposits deeper than those now being tapped by the current municipal wells. Accordingly, 66 VES (vertical electrical sounding) profiles were located in the Germantown area during the summer of 1983. Qualitative interpretation of the resistivity data consisted of plotting and examination of all VES profiles. The inversion technique of Zohdy (1973) was used in quantitative evaluation of the VES data. Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth below the center stake of the corresponding VES profile. Of particular interest were the results from five lines of VES profiles, AA′, BB′, CC′, DD′, and EE′ (figs. 6a-e).

Line AA′ of VES profiles (fig. 6a) extends east-west, roughly along the south line of Sections 8 and 9, T. 1N., R. 4W., beginning at the southwest corner of Section 8 and extending to VES profile 18 in Section 9. Layering parameters of VES profiles along this line generally indicate that coarse-grained deposits may exist at depths of less than 60 feet in the glacial drift. In addition, layering parameters of VES profiles 25, 26, and 27 indicate that sand and gravel deposits may be present just above the bedrock surface; these three profile locations are considered the most favorable test drilling sites along line AA′.

Line BB′ (fig. 6b) runs northwest-southeast across the northern half of Section 16, T. 1N., R. 4W., traversing a portion of the Shoal Creek bottomlands. "True" resistivity values tend to increase in a southerly direction along this line. Highest values appear to occur at least 20 to 40 feet above the bedrock surface. Possible test drilling sites along this line are at VES profiles 19 and 20.

A second set of VES profiles, CC′, traverses the Shoal Creek bottomlands in a roughly northwest-southeast direction (fig. 6c), extending across portions of Sections 10, 15, and 14, T. 1N., R. 4W. Elevation of bedrock surface at all stations is less than 300 feet. Layering parameters obtained along this line are similar to those along BB′, but highest "true" resistivity values are associated with relatively thick layers at or near the bedrock surface. VES profiles 32 and 33 appear to be the best sites for future test drilling. The location of VES profile 33 is shown on figure 5.

Line DD′ of VES profiles extends in an east-west direction from the center of Section 10, T. 1N., R. 4W., almost to the center of Section 11


**Figure 6a.** Layering parameters ("true" resistivities and thicknesses) along line A–A′, Germantown study area. "True" resistivity values are in ohm-meters.

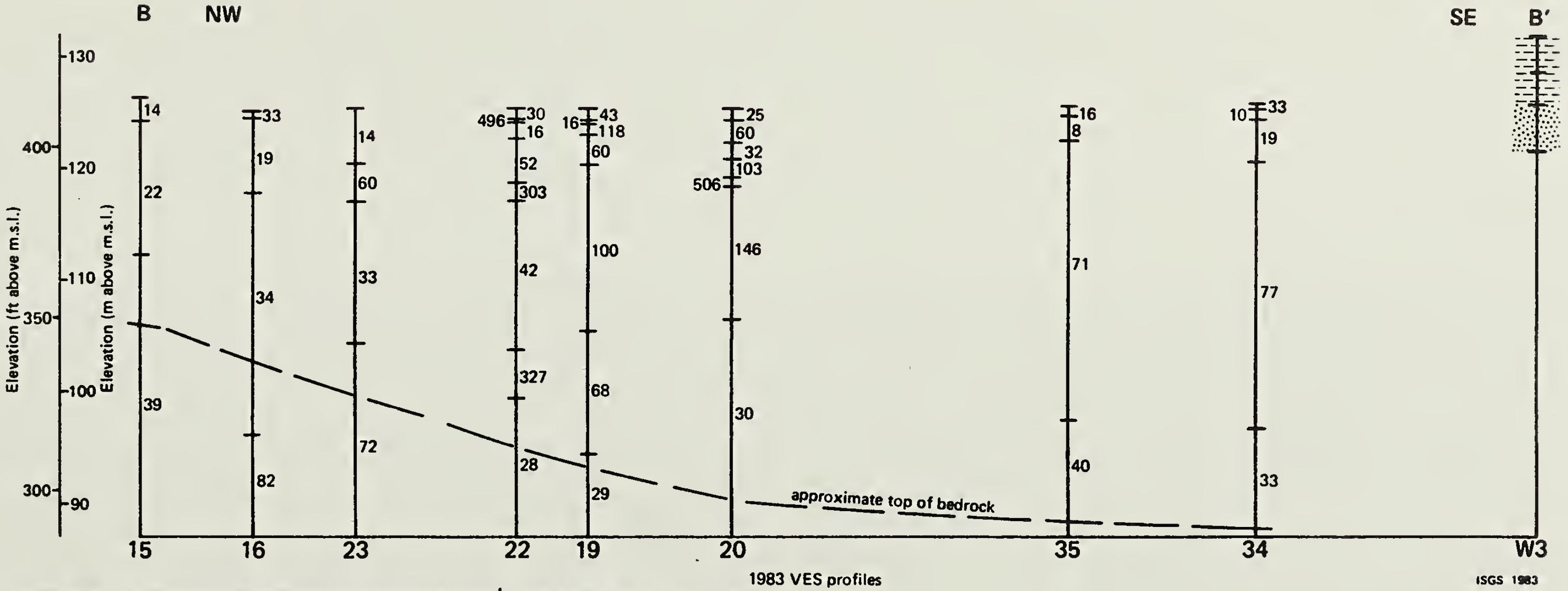



Figure 6b. Layering parameters along line B–B′, Germantown study area.

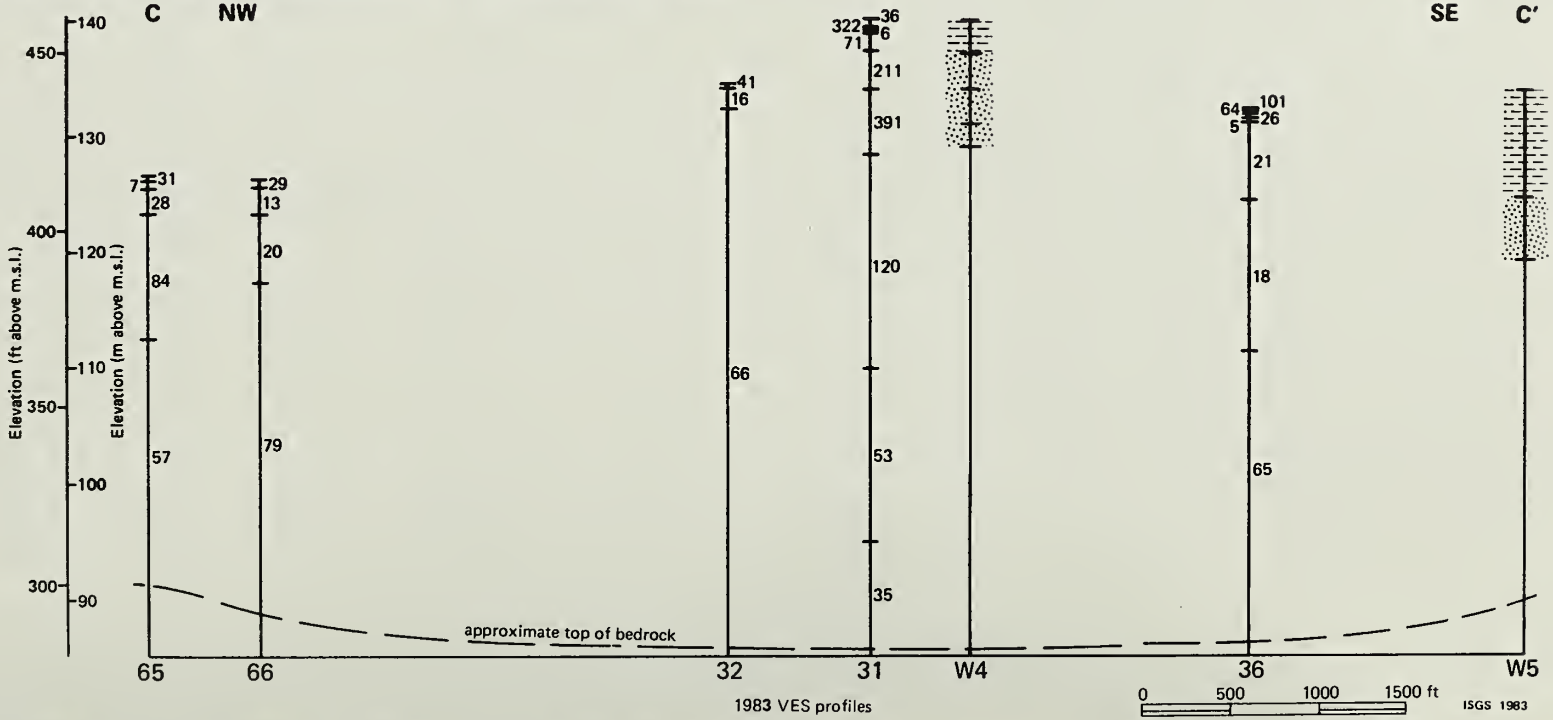



Figure 6c. Layering parameters along line C–C′, Germantown study area.

(fig. 6d). Layering parameters again show high "true" resistivity values for relatively thick (approximately 80-ft) layers beginning at a 20- to 30-foot depth and extending to or just above the estimated bedrock surface. VES profiles 37, 39, and 40 appear to be the most promising locations for test drilling along the line.

