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#11

State Geological Survey Division

ENR

Illinois Department of
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August 19, 1985

Mr. George Farnsworth
Farnsworth and Wylie
Consulting Engineers
2709 McGraw
Bloomington, IL 61701

Dear George:

Enclosed is our report entitled "Geology and Distribution of the Aquifers west of Normal, Illinois, an update," prepared at your request. It is the result of a rather extensive review of the available data and intensive hydrogeologic evaluation of the distribution, relationships and significance of the aquifers.

The section of the report entitled Possible Exploration Strategies provide our thoughts on ways to proceed. Vickie Poole has estimated that it would take approximately one month to run a resistivity survey over a one township area with stations every half mile and using the newest equipment. It would take one operator and four helpers. Additional time and personnel would be necessary to process and evaluate the data. I would be interested in keeping track of any test drilling and aiding in the evaluation of the logs and samples as time permits.

Adrian Visocky of the State Water Survey is being sent a copy of this report. He has had preliminary copies of the maps and cross sections to work from. He will send his report directly to you.

We would be pleased to meet with you at a mutually convenient time, if you feel it worthwhile to review our reports, discuss implementation of the exploration phase and any other strategies that may surface.

Very truly yours,

John

John P. Kempton
Geologist and Head
SSC Geological Task Force

JPK:lw

Enclosure

cc: Adrian Visocky

GEOLOGY AND DISTRIBUTION OF THE AQUIFERS WEST OF NORMAL, ILLINOIS
AN UPDATE

By

John P. Kempton and Vickie Poole
August 19, 1985

INTRODUCTION

This report, prepared at the request of Mr. George Farnsworth, Farnsworth and Wylie Consulting Engineers, 2709 McGraw, Bloomington, Illinois, provides a review of the geology of the glacial drift aquifers west of Normal, Illinois and suggests strategies for investigating the potential for development of a supplemental municipal groundwater supply for the City of Normal in that area.

With the prospect of the location of a major industrial facility near the Bloomington-Normal Metropolitan Area, there is a need to assure the availability of an additional groundwater supply up to 5 mgd. Hydrogeologic investigations during the period between 1969 and 1974 led to the development of a well field about 8 miles west of Normal. The history of the development of the west well field and the geologic framework is described in Illinois State Water Survey Circular 153, released in 1982.

In order to evaluate the potential for development of additional municipal groundwater supplies a reexamination of the region west of Normal was made. Because of the potential for additional drawdowns in the existing west well field by adding wells, emphasis for this review was placed on areas some distance from the west well field. Six townships were evaluated in detail; T. 23 and 24 N., R. 1 E. and 1 W., McLean County and T. 23 and 24 N., R. 2 W., Tazewell County (figs. 1, 2 and 3). The Villages of Mackinaw (to the northwest), Minier (to the southwest), Danvers (to the north) and Stanford (to the south) are located within this area.

GENERAL GEOLOGIC SETTING

The six township area is located over a major buried bedrock valley system, carved in Pennsylvanian rocks, that is completely filled with a sequence of glacial sediments. The Pennsylvanian rocks do not yield significant quantities of groundwater. The valleys eroded into the bedrock form an extensive system in central and east-central Illinois (fig. 1) which consists of two major valleys, the Mahomet to the east and the Mackinaw on the west, with their confluence just to the southwest of the Bloomington-Normal area. These valleys are filled with sediments deposited during the melting of numerous continental glaciers that invaded the region. These glacial sediments consist principally of either sand and/or gravel, deposited by glacial meltwaters or an unsorted mixture of clay silt, sand and gravel or pebbles (called glacial till) deposited directly by the melting glaciers. Within the bedrock valleys, the sand and gravel is generally concentrated in the lower part of the till of glacial sediments, frequently in excess of 100 feet thick (fig. 2) and locally nearly 200 feet thick. The total thickness of glacial drift over these buried valleys is frequently in excess of 300 feet and locally in excess of 400 feet thick. Where the thick sequence of sand and gravel deposits occur at the base of the drift they have been called the Mahomet Sand in the Mahomet Bedrock Valley and the Sankoty Sand in the Mackinaw Bedrock Valley.

