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SUMMARY - 1985

PRELIMINARY REMEDIAL INVESTIGATIONS REPORT

Freeman Chemical Corporation
Saukville, Wisconsin

Prepared by

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Job No. 0001-003

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1.0 Introduction

This report summarizes the results of field investigations made during 1985 by Hatcher Incorporated at the Saukville, Wisconsin plant site of Freeman Chemical Corporation. These investigations were designed specifically to acquire additional data needed to select appropriate remedial solutions to contaminated soil and groundwater problems at this plant site.

1.1 Previous Investigations

Investigations at this site began in 1983 by Olver, Inc., with a two-phased investigation of the site hydrology and geology, with emphasis on installation of monitoring wells and on developing an understanding of the interaction between the shallow and deep aquifer.

An interim report on the progress of Phases I and II was issued by Olver on June 20, 1984, detailing the results of the geotechnical investigations, piezometer installations, groundwater level monitoring, and groundwater collection and analysis activities. In addition, preliminary assessments of the hydrologic regime at Saukville were made. Soil boring and piezometer installatin logs, chemical analyses, and groundwater hydrographs were included. A pump test program designed to determine hydrologic characteristics (transmissivity, storage and leakage) of the dolomite aquifer and the interrelationship of the shallow and dolomite aquifers was conducted using the Saukville municipal wells, the Laubenstein well, and site piezometers.

Details of the pump test program, data analysis procedures, data evaluation, and aquifer characteristics were presented in a subsequent report by Olver issued January 10, 1985.

Results of the 1984 pump tests demonstrated that the dolomite aquifer is semi-confined by the surficial glacial materials and that recharge to the dolomite (probably from the Milwaukee River) occurs during pumpage.

The aquifer tests of the Saukville municipal wells in the dolomite aquifer also demonstrated a considerable local variability in yield. This variability is probably related to variability in fracture frequency, solutioning, and recharge opportunity at each well site. Transmissivity and storage coefficient values calculated from the test analyses also reflect aquifer anisotrophy; i.e., aquifer transmissivity and storage differ depending on the direction of the observation well(s) used in the test analyses from the pumped well. Transmissivity of the dolomite aquifer apparently ranges from 140 to 4,450 ft^2/day.

The rapid response of the Laubenstein well and the smaller delayed response of the site piezometers to pumping in nearby municipal wells indicated that the Laubenstein well and the site is at least partially in the drawdown cone of influence of those municipal wells. Thus, any pollutants in the dolomite in this drawdown cone can potentially move toward the pumped municipal wells.

Results of chemical analyses from the periodic sampling of the shallow piezometers indicated that organic solvents and phenols were present in the shallow aquifer. Although the data were not sufficiently detailed to be contourable, the higher concentrations tended to occur in the vicinity of the Freeman and Laubenstein warehouse sites. Analyses of water from the Laubenstein well pump test indicated contamination of the dolomite aquifer at that point. With regard to chlorinated solvents, the GC/MS analyses to date indicated that dichloroethylene was found beneath the Freeman site. Trichloroethylene has been identified in the Laubenstein well and in MW-2.

1.2 Summary of 1985 Activities

The field program conducted during the 1985 season was essentially the "Recommended Scope of Work" as proposed by Hatcher Incorporated in their January 1985 Report entitled "Summary - Hydrologic Assessment Activities, Wisconsin".

The 1985 fieldwork was initiated with a EM survey of the site and immediately surrounding area to determine any conductivity or resistivity anomalies related to contaminant plume geometry. The Geonics 34-XL was used at both antenna orientations on 10 and 20 meter spacing. Useable data was acquired outside the plant site; however, the concentration of on-site metallic buildings, power lines, and buried pipes made on-site data interpretation problematical.

Subsequently, a very successful, shallow seismic refraction survey was used to determine depth to dolomite on and immediately surrounding the Saukville plant site. In addition to better definition of the dolomite upper surface, a good quality top of saturated glacial materials was derived from the "first arrival" data.

Following evaluation of the seismic refraction data and comparison with existing geohydrologic data, new locations were selected for dolomite aquifer and overburden (surficial glacial) monitor/piezometer wells. Likewise, wells constructed across the dolomite-glacial overburden contact were selected for decomissioning and plugging. Finally, additional strategic locations for split spoon sampling for lab permeability analysis were selected for more comprehensive coverage of the site.

In all, 8 new monitoring wells were installed: 2 in glacial overburden, 1 in glacial sinkhole infill, and 5 in Silurian dolomite. Three existing piezometers were decommissioned; 3 were kept as is; and 6 were redone. See Figure 1. Short bailing and recovery tests were made on the new monitoring wells to estimate the hydrologic character of the glacial overburden materials.

At the initiation of the drilling program by Canonie Construction Co., a borehole geophysical survey of most of the existing and a few of the new monitoring wells was made by BPB Surveys. Where possible, natural gamma-gamma

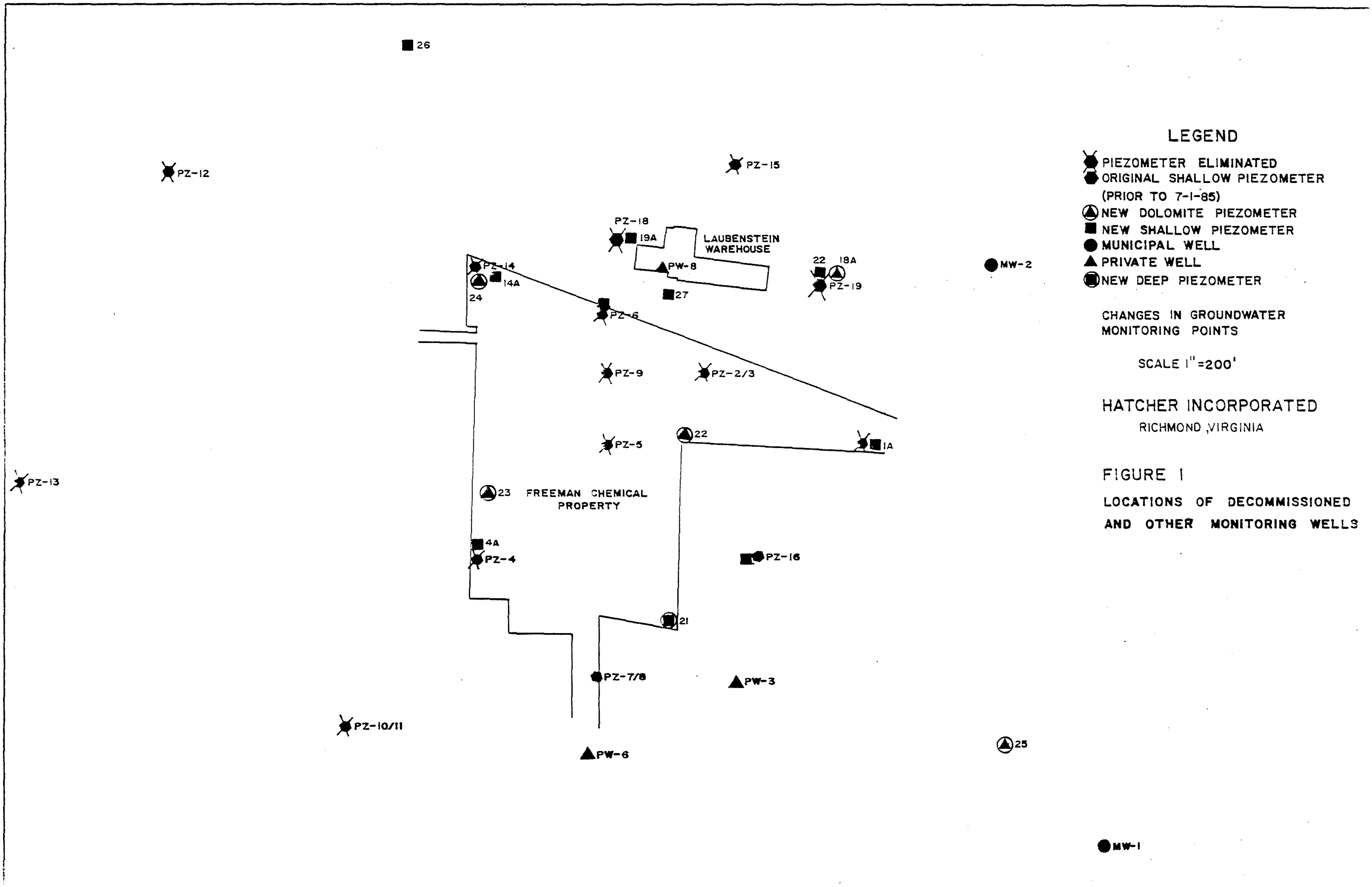


FIGURE 1

LOCATIONS OF DECOMMISSIONED AND OTHER MONITORING WELLS density, neutron, gamma, acoustic, temperature, and caliper logs were run to determine individual well site construction, geology, and hydrologic character.

The old, deep well in the warehouse on the property just west of the Freeman Chemical site, hereafter referred to as the Laubenstein well, was test-pumped and sampled during the 1985 field season to determine the effect of longer term pumping on the concentration of trichloroethylene. Water from the upper 100 feet of this well was excluded from the test by installation of an inflatable packer.

At the end of the field season, 2 pilot groundwater dewatering schemes were installed in the glacial overburden: 1) a ±30-foot trench, representing a section of a Ranney collector, installed north of the tank farm, and 2) a large diameter, shallow well installed west of Building 5 near the former "dry well".

2.0 Hatcher Investigations

2.1 Seismic Refraction Profiling

A seismic refraction survey of the plant site and environs was made in June 1985, as part of the overall effort to acquire a more detailed map of the upper surface of the Silurian dolomite. The survey was conducted by Bison Instruments, Inc., supervised by Hatcher Incorporated.

The Bison GeoPro 8012A Signal Processing Enhancement Seismograph was used, with 12 geophones and a sledge hammer source. Hard copy records were created of the seismic waveform data. The sledge hammer was struck against the ground surface sending energy through the ground. The energy was reflected and received by the geophone array which sent a signal to the GeoPro for recording. Successive strikes in the same location reinforced or "stack" the signal, thereby eliminating background noise and the need for large or explosive energy sources.

An array 120 feet in length was employed to assure that several refractions from the depth of interest were received. A 10-foot takeout (distance between geophones) and a 10-foot offset (distance between geophone one and the hammer position) was adopted for this study.

The hammer was impacted at both ends of the geophone array so true velocities and depths could be computed. Most of the 82 traverses were overlapped by 50 percent (see Figure 2 for locations of individual arrays).

Each set of waveforms was analyzed to determine the first arrival (initial seismic wave) at each geophone. The time of the first arrival was plotted against the source-togeophone distance to yield time-distance graphs. The slopes (layer velocities) and time intercepts of the lines formed by the time-distance data were checked for inconsistancies and then reduced to depth to each refractor. The seismic refractors have been plotted below their respective array position (Figures 3A and 3B) to create a series of seismic profiles which demonstrate: 1) that the dolomite upper surface is in places extensively pinnacled, with relief being as great as 20 ft./60 ft., 2) that sink holes and/or channels exist, and 3) that first returns are apparently coincident with the top of saturated soil.

2.2 Terrane Conductivity Mapping

An earth conductivity survey was made at the beginning of the field season to determine the applicability of this geophysical method for mapping contaminant dispersion. The Geonics 34-XL instrument was used for profiles on-site, along the railroad tracks west of the site, in the Immaculate Conception School ballfield north of the site, and in two large fields on the Logemann Co. property west and southwest of the site. See Figure 4.

Conductivity readings were taken at 10-meter station

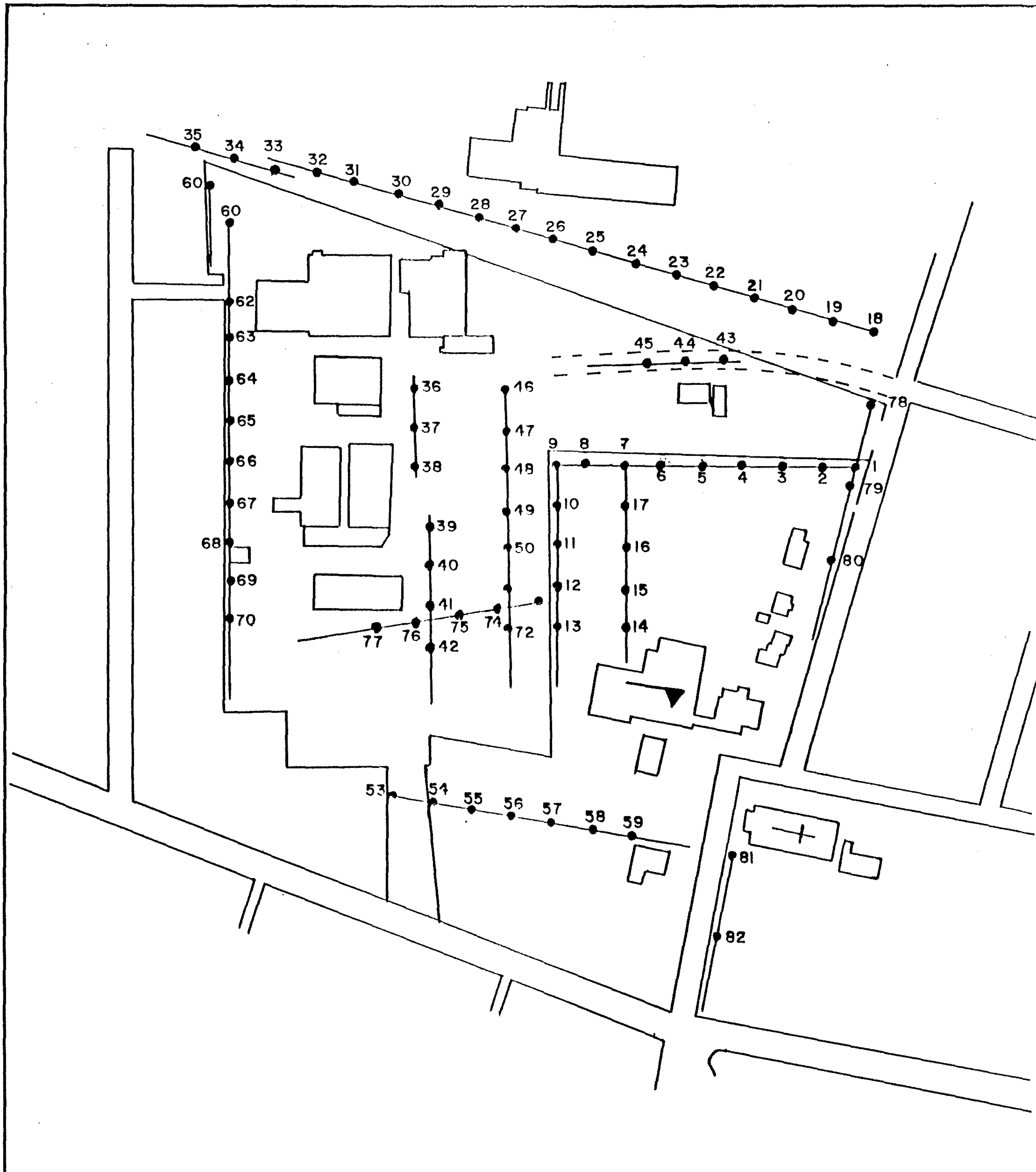


FIGURE 2
SEISMIC REFRACTION
PROFILE LOCATION MAP

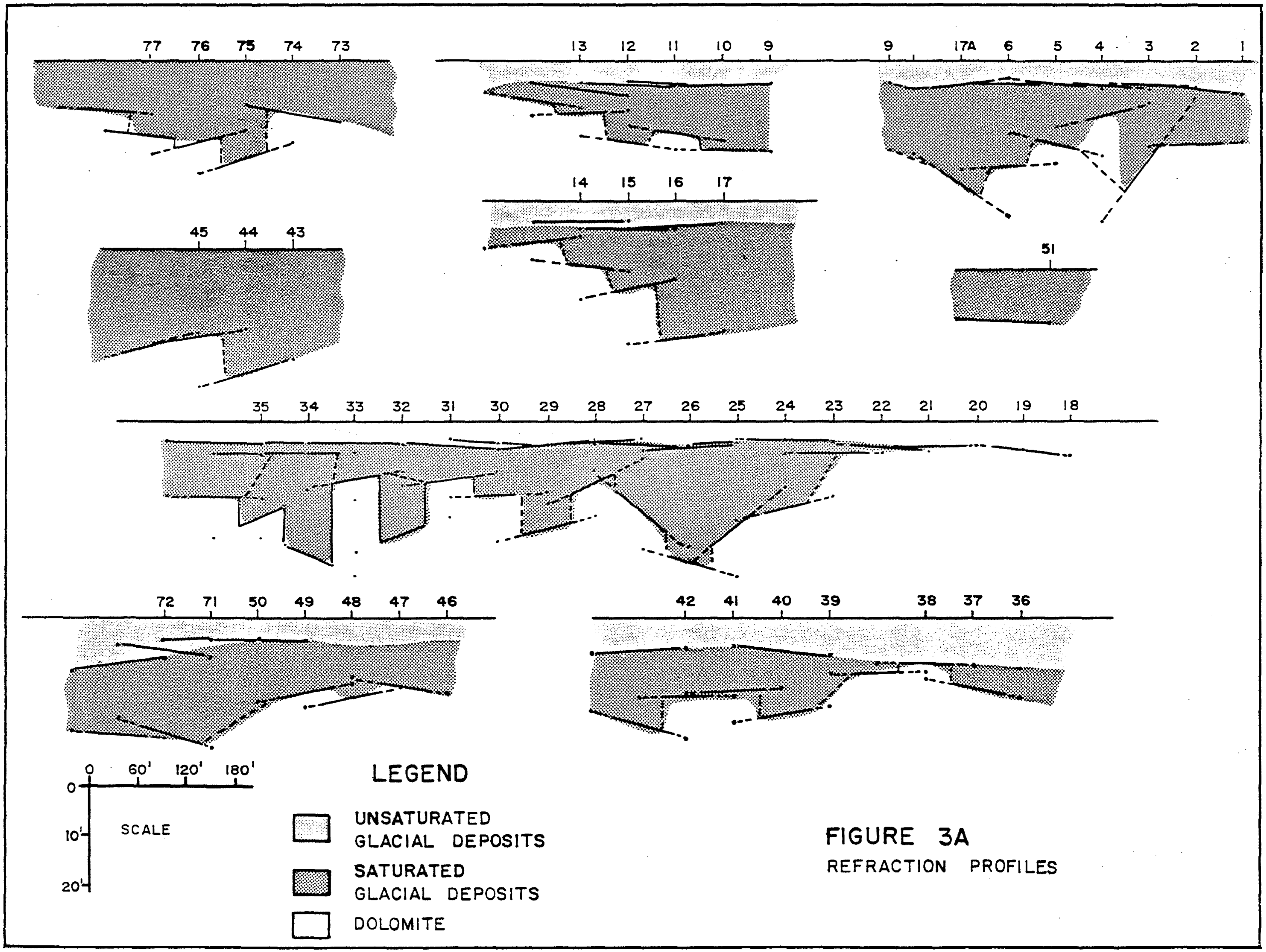


FIGURE 3A
REFRACTION PROFILES

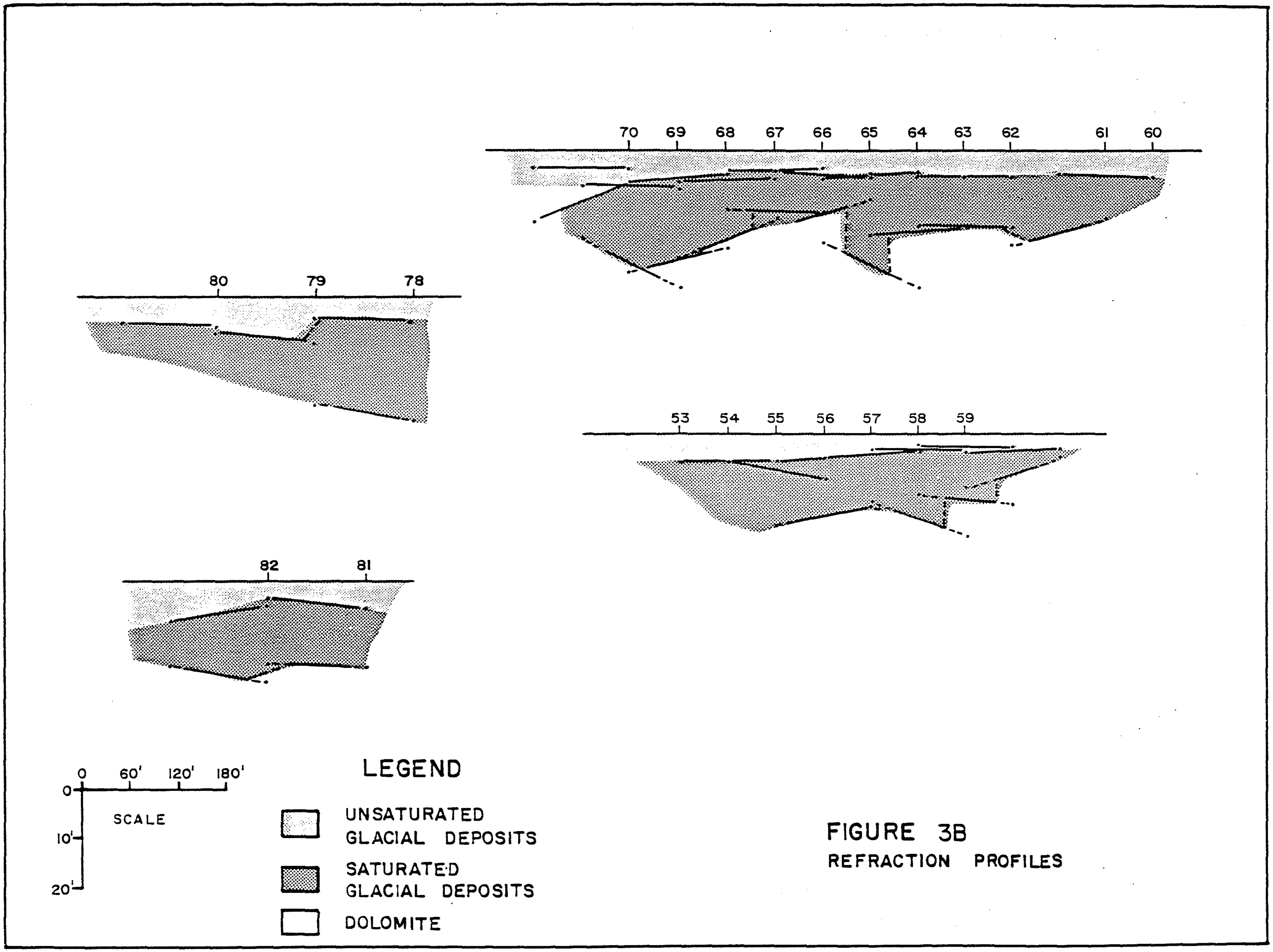


FIGURE 3B
REFRACTION PROFILES

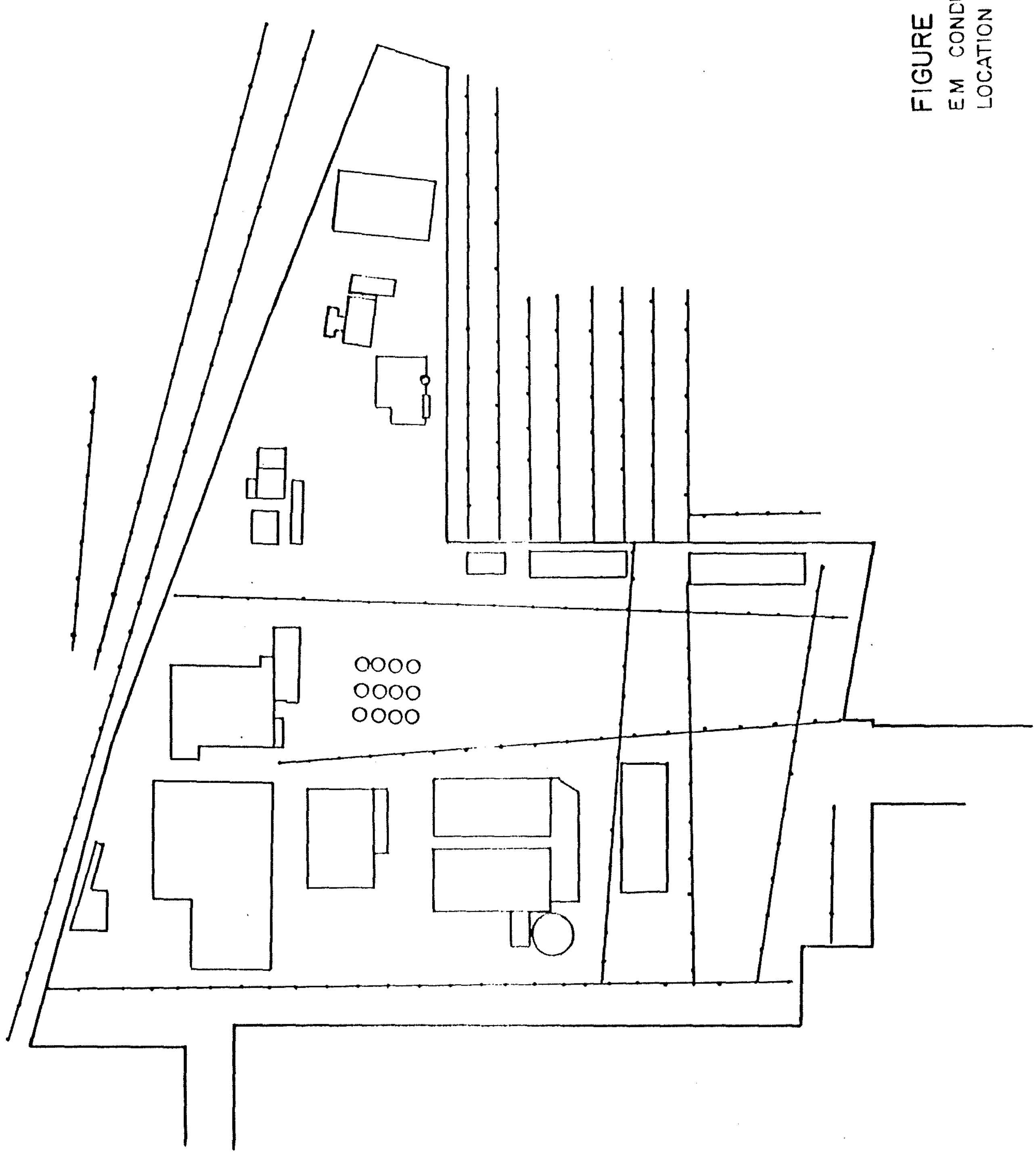


FIGURE 4
EM CONDUCTIVITY PROFILES
LOCATION MAP (VICINITY)

spacings for both the vertical and horizontal antenna orientations at the above locations. Additional readings at 20-meter station spacings were taken on most of the Logemann property.