Line EE′ of VES profiles is located a little more than a mile northeast of Germantown along portions of the north line of Sections 2 and 3, T. 1N., R. 4W (fig. 6e). EE′ traverses the western flank of the large bedrock valley and the west side of the Shoal Creek bottomlands. Most of the VES profiles along this line have a high resistivity layer at the approximate depth of the sand and gravel tapped by the current municipal wells. Whether this high resistivity layer represents an extension of the aquifer tapped by the Germantown municipal wells is unknown. VES profiles 50, 53, and 54 are considered the most favorable test drilling sites along this line; however, it should be noted that the shallow nature of this possible sand deposit makes it as sensitive to drought conditions as the current municipal wells.

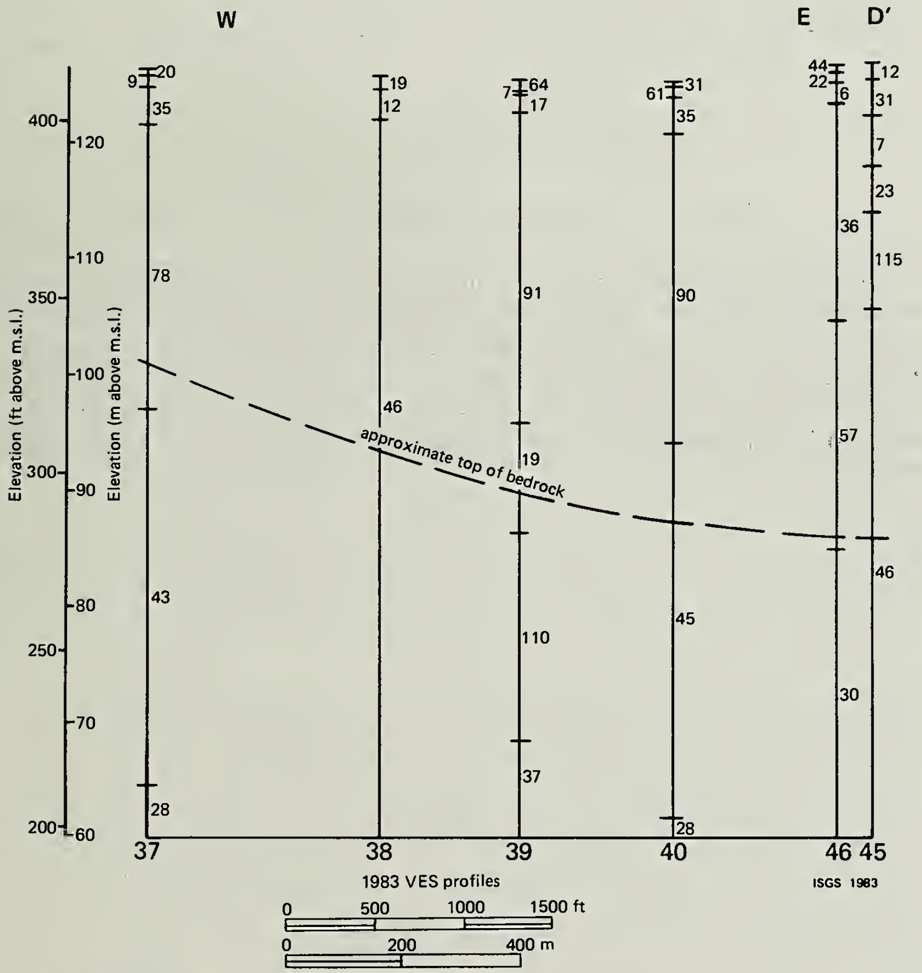



Figure 6d. Layering parameters along line D-D′, Germantown study area.

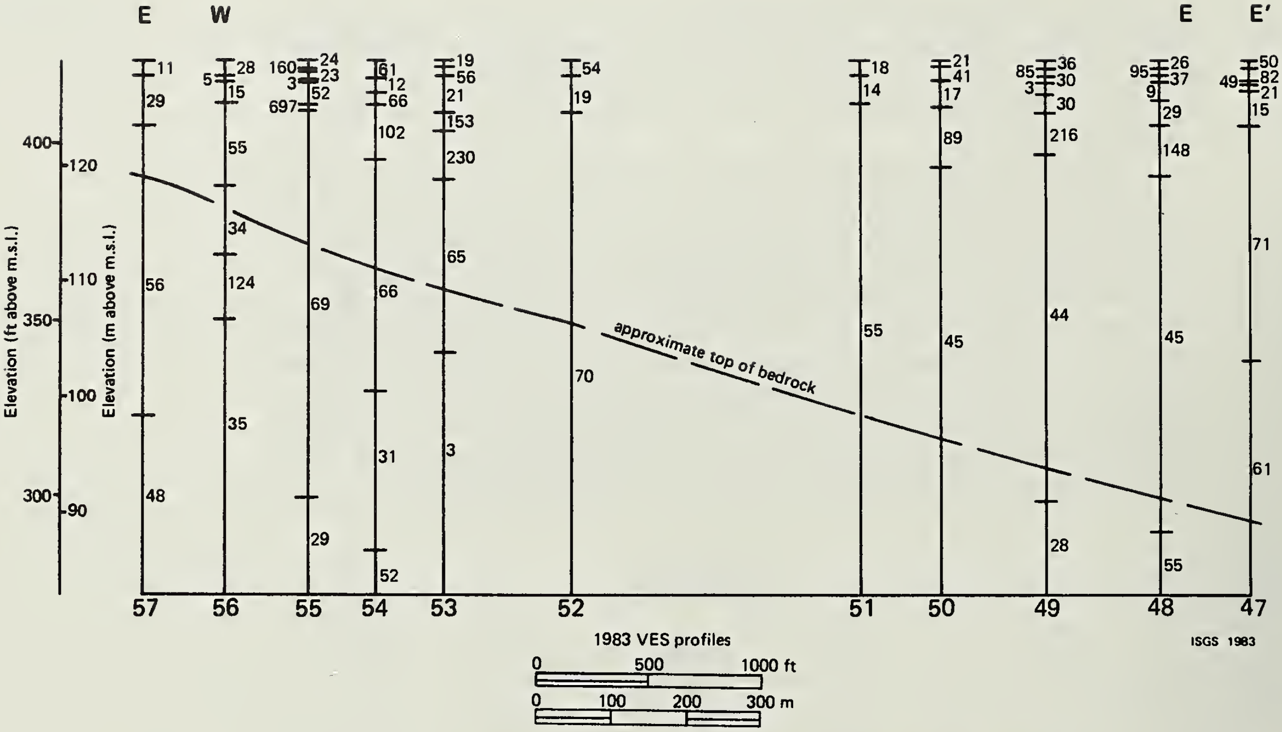



**Figure 6e.** Layering parameters along line E-E', Germantown study area.

To summarize, it seems very likely that additional groundwater resources can be developed from the glacial drift in the Germantown area. Primary choices for test drilling sites are the VES profile locations where coarse-grained sediments may exist at a depth in the glacial drift greater than that of the current Germantown municipal wells. Secondary choices are the VES profiles where data indicate possible coarse-grained sediments at depths of less than 40 feet.

## St. David-Dunfermline

The communities of St. David (population 786) and Dunfermline (population 313), are located in east-central Fulton County in portions of Sections 15, 16, 21, and 22, T. 6N., R. 4E. (fig. 7). The population and water demand of the St. David-Dunfermline Water District is expected to increase slightly by the year 2000 (Wehrmann et al., 1980).

St. David and Dunfermline physiographically lie approximately 8 miles northwest of the southeast edge of the Galesburg Plain of the Till Plains Section of the Central Lowland Province. The water district is situated on Illinoian ground moraine with local morainic and ridged drift deposits. The study area lies approximately 8 miles northwest of the Illinois River and 22 miles west of the westernmost extent of Wisconsinan glaciation in Illinois. Topographically, the area is a stream-dissected rolling upland that has been heavily strip-mined. Drainage east and south of the two towns is south to the Illinois River; north and west of St. David, drainage is southwest via Big Creek and its tributaries to Spoon River, a tributary to the southwestward-flowing Illinois River.

The uppermost bedrock in the water district area consists primarily of shales that do not yield water and major coal beds (#5 and #6) along with some sandstones and thin limestones of the Pennsylvanian Carbondale Formation. Elevation of the bedrock surface ranges from 550 feet above m.s.l., in a small area in the southern portion of the study area, to a little more than 600 feet above m.s.l. in most of the study area. No prominent features on the bedrock surface are known to exist. Outcrops of bedrock occur in some stream valleys. Wateryielding capability of the shallow bedrock is low to nonexistent. In some places, thin sandstones or limestones may yield enough water for domestic supplies, but cannot provide moderate-to-large municipal supplies of groundwater. Wehrmann et al. (1980) state that bedrock formations 400 to 3000 feet deep, such as the Burlington and Keokuk limestones, Silurian dolomite, and the St. Peter, Ironton, and Galesville Sandstones, "will yield small to large supplies of moderately mineralized water."

The glacial drift in the water district area consists primarily of a till deposit 15 to 25 feet deep of Illinoian age and windblown silt (loess) of Wisconsinan age. The thickness of the blanketing loess varies from approximately 10 to 20 feet. Sand and gravel deposits within the drift are thin (usually less than 15 ft) and discontinuous, and occur most often directly above the bedrock surface (Wehrmann et al., 1980). Some sand and gravel deposits have been removed by strip-mining. Where present (and not dewatered by mining activity below the natural groundwater level), sand and gravel deposits within the drift are known to produce small to moderate water supplies.