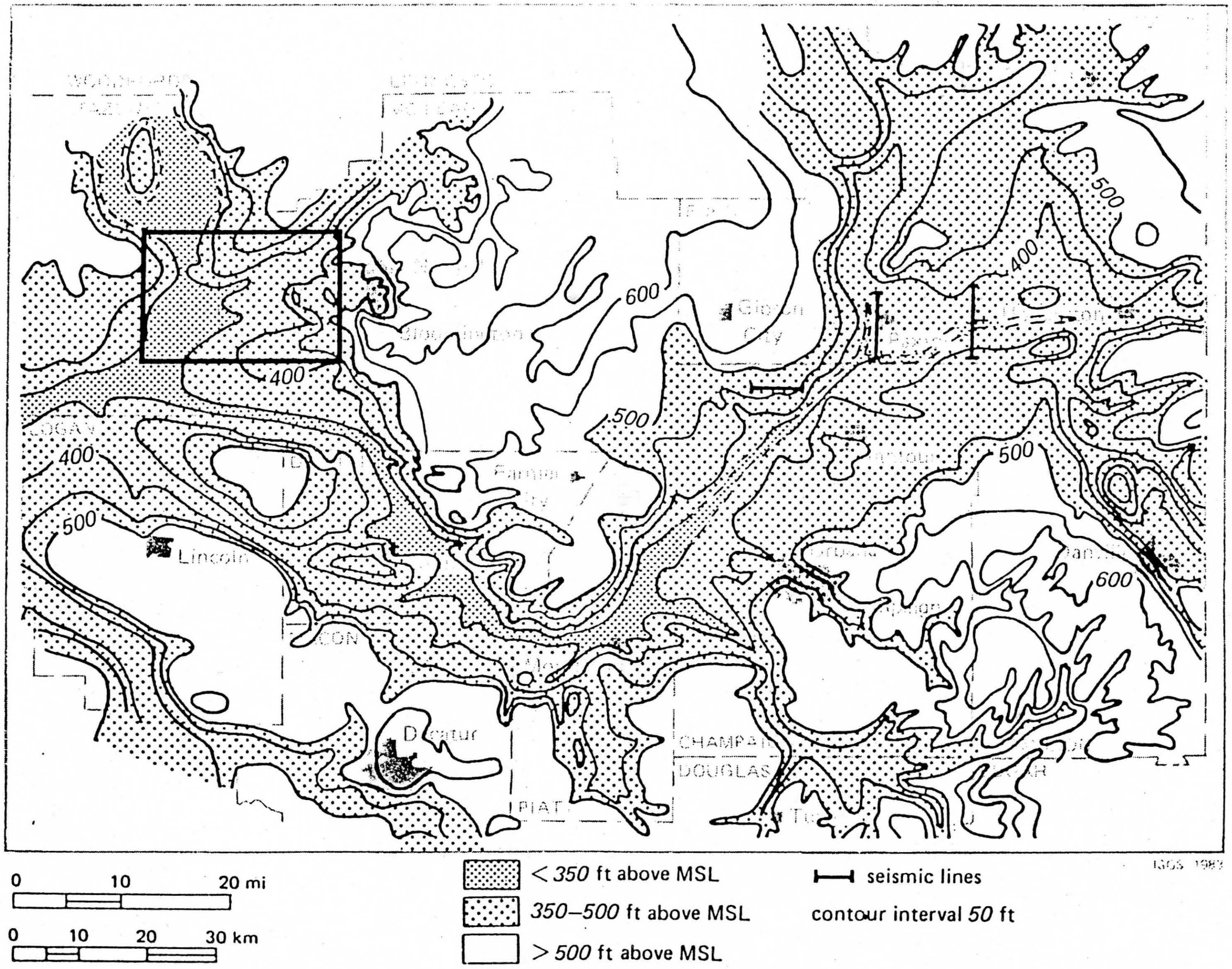

Figure 1. Topography of the Mahomet and Mackinaw Bedrock Valley Systems in Central Illinois and location of the Normal aquifer study area.

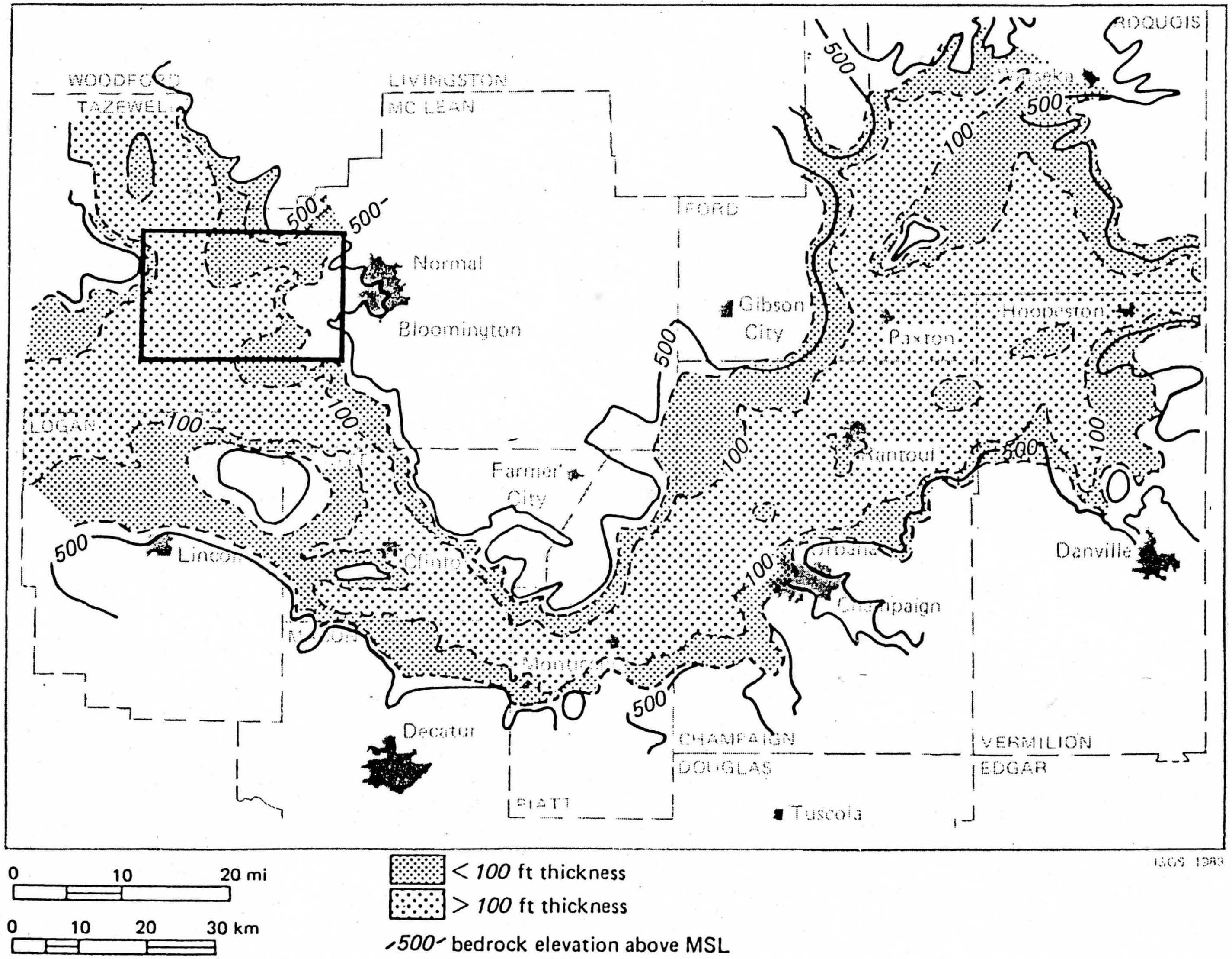

Figure 2. Generalized thickness of the Mahomet-Sankoty Sand in Central Illinois in relationship to Normal aquifer study area.