Plotted conductivities for station locations off-site are contourable and apparently meaningful, except at an old trash dump on the southwest end of the Logemann property. There, high and reversed (negative) readings indicate the probable presence of metallic trash. Contoured conductivities in the school ballfield define a slightly elevated conductivity anomaly trending northeast from and downwind of the incinerator area. This anomaly may indicate depth to bedrock or reflect the downwind fallout plume of the incinerator. On-site, higher conductivities were mapped at places where no other data indicated the subsurface contamination, such as along the south fence. There is little doubt that the on-site readings are heavily influenced by buried and overhead sources of "conductive noise".

2.3 Exploratory Augering

Exploratory augering and split spoon sampling were conducted during the monitoring well installation phase. Continuous split spoon samples were taken at PZ-14A and 6A, SP-B, SP-C, SP-D, SP-E, and SP-F at locations shown on Figure 5. These locations were selected for more comprehensive subsurface coverage of the site.

Samples were taken with an 18-inch NX core barrel through a 6-inch hollow stem auger. A representative part (6 inches) of each 18-inch sample was collected, bottled, and labeled. From these, appropriate samples were selected and have been submitted for laboratory permeability analyses.

When it was impossible to advance the auger, such as sometimes occurred in till and boulder zones, the hole was deepened with a rotary tri-cone. At the termination of each hole, the hole was sealed with a portland cement/ bentonite grout mixture pumped from the bottom of the hole,

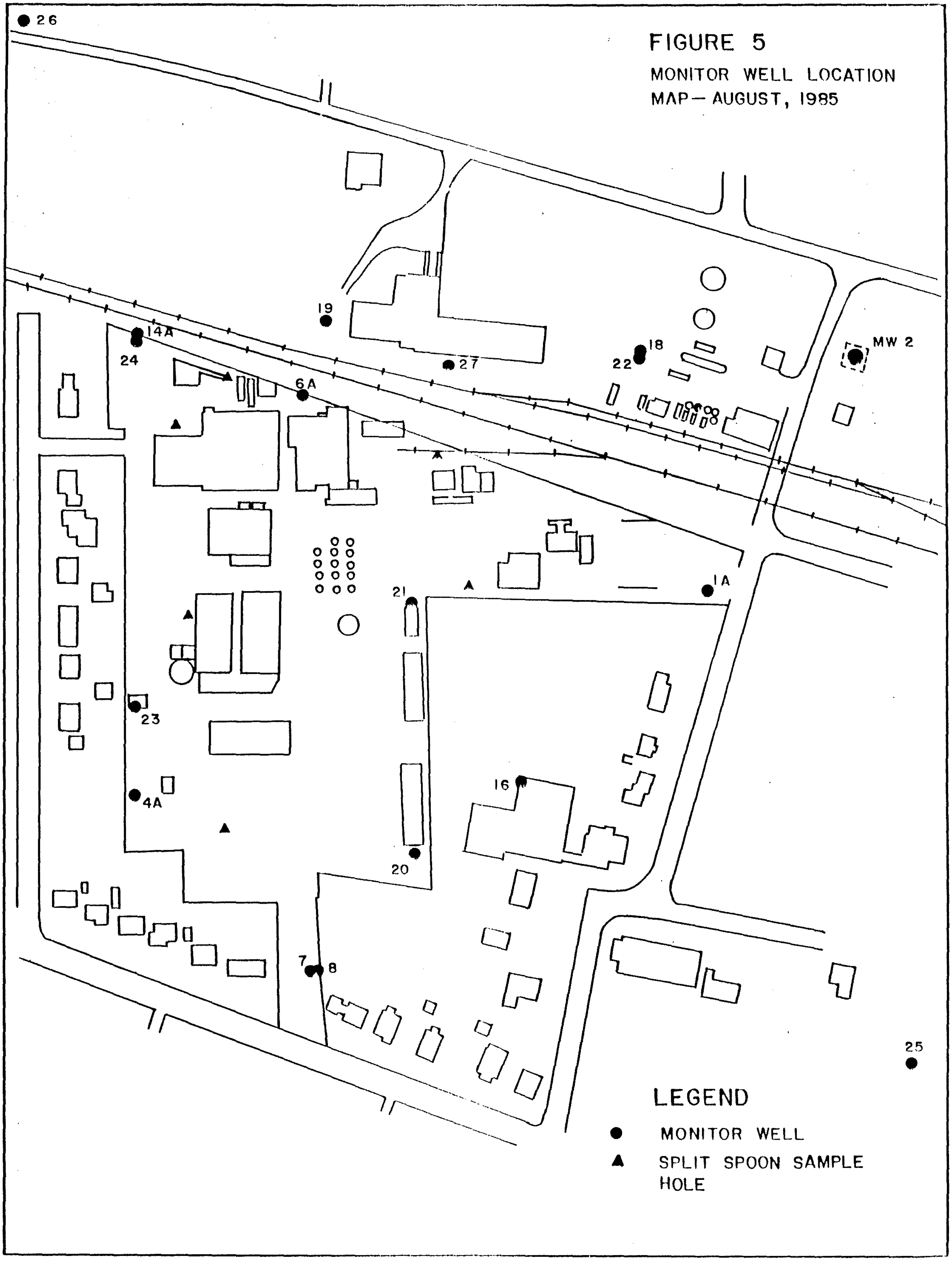


FIGURE 5
MONITOR WELL LOCATION
MAP— AUGUST, 1985
26
19
14A
24
6A
27
18
22
MW 2
21
1A
23
4A
16
20
7
8
25
LEGEND
MONITOR WELL
SPLIT SPOON SAMPLE HOLE

up around the outside of the casing, until the grout reached the surface. All augers, pipe, and sampling equipment and the drilling rig were steamed cleaned between each auger hole or monitor well installation.

2.4 Monitor Well/Piezometer Program

The prior monitor well network contained a number of wells screened opposite the interface between the overlying glacial sediments and the underlying weathered upper surface of the dolomite. Such construction provides a potential pathway for contaminant leakage from the glacial overburden into the Dolomite Aquifer and the groundwater head probably represents a composite shallow groundwater - Dolomite Aquifer head. In addition, the prior construction (5-foot screen at bottom of well) provided no opportunity to sample any solvents or hydrocarbons that might float on the groundwater.

Consequently, all monitor wells screened across the glacial-dolomite contact were decommissioned, except PZ-16. A number of these were replaced with monitor wells which were open only to the Dolomite Aquifer or screened through the saturated part of the glacial sediments. In addition, some new monitor wells were installed to obtain better chemical sampling and hydraulic head coverage of the site area. See Figure 1 for locations of new, replaced, and decommissioned wells.

Dolomite monitoring wells were constructed by mud rotary drilling into the top of the weathered dolomite and setting 4-inch O.D., schedule 80, PVC casing. The PVC casing was grouted in place by pumping a portland cement/ bentonite grout into the bottom of the well and up around the outside of the casing until it appeared at the surface. Following curing, the dolomite holes were advanced by coring a 2-inch continuous core, followed by reaming to a 3-5/8-inch hole size.

Existing 2-inch monitor wells screened across the glacial sediment/dolomite contact were decommissioned by: 1) drilling or driving through the bottom plug of the PVC screen, 2) pumping grout through the open end of the screen, 3) pulling the drill rods, PVC screen, and riser pipe. As in all individual auger hole and monitor well operations, the rig and all equipment were steamed cleaned between wells. New 2-inch PVC shallow monitoring wells were installed by: 1) augering to the target depth with a 6-inch hollow stem auger, 2) installing PVC screen of sufficient length to be open through the saturated section, and then 3) filling the annulus with filter material while removing auger sections. Typical new monitor well construction at the Saukville site is shown by Figures 6 and 7.

2.5 Borehole Geophysical Logging

A majority of the monitoring wells, the Laubenstein well (PW-8), new dolomite wells (W-23 and W-24), and the sinkhole well (W-20) were logged by BPB Instruments, Inc. Where possible, natural gamma, caliper, temperature, neutron, gamma-gamma density, and acoustic logs were run to obtain as much data as possible on the physical construction of the monitor wells and the geophysical character, hydrology, and stratigraphy of each well site. These logs are found in Appendix I.

The caliper logs showed PVC pipe joints and top of screen for almost all of the 2-inch PVC monitor wells. Individual vugs (small cavities), washouts, fractures, and other changes in hole diameter are especially evident on the caliper log of the Laubenstein well. The Laubenstein caliper log shows a large (4-5 ft.) "washout" at the end of the 8-5/8-inch casing. Smaller but significant enlargements are evident to about 125 feet, between 308 and 330 feet, and below 422 feet.

The temperature logs gave an accurate depth-to-water level in every instance by a sharp negative (colder) kick

FIGURE 6

TYPICAL SHALLOW MONITOR WELL

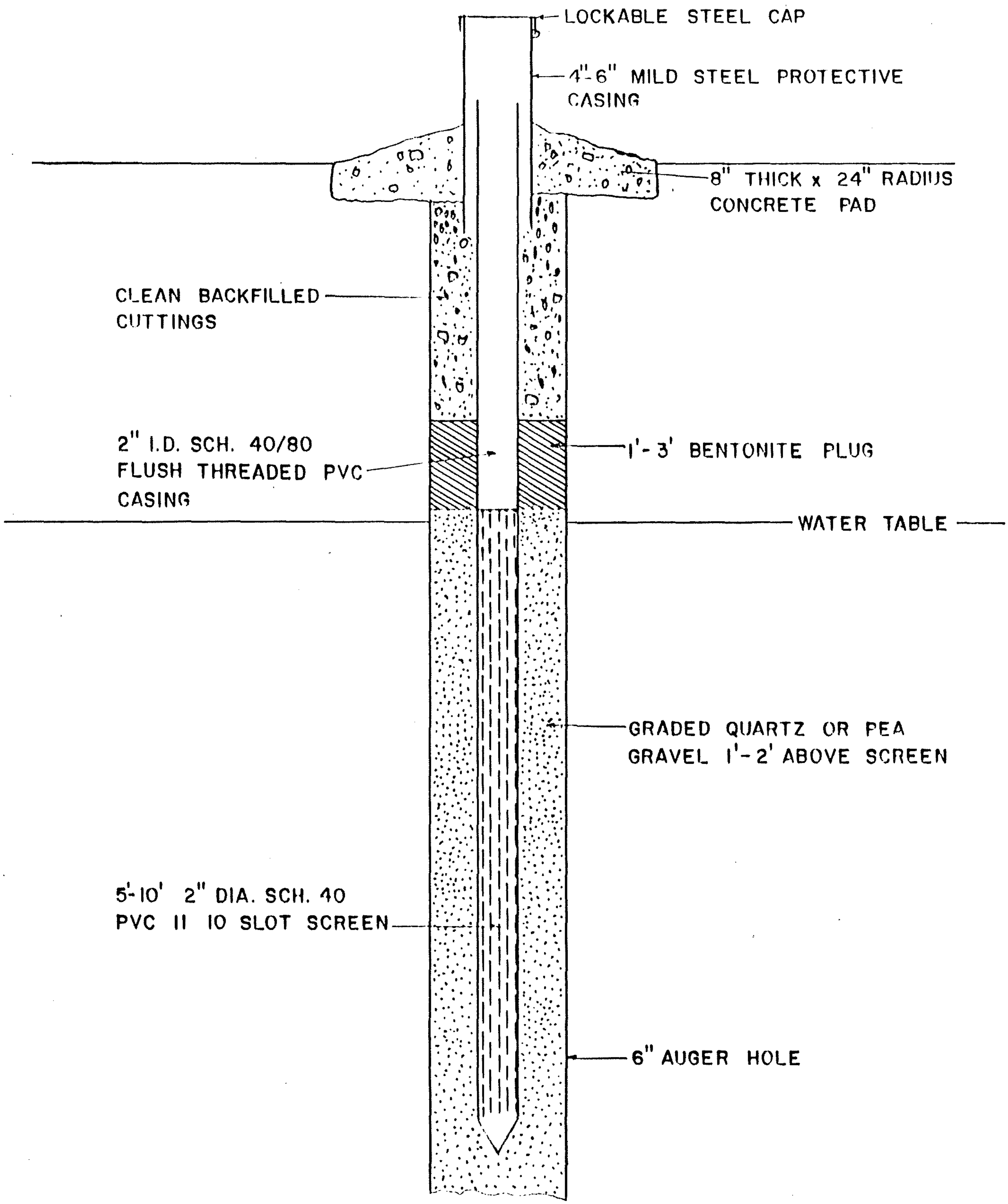
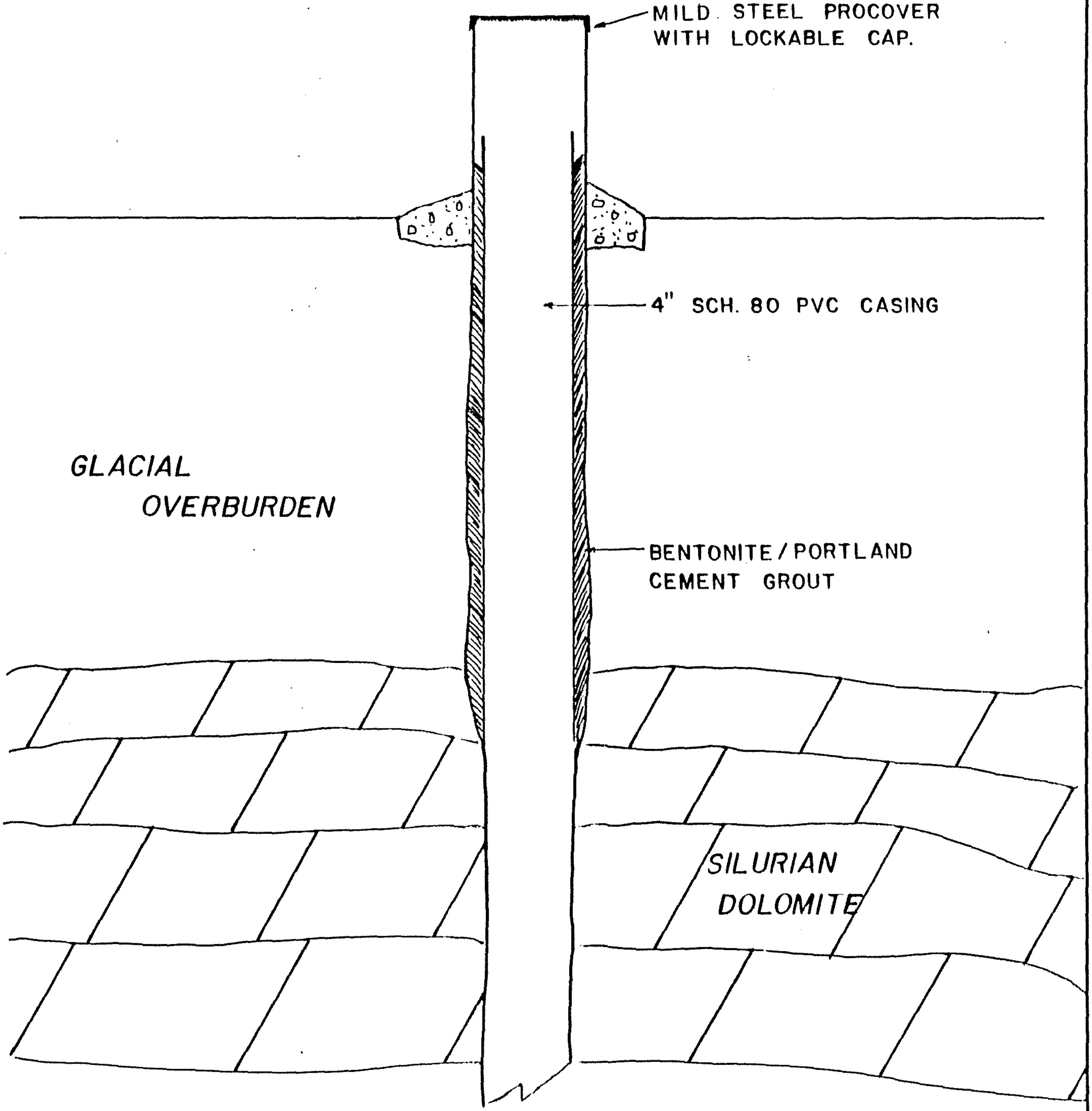


FIGURE 7

TYPICAL DOLOMITE MONITORING WELL CONSTRUCTION DIAGRAM



at the water-air interface. The negative temperature excursion at 17 feet in well 7 indicates colder ground water is entering the well bore at that point (top of screen). This is also the elevation of the top of the dolomite at this well site. The temperature log of the Laubenstein well demonstrates that there are several points within the well where groundwater is entering or leaving the well bore. Although, normally, well bore temperatures gradually increase with depth, well bore temperature in this well decreases (gets colder) to the 450 feet depth indicating that colder water from shallower depths may be moving down the well bore to that depth. The water level of 38 feet, as indicated by the temperature log, suggests that the nearby Municipal Well 2 was being pumped on this logging day. A well-bore, current-meter survey to determine direction and rate of water movement within the well bore of the Laubenstein well has not been run.

The temperature logs of those monitoring wells having screens across the dolomite-glacial sediment contact do not indicate significant vertical movement of water.

The gamma-gamma density logs gave a high-amplitude, low-density kick (to the left) opposite the location of bentonite plugs in the monitoring well annulus. Most all bentonite plugs were shown to be within 1 foot of their reported locations. Otherwise, the gamma-gamma logs demonstrated that the least dense materials were generally within the upper 10-12 feet in the shallow monitoring wells. The gamma-gamma log for the Laubenstein well shows good correlation with the caliper log, having obvious, low-density kicks opposite higher diameter anomalies on the caliper survey. The density logs also demonstrated that the density tool was probably more proficient at locating fractures and vugs than the caliper tool used on this survey. For example, low-density anomalies were located at 63.5 feet, 116 feet, and 428 feet. The large, low-density anomaly at 19 feet looks like a hole in the casing; however, if so, it was not detected by the caliper log.

The sonic survey of the Laubenstein well verifies the existence of the low-density and caliper anomalies which are probably solution cavities in the dolomite. However, the low-density kick at 63.5 is not confirmed by the acoustic log, which may mean that it is clay filled or contains some low density mineral filling. Significantly, the acoustic log also identifies the upper temperature anomaly at ±375 feet to be opposite a large (±3-foot) opening in the dolomite.

The acoustic log of W-24 was run in the drill rod and is therefore useless.

The sonic log of PZ-20 was run in an open, mud-filled hole in glacial till, clay, and silt in a dolomite sinkhole. Comparison with the caliper log indicates that the sonic log anomalies are principally related to hole size changes.

The acoustic log of W-23 does not correlate with the gamma-gamma or the caliper log. The poor definition of the gamma-gamma log may indicate an electronic problem with the equipment when the logs for W-23 were made. On the contrary, the neutron log for this well appears to be normal.

The neutron log, which is a measure of the relative abundance of hydrogen ions, was used at Saukville to indicate the presence of water and, therefore, higher permeability zones. The top of the saturated section on these logs is identified by the large negative shift (greater attenuation of neutron particles by hydrogen ions) and correlates well with the negative temperature anomalies. In general, they indicate that water in the glacial sediments decreases significantly with depth. Exceptions to this generality are PZ-19 and W-23, which indicate that more water exists toward the bottom of the glacial deposits at these two points. Likewise, PZ-20 (in the dolomite sinkhole) shows water to a depth of about 33 feet.

The neutron log of the Laubenstein well shows poor correlation with the temperature log, but fair correlation with the density and caliper logs. That is, higher hydrogen ion anomalies tend to match low-density, larger hole excursion anomalies.

2.6 Hydrologic tests

The need to prevent cross contamination of wells and introduction of foreign water and contaminants into the monitor wells severely limited the kinds of equipment that could be used and the types of hydrologic testing that could be done. Short bailing tests followed by notation of recovery rate versus time, were made in all newly installed 2-inch-diameter, shallow monitoring wells. The large diameter pilot well was dewatered several times with a pump, and the rate of recovery was observed. The dolomite wells were bailed by the drilling contractor to clean the wells of mud and cuttings, but recovery or bailing rates were not recorded. The water level of the pilot Ranney collector ditch was mnitored over several days to document rate of filling. (Evaluation of these tests is incomplete.) See Figure 8.

The Laubenstein well was pumped at 50 gpm over a period of one week. This was not designed strictly as a controlled hydrologic test, but to determine the change of trichloroethylene with time. The results of this test are also presented in Figure 8.

During the course of the exploratory augering, continuous split-spoon samples were collected. From these, representative samples of the tills and silty clays were selected for lab permeability analyses. Water for saturating the samples and running these tests was collected from a shallow on-site well. These tests are being run, but the results are incomplete at this date. Longer than anticipated saturation times, caused by the extreme "tightness" of these materials, has delayed the timely completion of these analyses.

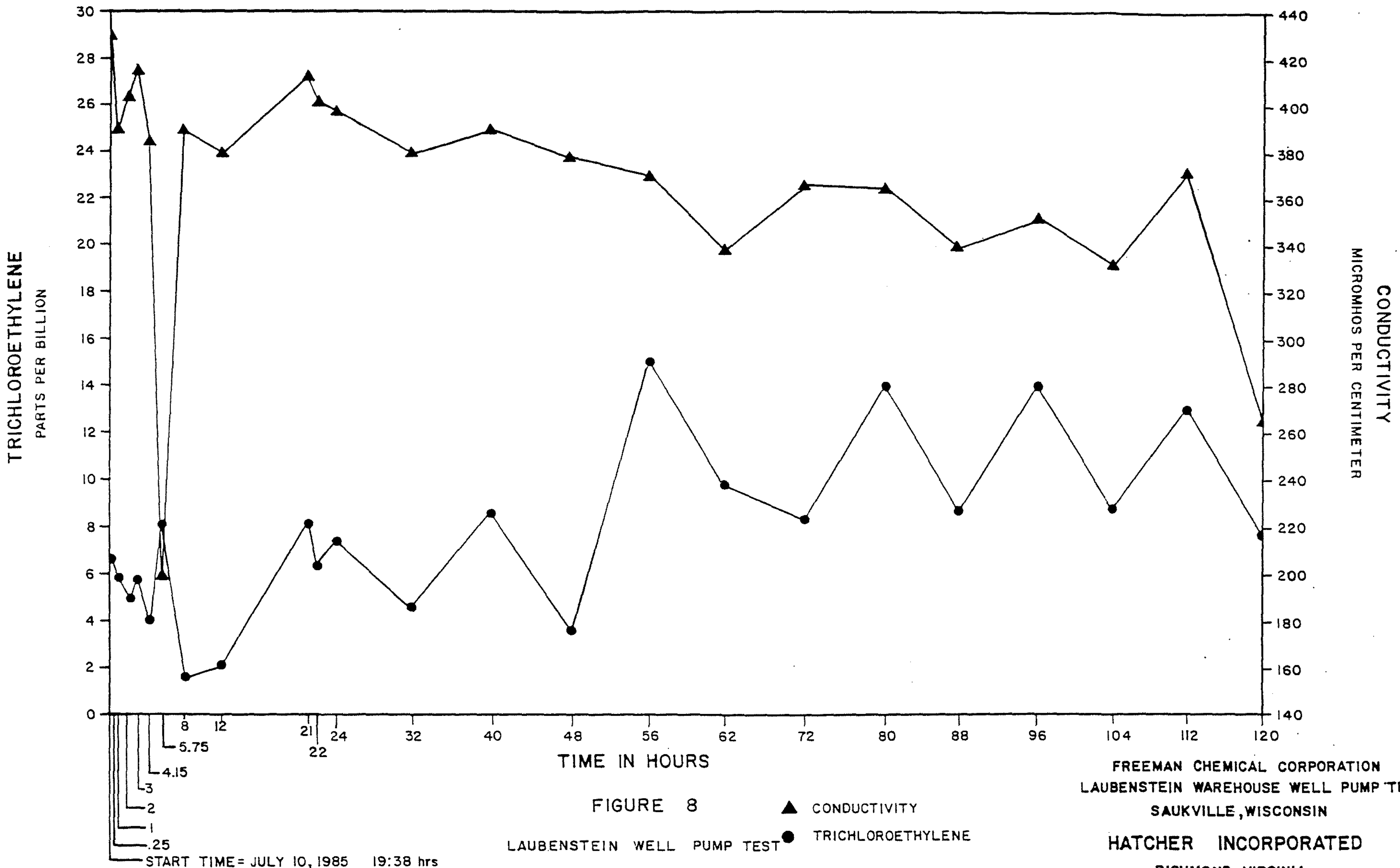


FIGURE 8

LAUBENSTEIN WELL PUMP TEST

▲ CONDUCTIVITY
● TRICHLOROETHYLENE

FREEMAN CHEMICAL CORPORATION
LAUBENSTEIN WAREHOUSE WELL PUMP TEST
SAUKVILLE, WISCONSIN

HATCHER INCORPORATED
RICHMOND, VIRGINIA
AUGUST 6, 1985

3.0 Geohydrologic Summary

3.1 Geology

3.1.1 Top of Dolomite

The seismic refraction data, the depths to the top of dolomite from construction of the present and prior monitor well network, and the depths obtained from the present and prior exploratory augering have provided control for a more detailed top-of-dolomite contour map. A recently completed, more detailed (1-foot contour interval) site topographic map has also permitted increased top-of-dolomite elevation accuracy (see Figures 9 and 10).