Until February, 1980, the St. David-Dunfermline Water District operated 3 wells approximately 1½ miles north of St. David in the south-central

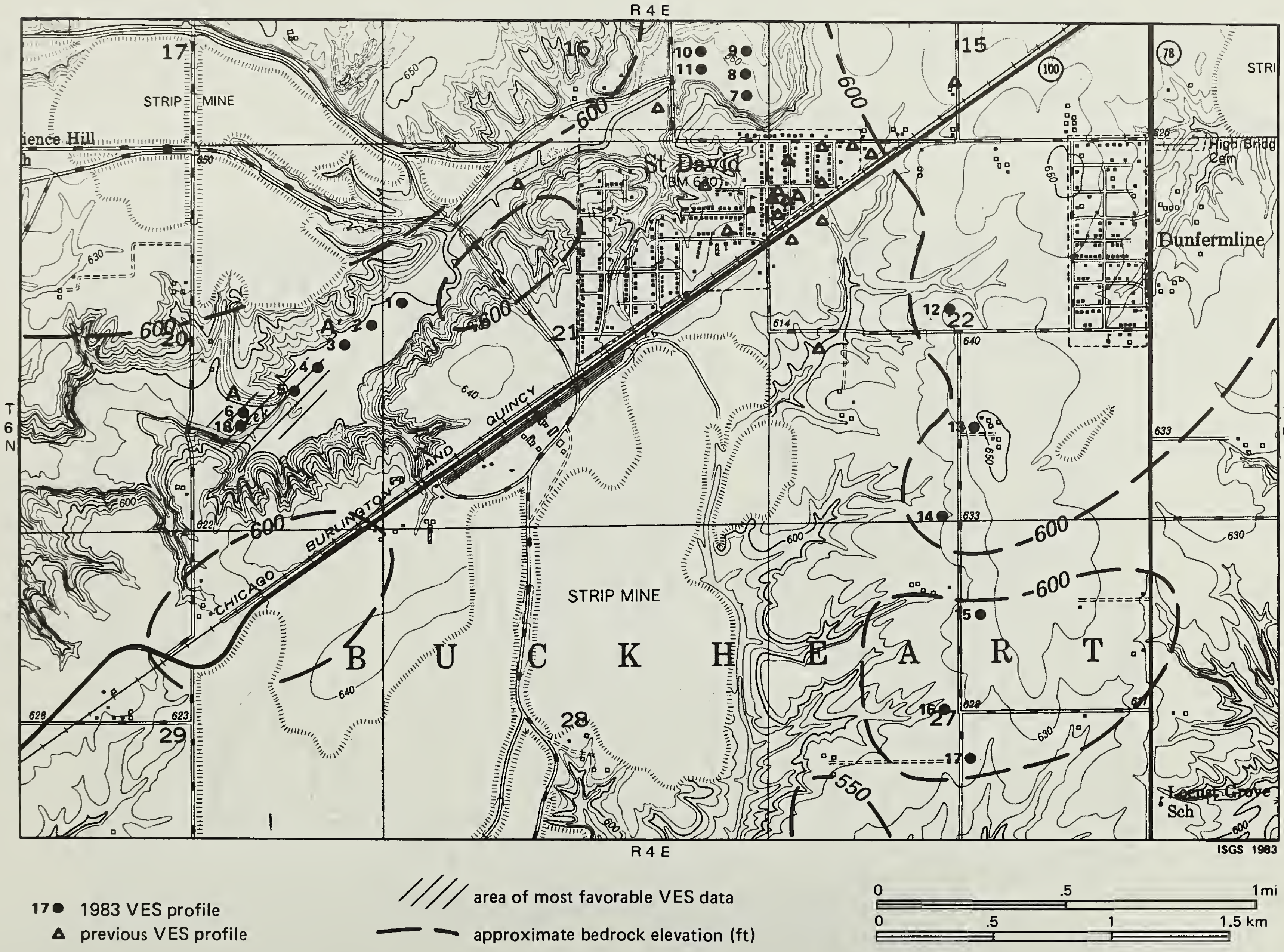



Figure 7. St. David-Dunfermline study area.

portion of Section 10, T. 6N., R. 4E. The wells were drilled to depths between 43 and 48 feet, and the bottom 8 feet of each well was screened. In 1979, the district reported that pumpage for each well began at 30 to 50 gallons per minute, and gradually decreased to 10 to 25 gallons per minute by the end of the day (Wehrmann et al., 1980). Total average demand in 1979 was 65,000 to 70,000 gallons per day. The total sustained yield of the district well field under normal precipitation conditions was estimated by Wehrmann et al. (1980) at 100,000 gallons per day; under drought conditions the yield is reduced as available drawdown decreases. Water demand of the district by the year 2000 has been estimated at slightly over 75,000 gallons per day by the State Division of Water Resources (Wehrmann et al., 1980).

Wehrmann et al. (1980) suggested four alternative approaches that could help provide for future needs: (1) locate an extension of the aquifer tapped by the district wells closer to the two towns; (2) have an EER survey made of the largely unexplored flat of Big Creek; (3) draw water from strip mine lakes; or (4) draw water from deep bedrock formations and desalinize it. During the course of this study, the St. David-Dunfermline water district abandoned its wells and began purchasing water from the Canton public water supply (Robert Olson, personal communication, 1983.) The results of this study are presented as reference information in the event that the district decides to reestablish its own water supply system.

During the EER survey conducted in 1983, vertical electrical sounding (VES) profiles were located in the bottomland of Big Creek just southwest of St. David and just north of St. David, and in an area between and south of St. David and Dunfermline where coal test logs indicate unconsolidated sediments 35 to 60 feet thick. Qualitative interpretation of VES data consisted of construction and examination of all VES profiles. Quantitative evaluation utilized the inversion technique of Zohdy (1973) to produce layering parameters ("true" resistivities and thicknesses) for the sediments below the center stake of the corresponding VES profiles. Line AA′ (fig. 8)

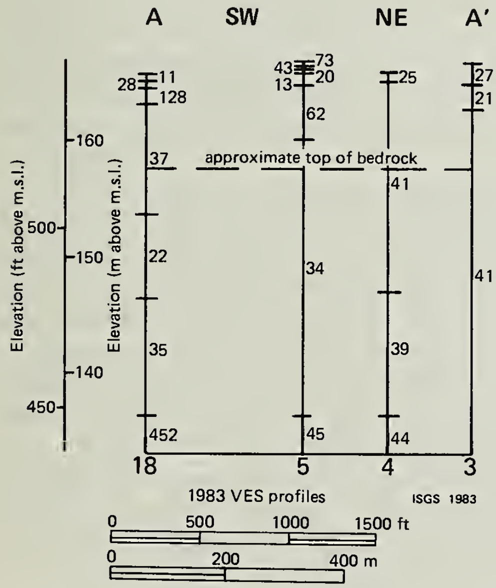



Figure 8. Layering parameters ("true" resistivities and thicknesses) along line A-A′, St. David-Dunfermline study area. "True" resistivity values are in ohm-meters.

of VES profiles illustrates the layering parameters associated with the area of most favorable VES data.

Line AA′ of VES profiles trends northeast and is located in the Big Creek bottomlands across the southeast quarter of Section 20, T. 6N., R. 4E., ½ to 1 mile southwest of St. David (fig. 7). Most VES profiles along this line exhibit relatively high "true" resistivity values just above the estimated elevation of the bedrock surface. High "true" resistivity values of surface sediments at profiles 5 and 6 probably reflect the presence of drained coarse-grained deposits. Resistivity values of profiles 18, 5, and 3 are most indicative of possible sand and gravel deposits.

To summarize, although deposits of sand and gravel may exist in the Big Creek bottomlands, they are shallow and would be highly sensitive to drought conditions. Although VES profile 18 was the most favorable site of the 1983 survey, no specific sites for future test-drilling for district water supplies are recommended. The decision of the district to purchase its water supply from Canton is considered the most reasonable alternative at the present time.

## Sidney

The community of Sidney (population 886), is located in the southeast quarter of Champaign County in portions of Sections 9, 10, and 16, T. 18N., R. 10E. (fig. 9). The population of Sidney has decreased slightly (3.2%) over the last10 years, but water demand is expected to increase by about 15 percent by the year 2000 (Siavash Mostoufi, personal communication, 1984).

Sidney is physiographically located in the east-central portion of the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province; it lies on Wisconsinan ground moraine approximately 2½ miles north of the Urbana Moraine of Woodfordian age. Topographic elevations in the Sidney area range from approximately 690 feet above m.s.l. in the extreme southeast portion of the study area to approximately 640 feet above m.s.l. along the eastern half of the Salt Fork. Maximum relief is in the southern and eastern half of the study area; the western half is flat to slightly rolling. Drainage is north via small streams to the Salt Fork at the north edge of town. The Salt Fork flows south to the north edge of Sidney, then east to the Vermilion River.

The uppermost bedrock consists primarily of non-wateryielding shales containing some thin sandstones and limestones of the Pennsylvanian Carbondale Formation (Wehrmann et al., 1980). Although no water wells are known to be developed in the shallow bedrock in the Sidney study area, it is possible that small domestic supplies could be developed from weathered sandstone or fractured limestone occurring near the surface of the bedrock. However, the bedrock cannot be considered as a possible source for moderate or large municipal supplies of groundwater. Located on a regional bedrock high, Sidney has an elevation of between 550 and 600 feet above m.s.l.. The bedrock high is situated between ancient tributaries to the Mahomet Bedrock Valley to the northwest and ancient tributaries to the Pesotum Bedrock Valley to the south and southeast. Elevation of the bedrock surface decreases in those directions to between 400 and 500 feet above m.s.l.