LOCAL GEOLOGY

The area under study west of Normal lies over the center and eastern side of the Mackinaw Bedrock Valley and over the confluence of three bedrock valleys tributary to the Mackinaw (fig. 3). The configuration of the bedrock surface was constructed by interpreting the downhole geophysical logs of commercial structure test holes (mainly in Tazewell County) and from logs and samples from water wells, test wells, and test holes, most of the latter a result of previous investigations for the City of Normal. Since the bedrock surface nearly always forms the base of the lower sand and gravel aquifer, knowledge of its position is important in estimating the thickness of the overlying sand and gravel.

While the configuration of the bedrock surface is generally known in the area west of Normal (fig. 3) there are rather large areas where there are few wells that penetrate bedrock, particularly north and northwest of the west well field and in the southern two-thirds of the area in Tazewell County. For the area within the dashed 300' contours (fig. 3) it is conjecture as to whether the bedrock is below an elevation of 300 feet. While the elevations of the two wells shown within the 300' contours are subject ot interpretation, there is little evidence down valley to suggest deepest elevations are much below an elevation of 340 feet west of Normal.

The generalized sequence of the glacial deposits above the bedrock is shown by cross sections in Figures 4 and 5. While the sequence of glacial deposits is quite complex, recording many episodes of glacial deposition and also episodes of erosion, this report will concentrate only on the lower portion of the sequence that contains the principal sand and gravel aquifers.

Three separate aquifers were identified in the studies for the development of the west well field (see ISWS Circular 153). These were identified as the Upper, Intermediate and Lower aquifers (figs. 4 and 5). As shown in Circular 153, p. 6, the Upper aquifer is generally a narrow east-west trending deposit that reaches its maximum development at and just west of the west well field, based on available data. While this aquifer is important to recharge and production in the west well field, an equivalent unit may be present only in scattered localities through the remainder of the six township area. The upper aquifer is usually separated by five feet or more of glacial till although it may locally be indirect contact with the intermediate aquifer (e.g. TH 2-69, Well 101, fig. 4).

Of most significance to development of additional groundwater supplies, and in particular, to locating a new well field, is the distribution, thickness, and aquifer characteristics of the intermediate and lower aquifers. As implied in Figure 2, an extensive area of sand and gravel greater than 100 feet thick (the Sankoty Sand) occurs over much of the western half of the six township area. A review of the data undertaken for this report confirms the regional mapping but provides additional detail. Figure 6 is the detailed remapping of the area west of Normal for which only the lower two aquifers were identified specifically. It is important to note that throughout nearly all of the Tazewell County portion of the area under review, the intermediate aquifer appears to directly overly the lower aquifer. This relationship extends eastward in a relatively narrow band just north of Stanford and ends just north of the Normal West well field (also see figs. 4 and 5). Throughout that area sand and gravel is consistantly in excess of 100 feet thick.

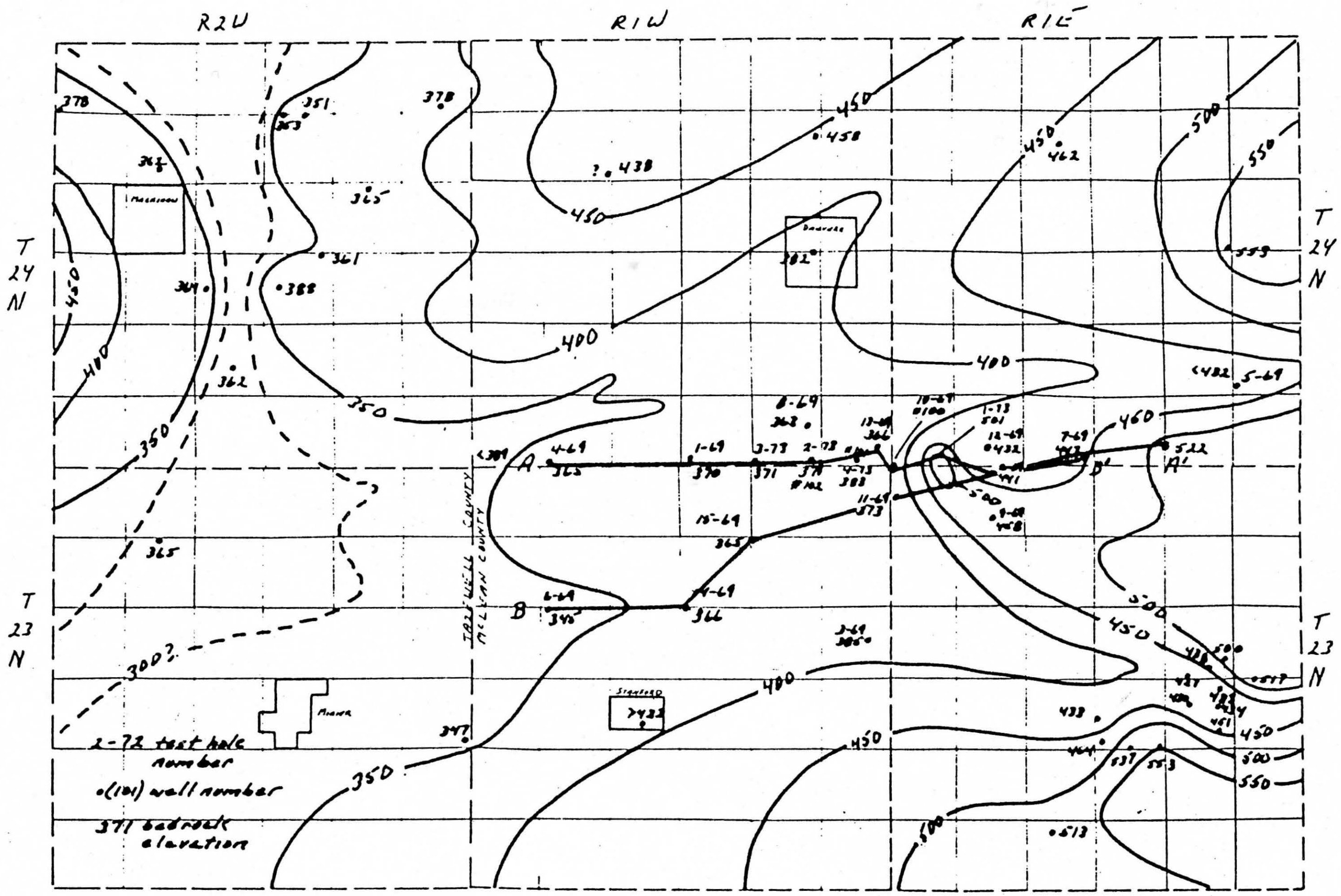

Figure 3. Elevation (topography) of the bedrock surface west of Normal showing lines of cross sections (figs. 4 and 5); contour interval 50 feet.