This dolomite topographic map, when compared with Figure 1 of the January 1985 report, demonstrates that the site is indeed dominated by a local bedrock high. However, additional control has changed its shape significantly. In fact, increased drill and auger data confirm what is indicated by the seismic refraction profiling; i.e., the dolomite surface is highly pinnacled and contains deep, narrow, irregular channels or, more likely, sink holes.

Closed depressions, interpreted as sink holes are still indicated in the vicinity of the Laubenstein well, in the southwest corner of the Immaculate Conception School ballfield, in the tanker parking area just north of Building 45, and in the extreme northeastern corner of the site where well PZ-20 was drilled to a depth of 190 feet through till, clay, and silty sand without obtaining bedrock. An alternate interpretation is that the latter depression may be a filled river channel.

The new dolomite monitor wells were cored from top of bedrock to a depth ranging from 65-85 feet. Well logs

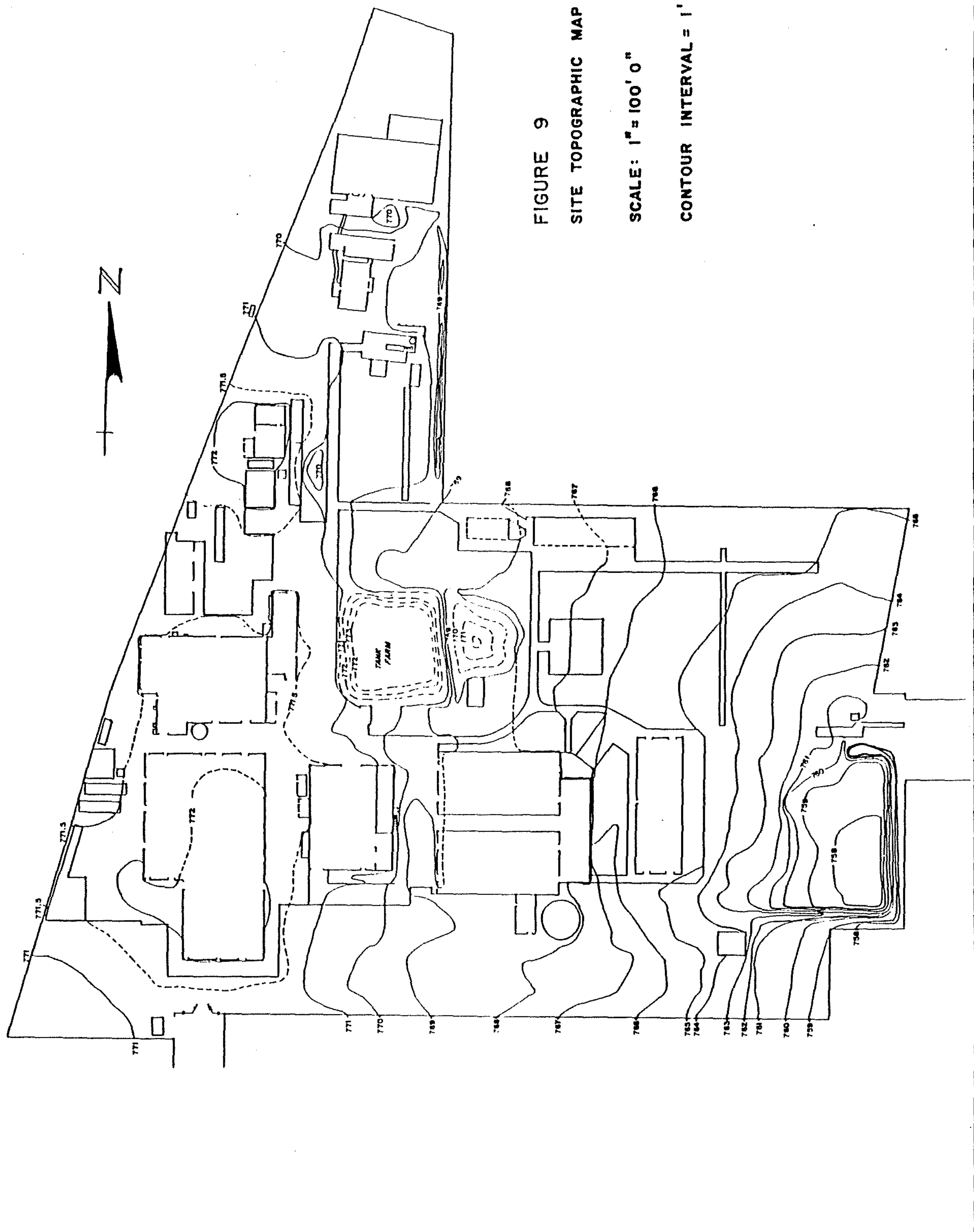


FIGURE 9
SITE TOPOGRAPHIC MAP
SCALE: 1" = 100' 0"
CONTOUR INTERVAL = 1'

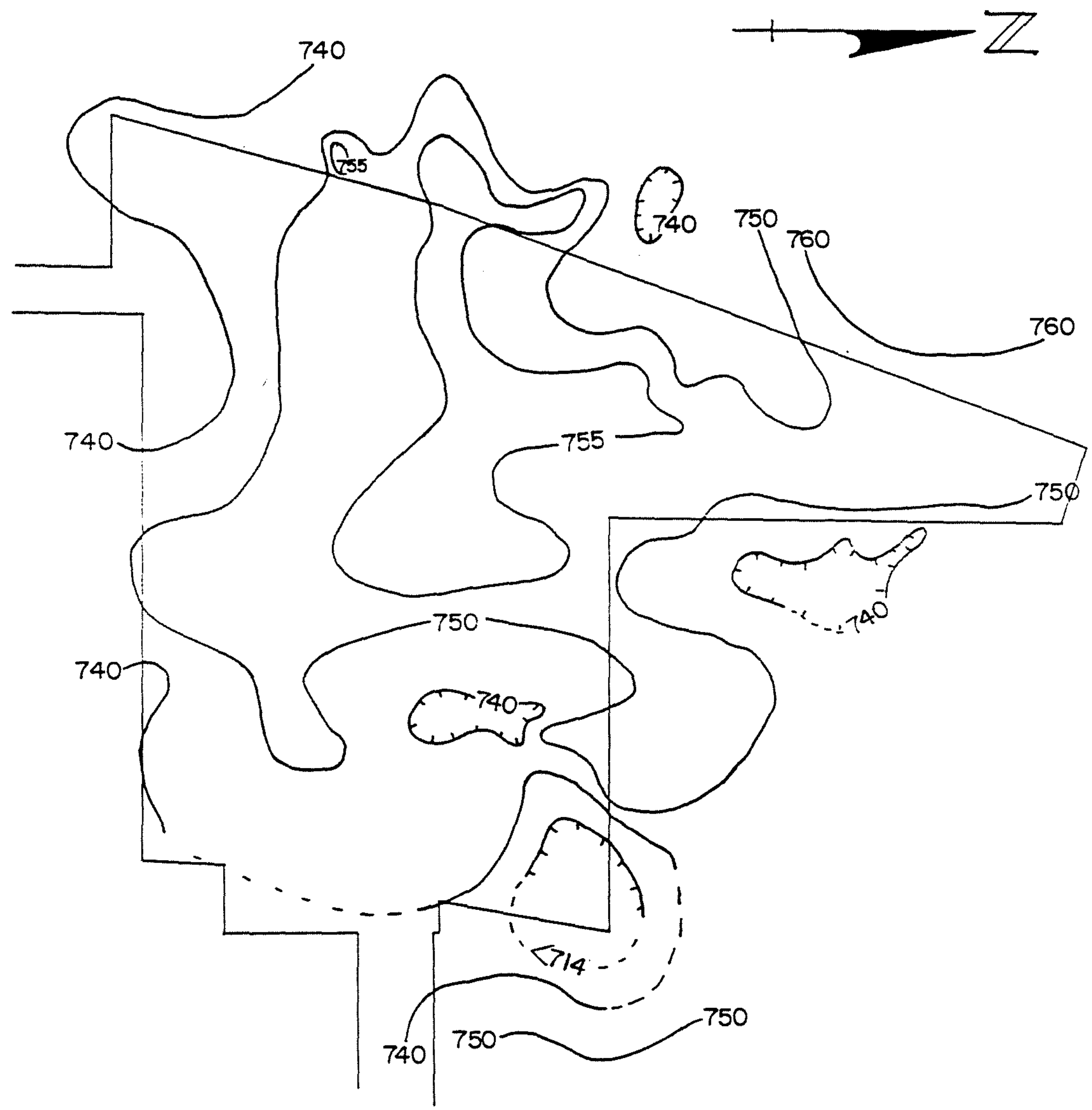


FIGURE 10

TOP OF DOLOMITE CONTOUR MAP

LEGEND

~750 ELEVATION ABOVE MEAN SEA LEVEL

for these wells are presented in Appendix II. These 2-inch cores reveal that the upper surface is severely solutioned. Some large vugs are sand and/or clay filled and there is some evidence that the largest contain till and boulders. The core is also highly fractured, tending to come out of the core barrel in fragments. Opening size and fracture frequency decrease with depth, but the bottoms of all the drilled shallow dolomite wells were still quite open and permeable.

The dolomite surface is usually immediately overlain by a thin (less than 1 foot), fine to medium, usually clean sand, below which a few inches of blue clay from the weathered dolomite is sometimes present.

The surficial glacial materials blanketing the dolomite at this site consist of till, loess or varved lacustrine clay, and fluvial sands and gravels. The most common section consists, from the top down, of:

1. soil and/or fill
2. silty sand, plastic clay, or till
3. dense, varved, argillaceous clay
4. very dense till.

A few very thin, usually dry, sand seams are present in the clay. The tills appear to be totally unsorted and are very difficult to penetrate. The southern edge of the site contains a greater abundance of stream transported sediment. See logs of SP-E, PZ-26 and 14A in Appendix II, for example.

3.1.2 Glacial Overburden Thickness

The top-of-dolomite elevation map and the new site topographic contour map were used to produce an overburden thickness map - Figure 11. This map was constructed by contouring data points provided by elevations of each surface

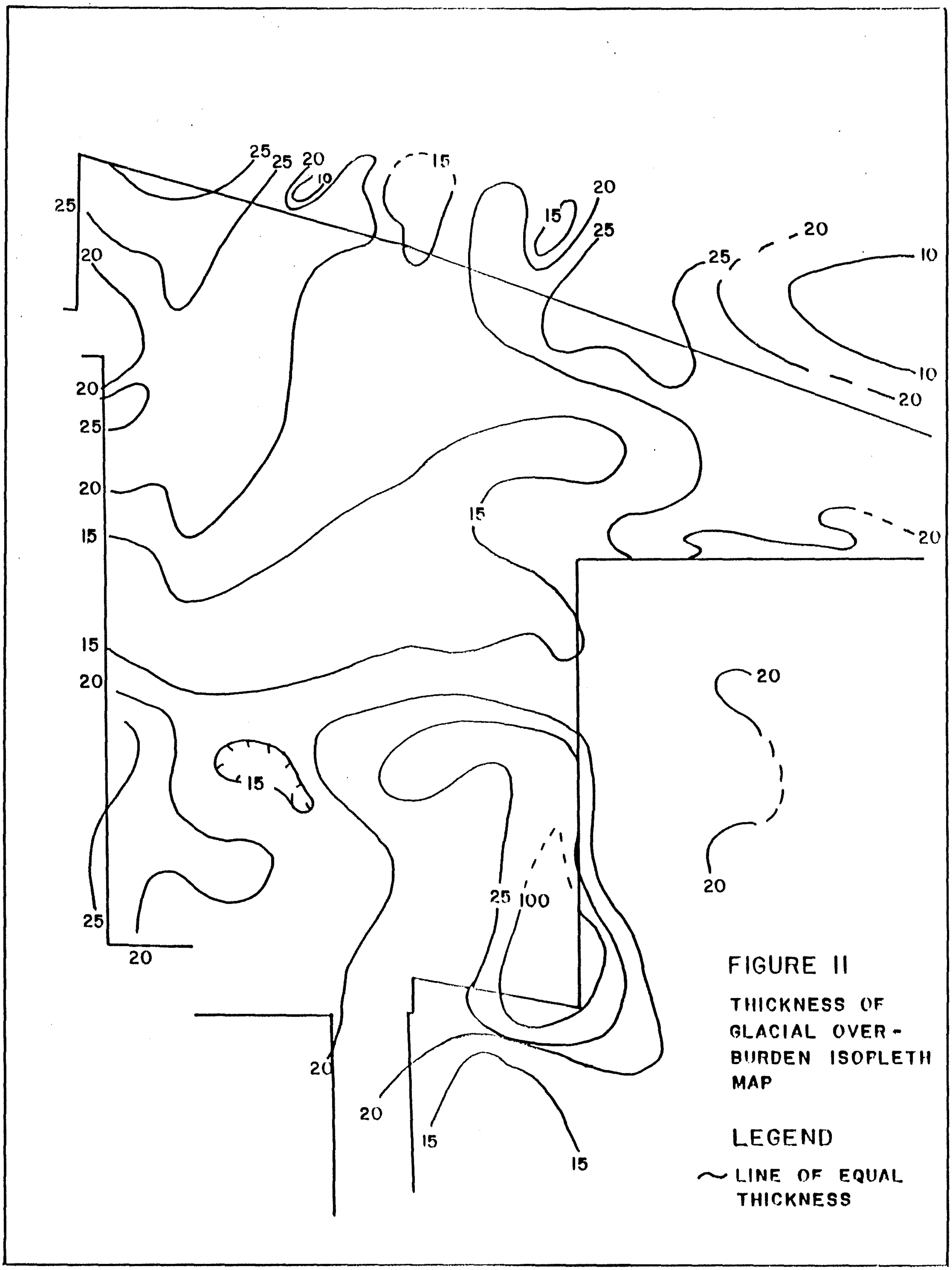


FIGURE II

THICKNESS OF GLACIAL OVER-BURDEN ISOPLETH MAP

LEGEND

~ LINE OF EQUAL THICKNESS

from the auger holes and wells and from differences in elevation at the points where their respective contours intersected. The resulting map consists of isopleths of equal overburden thickness and should not be confused with a topographic map.

This thickness isopleth map shows that the glacial sediment cover blanketing the underlying site is thinnest in the western central portion of the site beneath the main group of buildings and the tank farm. Off-site, sediment cover is thinnest just off the northwestern corner and beneath the Saukville Feed Company property (also the northwest). Sediment cover is thickest, of course, at the loctions of the proposed sinkholes.

3.1.3 Geologic Cross Sections

Geologic cross sections have been constructed from the well and auger hole logs along lines shown on Figure 12. The cross sections are presented in Figure 13 (this figure is presently incomplete).

3.2 Hydrology

3.2.1 Water Table Map

Water levels measured in the new shallow piezometers and first returns from the seismic refraction survey have been combined to produce a more highly detailed water table map of the site and local surrounding area. See Figure 14. As is typical, this map looks much like the configuation of the site topographic map. Water levels are highest along the western edge of the site and at the Immaculate Conception Church/School property.

Groundwater drainage divides have been superimposed

FIGURE 12

Geologic Cross Section Location Map

(In preparation. Refer to Figure 21 for approximate locations.)

FIGURE 13

Geologic Cross Sections

(In preparation)

on this figure to indicate general direction of water-table flow from the site. Most shallow groundwater flows to the lower southeastern part of the plant site (as does most surface water). All shallow groundwater along the western edge of the site flows to the railroad track area. Figure 14 also suggests that groundwater flows onto the site from the Immaculate Conception Church/School property and, possibly from the western Linden Street area.

Water table levels are shallow. They range from a low of about 4 feet along the western edge of the property to approximately 13 feet at the eastern edge. See Appendix III for water level hydrographs.

3.2.2 Dolomite Water Level Map

Water levels measured in the 5 new dolomite monitor wells, the Laubenstein well, and PZ-7 have been used as a basis for this map. Figure 15 represents one interpretation of the semi-piezometric surface for the Dolomite Aquifer. However, during the course of this year's investigation, it became evident from development of the water table map described above (Figure 14), that water levels in the prior piezometers, screened opposite the glacial sediment/dolomite contact, represent head of the top of dolomite rather than of the overburden. This conclusion is supported by the extreme low permeability of the dense glacial clays and the higher head differences between the top and bottom of the glacial overburden.

Consequently, water levels measured in the decommissioned wells have been used to augment water level data used in Figure 15 above to produce the more accurate dolomite semi-piezometric map shown in Figure 16. Because of the placement of W-22 between the Laubenstein well and MW-2, we are now able to document that the Laubenstein well has developed its own drawdown cone, even though it is unpumped. This is shown by both Figures 15 and 16. The latter figure indicates that a local groundwater

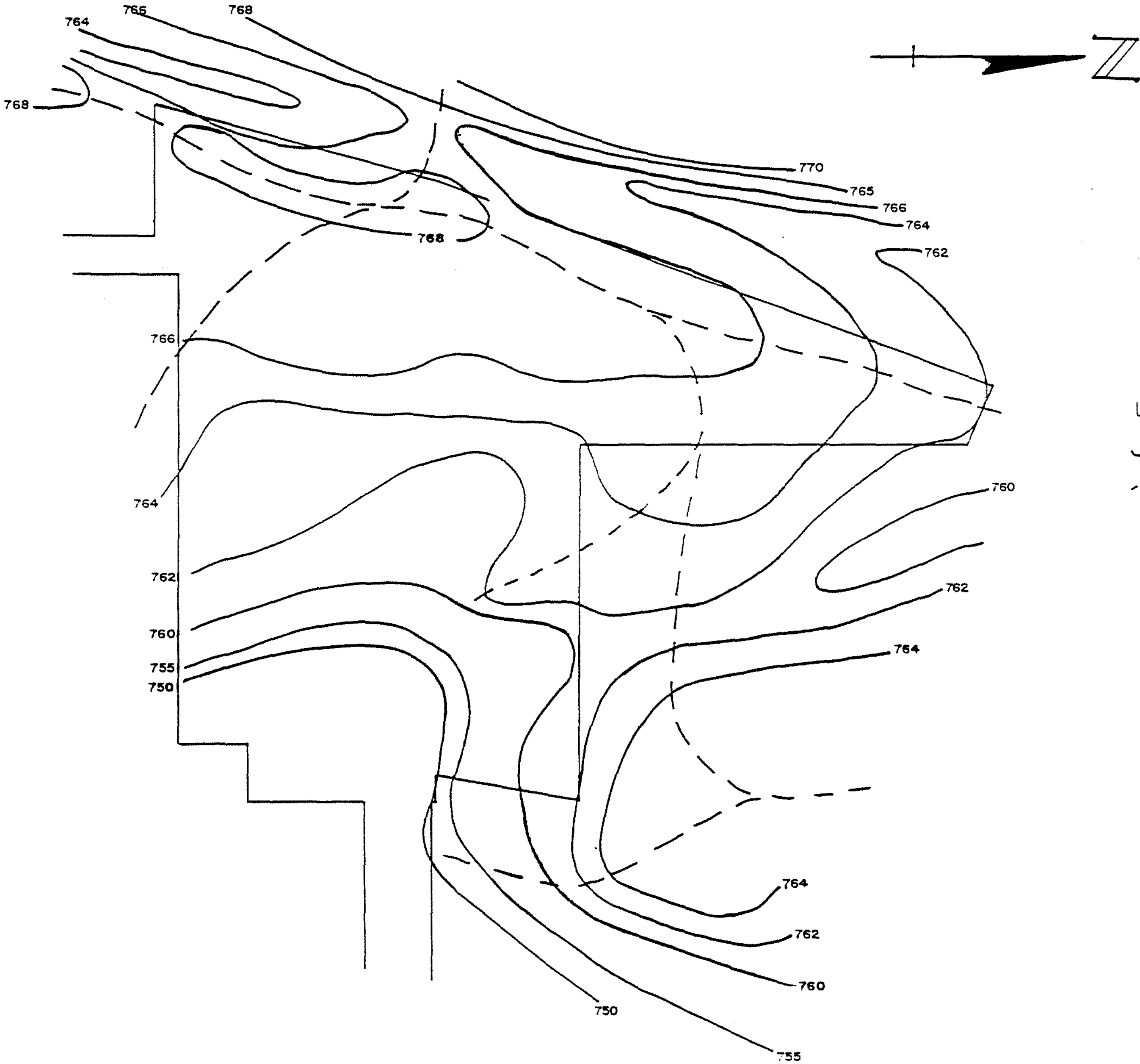


FIGURE 14

WATER TABLE MAP - SUMMER 1985

LEGEND

WATER TABLE CONTOUR

GROUNDWATER DIVIDE

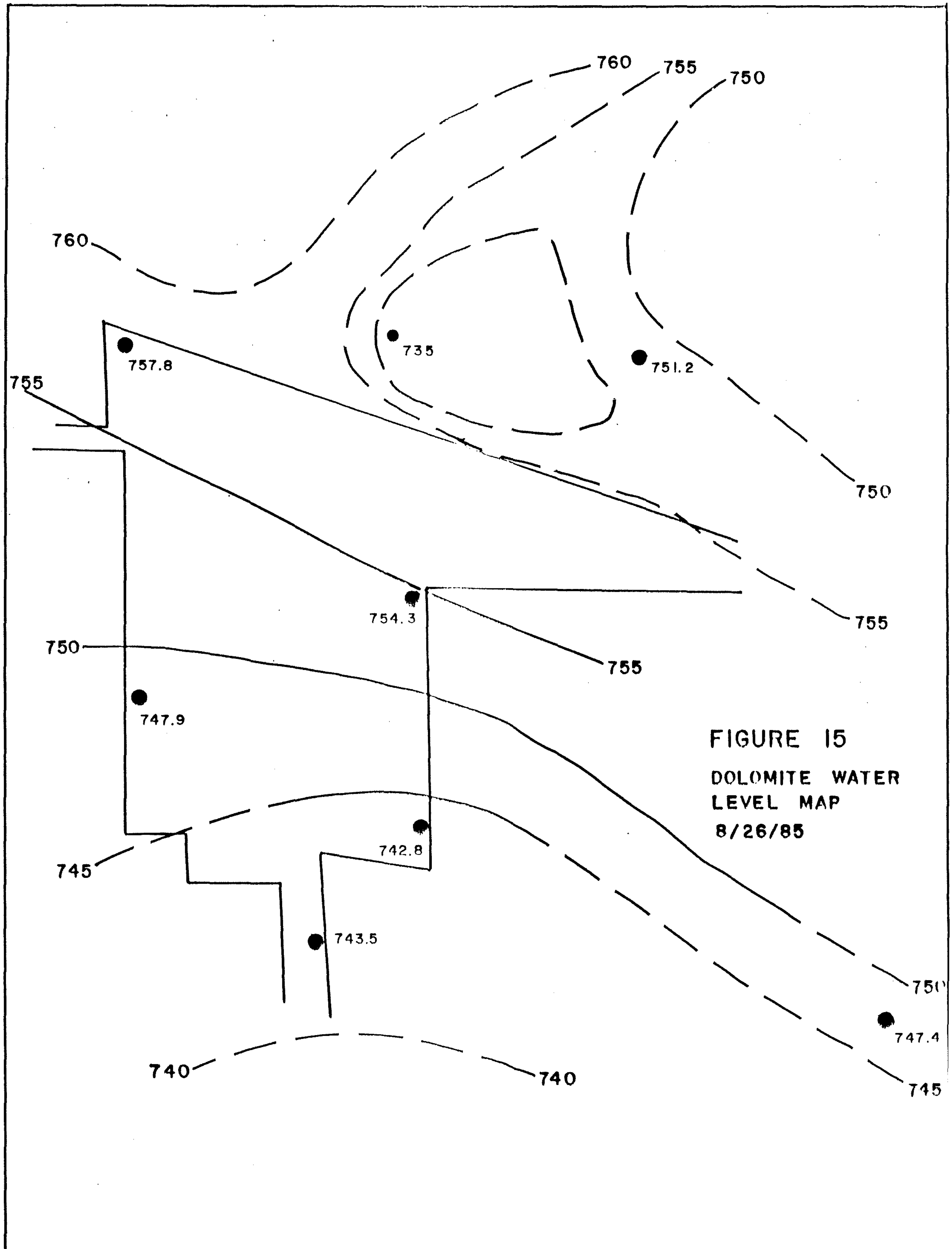


FIGURE 15

DOLOMITE WATER LEVEL MAP

8/26/85

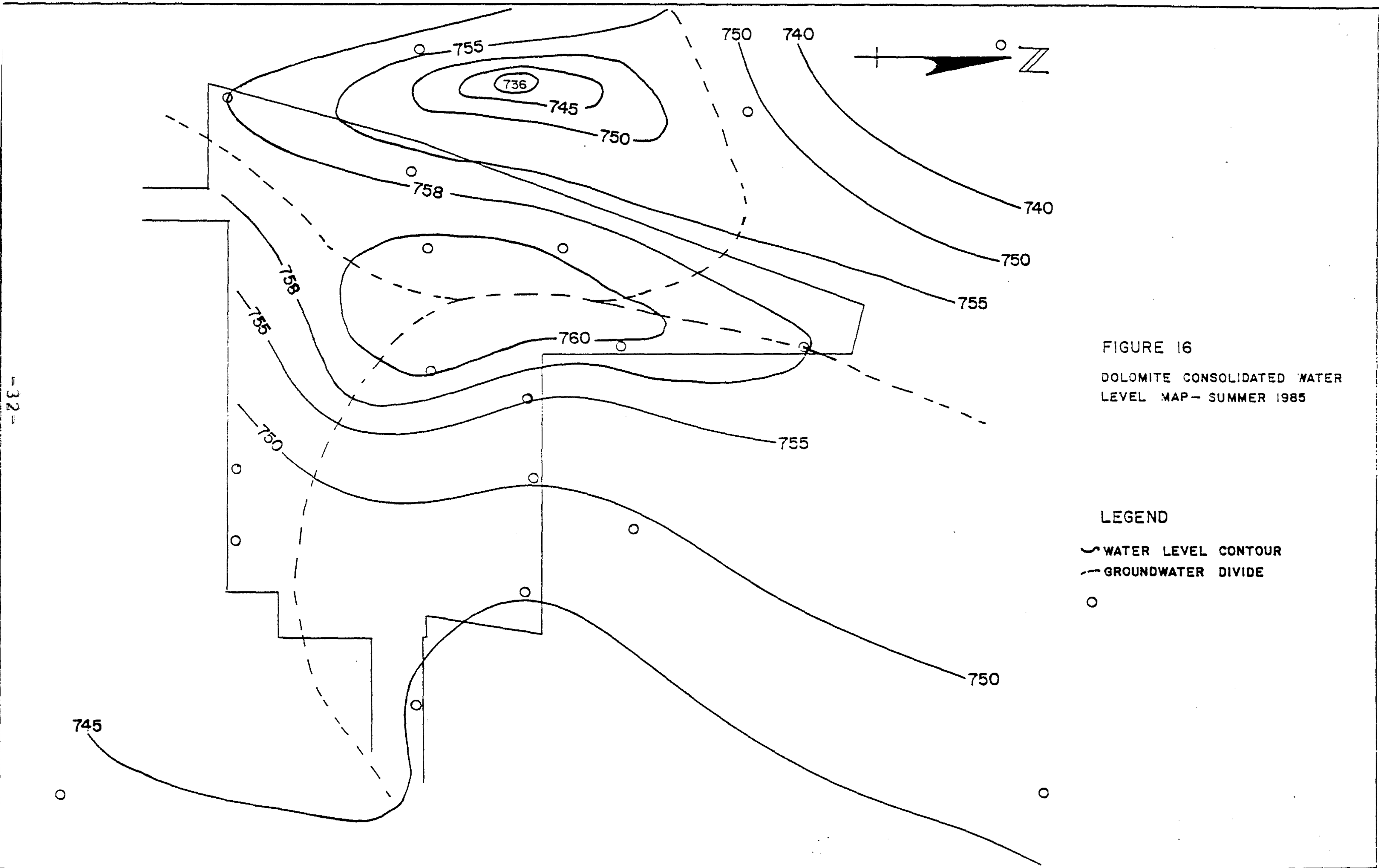


FIGURE 16

DOLOMITE CONSOLIDATED WATER LEVEL MAP – SUMMER 1985 high exists in the dolomite in the west central part of the Saukville site from which groundwater flows in almost every direction, except possibly to the southwest at the head of Linden Street.