The glacial drift consists of deposits of pre-Illinoian, Illinoian, and Wisconsinan age (Wehrmann, 1980; Kempton et al., 1982). These deposits are mostly till (pebbly clay) with some outwash, alluvium, and windblown silt (loess). The blanketing loess averages 2 to 4 feet thick. Drift thickness ranges from approximately 60 to 100 feet over the area of high bedrock elevation to approximately 200 feet over the bedrock valleys. All water supplies recorded with the State Water and Geological Surveys in the Sidney study area are developed from sand and gravel deposits at various depths in the glacial drift. Sand and gravel deposits have been distinguished at two principal intervals within the drift (Wehrmann et al., 1980; Kempton et al., 1982): one discontinuous, 2 to 4 feet thick, occurring at an elevation of 600 to 620 feet above m.s.l.; the second more extensive, usually 3 to 12 feet

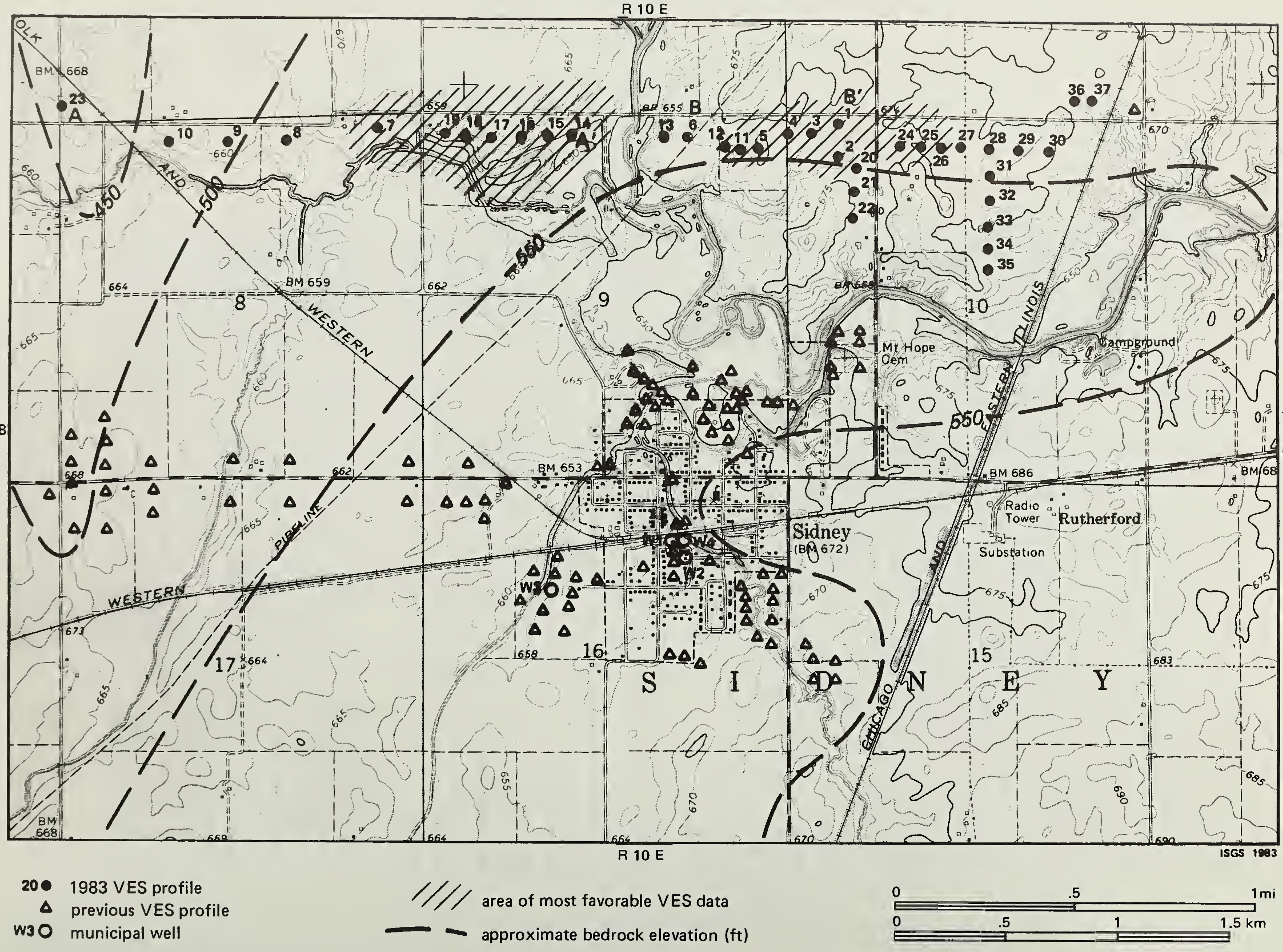



Figure 9. Sidney study area.

thick, occurring at an elevation of 550 to 590 feet above m.s.l. Continuity and thickness of alluvial sands and gravels within the Salt Fork Valley are unknown.

Sidney's municipal wells are developed in a sand and gravel deposit of the upper interval identified by Wehrmann et al. (1980). Wells 1, 2, and 4 are in the SE¼ NW NE Section 16, T. 18N., R. 10E.; well 3 is near a northward-flowing intermittent stream—a tributary of the Salt Fork—in the center of the N½ SE NW Section 16, T. 18N., R. 10E. The wells are drilled between 53 to 58 3/4 feet deep, and the bottom 10 to 13 feet is screened (Wehrmann et al., 1980). Pumpage data was available only for wells 1, 2, and 3, in 1982; yields reported were 18,475 gallons per day, 10,816 gallons per day, and 29,434 gallons per day, respectively (Robert Olson, personal communication, 1983). The total sustained yield of the Sidney Municipal Well field was estimated at 144,000 to 158,000 gallons per day, a yield that could be reduced by approximately 40 percent during drought conditions, according to Wehrmann et al. (1980). Excluding pumpage of well 4, current (1982) total water demand at Sidney is 58,725 gallons per day. According to the Division of Water Resources (Siavash Mostoufi, personal communication, 1984), demand for water resources at Sidney is expected to increase by approximately 15 percent by the year 2000.

Wehrmann et al. (1980) recommended that electrical earth resistivity surveys be made in two general areas to locate optimal sites for test drilling: (1) the north half of Section 8, T. 18N., R. 10E., and (2) the north half of Section 9 and the east half and northwest quarter of Section 10, T. 18N., R. 10E. On the basis of these recommendations, vertical electrical sounding (VES) profiles were located north of Sidney across the northern portions of Sections 8 through 10, T. 18N., R. 10E.

Interpretation of the resistivity data consisted of construction, examination, and inversion (according to the inversion technique of Zohdy, 1973) of VES curves for all VES profiles. The inversion technique provides layering parameters ("true" resistivities and thicknesses) for the sediments below the center stake of the corresponding VES profile. Two lines of VES profiles, AA' and BB', show the layering parameters associated with the areas of most favorable resistivity values.

Line AA' of VES profiles extends east-west near the northline of Section 8 and near the western half of the northline of Section 9, T. 18N., R. 10E. (fig. 10a). Layering parameters of VES profiles along AA' indicate that coarse-grained deposits may occur at both of the intervals in the drift identified by Wehrmann et al. (1980) and Kempton et al. (1982). VES profiles 23, 9, 18, 15, and 14 exhibit high "true" resistivity values at the upper interval; all other profiles exhibit high "true" resistivity values over the range of both intervals. The VES profile locations 7, 19, 18, and 17 are considered primary choices for test drilling sites.

Line BB' of VES profiles extends in an east-west direction from VES profile 6 along the north line in the northeast quarter of Section 9 to VES profile 1, along the north line in the northwest quarter of Section 10, T. 18N., R. 10E. (fig. 10b). High "true" resistivity values for VES profiles along BB' are generally lower than values calculated for profiles along AA'. High "true" resistivity values along BB' (as along AA') occur over the depth range of both major sand and gravel intervals. The most favorable locations for future test drilling appear to be at or near VES profiles 4, 5, and 11.