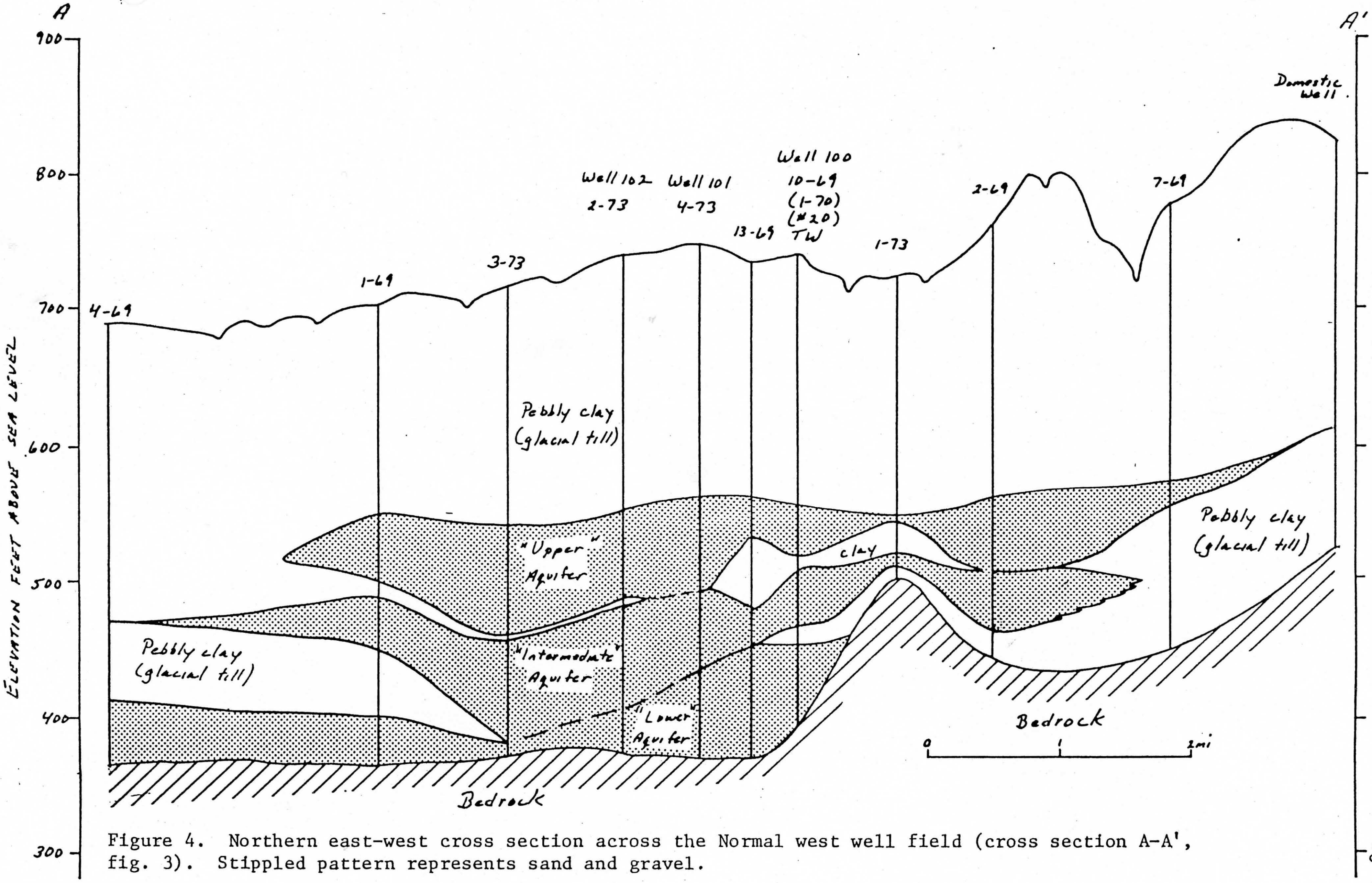

Figure 4. Northern east-west cross section across the Normal west well field (cross section A-A', fig. 3). Stippled pattern represents sand and gravel.