Groundwater divides superimposed on Figure 16 indicate that water in the upper part of the dolomite is flowing: 1) directly toward MW-2 and 2) first to the Laubenstein well for about the western 35 percent of the site and then ultimately to MW-2. Water from about 25 percent of the site is flowing southward and ultimately to the Milwaukee River. Water in the dolomite for about 50 percent of the site is flowing northeastward to the River and perhaps to some extent to MW-1.

Regardless of the interpretation, it is apparent that the local groundwater high in the west central part of the site results from local, on-site recharge.

3.2.3 Head Difference Map

The water table map (Figure 14) and the dolomite semi-piezometric map (Figure 16) have been used to construct a isopleth map of the difference in head between the top and bottom of the glacial sediment overburden (Figure 17). The latter map indicates that the top of the dolomite and the glacial sediment are at or near the same head at the center of the site and at the extreme northern corner. These two locations also coincide with points where overburden thickness is least. This head difference map will be combined with the thickness of overburden isopleth map (Figure 11) and the permeability data to calculate leakage rates through the glacial cover into the underlying dolomite for the final report.

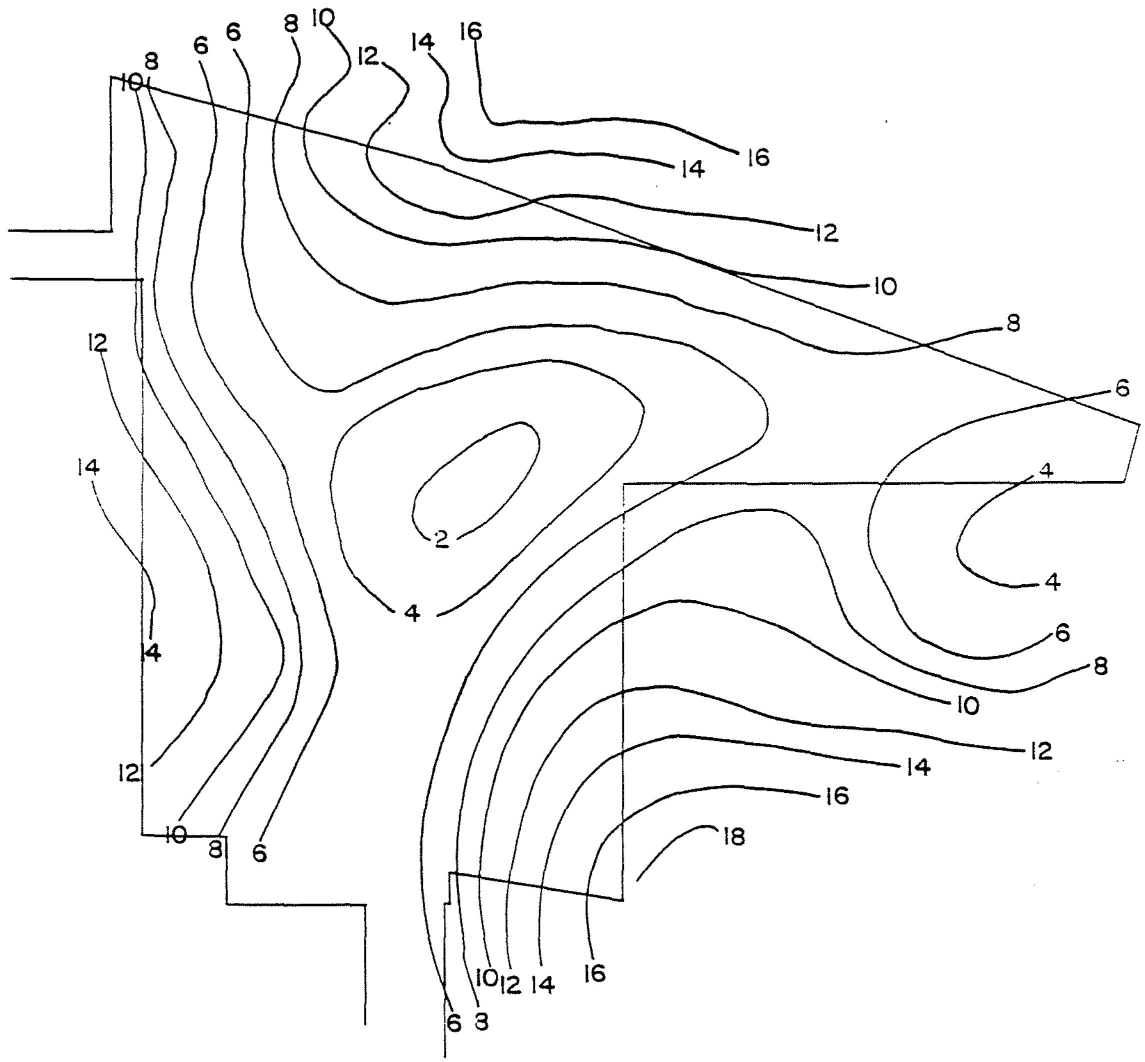


FIGURE 17

DIFFERENCE IN HEAD BETWEEN WATER TABLE AND DOLOMITE AQUIFER

LEGEND

LINE OF EQUAL HEAD

CONTOUR INTERVAL = 2'

3.2.4 Contaminant Dispersion

Probable Contaminant Sources

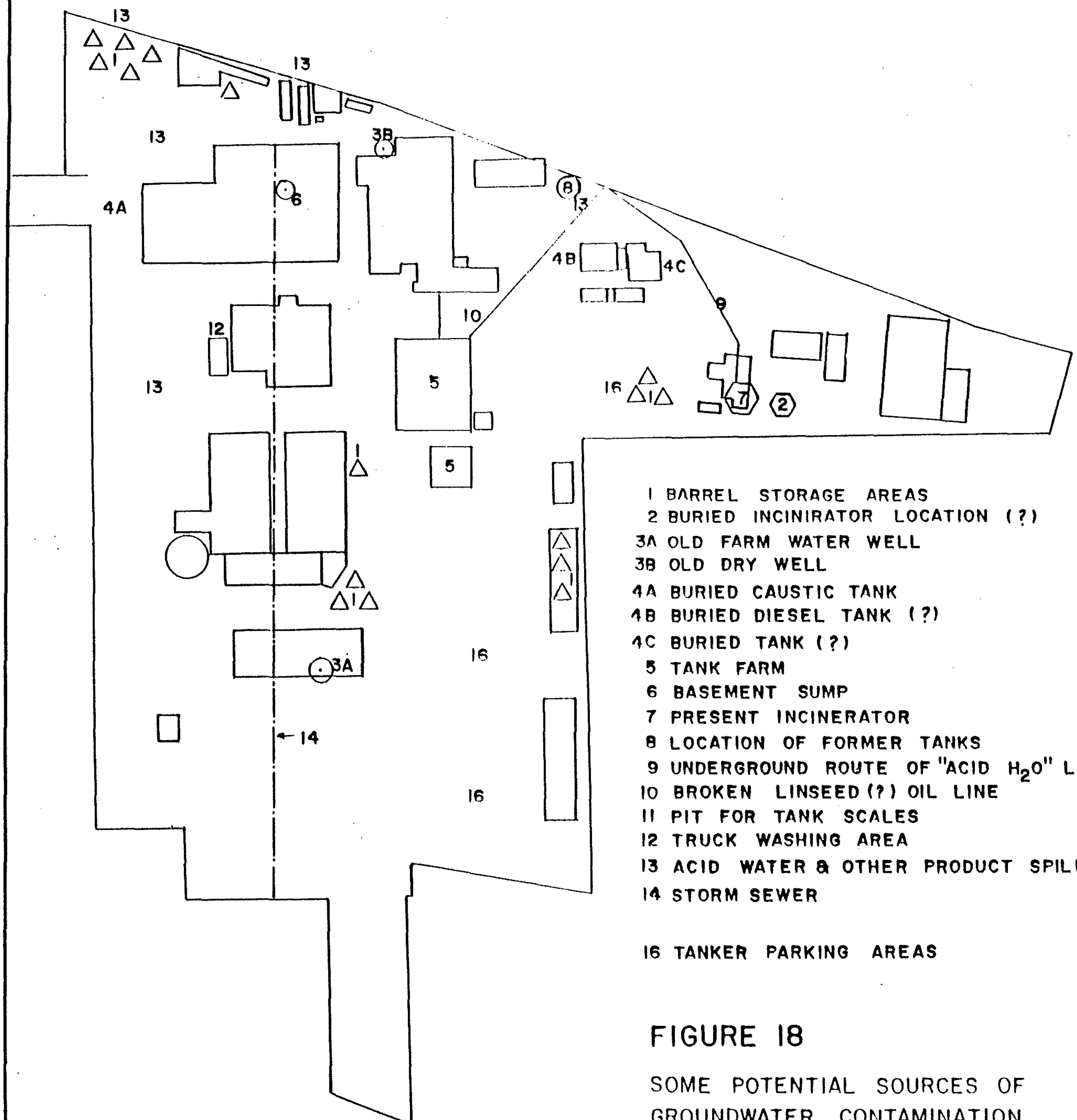
Accidental spillage of raw materials, resins, and by-products have occurred at the Saukville plant site in the normal daily manufacturing process since the plant's inception in 1949. Controlled seepage of reaction water to the glacial sediment occurred throughout a number of years through a "dry well" licensed by the Wisconsin DNR. This "dry well" may have been, in fact, constructed into the top of the dolomite. Reaction water has been accidently spilled both at the incinerator location and through at least one underground pipe leak.

Small leakage has occurred over the years from barrel storage areas, such as in the far southwest corner, and in an area east of the scales along the ballfield fence presently used for tanker parking. Apparently, large volumes of barrels were stored at one time in the old barn formerly located just west of Building 45A.

Accidental spillage of raw materials apparently occurred at the railroad siding during normal unloading of raw materials. Some raw materials were piped from that area to their point of use and/or storage providing opportunity for leakage from ruptured raw material lines.

The bottom of a sump in at least one of the basements (e.g., Building 20) is constructed at or very close to the projected elevation of the top of dolomite. If so, this sump and others like it provide direct access to the dolomite from occasional spills from the kettles. The present tank farm is also sited in an area having thin cover over the dolomite.

Gasoline, diesel fuel, and "caustic" have been stored in underground tanks in the past. Figure 18 shows the locations of pipelines and other utilities in relationship to buildings and the possible location of contaminant sources.



1 BARREL STORAGE AREAS
2 BURIED INCINIRATOR LOCATION (?)
3A OLD FARM WATER WELL
3B OLD DRY WELL
4A BURIED CAUSTIC TANK
4B BURIED DIESEL TANK (?)
4C BURIED TANK (?)
5 TANK FARM
6 BASEMENT SUMP
7 PRESENT INCINERATOR
8 LOCATION OF FORMER TANKS
9 UNDERGROUND ROUTE OF "ACID H_2O" LINE
10 BROKEN LINSEED (?) OIL LINE
11 PIT FOR TANK SCALES
12 TRUCK WASHING AREA
13 ACID WATER & OTHER PRODUCT SPILL AREAS
14 STORM SEWER

16 TANKER PARKING AREAS

FIGURE 18

SOME POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

Chemical Odor Distribution

Although the soil and rock obtained from the exploratory augering, split-spoon sampling, and coring have not been systematically sampled for contaminant level analysis. The presence or absence of VOC's in the collected samples has been documented the simple presence or absence of odor at the time of collection. These qualitative odor data are used in two ways in this report. First, their total absence in some holes gives good control of the lateral limit of contaminant dispersion from the site. This criterion is supported by past chemical analyses of groundwater from these holes; i.e., where no odor is present there is no contamination. Figure 19 shows the probable present-day limits of the site contaminant plume within the glacial overburden. Comparison with the water table map (Figure 14) shows that plume shape is consistant with expected flow direction.

Secondly, the odor data (from both the present and prior well and exploratory hole data) have been qualitatively divided into very strong, strong, moderate, and slight odor and have been used to illustrate the plume's 3-dimensional character. Therefore, Figure 19 is also a "birds eye" view of the distribution of different levels of odor concentration. The areas of strongest odor are located: 1) downslope from the tank farm and just north of Building 45A, 2) on the southwest corner of the Immaculate Conception Church ballfield (these two locations are at or near points on the site underlain by probable sink holes), 3) west and southwest of Buildings 20 and 5 along the western fence, 4) at the tank farm proper, and 5) at Building 33 north of the scales. It is also noteworthy that an area of low odor concentration exists in the west central part of the site coincident with the water table divide.

Diagramatic cross sections have been drawn through the plant site to show the vertical and lateral distribution of different levels of odor concentration relative to site

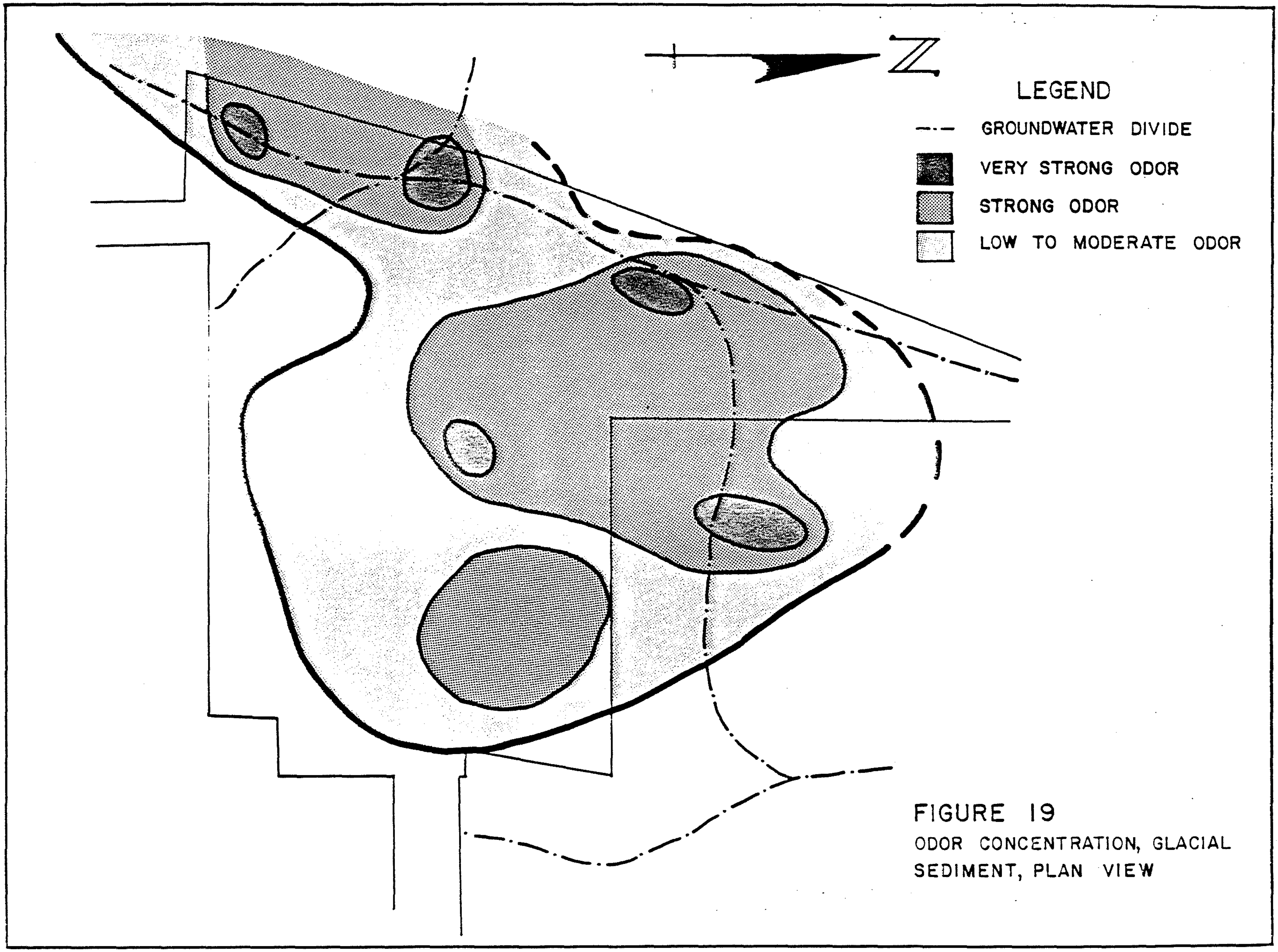


FIGURE 19
ODOR CONCENTRATION, GLACIAL SEDIMENT, PLAN VIEW

facilities. See Figure 20 for the locations and Figure 21, Sheets 1-12 for the cross sections. These cross sections are drawn at a vertical exaggeration of 2.5 times the horizontal. They illustrate: 1) the thinness of glacial cover at critical points, 2) the vertical distribution of odor concentration, 3) the presence of probable sink holes, 4) the real or near juxtaposition of the bottom of the sump in Building 20 with the top of dolomite, and 5) the unknown extent of contaminates southward along the railroad tracks.

3.2.5 Verification from Chemical Analyses

(Not available at this time.)

3.2.6 Pilot Remedial Measures Construction

A pilot section of a Ranney collector ditch and a large-diameter, shallow well were constructed at Saukville to determine the cost, construction feasibility, and dewatering efficiency of these techniques in low permeable glacial sediments. Sufficient data were deemed already available on the hydrology of well points from installation and testing of existing monitor wells.

3.2.6.1 Pilot Ranney Collector Ditch

A section of a Ranney-type collector was constructed north of the tank farm in an area used for tanker truck parking. A test ditch approximately 3 feet wide, 30 feet long and 15 feet deep was dug with a large backhoe. See Figure 22. The ditch was backfilled with clean pea gravel to a depth of 1 foot followed by installation of a 20-foot section of 4-inch, schedule 80 PVC screen laid horizontally and a 12-foot section of solid 4-inch PVC standpipe. The