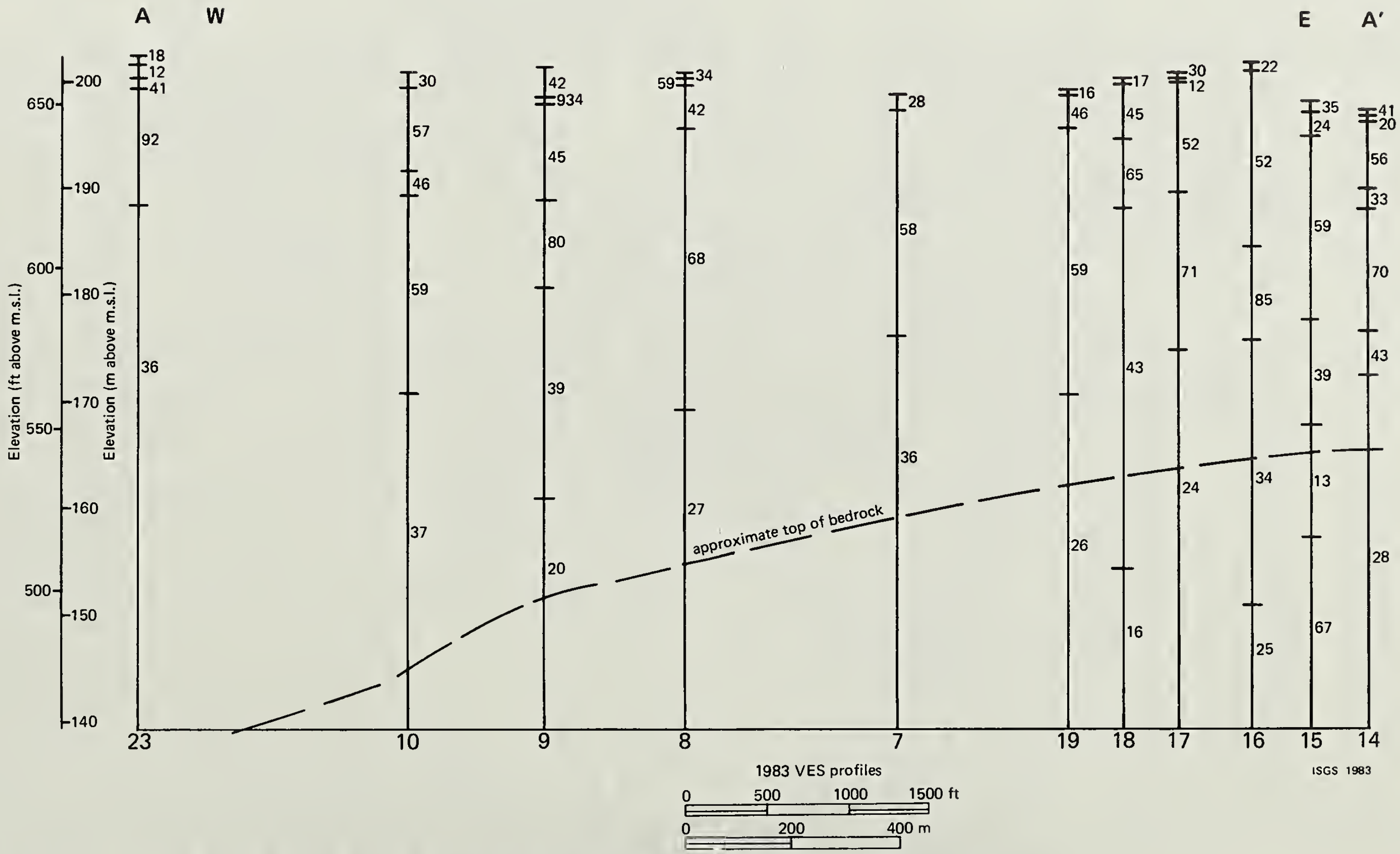



**Figure 10a.** Layering parameters ("true" resistivities and thicknesses) along line A–A′, Sidney study area.

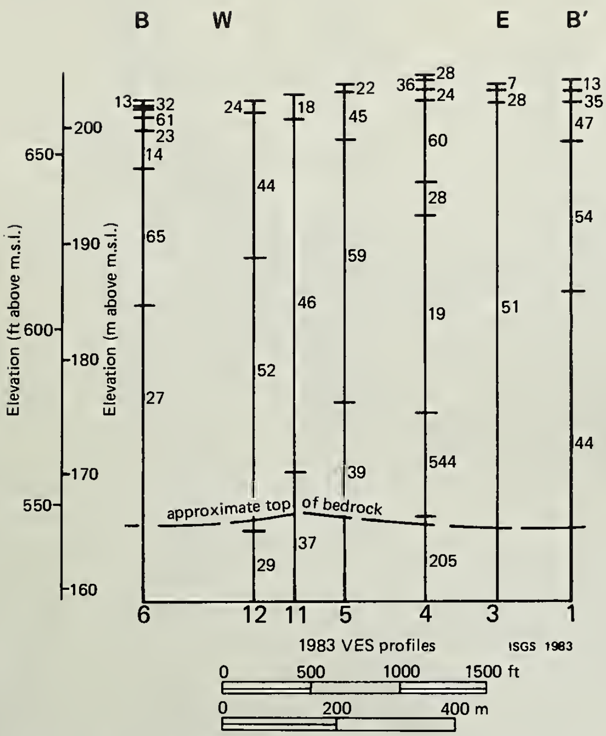



**Figure 10b.** Layering parameters along line B–B′, Sidney study area.

To summarize, the possibility of obtaining additional municipal groundwater resources in the recommended area north of Sidney appears good. If test drilling is undertaken in this area, VES profile locations 7 (Sec. 8, T. 18N., R. 10E.), 19, 18, and 17 (Sec. 9, T. 18N., R. 10E.) should be considered as primary choices. VES profiles 4 (Sec. 10, T. 18N., R. 10E.), 5, and 11 (Sec. 9, T. 18N., R. 10E.) are less desirable choices.


Figure 11. Westfield study area.

## Westfield

The community of Westfield (population 733) is located in northwestern Clark County, in portions of Sections 29-32, T. 11N., R. 14W. (fig. 11). The population of Westfield has increased by slightly more than 8 percent over the last 10 years and is projected to increase slowly through the year 2000. Current water demand at Westfield is close to exceeding the estimated average demand for the year 2000 (Wehrmann et al., 1980).

The Westfield area is physiographically situated at the southeast edge of the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province. It lies approximately 1 mile north of the southernmost limit of Wisconsinan glaciation in Illinois, between two morainic ridges of Woodfordian age. The ridge south and east of town is the Westfield Moraine, and the ridge north of town is the Nevins Moraine. Topography in the vicinity of Westfield varies from nearly flat to gently rolling to ridged. The ridged area occurs where drainage has developed across the moraines. Drainage in the Westfield study area is generally east and south to West Fork and Lambs Branch, tributaries of the predominantly south-flowing North Fork of the Embarras River. West and southwest of the study area, drainage is west and south, via the East and West Branches of Hurricane Creek, to the Embarras River.

The uppermost bedrock in the Westfield area consists primarily of non-wateryielding gray shale, containing some sandstone, thin limestones, and coal beds of the Pennsylvanian Modesto and Carbondale Formations. In some places, the sandstones and limestones can yield small supplies of water. The shallow bedrock is not generally considered a potential source of moderate to large water supplies. Water from deeper bedrock is generally too mineralized for most water supply uses.

The glacial drift in the Westfield area is composed of deposits of pre-Illinoian, Illinoian, and Wisconsinan age. These deposits are till, sand and gravel outwash and alluvium, water-laid silt, and windblown silt (loess). Drift thickness ranges from approximately 80 to 120 feet within the moraines (Wehrmann et al., 1980; Kempton et al., 1982), to 17 to 45 feet away from the moraines, to approximately 165 to 190 feet within a buried valley coincident with the present-day valley of the North Fork of the Embarras River (fig. 11), in Sections 34-35, T. 12N., R. 14W. Nearly all water supplies in the Westfield study area come from sand and gravel deposits of the glacial drift. Most deposits are thin and/or discontinuous. Deposits that seem to be relatively widespread occur within the Nevins Moraine north of town (at depths of 30 to 60 feet) and within an area south of the Westfield Moraine and west of the buried valley west of town, usually at the base of the drift (Wehrmann et al., 1980; Kempton et al., 1982). Data on the continuity and thickness of sand and gravel deposits within the outwash plain and buried valley are somewhat sparse, and oil and gas log data on glacial drift are generally unreliable.