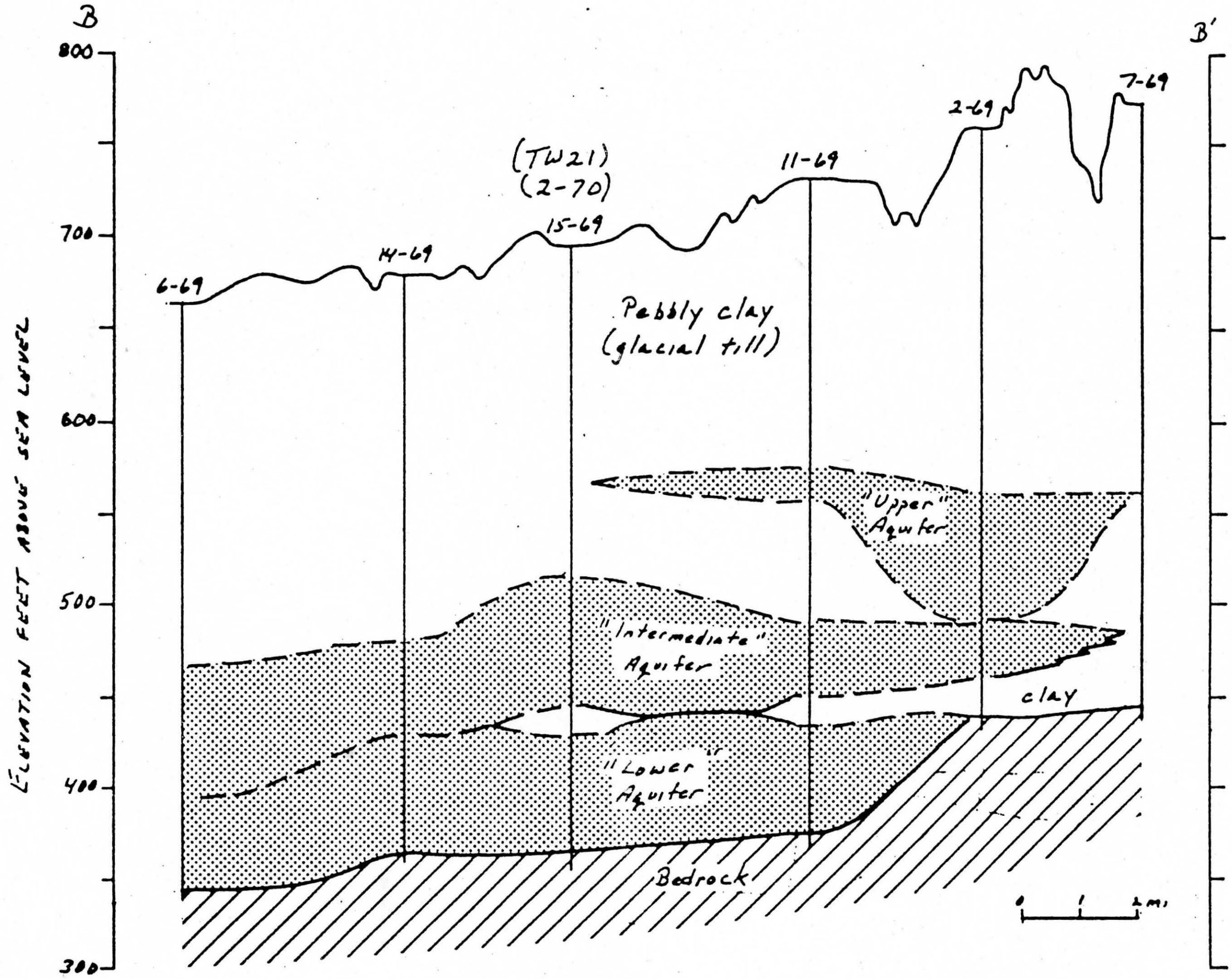

Figure 5. Southern east-west cross section across the Normal west well field (cross section B-B', fig. 3). Stippled pattern represents sand and gravel.

The previous study showed that the intermediate and lower aquifers were often separated by finer textured materials, mostly glacial till, or that one or the other was absent in the eastern four townships. Figure 6 suggests the thickness and distribution of each of these aquifers and their relationship to each other. These relationships are shown vertically by Figures 4 and 5.

The lower aquifer appears to have a finer texture, mainly sand and fine gravel with a pinkish hue near its eastern margin but becomes coarser to the west. The intermediate aquifer is more consistantly medium to coarse sand and gravel. The top of the lower aquifer almost always lies below an elevation of 450 feet while the top of the intermediate aquifer ranges in elevation from about 460 feet to 510 feet. Where the upper aquifer directly overlies the intermediate in the west well field, the top of a continuous sequence of sand and gravel may be as high as 560 feet (figs. 4 and 5). In this area the total continuous sequence of sand and gravel ranges from 169 to 198 feet in thickness. Without the upper aquifer, the combined thickness of the intermediate and lower aquifers ranges from about 100 to 150 feet where not separated by till. Therefore, in the Tazewell County portion of the area, where aquifer thickness exceeds 150 feet or where the elevation of the top of the sand and gravel is above an elevation of 520 feet, the upper aquifer may be present (fig. 6). Essentially no information is available on these aquifers in T. 23 N., R. 2 W., Tazewell County.

SUMMARY OF AQUIFER DISTRIBUTION

Based on the current review of the hydrogeology of the region west of Normal there appears to be a reasonably good chance of developing an additional well field for the City of Normal or at least providing a supplemental supply of groundwater. Figure 7 provides a general summary of the aquifer distribution and suggests a possible rating of the various areas identified. The areas, labeled A-1 through A-8 (greatest potential to least potential), take into account thickness, vertical continuity, number of aquifers present and separation between aquifers. The relationship to the existing well field and nearby communities must also be considered.

Area 1 would appear to be the best area for the development of additional wells or possibly a new well field. Available data suggests that the Intermediate aquifer directly overlies the lower aquifer throughout most, if not all, of the area providing locally 150 feet of aquifer. While the occurrence of till separating the two in this area is possible, it would most likely occur close to the mapped boundaries.

Areas 2 and 3 (A-2, A-3) are similar in that both the Intermediate and Lower aquifers may be present separated by more than five feet of till. There is a suggestion that the Intermediate aquifer may be somewhat thinner in A-3 (e.g. at Stanford). Since little information is available for both of these areas, the extent and boundaries are highly interpretive.

Areas 4, 5 and 6 appear to contain only the Lower aquifer. Area 5 is separated on the basis of test hole 4-69 only and the boundary is also interpretive. Areas 4 and 6, while at the eastern limits of the lower aquifer, do contain up to at least 46 and 71 feet of sand respectively. All three of these areas could provide supplemental supplies from individual wells.