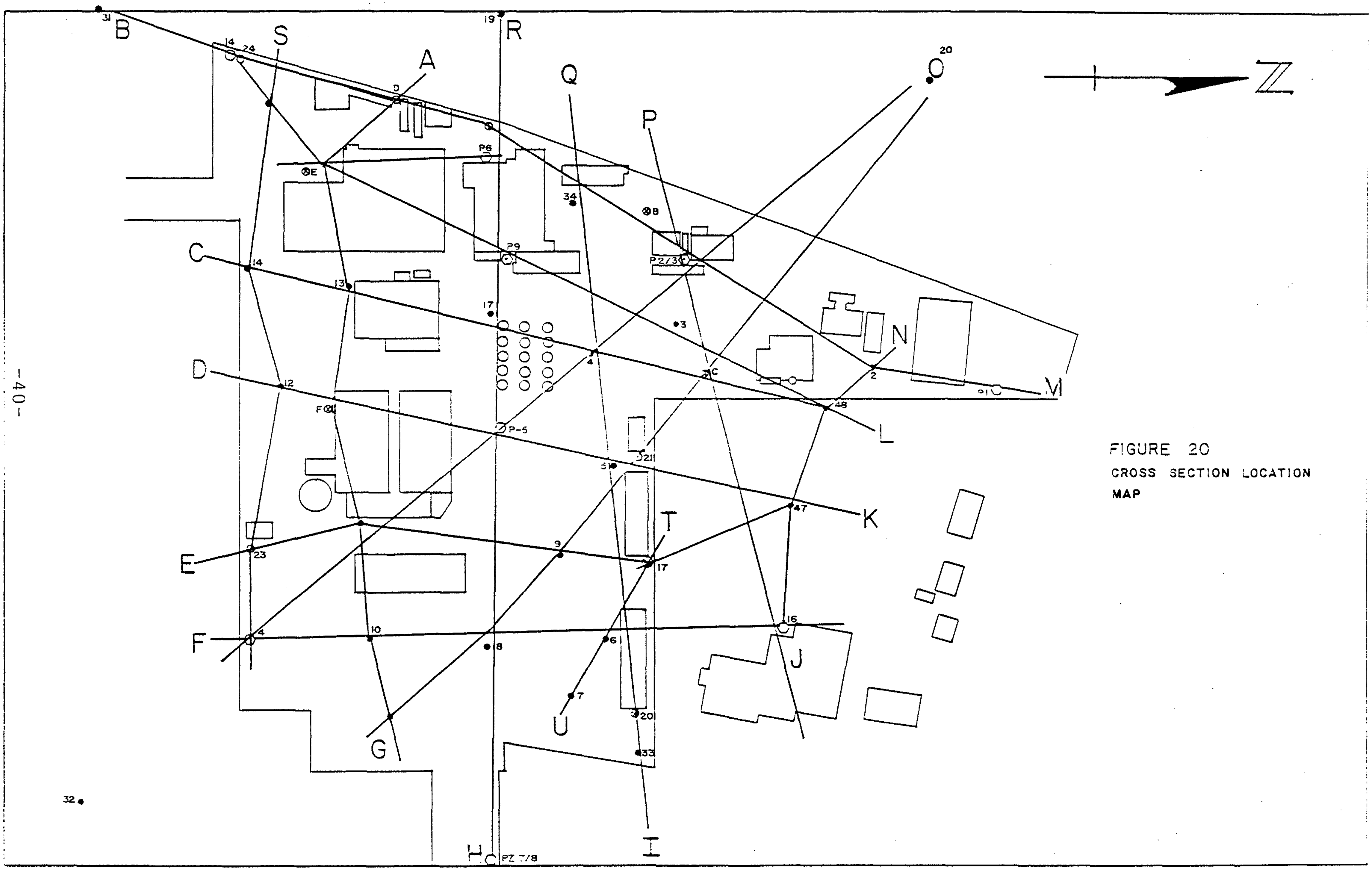


FIGURE 20
CROSS SECTION LOCATION MAP

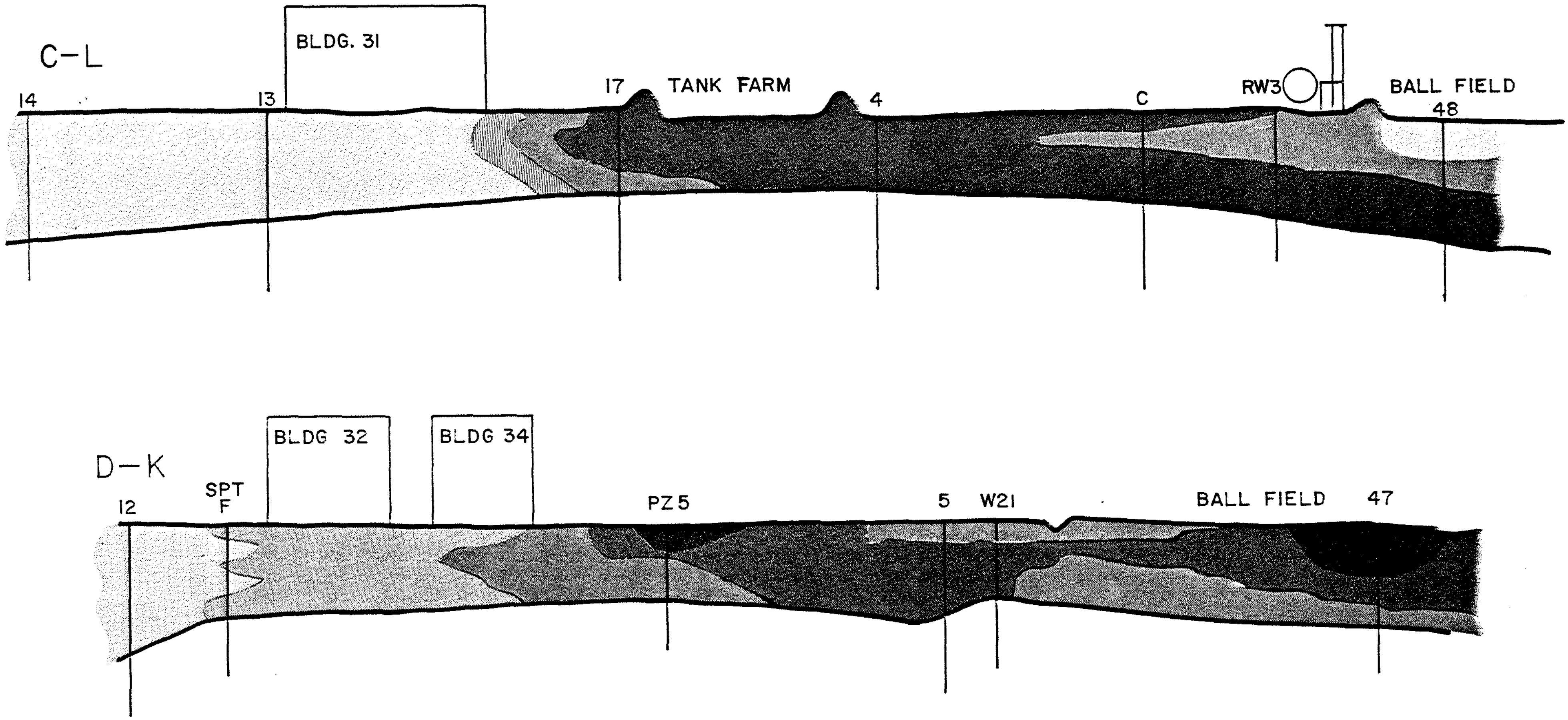


FIGURE 21C
DIAGRAMMATIC CROSS SECTIONS
-SUBSUFACE ODOR DISTRIBUTION

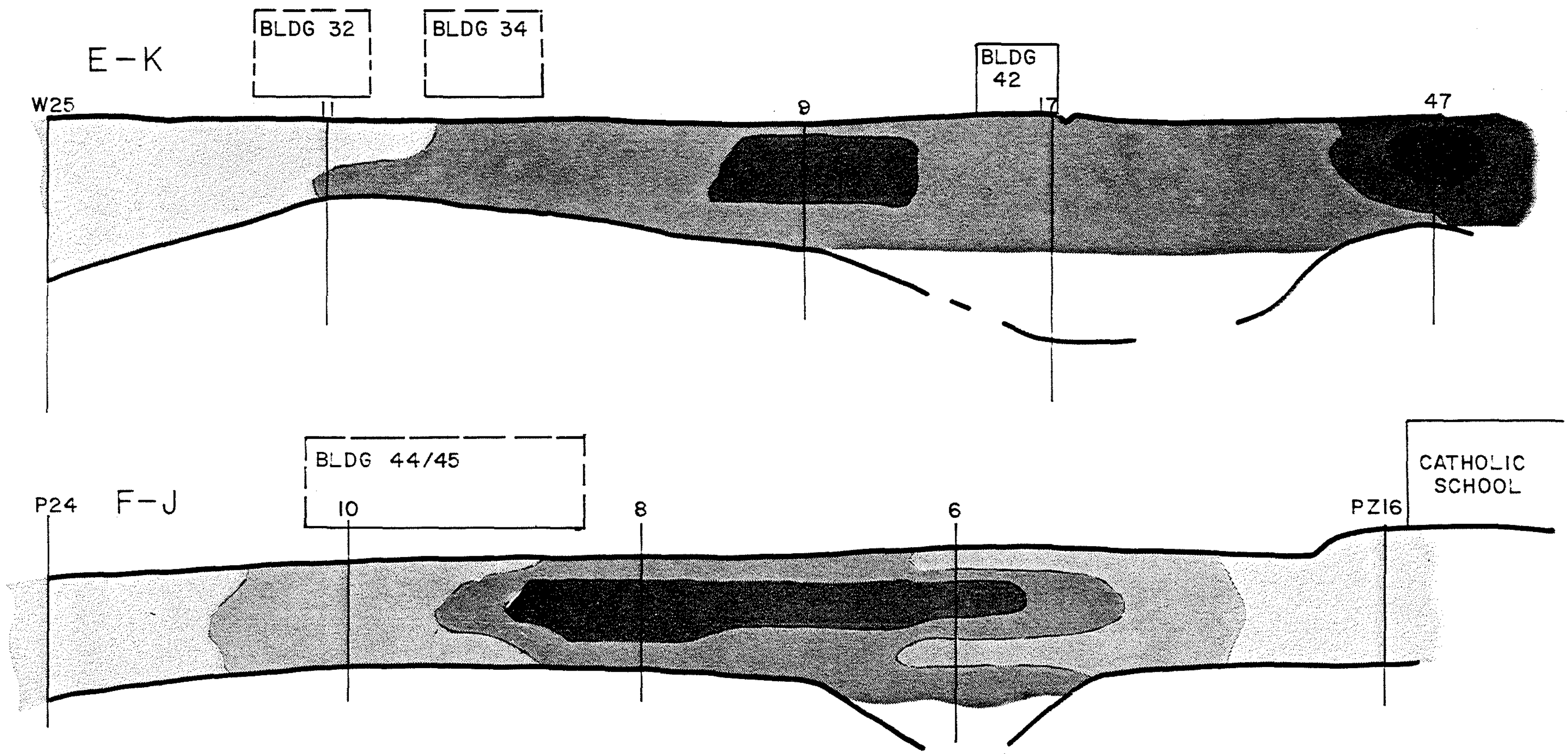


FIGURE 21B
DIAGRAMMATIC CROSS SECTIONS
-SUBSURFACE ODOR DISTRIBUTION

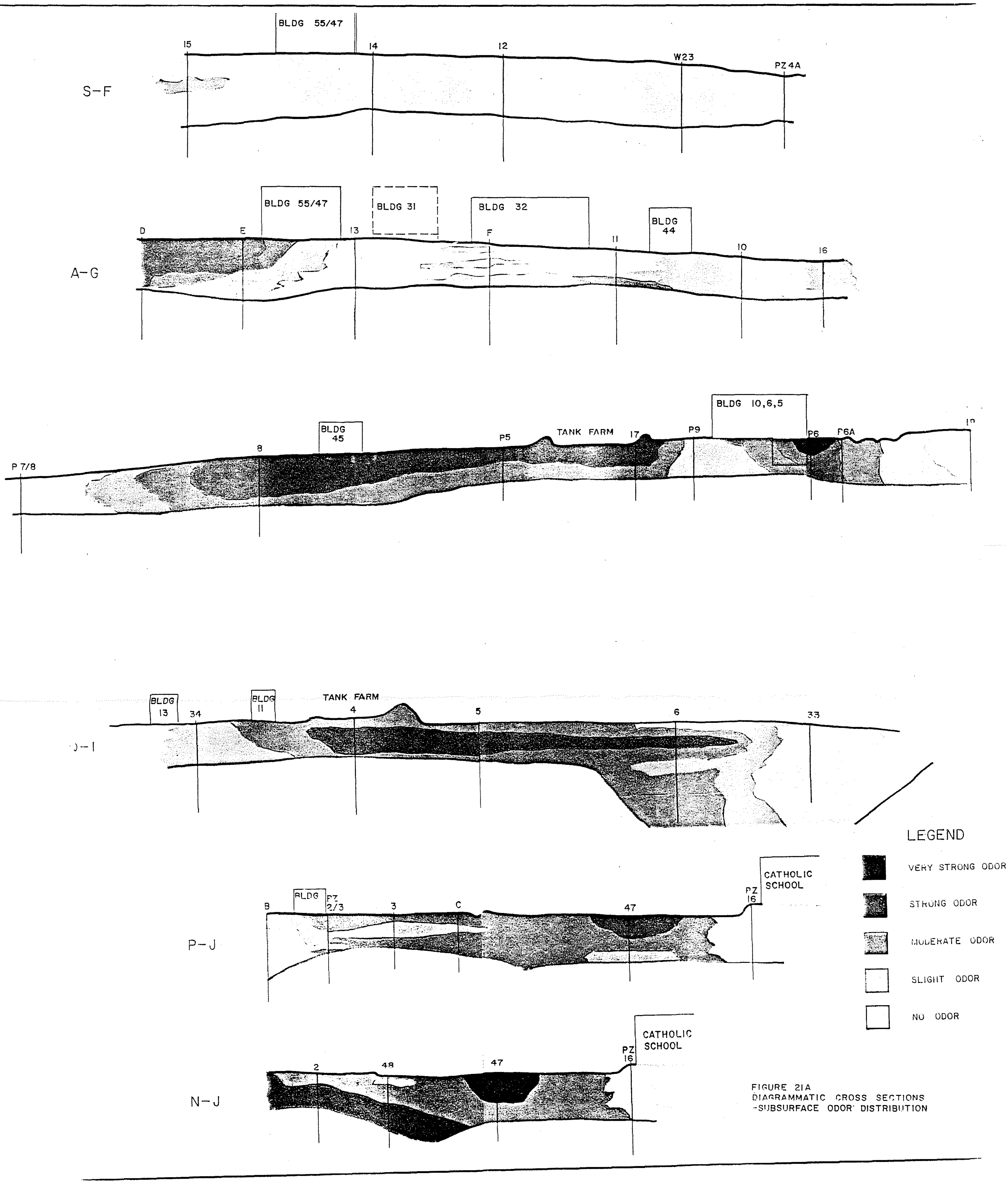


FIGURE 21A
DIAGRAMMATIC CROSS SECTIONS
-SUBSURFACE ODOR DISTRIBUTION

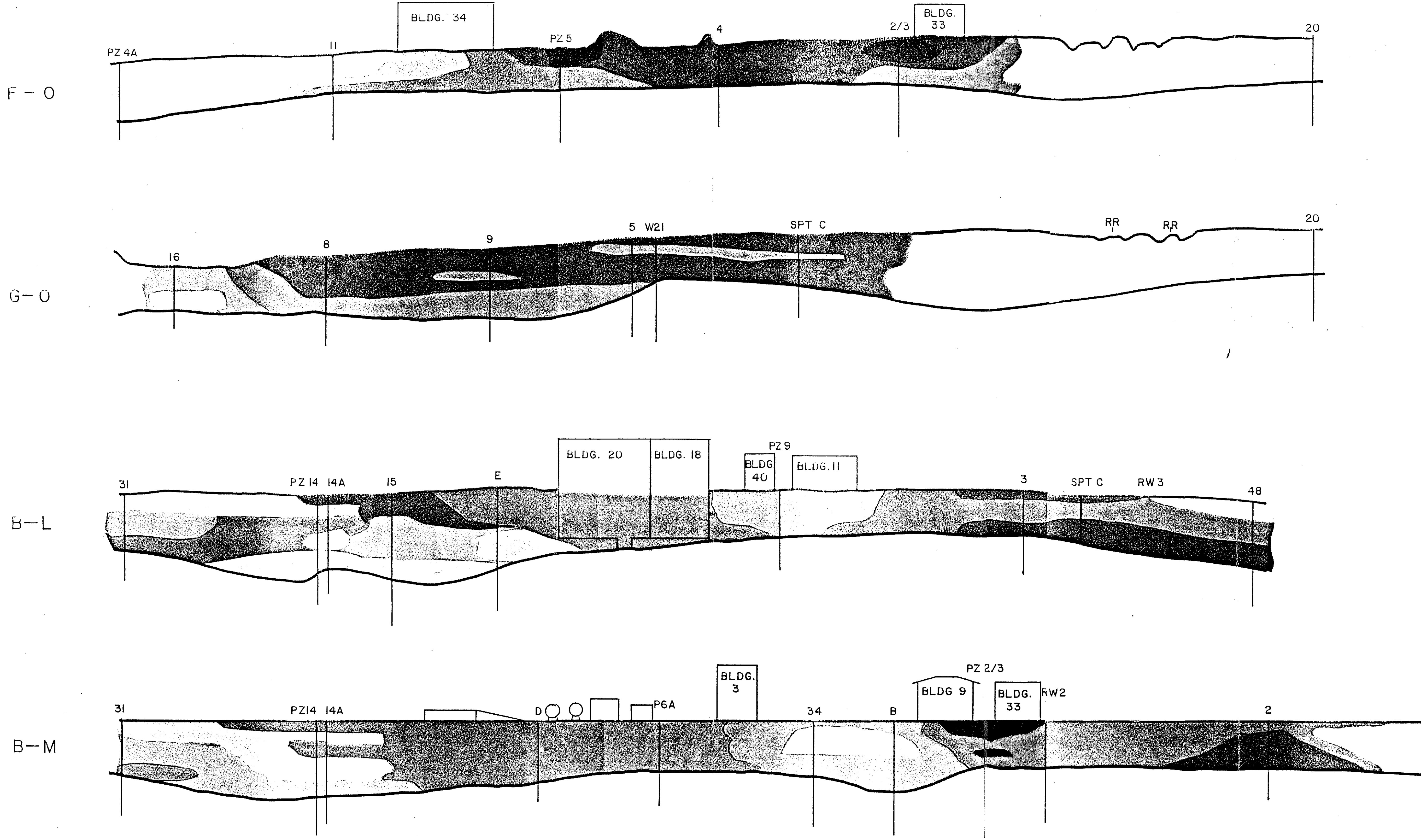
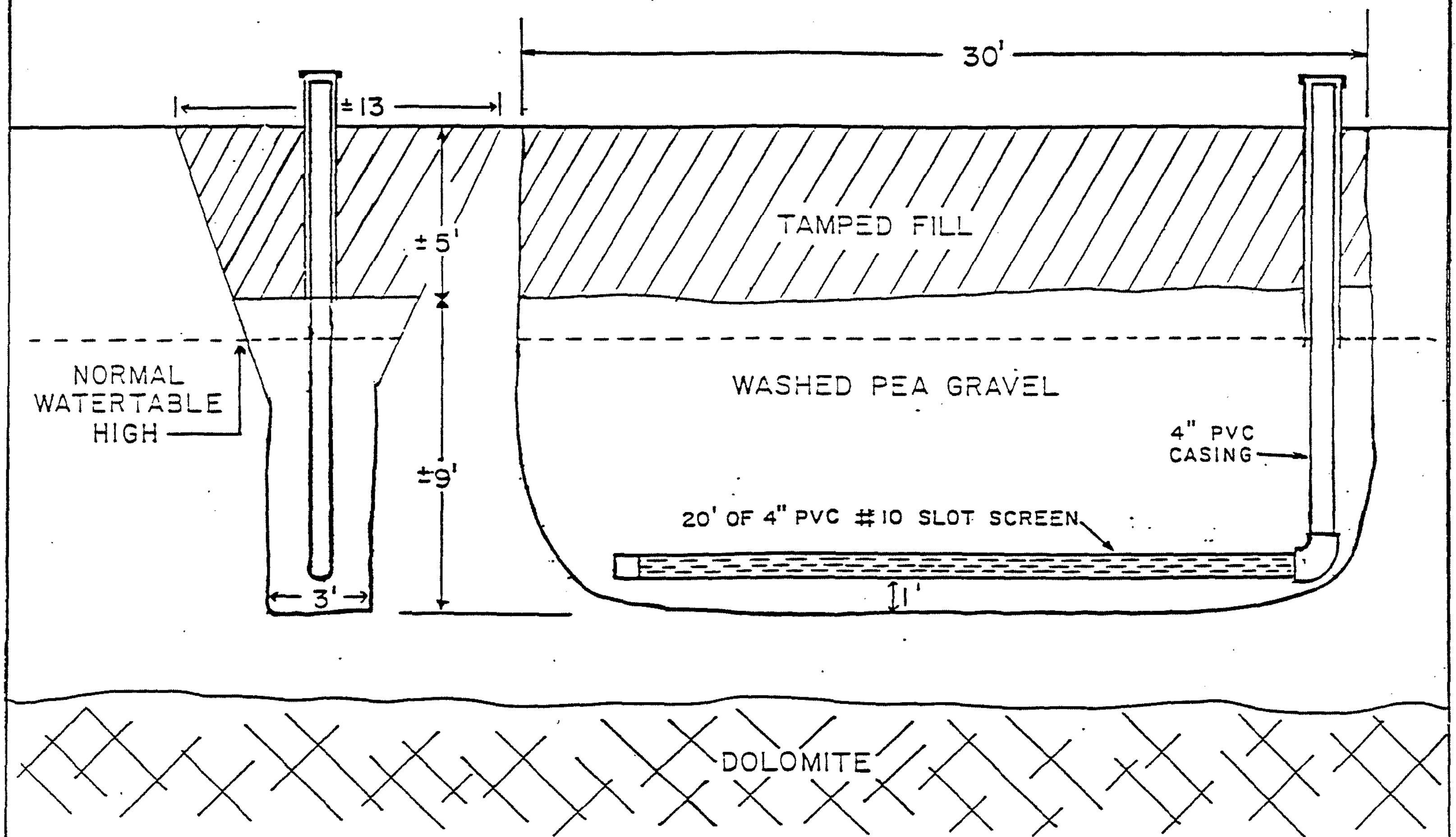


FIGURE 2
DIAGRAM
-SUBSUR

FIGURE 22

PILOT FRENCH DRAIN



ditch was then backfilled to approximately 4 feet from the surface with pea gravel and the remainder with spoil from excavation of the ditch.

Water level rise in the ditch was monitored over a period of 5 days. The volume of the excavation and the probable porosity of the pea gravel was used to calculate rate of filling. Rate of water level recovery versus time is plotted on Figure 23. Assuming a porosity of 0.20 for the pea gravel fill, this ±30-foot-long ditch has an approximate yield of 0.12 gpm or 0.006 gpm per foot of ditch.

3.2.6.2 Shallow, Large-Diameter, Gravel-Packed Well

A 19-foot-deep, 16-inch-diameter, gravel-packed well was constructed in a 24-inch hole near PZ-6A west of Building 5 and in the vicinity of the reported "dry well". Figure 24 shows the construction details. This well, like the Ranney-type collector, was constructed to determine the construction cost, feasibility, and dewatering efficiency of such wells in tight glacial sediments. The well was constructed and briefly tested during an extended rainstorm when groundwater level at the well was at the surface and surface water surrounded the well. Yield of this well was tested under those non-representative conditions at about 1.4 gpm over a period of approximately ½ hour. A 2-inch monitor well, approximately 15 feet south of this well, was tested at 0.44 gpm during dry weather.

4.0 Conclusions

4.1 Geologic

- The fieldwork to date confirms that the Saukville Plant is sited on Silurian dolomite covered by a

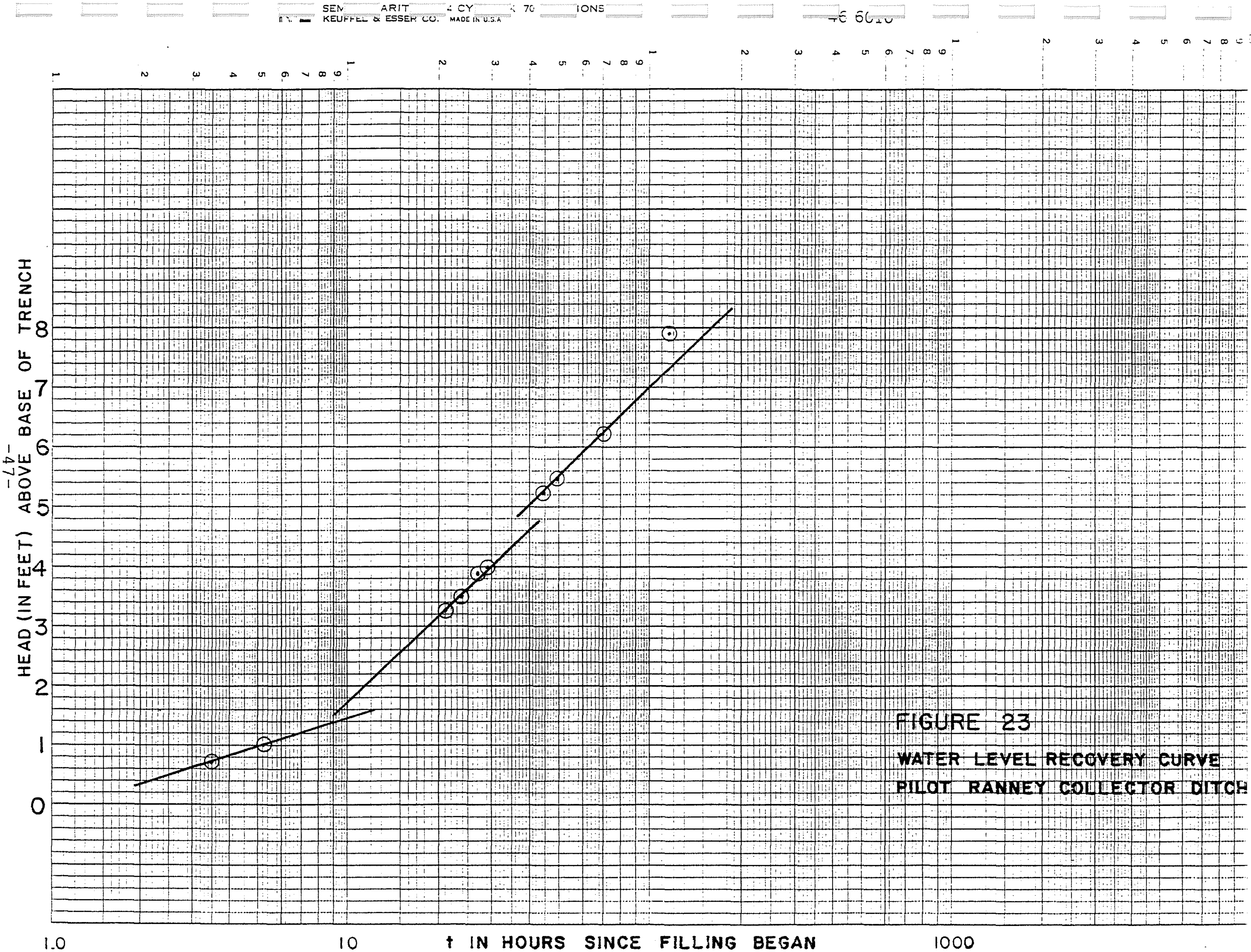
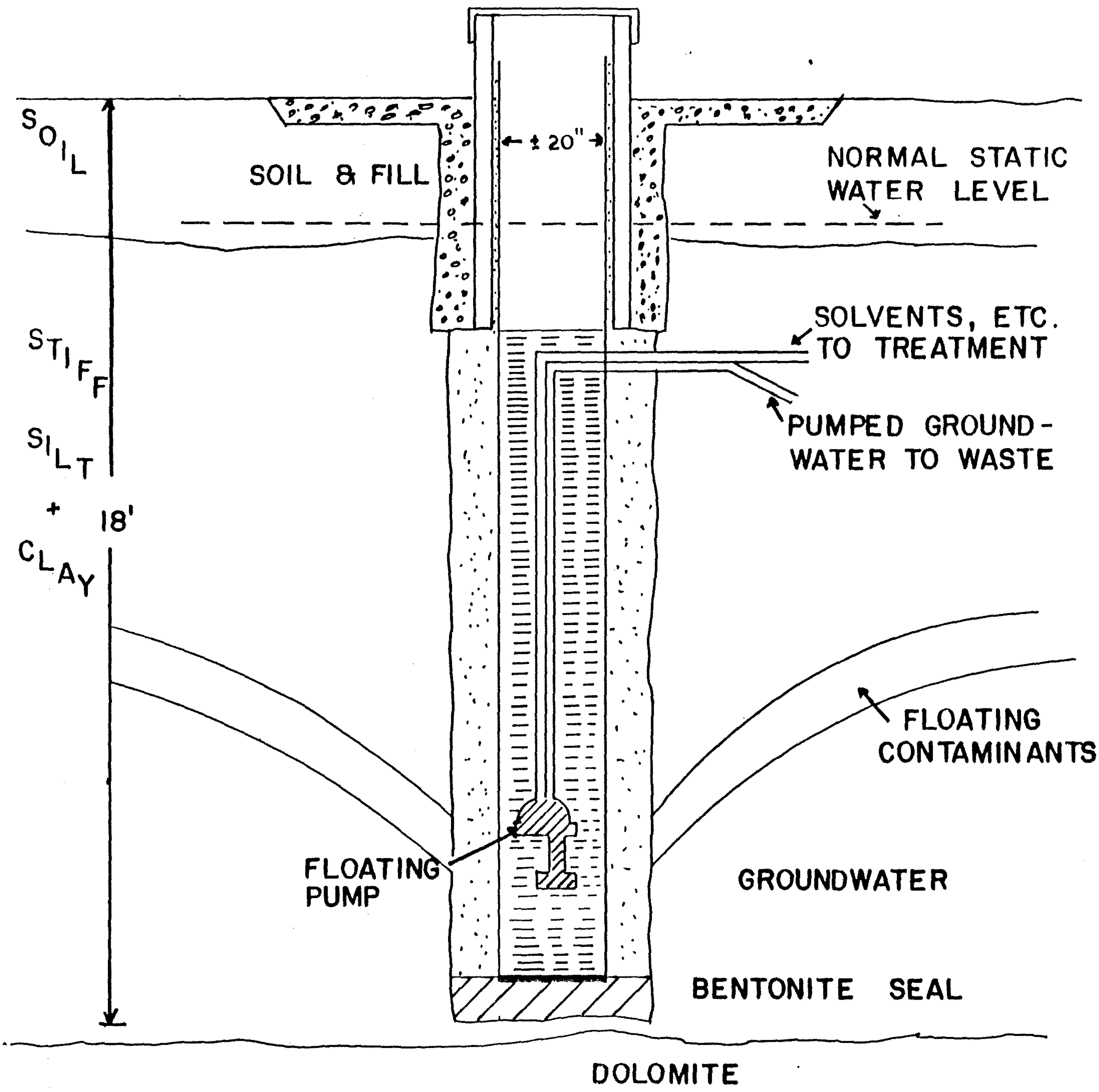


FIGURE 23

WATER LEVEL RECOVERY CURVE

PILOT RANNEY COLLECTOR DITCH

FIGURE 24
PROPOSED
PILOT
REACTION WATER/SOLVENTS
PUMPING UNIT



fairly thin veneer of Pleistocene glacial materials.