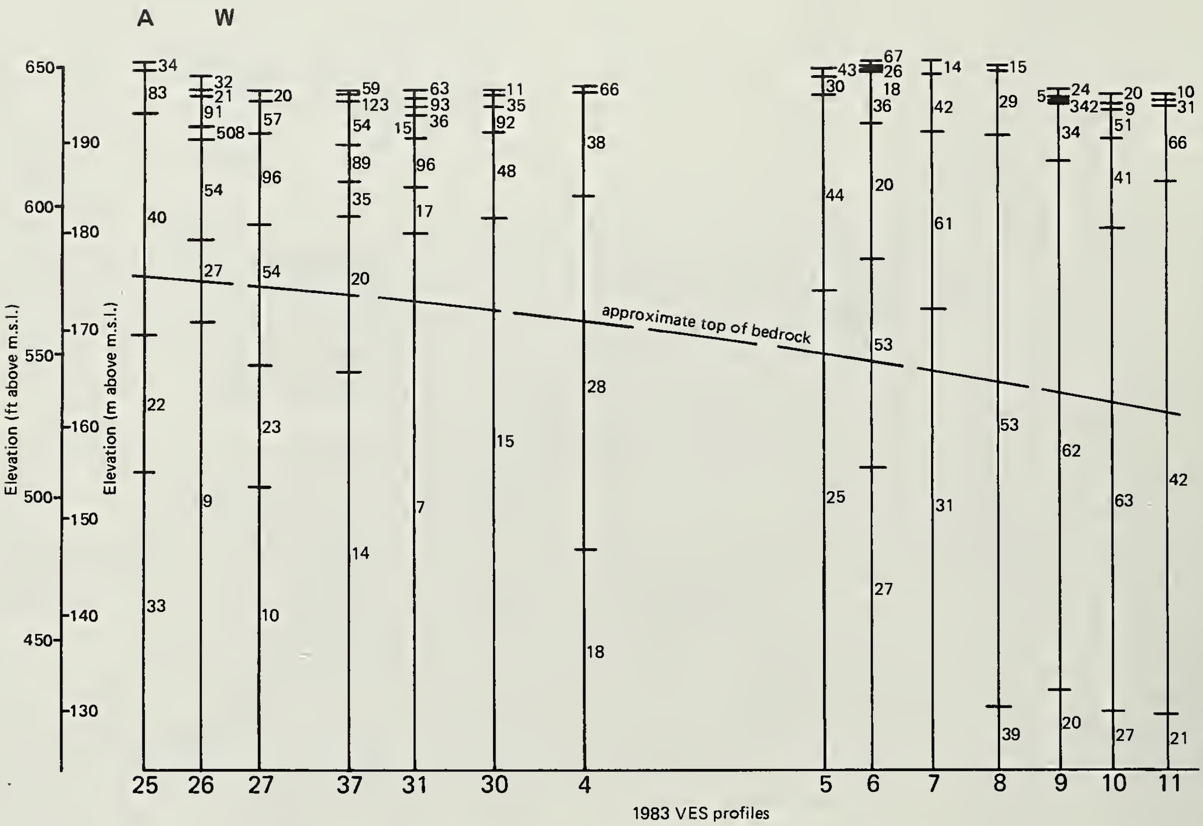
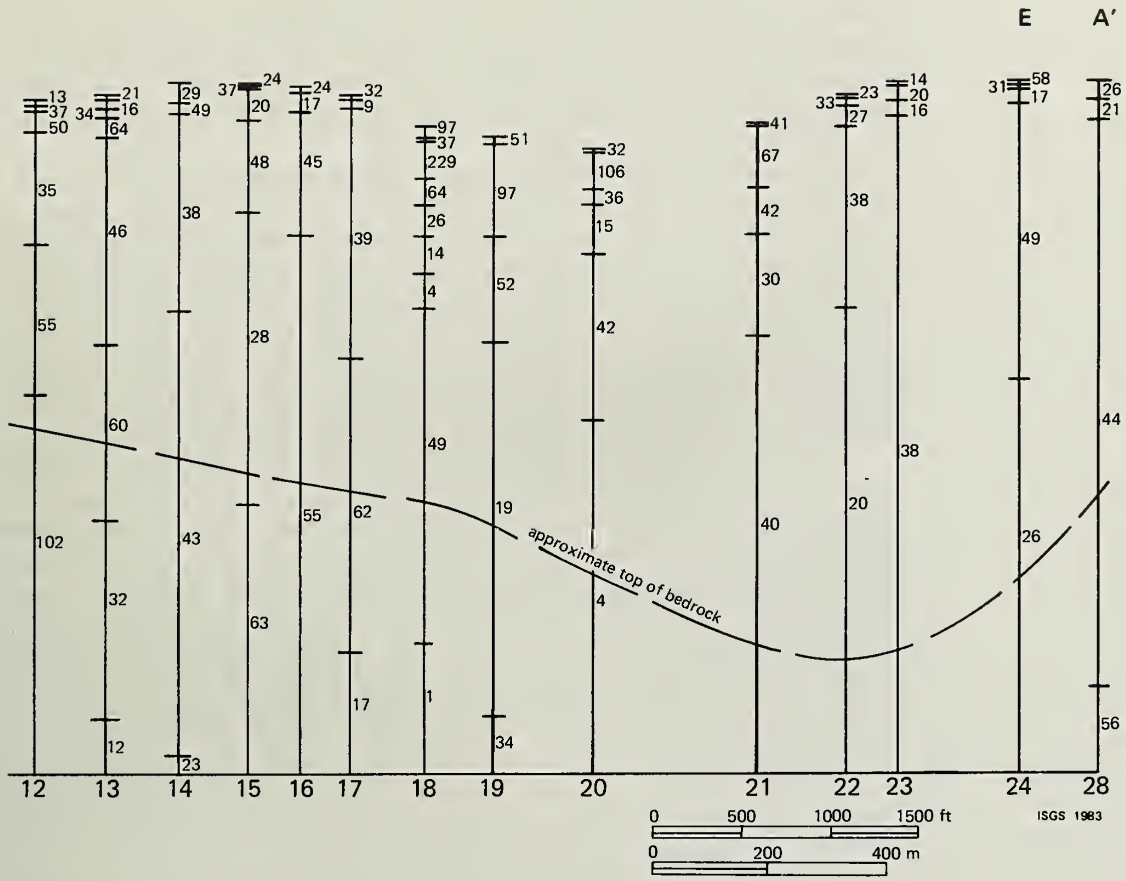



**Figure 12a.** Layering parameters ("true" thicknesses and resistivities) along line A-A′, Westfield study area. "True" resistivity values are in ohm-meters.

The two municipal wells currently operated by Westfield are finished in sand and gravel deposits within the Nevins Moraine. Municipal Well 6 (located 1300 feet east and 1968 feet north of the southwest corner of Section 20, T. 12N., R. 14W.) is finished at a depth of 53 feet, and the bottom 7 feet is screened. Municipal Well 7 (located approximately 712 feet northwest of well 6) is 58 feet deep and is screened in the bottom 10 feet. In 1980, a drought year, well 6 averaged 25,600 gallons per day (17.9 gpm), and well 7 averaged 37,700 gallons per day (26 gpm). Combined annual pumpage of the wells in 1982, an average rainfall year, was 20,075,000 gallons (55,000 gpd) (Bob Olson, personal communication, 1983). Wehrmann et al. (1980) estimated the long-term sustained yield of the current Westfield well field to be approximately 65,000 gallons per day, only 1700 gallons per day greater than withdrawals during 1980. As the population of Westfield increases, water shortages during times of drought will become more frequent and severe.

In the 1980 report, Wehrmann et al. recommended exploration for additional groundwater supplies outside the vicinity of the present well field. Suggested areas included the outwash plain south of the Westfield Moraine in Sections 32 through 34, T. 12N., R. 14W. (fig. 11), and the buried valley and a possible glacial outwash channel in Section 34, T. 12N., R. 14W. On the basis of these recommendations, we located VES profiles in those areas in our 1983 study.




Qualitative interpretation of VES data consisted of construction and examination of all VES profiles. Quantitative evaluation utilized the inversion technique of Zohdy (1973) to produce layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profiles. Two lines of VES profiles, AA' and BB' (fig. 11), illustrate the layering parameters associated with the areas of most favorable VES profiles delineated during this survey.

East-west line AA' (fig. 12a) is located approximately 1½ miles southeast of Westfield. It begins just north of the center of the south line of Section 33, T. 12N., R. 14W., and extends east to the east half of Section 35, T. 12N., R. 14W. and the NE¼ of Section 2, T. 11N., R. 14W., where it traverses a portion of the buried bedrock valley. Interpretation of VES data along AA' suggests the presence of two aquifers in the outwash plain west of the buried channel in front of the Westfield Moraine: one within 20 to 30 feet of the land surface and one between 40 feet and the bedrock surface. VES profiles 25 through 31 suggest a shallow sand deposit at profile 25 that seems to thicken and occur at a greater depth toward the east. The location of VES profile 27 is recommended for consideration as a future test drilling site. In the central portion of AA', VES profiles 7 through 10 indicate relatively coarse-grained sediments directly above the bedrock surface. VES profiles 9 through 11 also indicate a possible thin sand deposit within 30 feet of the land surface. Profiles 7 and 9 are considered the most favorable in this portion of AA′. Toward the eastern end of AA′ a coarse-grained deposit is clearly defined in the upper 30 feet of unconsolidated sediments at profiles 18 through 21. Much less clearly defined is a possible sand deposit above the bedrock surface. VES profile 18 is considered the most favorable test drilling site.

East-West line BB′ of VES profiles is located just south of and across the central portions of the east half of Section 34 and the west half of Section 35, T. 12N., R. 14W. (fig. 12b). BB′ traverses the western edge of the buried valley. All VES profiles of BB′ exhibit a high "true" resistivity layer in the upper 30 to 40 feet of the glacial drift. There is no conclusive evidence of a sand and gravel layer just above the bedrock. The extremely high "true" resistivity values obtained at profiles 40 and 41 may be attributable to drainage of at least the upper portion of the coarse-grained layer. Profiles 41, 42, and 44 are recommended sites for future test drilling.

To summarize, there is a good possibility that additional groundwater resources can be developed from the outwash plain and/or the buried channel in front of the Westfield Moraine southeast of town. Specifically recommended as possible future test drilling sites are the following locations: (1) at or near VES profile 42, Section 35, T. 12N., R. 14W.; (2) at or near VES profile 44, Section 35, T. 12N., R. 14W.; (3) at or near VES profiles 27, Section 33, T. 12N., R. 14W., and 41, Section 35, T. 12N., R. 14W.; (4) at or near VES profile 18, Section 35, T. 12N., R. 14W.; and (5) at or near VES profiles 7 and 9, Section 34, T. 12N., R. 14W.

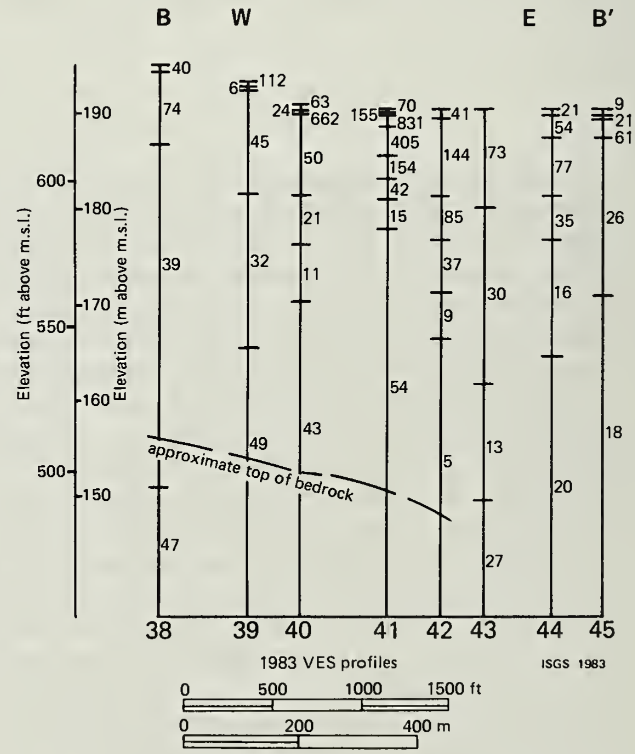



Figure 12b. Layering parameters along line B-B′, Westfield study area.