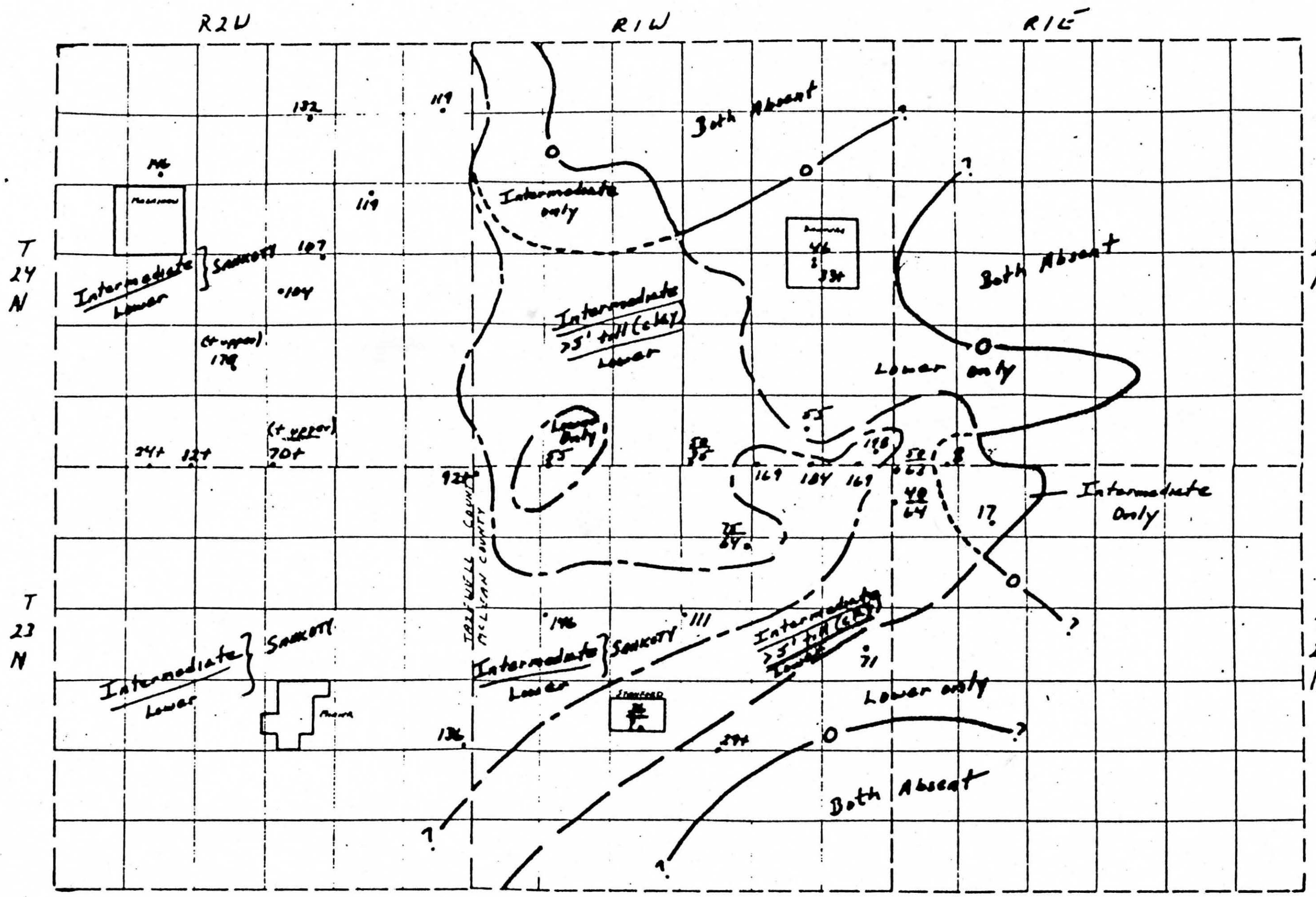

Figure 6. Distribution of the Intermediate and Lower aquifers west of Normal (Sankoty Sand where no clay separation).