- The dolomite is highly solutioned and fractured at the top and has an irregular upper surface (karsted). Small pinnacles and depressions or sinkholes are common. Also, at least one large sinkhole or filled river channel (thalweg) exists on the northeast edge of the site.

- The glacial overburden consists mostly of very dense tills and varved, lacustrine, silty clays that have very low permeabilities and fluvial sands and gravels. These materials do not constitute a useable aquifer. The southern edge of the property contains a higher percentage of fluvial sands and gravels.

- The contact between the glacial sediments and the dolomite is usually marked by a thin, permeable sand.

- Glacial overburden is thinnest in the central part of the site.

4.2 Hydrologic

- The tight, glacial sediments are saturated and the water table is shallow.

- The weathered dolomite is the uppermost useable aquifer and is quite permeable. It includes the overlying thin permeable sand.

- The dolomite aquifer is semi-confined and is being slowly recharged through the overlying glacial materials.

- At the center of the site, the dolomite aquifer is essentially at water table head.

- Except at the solutioned and weathered surface, the hydrology of the dolomite is complex being related to the location, frequency, and size of solution channels.

- The Laubenstein well and MW-2 are probably connected by one or more solution channels.

- The head across the saturated glacial sediments ranges from <2 to 20 ft. in the site vicinity.

- Both the water table and the dolomite head maps indicate that a groundwater drainage divide exists across the western part of the site.

- The present position of the drainage divide in the dolomite aquifer is in direct response to pumpage of MW-2.

4.3 Contaminant Sources and Dispersion

- The tight glacial sediments are saturated with contaminated groundwater having a strong and distinctive "reaction water" and/or solvent odor over approximately one third of the site.

- The above odor plume extends a short distance into the adjacent ballfield of the Immaculate Conception Church and to an unknown distance, but less than the position of former PZ-12, southward along the railroad tracks. The area of strong groundwater odor is surrounded by a "halo" of significantly less odor, extending in all downgradient directions.

- Very strong odors occur:

  a. At the tank farm
  b. At Building 33
  c. In the southwestern corner of the ballfield
  d. West of Building 5 in the vicinity of the old "dry well"
  e. In the extreme southwestern corner of the plant site
  f. In an area just north of Building 45A.

- The distribution of the odor plume is consistent with the direction of groundwater flow from the site.

- The upper part of the dolomite contains contaminanted groundwater in at least the area north of the tank farm.

- The sump in the basement of Building 20 is at or very near the top of the dolomite. This sump, other similar sumps, building foundations, the dry well, pipelines, and tank excavations constructed into or nearly into the underlying dolomite are potential points of direct contaminant entry into that dolomite.

5.0 Preliminary Remedial Recommendations

5.1 Technical Considerations

The glacial sediment cover over the karsted pervious Upper Dolomite Aquifer has quite low permeability. However, because surface contamination has been going on for many years, the clays, silts, and tills over parts of the site are saturated with contaminants that continually and slowly recharge the Upper Dolomite Aquifer. Once in the Upper Dolomite Aquifer, the rate of movement may be at least one order of magnitude greater. Contaminated groundwater in the Upper Dolomite Aquifer, as demonstrated by the dolomite semi-piezometric map, flows both toward the river and toward the Laubenstein/MW-2 drawdown cone to the northwest.

This geohydrologic situation, plus the need to keep a manufacturing facility on line, limits the number and kind of practical and cost-effective remedial actions at Saukville to:

1. Decontamination of the soil and groundwater by groundwater withdrawal and subsequent treatment or by some yet to be developed in-situ treatment process.
2. Use of groundwater management techniques that halt, if not reverse, the migration of contaminated groundwater off-site.
3. Removal of any present contaminant sources other than soil and elimination of contaminant pathways from the site to the surrounding environment.

5.2 Remedial Construction

- It is recommended that the shallow glacial materials be dewatered through installation and use of 3 Ranney-type collector systems installed at locations and in the feeder-ditch configurations shown on Figure 25. The pilot Ranney ditch, installed in the Fall of 1985, has demonstrated that such is economically and technically feasible from a construction standpoint. Water from the central well of the 3 individual collection systems would be pumped to a central facility for treatment. Two or 3 large-diameter, gravel-packed wells may be necessary to dewater deeper depressions in the dolomite surface, as located by points shown on Figure 25.

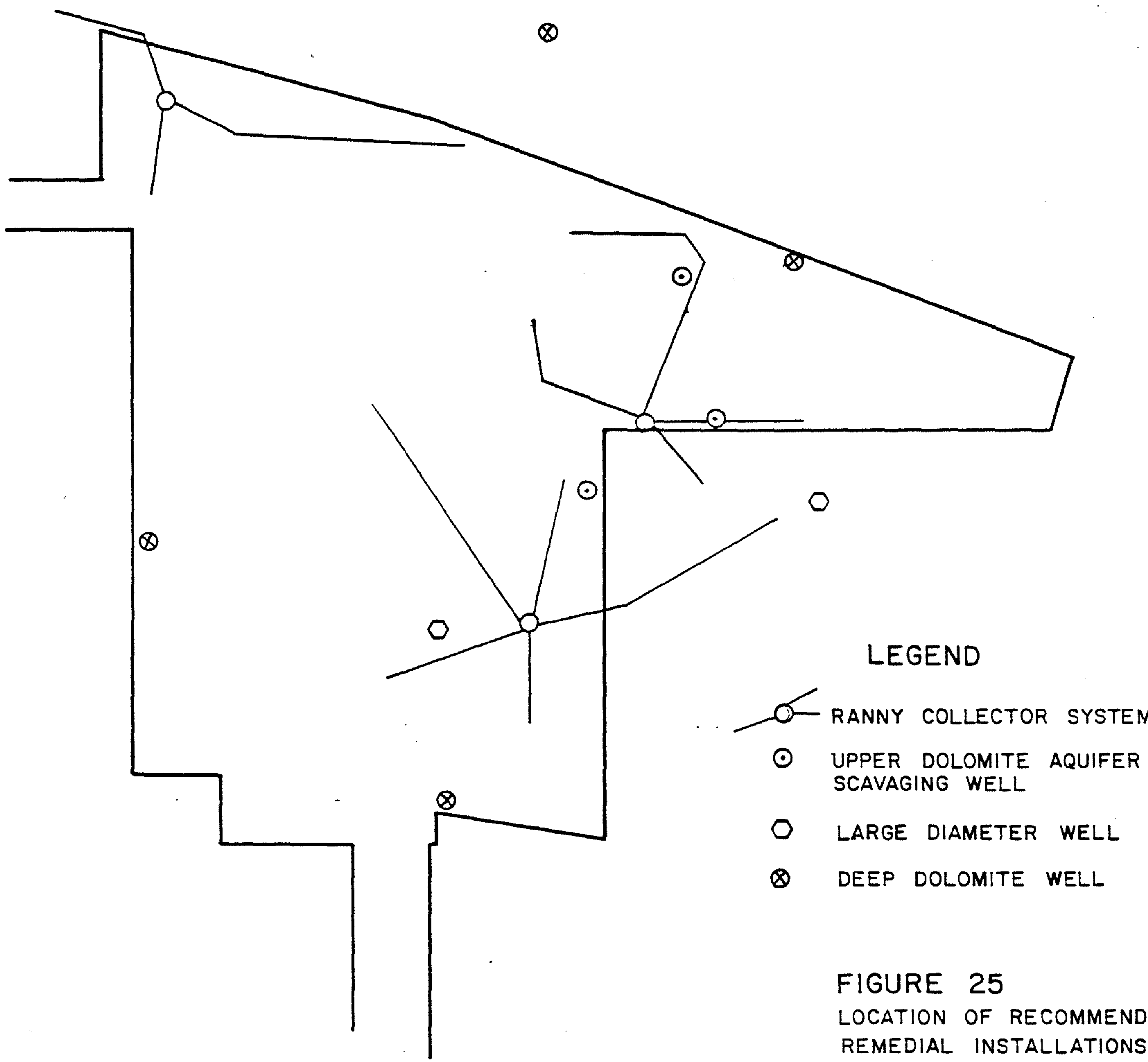


FIGURE 25
LOCATION OF RECOMMENDED REMEDIAL INSTALLATIONS

- It is recommended that the further spread of contamination in the upper dolomite aquifer be stopped and the water removed for treatment through the use of a series of shallow, 4-6 inch diameter, open hole, scavanging wells placed in the upper surface of the dolomite. Some of the newly installed shallow dolomite monitor wells could be used for this purpose.

- It is recommended that groundwater flow toward MW-2 be reversed through a combination of the following practices:

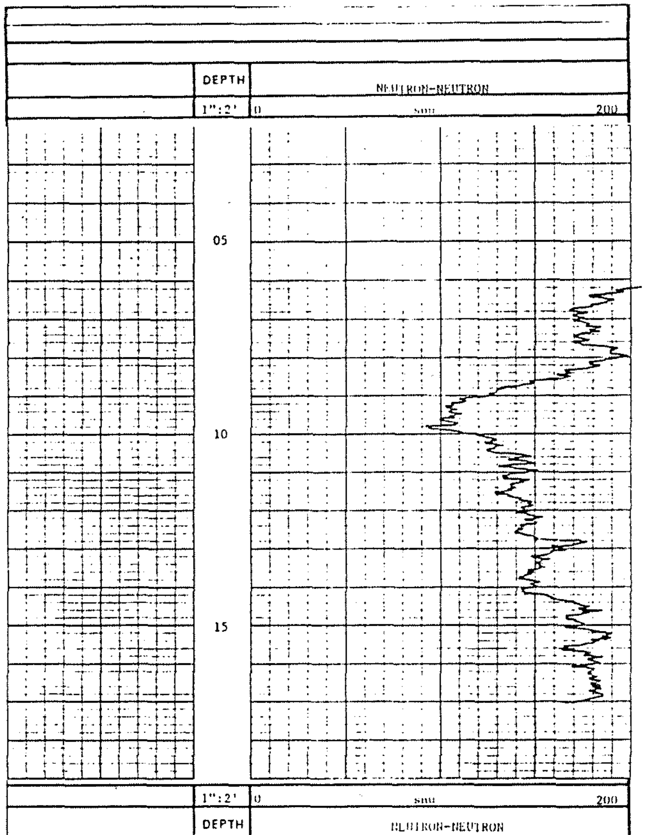
    1. Placing MW-2 out of service permanently or at least until the lower dolomite aquifer is flushed of contaminants.
    2. Repair of the casing and pumpage of the Laubenstein well for partial supply of cooling water at the Saukville plant.
    3. Installation and pumpage of one or more 550-foot dolomite production wells at sites shown on Figure 25.

- It is recommended that present potential sources of contamination and contaminant pathways be eliminated by a combination of exhumation, plugging, paving and reconstruction techniques. Such remediation includes:

    1. Removal of the buried caustic tank, unused diesel and gasoline tanks, and any other unused tanks.
    2. Exhumation of and appropriate backfill sealing of the "dry well".
    3. Reconstruction of all floor sumps to prevent inadvertent drainages of spilled process chemicals into the underlying glacial sediments and dolomite.

4. Paving of the present tank farm floor after the tanks are moved to their new location.
5. Exhumation and removal or other neutralization of the buried pipe incinerator such that it is no longer a potential leachable source of hazardous waste.
6. Removal or flushing of all buried unused raw material pipes.
7. Location of the top of the old farm well in Building 45A for appropriate sealing.

APPENDIX 1



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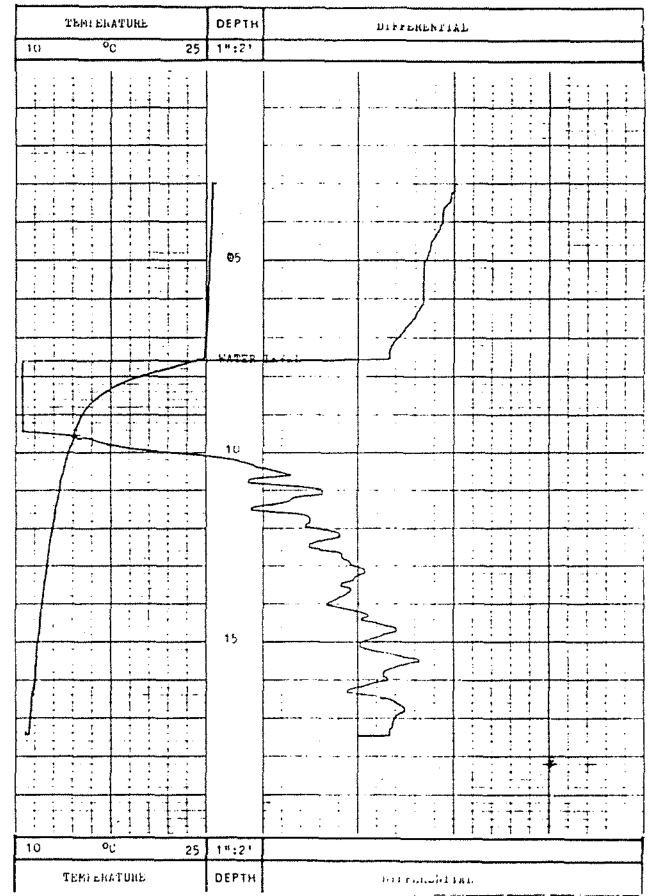

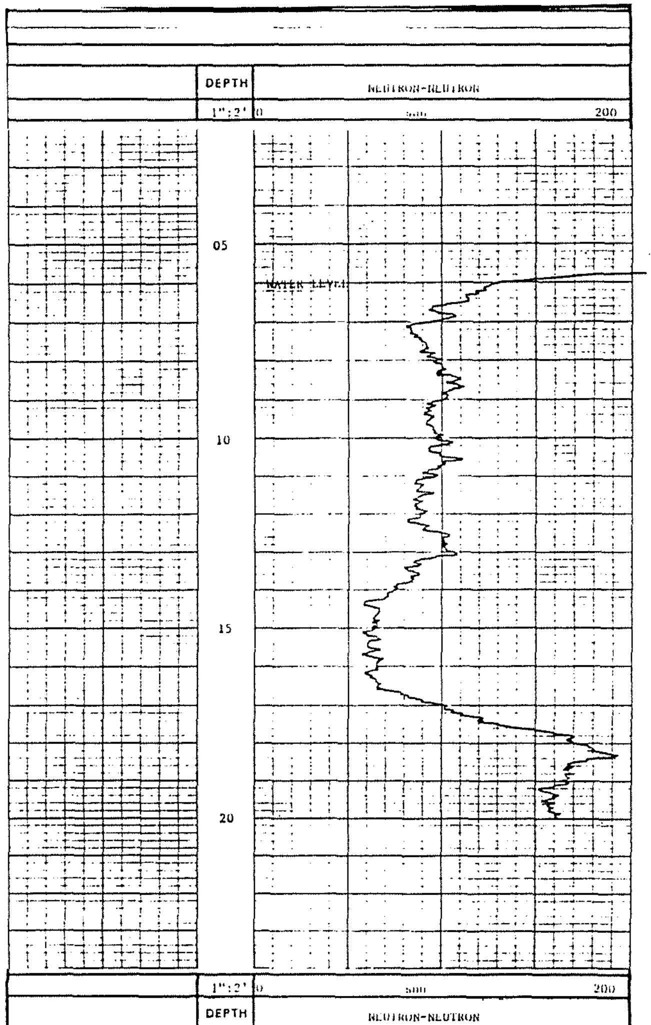

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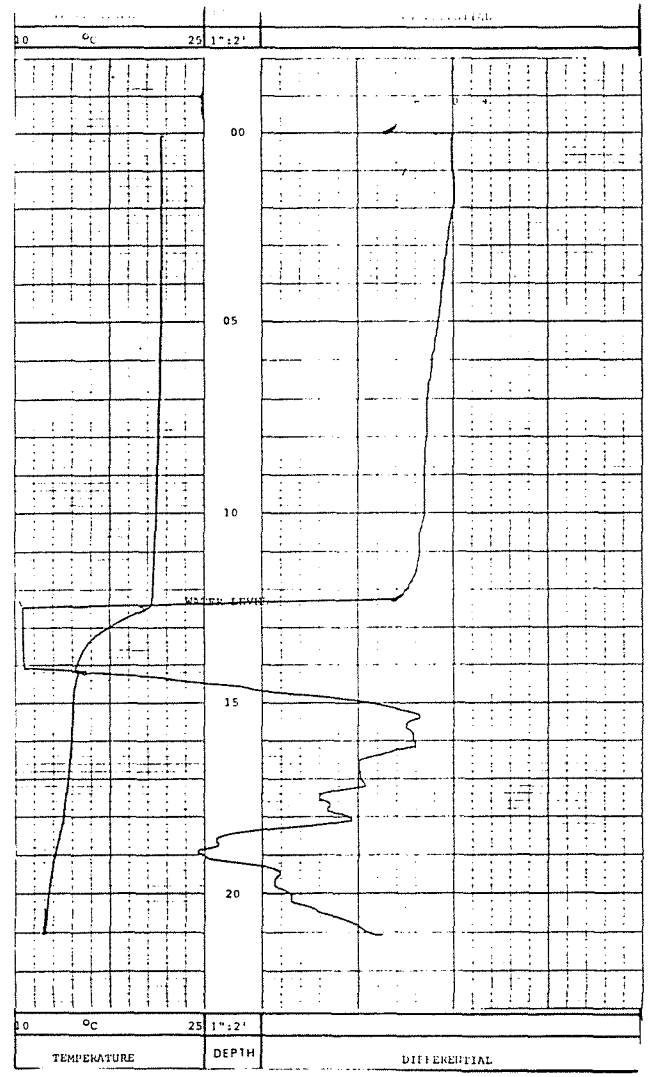