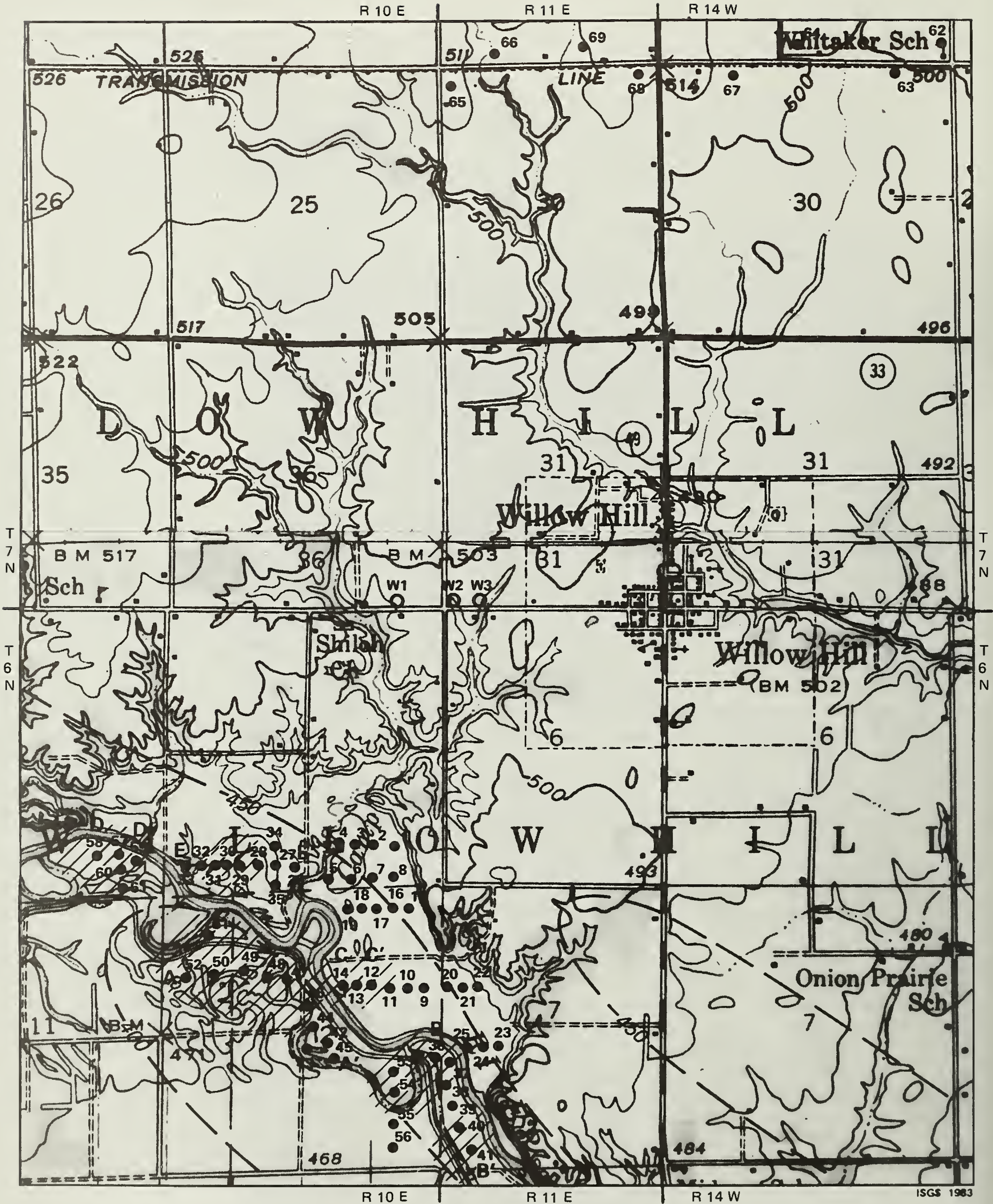
## Willow Hill

The community of Willow Hill (population 292) is located in east-central Jasper County (fig. 13) in portions of Section 31 (T. 7N., R. 14W. and T. 7N., R. 11E.) and Section 6 (T. 6N., R. 14W. and T. 6N., R. 11E.). In 1980, pumpage of the Willow Hill municipal wells averaged 17,000 gallons per day. Current pumpage is reported to be approximately 30,000 gallons per day, which is more than the 28,000 gallons per day estimated demand for the year 2000 reported by Wehrmann et al. (1980).

Willow Hill is physiographically located in the Springfield Plain of the Till Plains Section of the Central Lowland Province. It lies on a glacial ground moraine of Illinoian age approximately 30 miles south of the southernmost edge of Wisconsinan glaciation in Illinois. It is approximately 24 miles west of the Wabash River and 1½ miles northeast of the Embarras River. Willow Hill is situated on a small drainage divide where topography varies from flat to gently rolling to ridged (where cut by streams). In the immediate vicinity of the town, elevations range from slightly less to slightly more than 500 feet above m.s.l. Maximum relief is in the southwest portion of the study area in the Embarras valley where elevations range from slightly less than 460 to approximately 500 feet above m.s.l. The highest elevation (525 ft) occurs in the northwest portion of the study area. Drainage north and east of town flows south and east, via small streams, to the North Fork of the Embarras River. South and west of town, drainage is south directly to the Embarras River.

Shallow bedrock lithologies in the vicinity of Willow Hill are mostly shales and sandstones; some limestones and thin (6 in. or less) coals of the Pennsylvanian Mattoon Formation are also present. Several water wells are finished in one of two major sandstone units that occur in a depth range of 67 to 350 feet. Approximately 1½ miles southeast of town at least one domestic water well has been completed in heavily weathered and fractured sandstone occurring within 25 feet of land surface. Wehrmann et al. (1980) state that the lower unit is appreciably thicker and more continuous than the upper unit. Municipal wells presently operated by Willow Hill are finished in the lower sandstone unit. Outside the study area, the buried Embarras Bedrock Valley trends northwest approximately 6 miles north of town. Approximately 4 miles east of town the bedrock valley becomes coincident with the modern Embarras River valley. South of town the Embarras River roughly follows a small shallow bedrock valley that appears to have been a tributary of the ancient Embarras River. Elevation of the bedrock surface ranges from slightly less than 400 feet above m.s.l. in this small bedrock valley just south of the Embarras River, to almost 500 feet above m.s.l. north and northwest of town.

The glacial drift consists mostly of till plus some sand and gravel outwash and alluvium of Illinoian age, and outwash and alluvium, windblown sand, and windblown silt (loess) of Wisconsinan and Recent age. Few logs for water wells finished in the unconsolidated sediments are on file at the ISGS, and most of those on file show water obtained from sand or sandy clay at depths of 6 to 25 feet. In places where drift thickness is greater than




21● 1983 VES profile

W3○ municipal well

//// area of most favorable VES data

— — approximate bedrock elevation (ft)

0 .5 1 mi

0 .5 1 1.5 km

Figure 13. Willow Hill study area.

25 feet, a discontinuous sand and gravel deposit is sometimes encountered directly above the bedrock surface. Yields are usually 1 to 2 gallons per minute. Logs from oil and gas wells in the Embarras River valley indicate that sand and gravel deposits up to 95 feet thick in the alluvium are possible, but these logs often provide unreliable data on unconsolidated sediments.

Willow Hill operates three municipal wells finished in the lower of the two main sandstone units (Wehrmann et al., 1980). Well no. 1 is located near the SW/c SE¼ SE¼ Section 36, T. 7N., R. 10E., and wells 2 and 3 are near the SW/c Section 31, T. 7N., R. 11E. Well 2 is approximately 950 feet east of Well 1. Wells 1, 2, and 3 are finished at depths of 295, 275, and 269 feet and according to the Illinois State Water Survey, are currently pumped at approximately 1, 5, and 20 gallons per minute respectively. Demand in 1980 was believed to average 17,000 gallons per day, between one-half and one-third of the estimated practical sustained yield of 43,000 gallons per day. Average daily demand in 1983, as reported to the State Water Survey, averaged 29,882 gallons per day. Since water demand at Willow Hill is expected to increase by the year 2000, new municipal wells will probably be needed.

In addition to recommending that additional wells be drilled in the lower sandstone unit at a reasonable distance from the current wells, Wehrmann et al. (1980) recommended that an EER study be conducted to explore the bottomlands of the Embarras River southwest of town where oil and gas logs have indicated possible thick sands and gravels. In response to those recommendations, 61 VES profiles were located in the Embarras River bottomlands southwest of town (fig. 13). An additional 8 VES profiles were located approximately 1½ miles north of town near the northline of Section 30, T. 7N., R. 11E., and Section 30, T. 7N., R. 14W., and the southline of Section 19, T. 7N., R. 11E., and Section 19, T. 7N., R. 14W., where the glacial drift may be more than 25 feet thick in places.