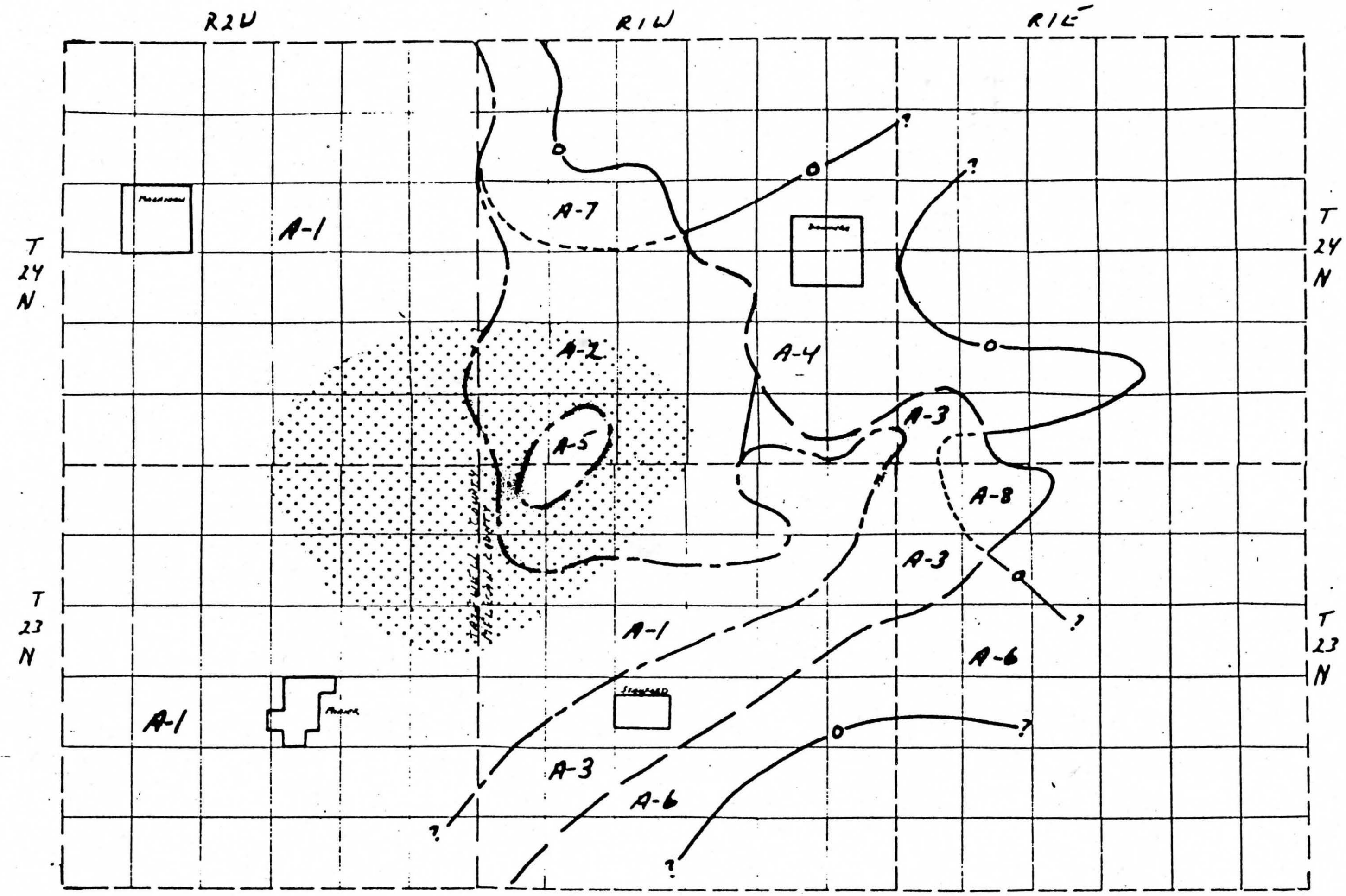

Figure 7. Potential areas to explore for development of a supplemental municipal well field. Stippled pattern indicates suggested area for preliminary test drilling program.

Areas 7 and 8 probably contain only the Intermediate aquifer and are located near its eastern margin. Little inforamtion is available for A-7 while in A-8, generally 17 feet or less of aquifer is present.

POSSIBLE EXPLORATION STRATEGIES

Based on the available information from existing wells and test holes a reasonable pattern of aquifer thickness and distribution has emerged from this review (figs. 6,7). Several strategies for exploration and development should be considered, although not necessarily in the listed order:

1) drill a few preliminary test holes in areas 1 and 2 (within stippled area shown on fig. 7) to verify conditions mapped,
2) explore selected areas with a resistivity survey using modern equipment and quantitative interpretation,
3) Continue pipeline west along township line to pick a well at test hole site 3-73 if hydrologically feasible,
4) drill additional test holes and test wells in A-2 and A-1, if preliminary test drilling and/or resistivity warrant and
5) develop well field in A-1 if test drilling/resistivity proves the area good. Two or three additional wells might be picked up north and south along the pipeline or another well field location be selected.

Up to 5 or 6 preliminary test holes in A-1 and A-2 within the area shown by the stippled pattern on Figure 7 should be sufficient to confirm or modify the interpretation of the aquifer conditions suggested on figures 6 and 7. Their locations should be based on the location of existing data and on obtaining a reasonably good spread in each area. A few split-spoon samples should be taken as selected intervals in each hole, and a suite of geophysical logs should be made in each.

The need for and value of either a regional or localized resistivity survey should be considered. The results of preliminary test drilling could dictate their value.

In the past, resistivity surveys for the City of Normal and ISU have been confined to 13 contiguous sections on the north side of Normal in Normal Township; Sections 19-23, 26-33, T. 24 N., R. 2 E.. Resistivities were measured at 68 staitons in 1947 by Merlyn Buhle, at 44 stations in 1959 by M. Buhle, at 26 stations in 1956 by Arthur Ziezel and at 60 stations in 1962 by M. Buhle. Areas of relatively high resistivities delineated by these earlier surveys were, in general, related to sand and gravel deposits at depths of 100 feet or less.

Thirteen additional resistivity surveys have been conducted for individuals or institutions in Normal Township and the two townships to the west, T. 24 N., R. 1 E. and T. 24 N., R. 1 W.. These surveys were made during the time period 1939 to 1984 and range from 2 to 39 stations per survey. For many of the surveys, recommendations of areas for test drilling were difficult or impossible to make based solely on the resistivity data. Often, resistivity values were low to intermediate and showed little change over the area surveyed.