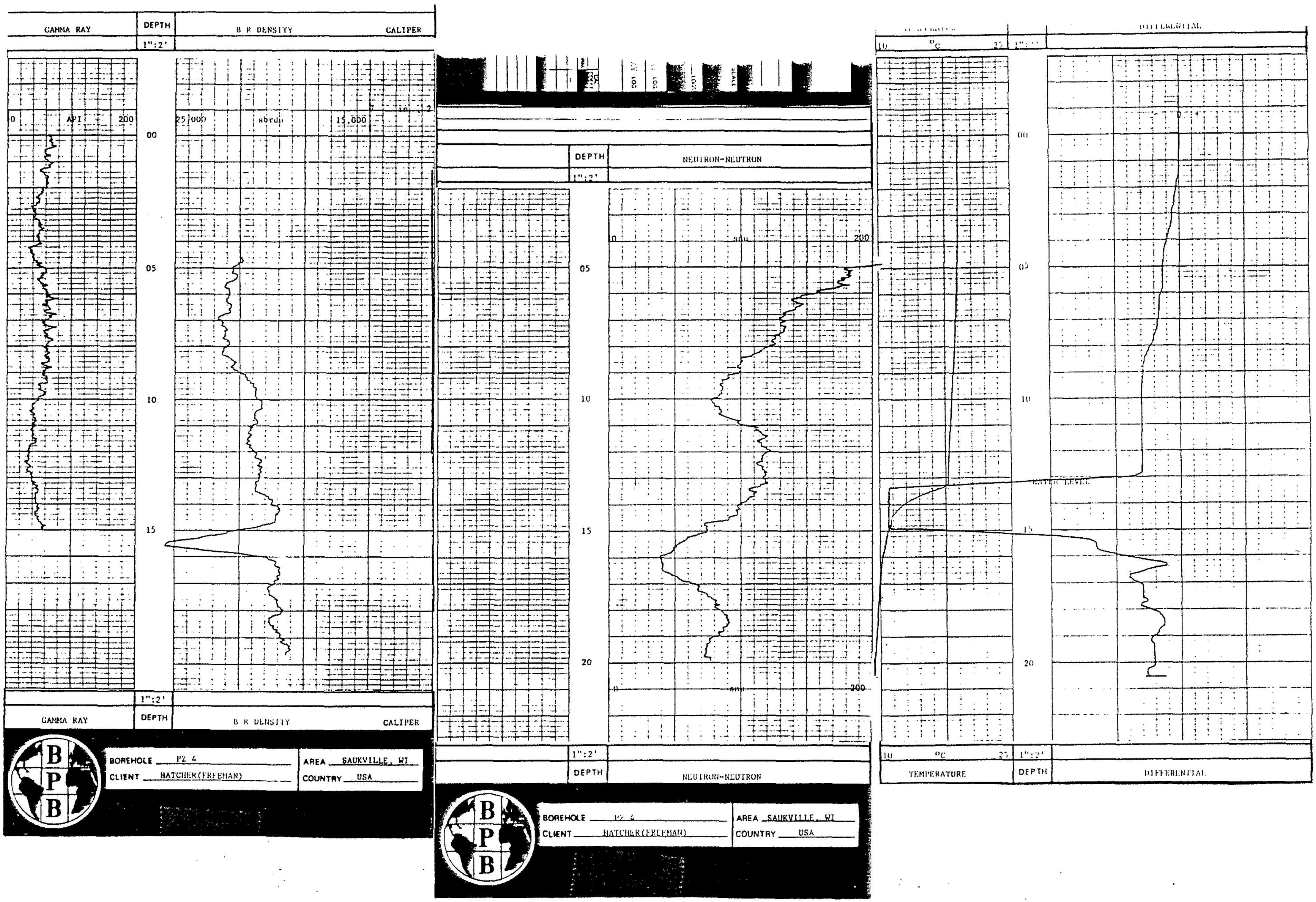

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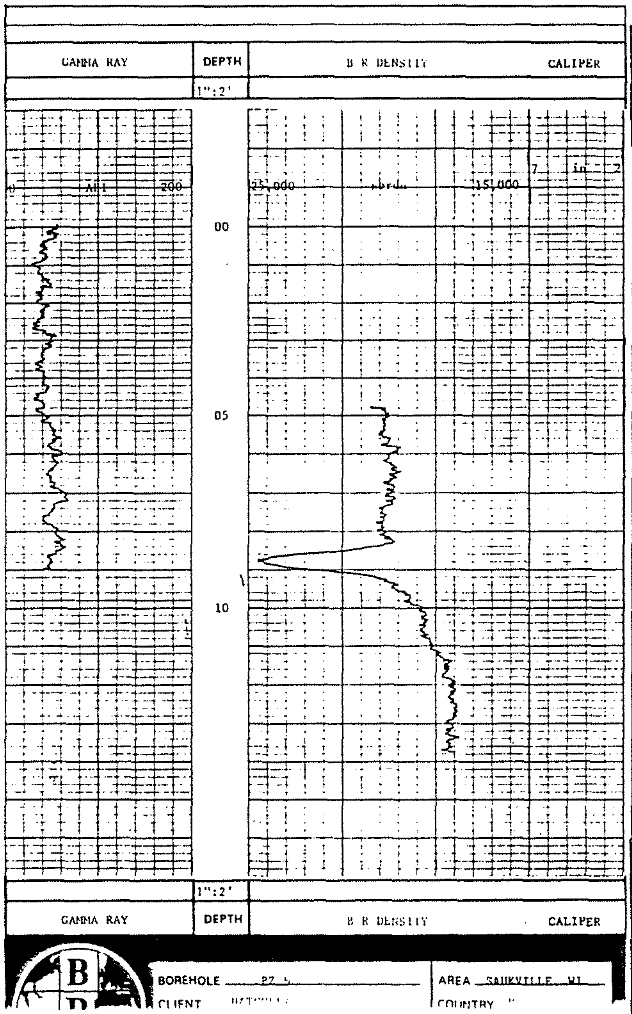
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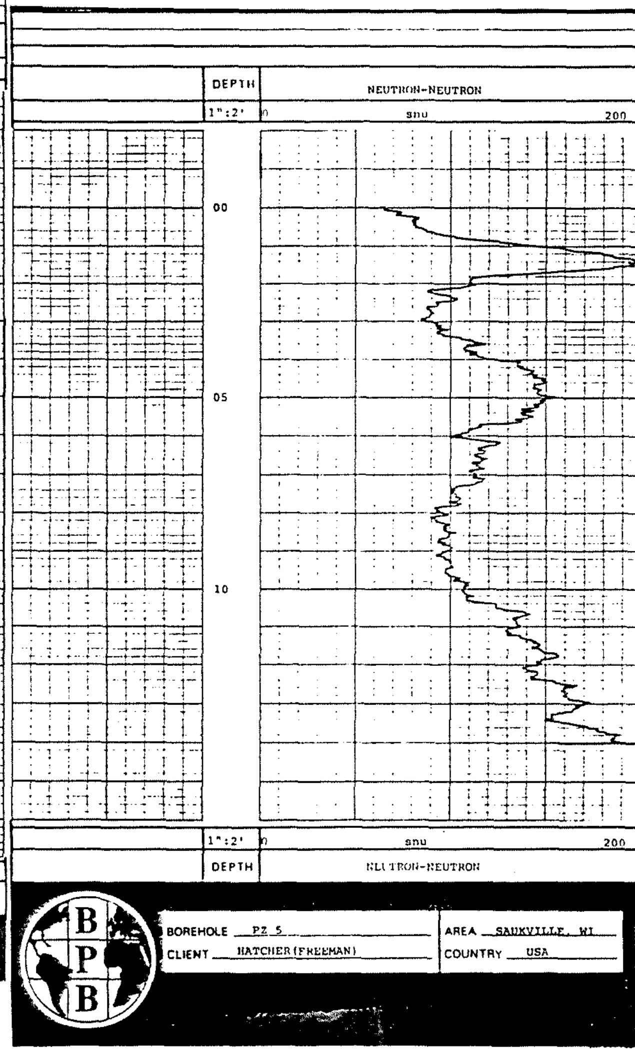
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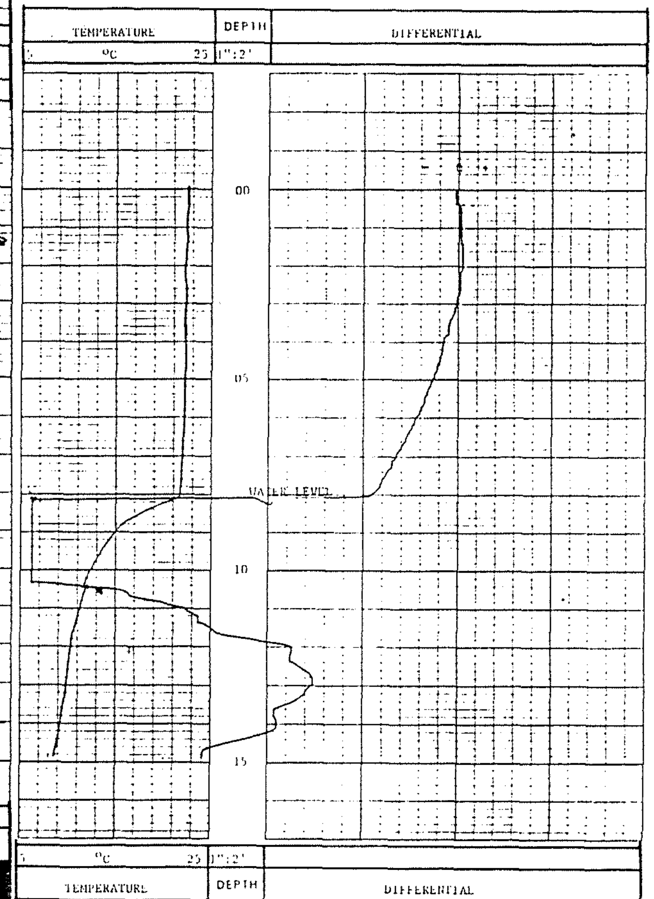
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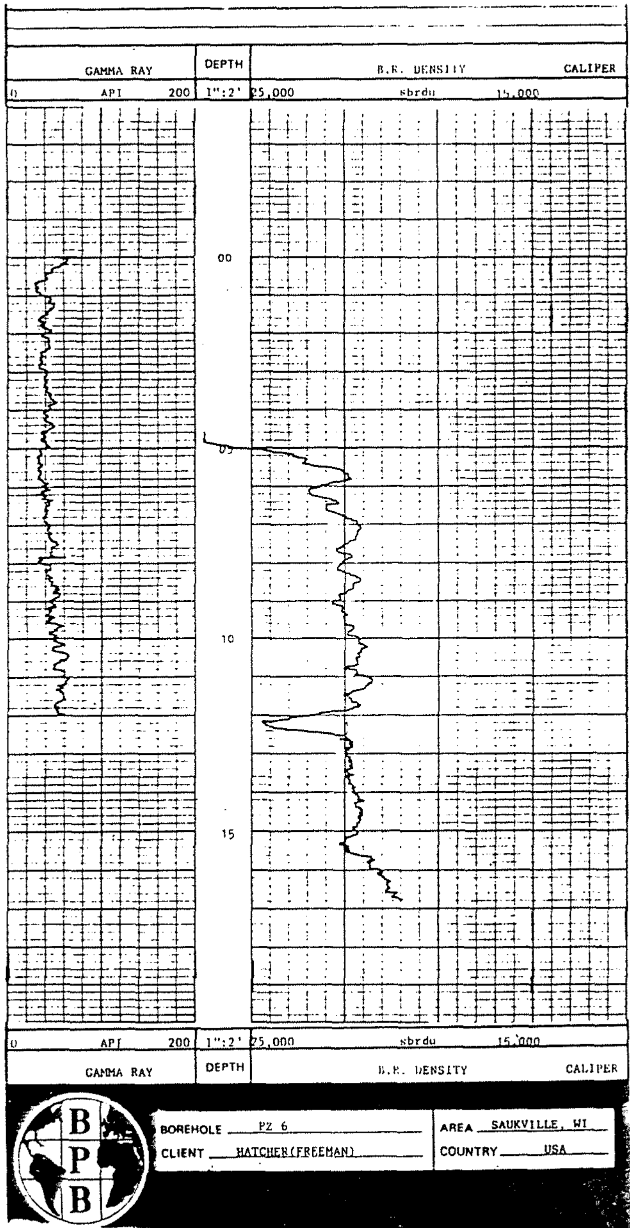
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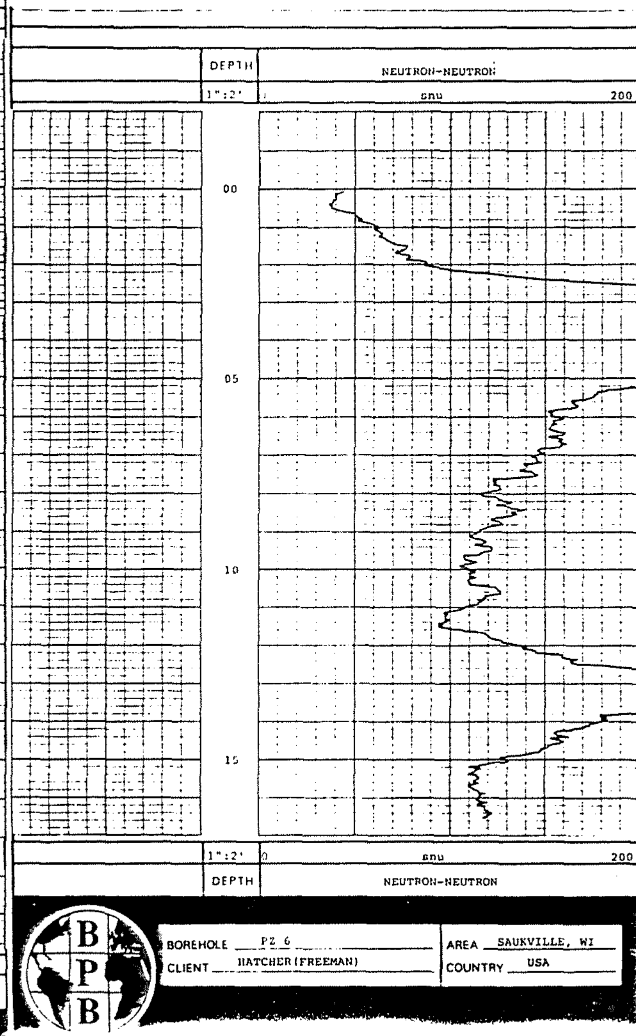
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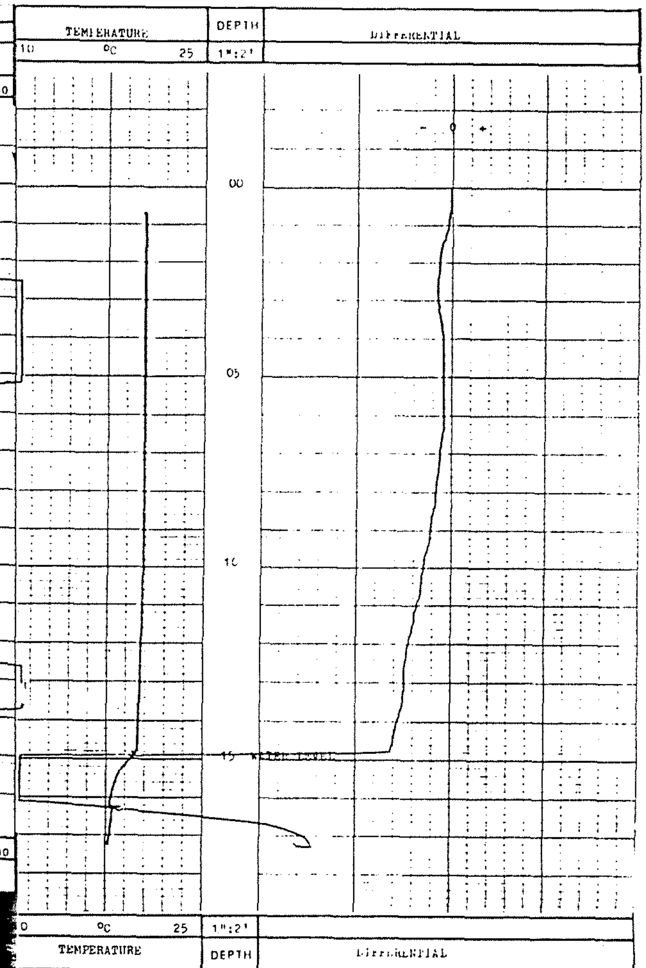
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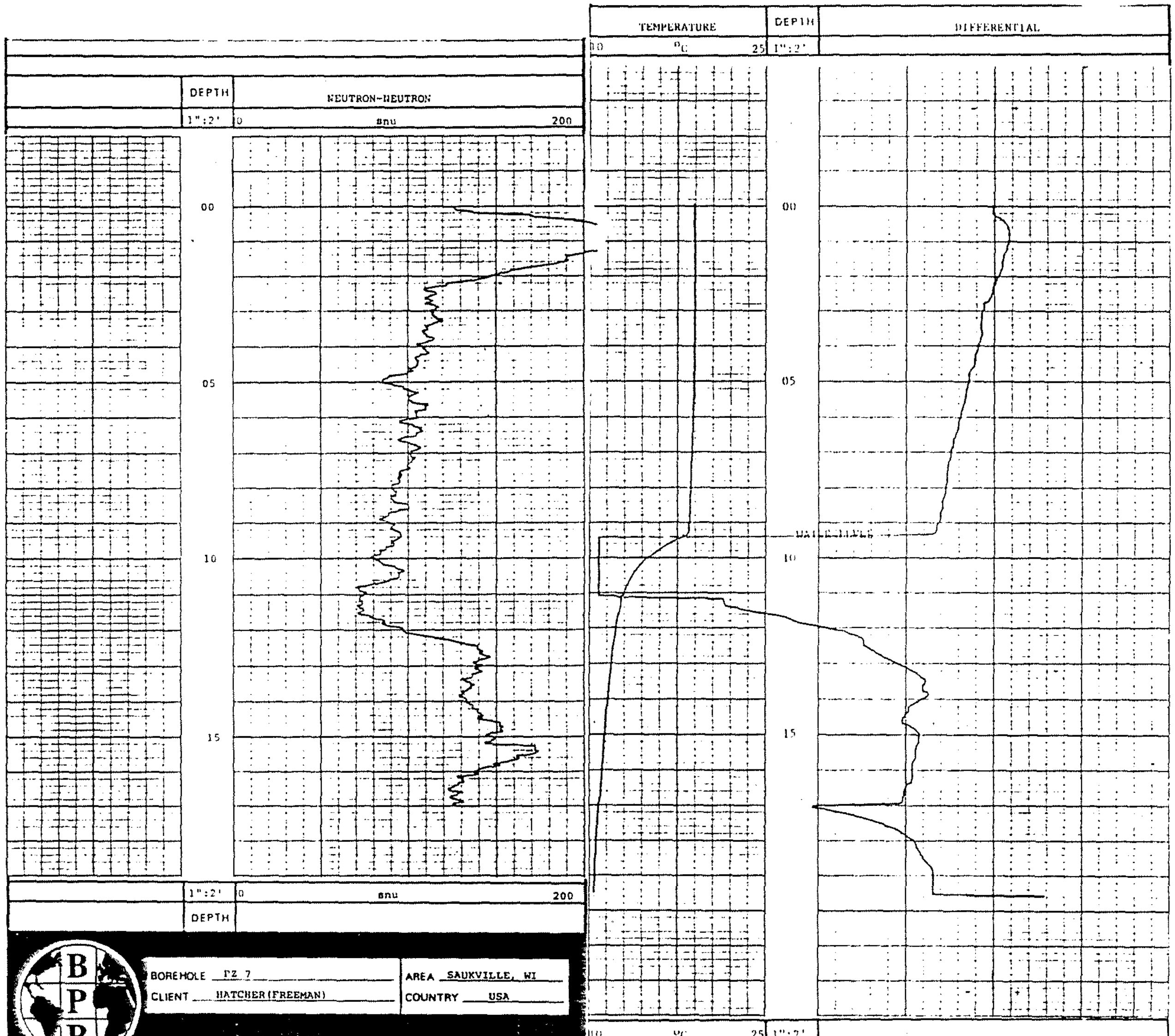

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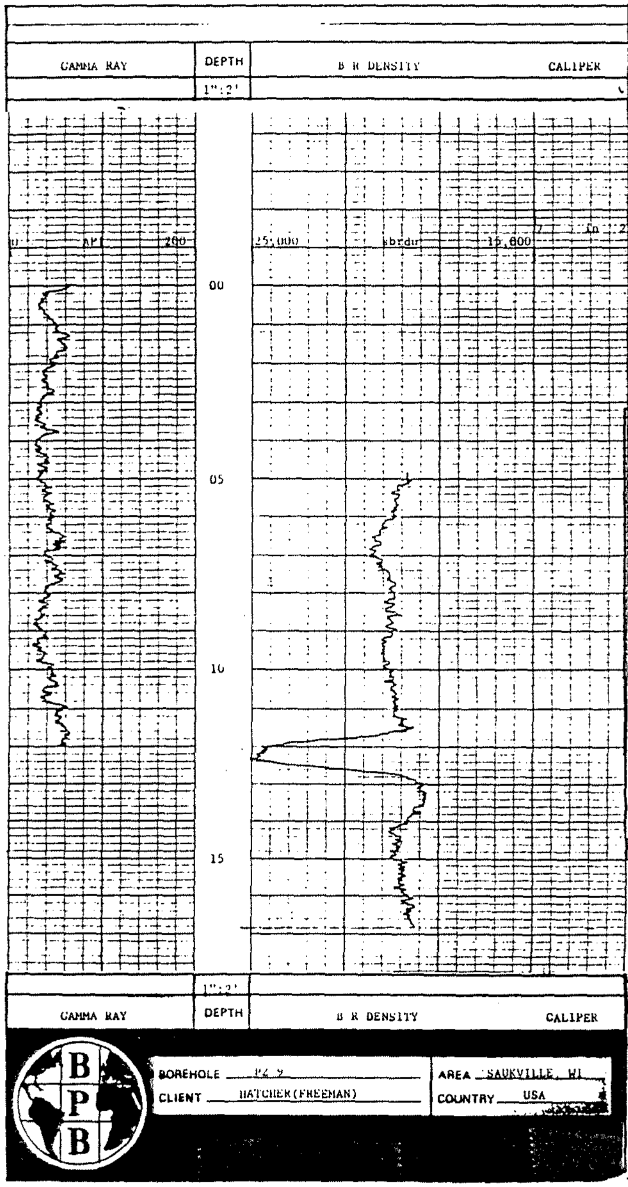
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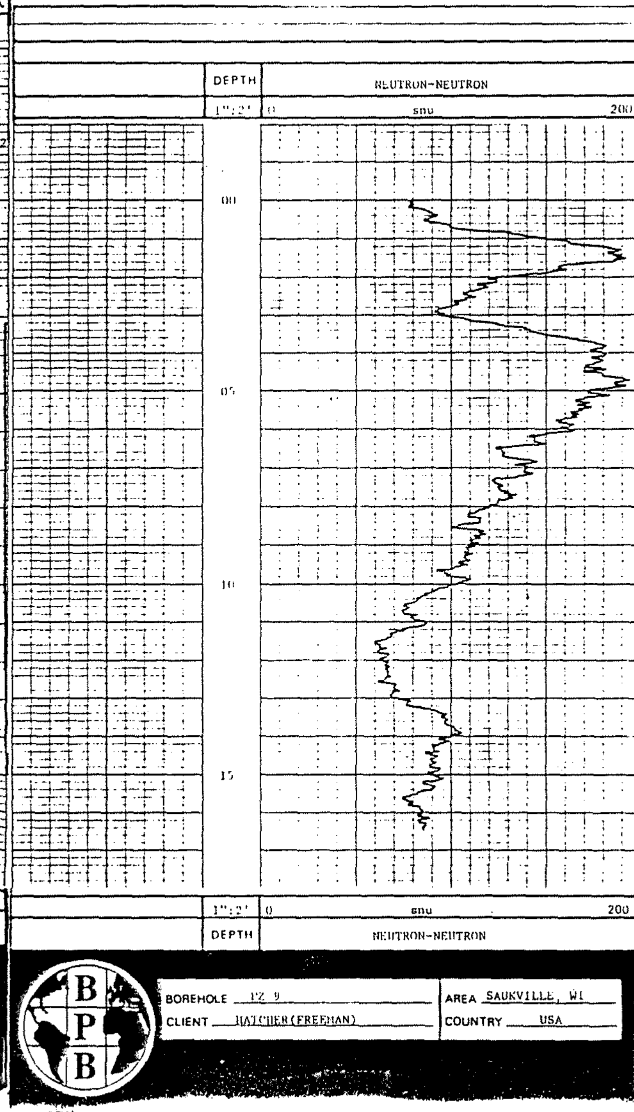
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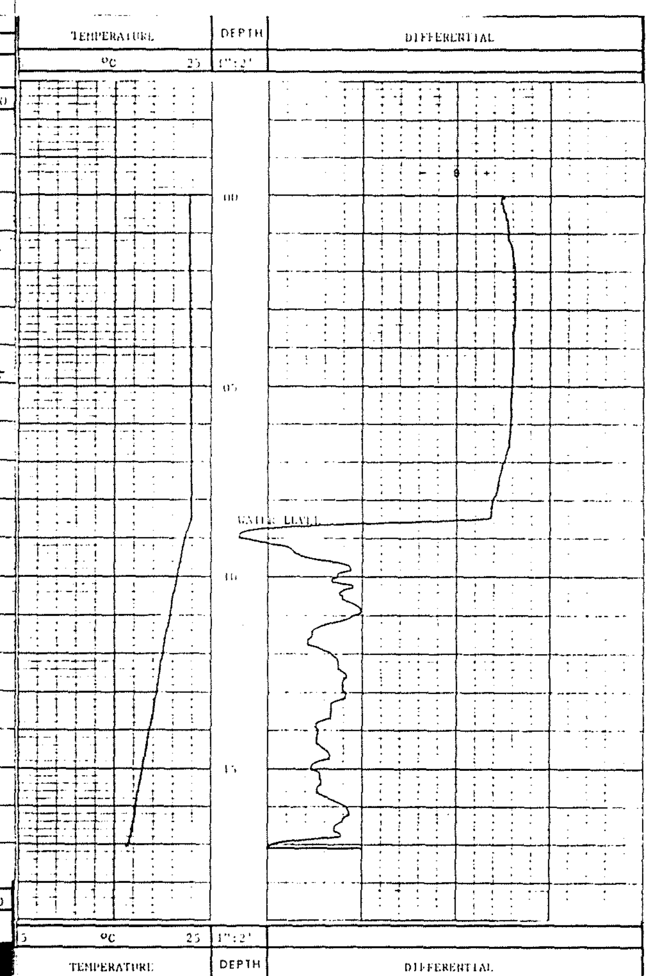
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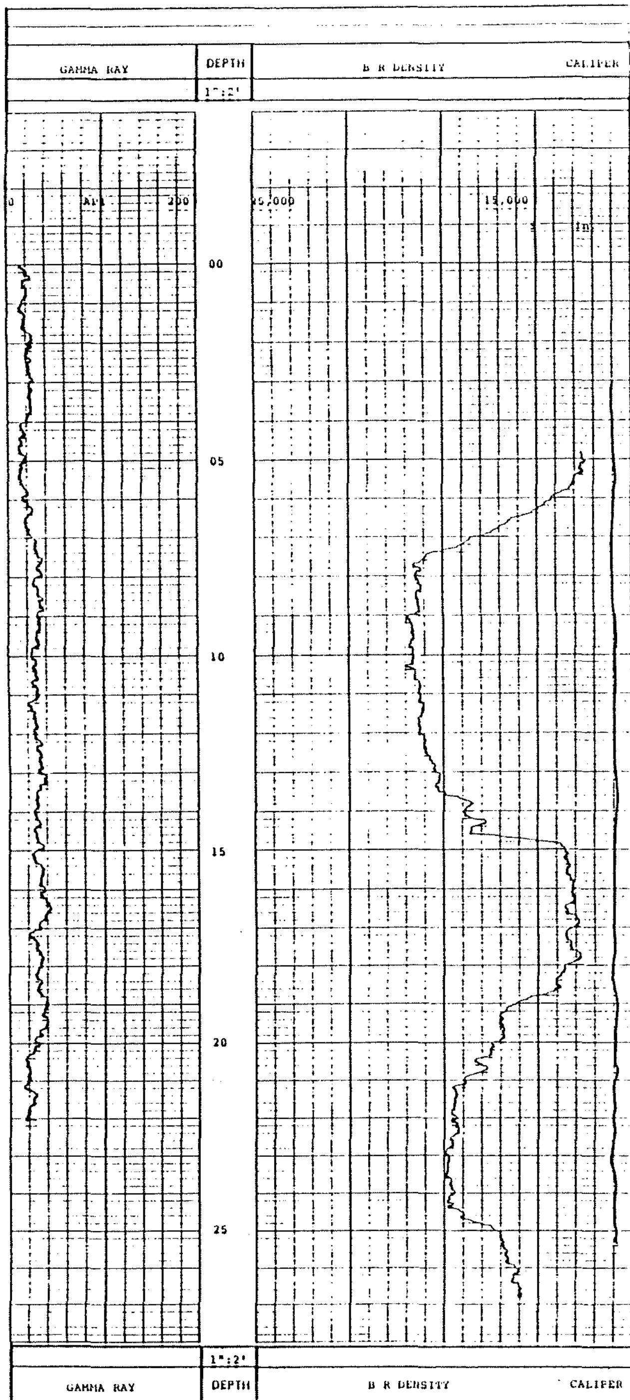

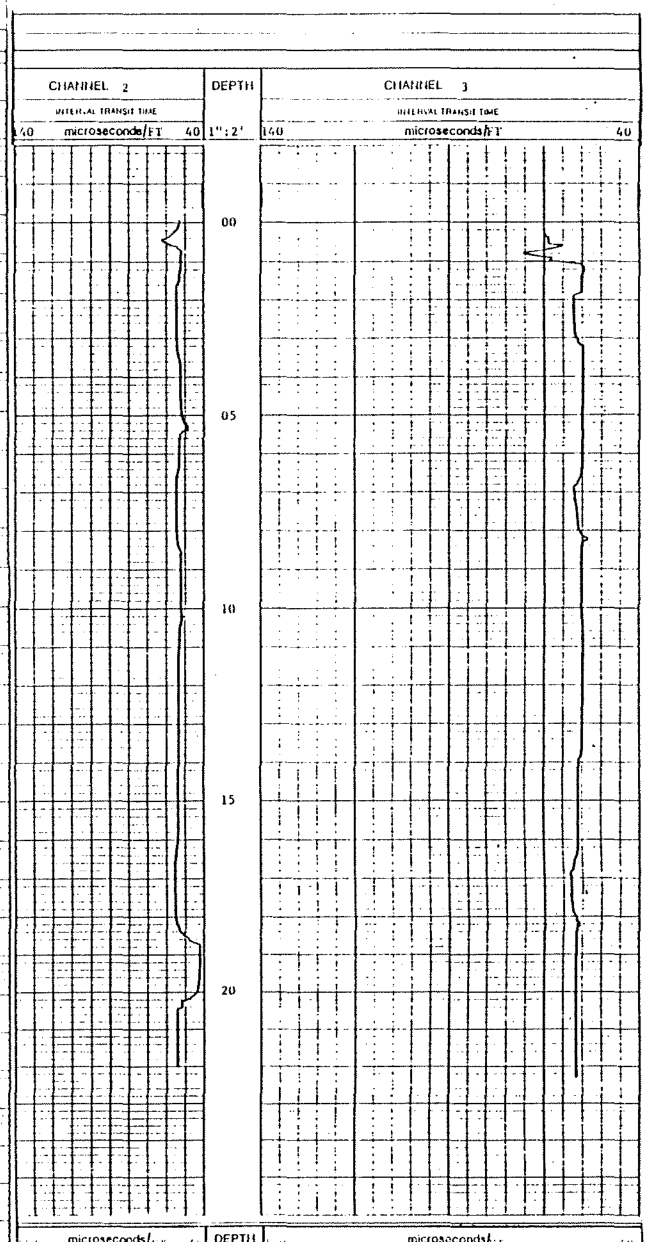

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BOREHOLE PZ 11

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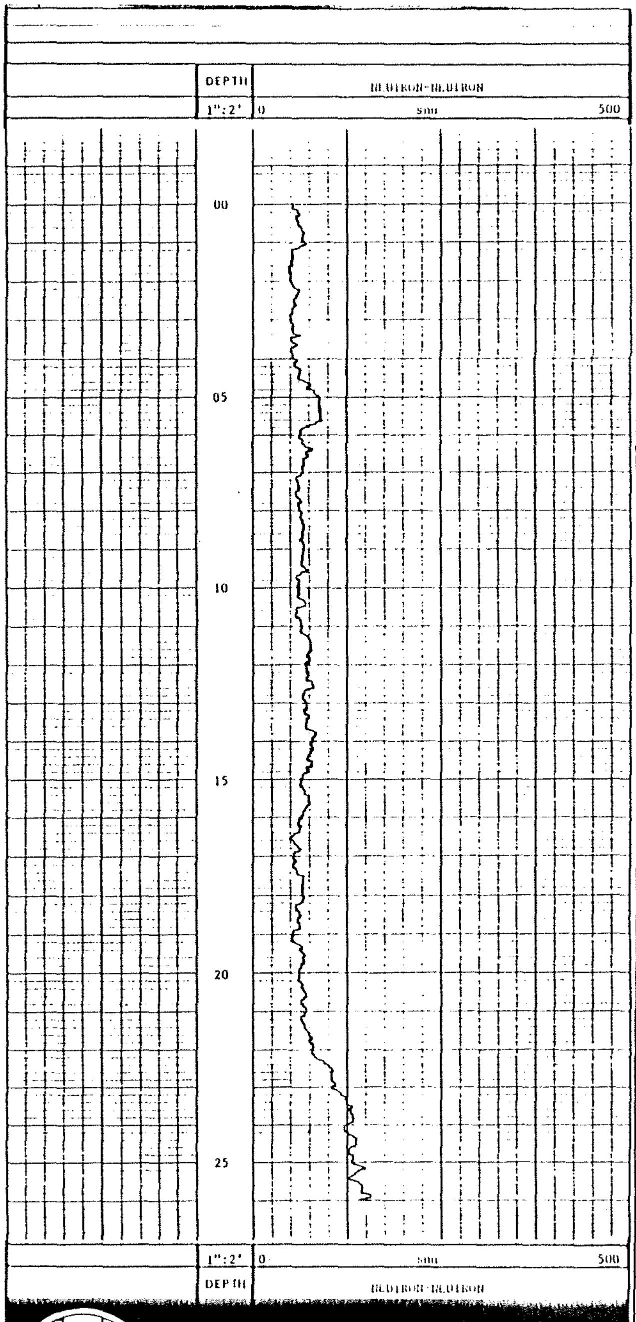
AREA SAUKVILLE, WI