Interpretation of the resistivity data consisted of construction, examination, and inversion (Zohdy, 1973) of all VES profiles. The inversion technique provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. Lines of VES profiles AA′ through EE′ (figs. 14a-d) illustrate the layering parameters associated with the areas of most favorable resistivity delineated during the 1983 survey.

A line of VES profiles AA′ trending roughly northwest, is located in Section 12, T. 6N., R. 10E., just south of the Embarras River (fig. 14a). It traverses the area of lowest estimated bedrock elevation where the thickness of unconsolidated sediments is likely to be greatest. All VES profiles along this line, except for profile 42, exhibit "true" resistivity values in excess of 100 ohm-meters. Test drilling will be necessary to confirm that the high resistivity values result from coarse-grained sediments such as sand and gravel, and to provide information on the continuity and thickness of the deposits. VES profiles 47, 48, 50, and 51 are considered the most favorable sites for test drilling. The location of VES profile 51 is shown on figure 13.

BB′ (fig. 14b) is a nearly north-south line of VES profiles located on the southwest side of the Embarras River in the southwest quarter of Section 7, T. 6N., R. 11E. "True" resistivity values of VES profiles along BB′ are not as consistently high as those along AA′. VES profiles before and after inversion indicate that sand and gravel deposits may exist in the area covered

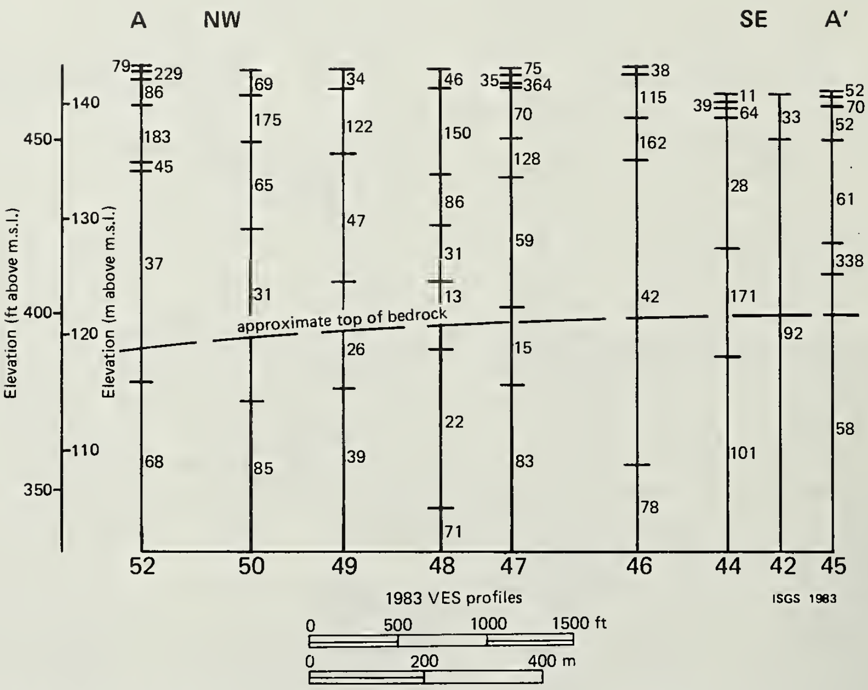



**Figure 14a.** Layering parameters ("true" resistivities and thicknesses) along line A–A', Willow Hill study area. "True" resistivity values are in ohm-meters.

by BB', but suggest that the bedrock surface elevation may be higher and the coarse-grained deposits thinner along BB' than along AA'. VES profiles 36, 40, and 41 appear to be the best sites along BB' for future test drilling.

East-west line CC' of VES profiles is located just northeast of the Embarras River in the northeast quarter of Section 12, T. 6N., R. 10E. (fig. 14c). "True" resistivity values greater than 100 ohm-meters occur in the upper 20 to 25 feet of the drift at most VES profiles along this line. Wells finished in sands and gravels at this depth are often sensitive to drought conditions. Extremely high "true" resistivity values that occur near the surface may be attributed to drained sediments. The locations of profiles 12, 13, and 14 are considered secondary choices as possible test drilling sites.

East-west line DD' of VES profiles is located near the southeast corner of Section 2, T. 6N., R. 10E. (fig. 14c). Layering parameters of VES profiles along this line are very similar to those found along BB'. Any profile locations along DD' are favorable sites for future test drilling.

The final line of VES profiles is east-west line EE' (fig. 14d), located in the south half of the SW¼ Section 1, T. 6N., R. 10E., just north of the Embarras River. "True" resistivity values of VES profiles along this line are generally lower than those of profiles along AA' through DD', except those of VES profiles 29 and 30. The high "true" resistivity values at VES profiles 29 and 30 may reflect a local bedrock high rather than unconsolidated sands and gravels, and these profile locations are therefore secondary choices for test drilling sites.

To summarize, test drilling will be necessary to confirm the presence and extent of thick sand and gravel deposits that may exist in the Embarras bottomlands. The following recommended test drilling locations are listed in order of most to least favorable: (1) profiles 47, 48, 50, and 51 along AA'; (2) profiles 36, 40, 41, 57, 58, 59 along BB' and DD'; and (3) profiles 12, 13, 14, 29, and 30 along CC' and EE'.

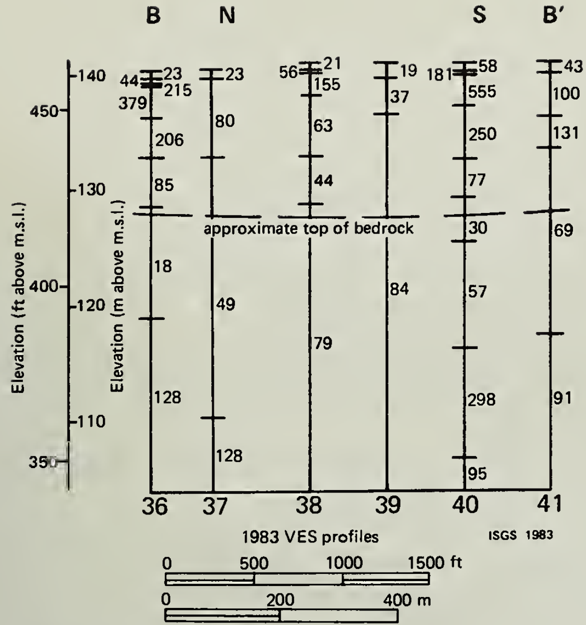



**Figure 14b.** Layering parameters along line B-B′, Willow Hill study area.

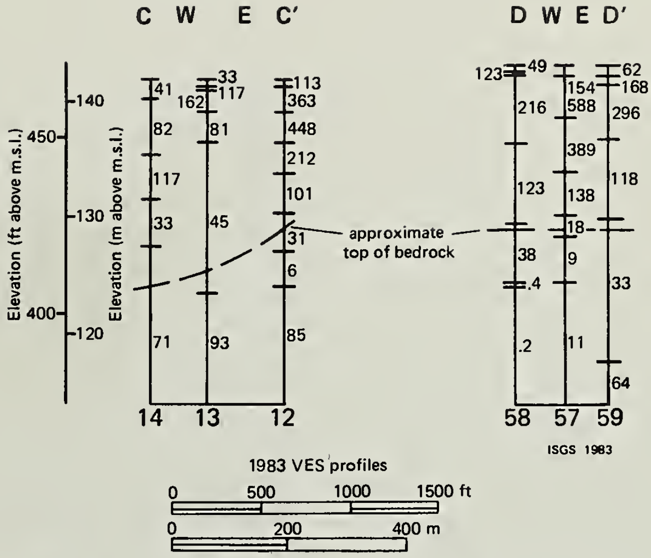



**Figure 14c.** Layering parameters along line C-C′ and D-D′, Willow Hill study area.

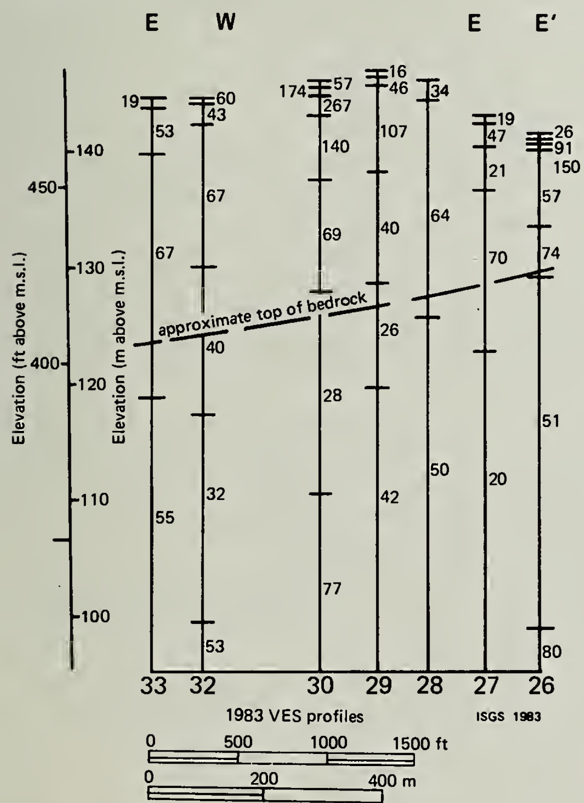



**Figure 14d.** Layering parameters along line E-E′, Willow Hill study area.

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