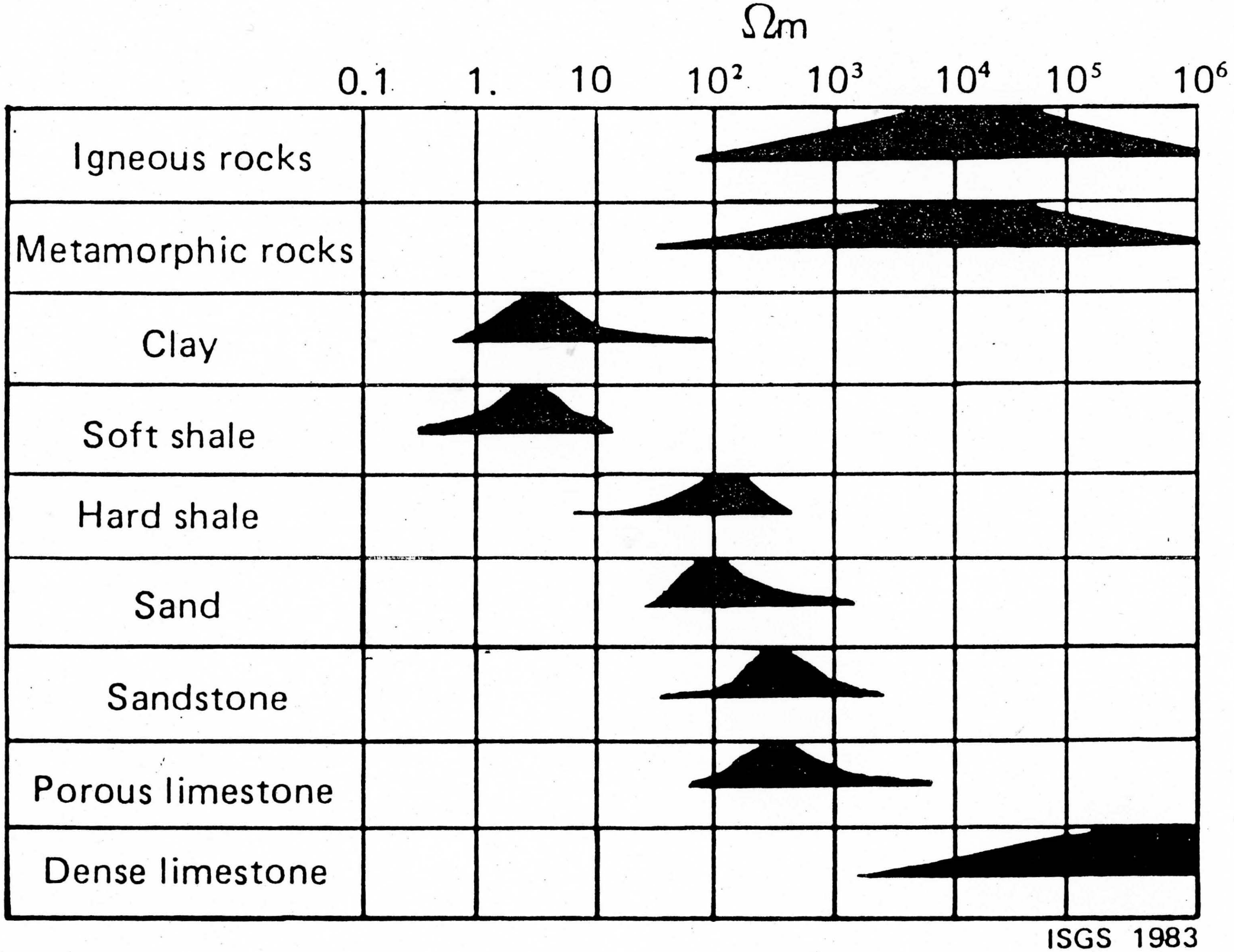

Figure 8. Approximate resistivity ranges for some earth materials.

However, the thickness and resistivity of the material overlying a sand and gravel deposit have a large influence on the resistivity measurements. The measured resistivity is an apparent resistivity, that is, a weighted average of the resistivities of all materials below the electrodes. As the electrodes used in making resistivity measurements are moved further apart, the resistivities of deeper materials have greater effect on the measured apparent resistivity.

In the area around Normal, thick water-bearing sand and gravel deposits may be overlain by as much as 200 feet of glacial till (pebbly clay), as is shown in figures 4 and 5. Resistivities of clays are generally much lower than those of sands. Figure 8 illustrates the difference between the approximate resistivity ranges (in ohm-meters) of sand, clay and several other rock types. As a result of the thickness and relatively low resistivity of the overlying glacial till deposits, resistivity values of the area are generally in the low to intermediate range and even small changes may be indicative of buried sand and gravel deposits. The relatively high resistivity of a 10-foot thick sand and gravel aquifer would have little effect on the measured resistivity value when added to the low apparent resistivity of 200 feet of clay.

This problem in interpretation may be partially overcome with a computer-aided technique which converts the weighted average apparent resistivity values measured at a station into a sequence of layers representing types of earth materials of varying thickness and calculated 'true' resistivity. This technique has never been applied to resistivity data collected in the Normal area. The problem of measuring/identifying significant variations or changes in apparent resistivity values at depth may also be aided by the use of a new, more powerful resistivity instrument which the Survey has recently acquired. The higher power input results in a higher percent of the current reaching the greater depths.

The area west of Normal has not been extensively explored, using resistivity, prior to any previous test drilling. The thickness and low resistivity of the overlying earth material has made it difficult to impossible in the past to accurately define deeply buried sand and gravel deposits using the old resistivity instrument and qualitative interpretation techniques. The probability of doing so with the newer, more powerful instrument and quantitative interpretation technique is much higher. A resistivity survey may therefore be a valuable aid in optimally locating new test holes.

While in no way minimizing the potential usefulness of a modern resistivity survey, its use should be dictated by both the results of the preliminary test drilling and the time and resources available. It obviously should be planned for optimum crop and weather conditions.

While developing new information for locating a new well field, consideration should be given to extending the pipeline ending at the current well field westward to the site of TH 3-73. The hydrologic feasibility should be investigated to establish if an additional well could be placed there or just to the south.

Finally, based on the information obtained from the preliminary test drilling (and resistivity data), an additional detailed test drilling and test well program should be designed for the most promising area, presumably to the west in Area 1. Other potential well sites could also be developed to the north and south of the pipeline extended westward along the township line.

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Illinois Department of
Energy and Natural Resources

August 27, 1985

Mr. George L. Farnsworth, Jr.
Farnsworth and Wylie
Consulting Engineers
2709 McGraw Drive
Bloomington, IL 61701

Dear George:

We have received a copy of the report, "Geology and Distribution of the Aquifers West of Normal, Illinois, An Update," prepared for your office by John Kempton of the State Geological Survey. We concur with his stategies for ground-water exploration, especially in regard to the areas far west of the current well field (labeled area 1 in his report).

If a water supply of up to 5 mgd is desired, it is important from a hydrologic standpoint to develop the supply as far away as possible from the current well field. Preliminary estimates of well field interference from a 5 mgd field centered six miles to the west suggest that between 15 and 20 feet of additional drawdown could reasonably be expected. This preliminary analysis is based on extrapolation of data from the existing well field, along with information in John Kempton's report.

In earlier discussions of the feasibility of constructing an additional well at site 3-73, we had estimated that such a well might cause up to 20 feet of additional drawdown in the current well field. This estimate was also, of course, based on extrapolation of hydraulic properties from wells 100-102 and would have to be verified by field tests. If our estimates were to be verified, then the value of adding the extra well would have to be weighed in relation to its impact on the present well field and on area farm wells.

We look forward to meeting again with you, as necessary, to discuss your plans for ground-water exploration and development.

Very truly yours,
ILLINOIS STATE WATER SURVEY

Adrian P. Visocky

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Hydrologist
Phone: (217) 333-1724

APV/psm