COUNTRY USA



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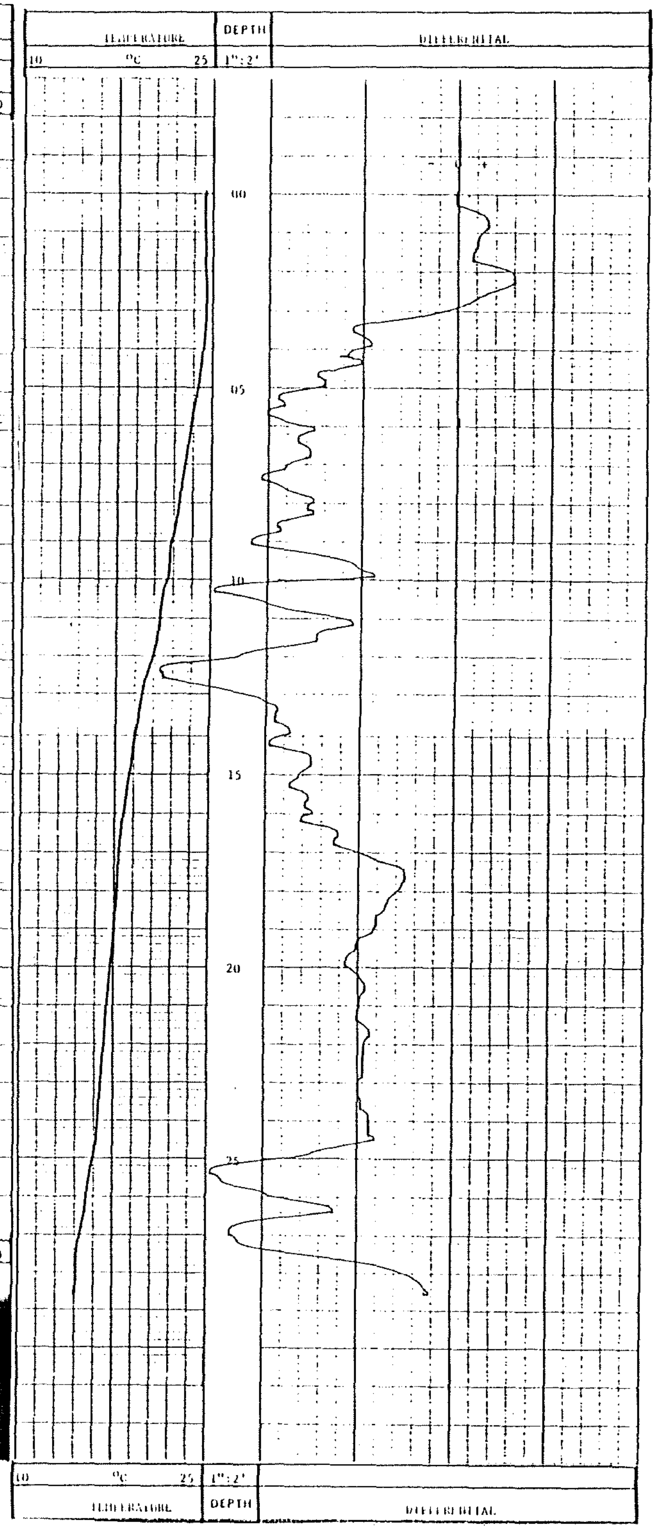
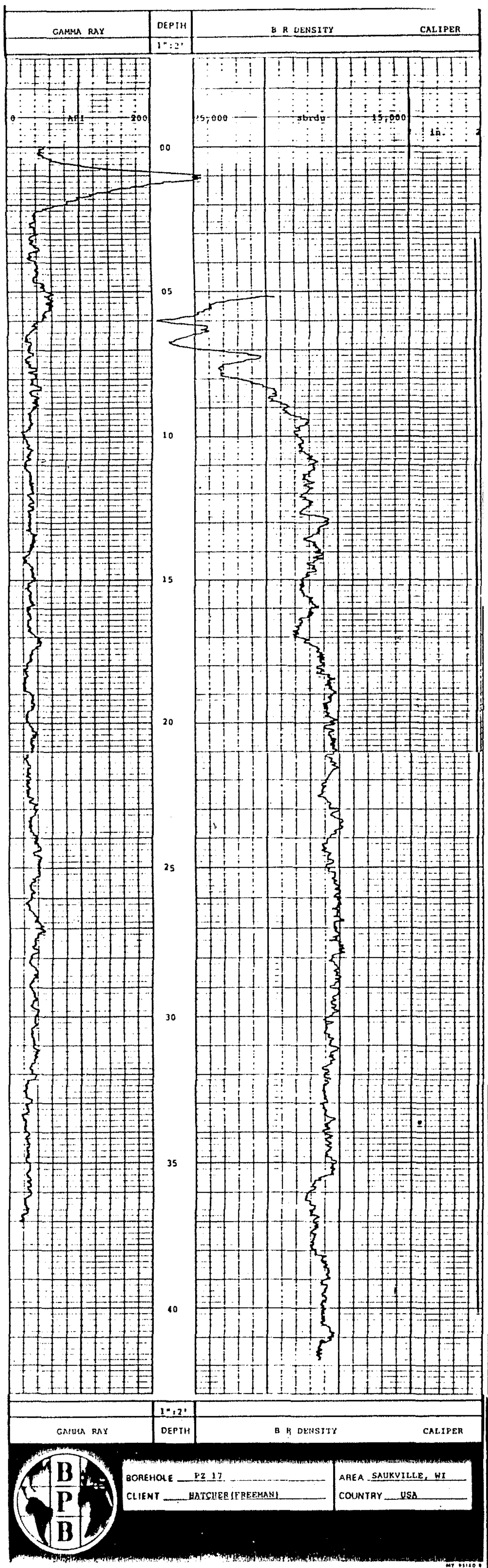
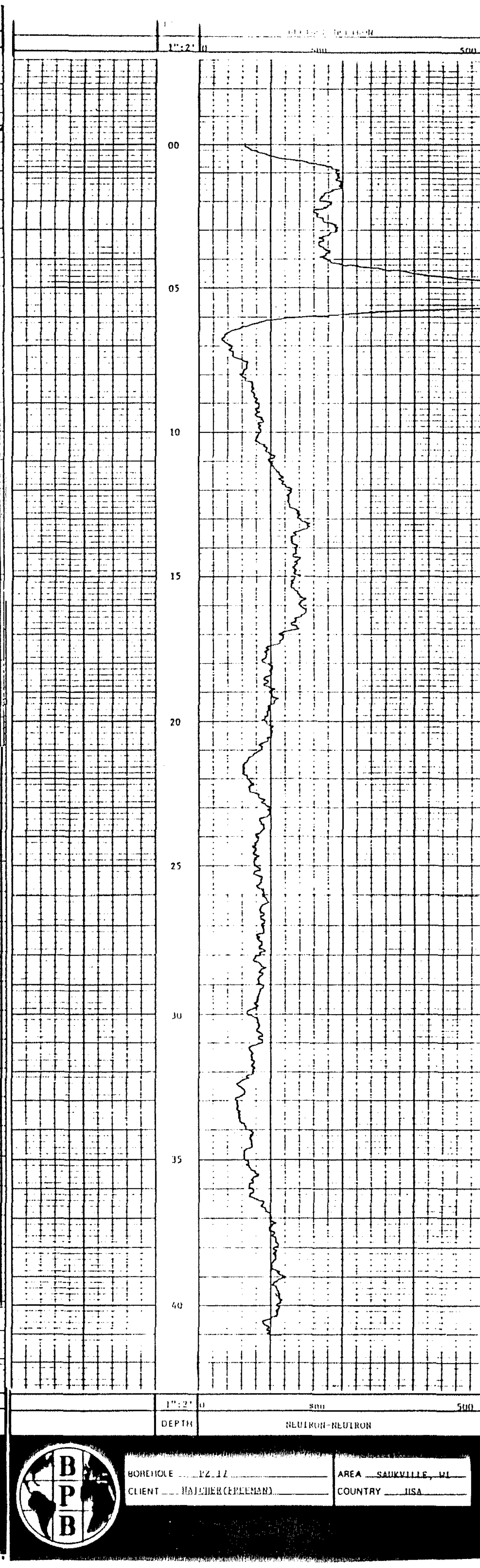
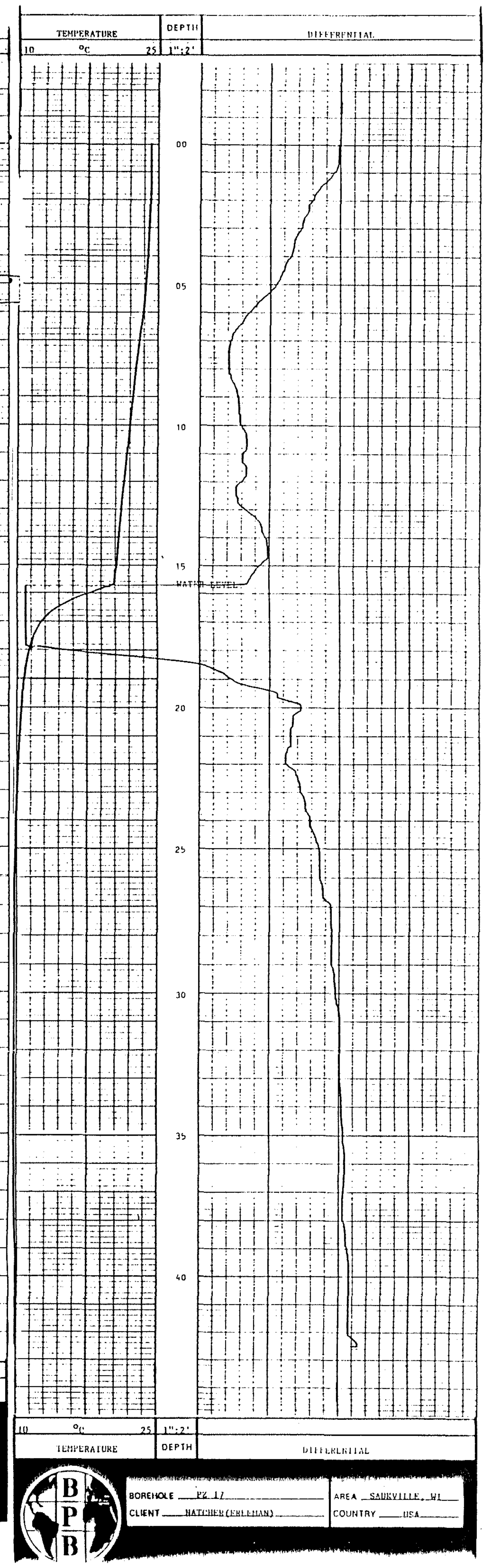
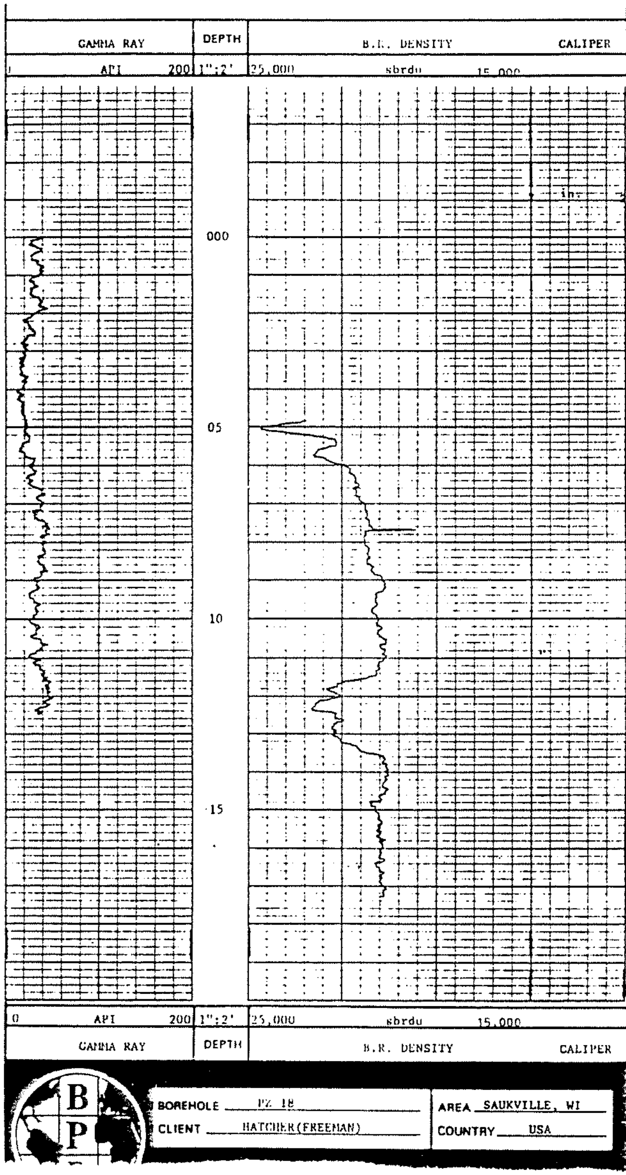
AREA SAUKVILLE, WI
COUNTRY USA

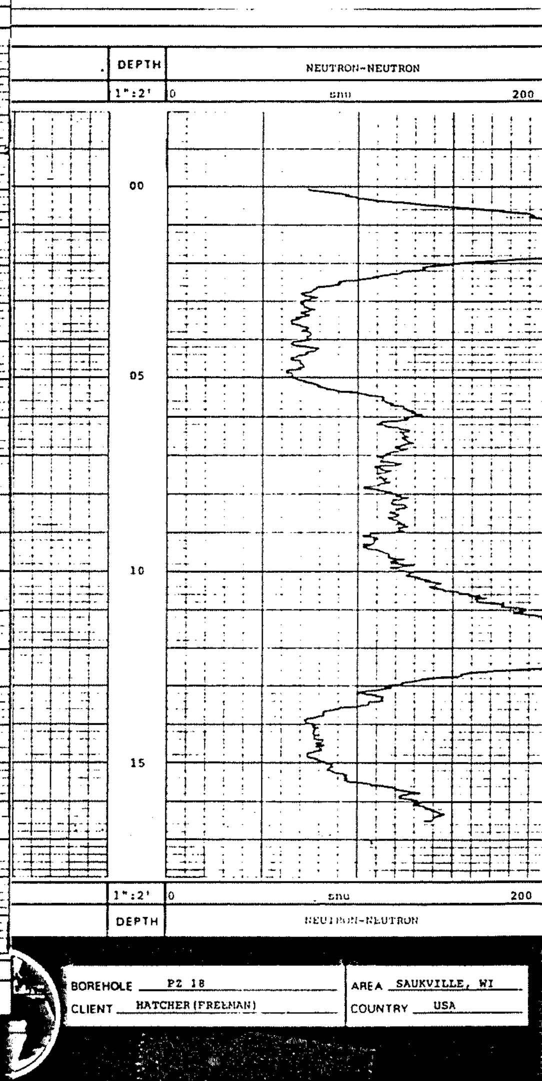


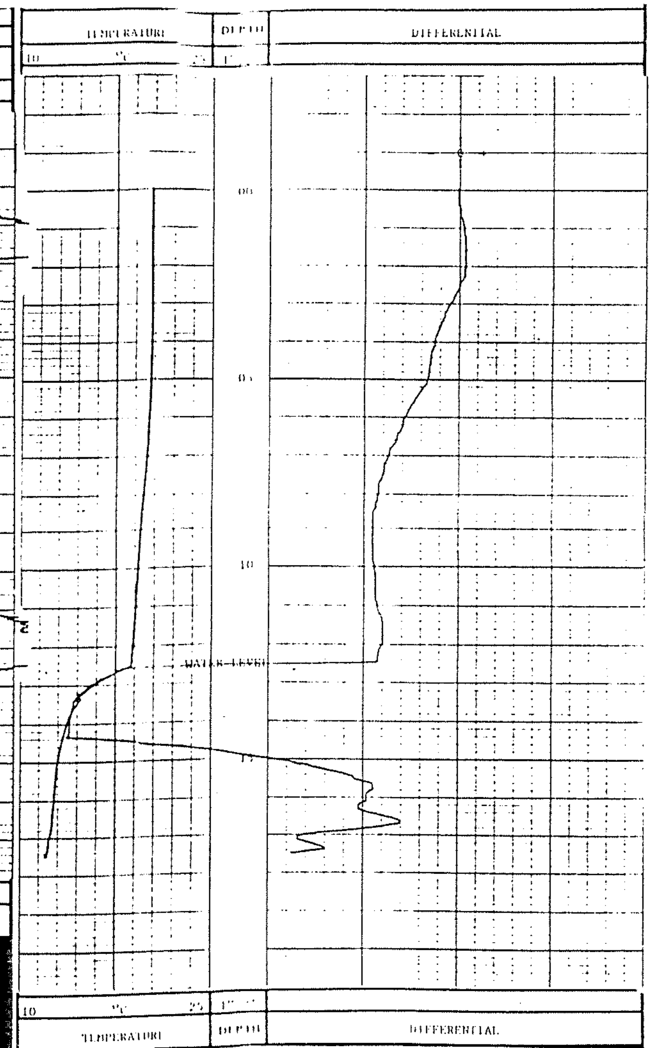

GAMMA RAY
DEPTH
1":2'
B R DENSITY
CALIPER
0 API 200
BOREHOLE PZ 17
CLIENT HATCHER (FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA

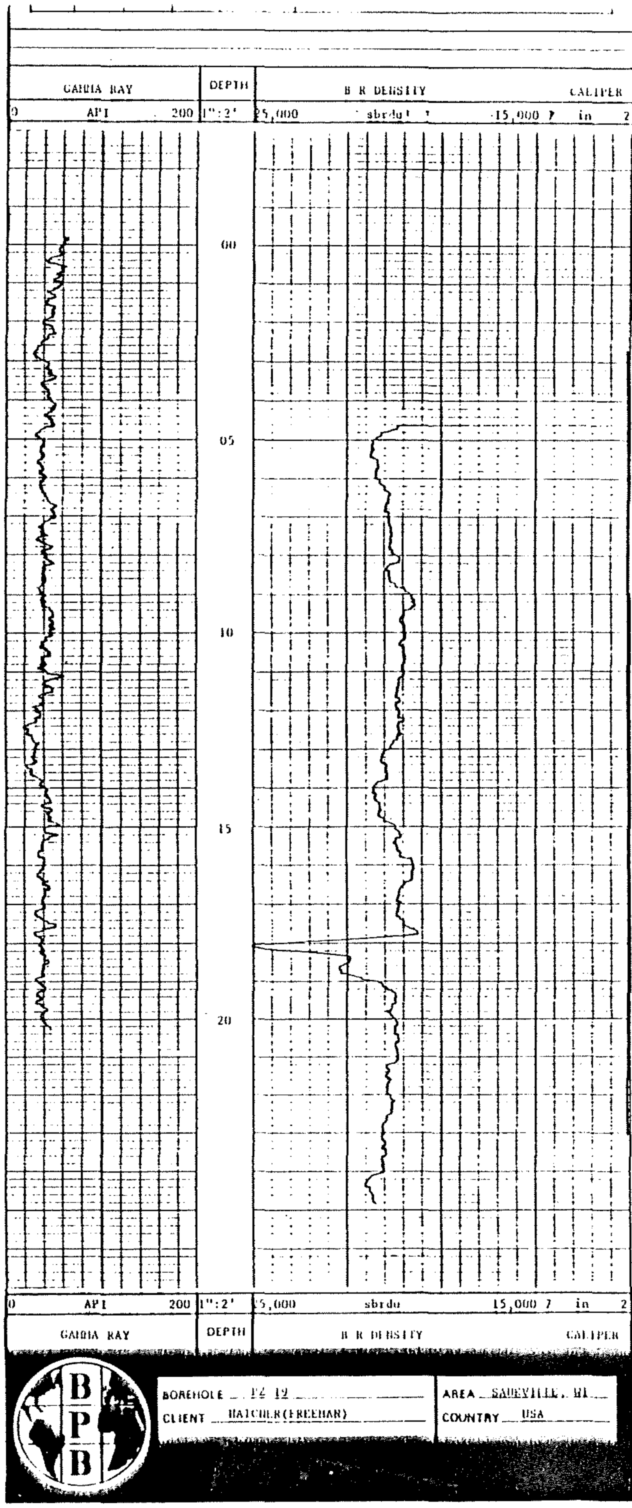

1":2'
DEPTH
NEUTRON-NEUTRON
0 500
BOREHOLE PZ 17
CLIENT HATCHER (FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA

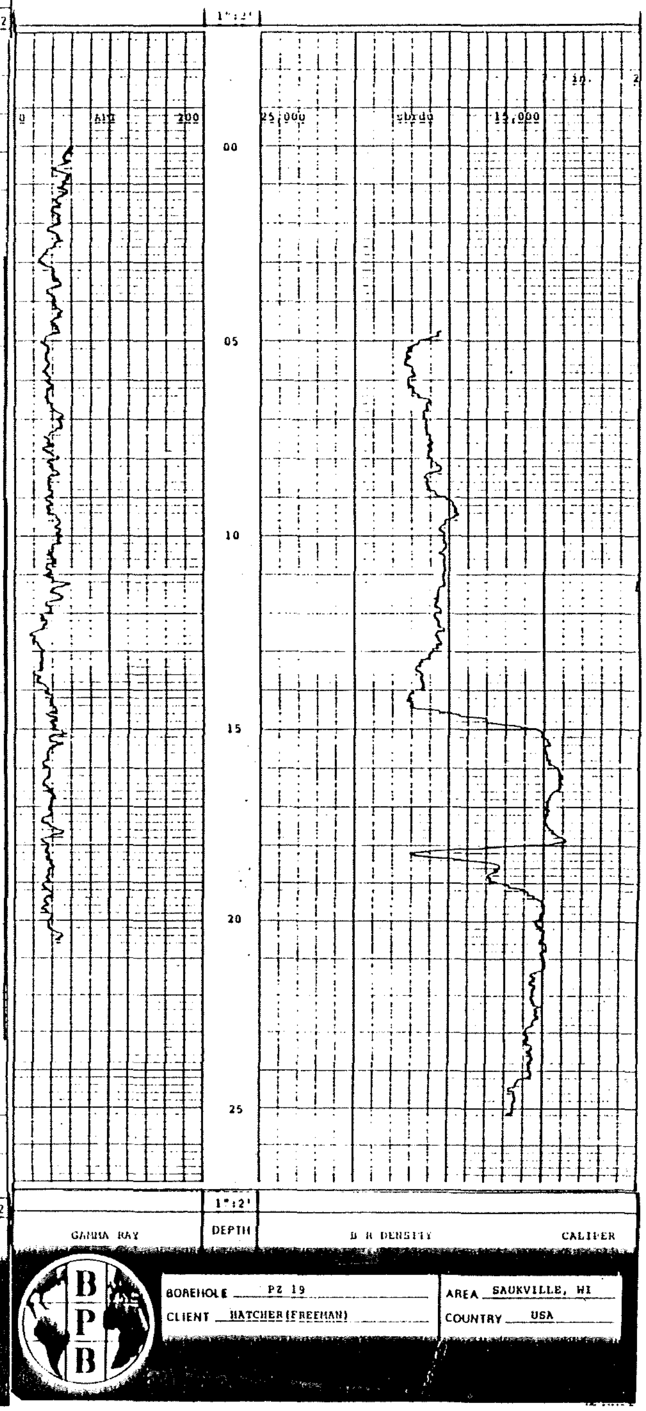

TEMPERATURE
DEPTH
1":2'
DIFFERENTIAL
10 °C 25
WATER LEVEL
BOREHOLE PZ 17
CLIENT HATCHER (FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA


GAMMA RAY
DEPTH
B.R. DENSITY
CALIPER
API 200
1":2'
25,000
sbrdu
15,000
in.
000
05
10
15
0 API 200
1":2'
25,000 sbrdu 15,000
GAMMA RAY
DEPTH
B.R. DENSITY
CALIPER
BOREHOLE PZ 18
CLIENT HATCHER (FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA

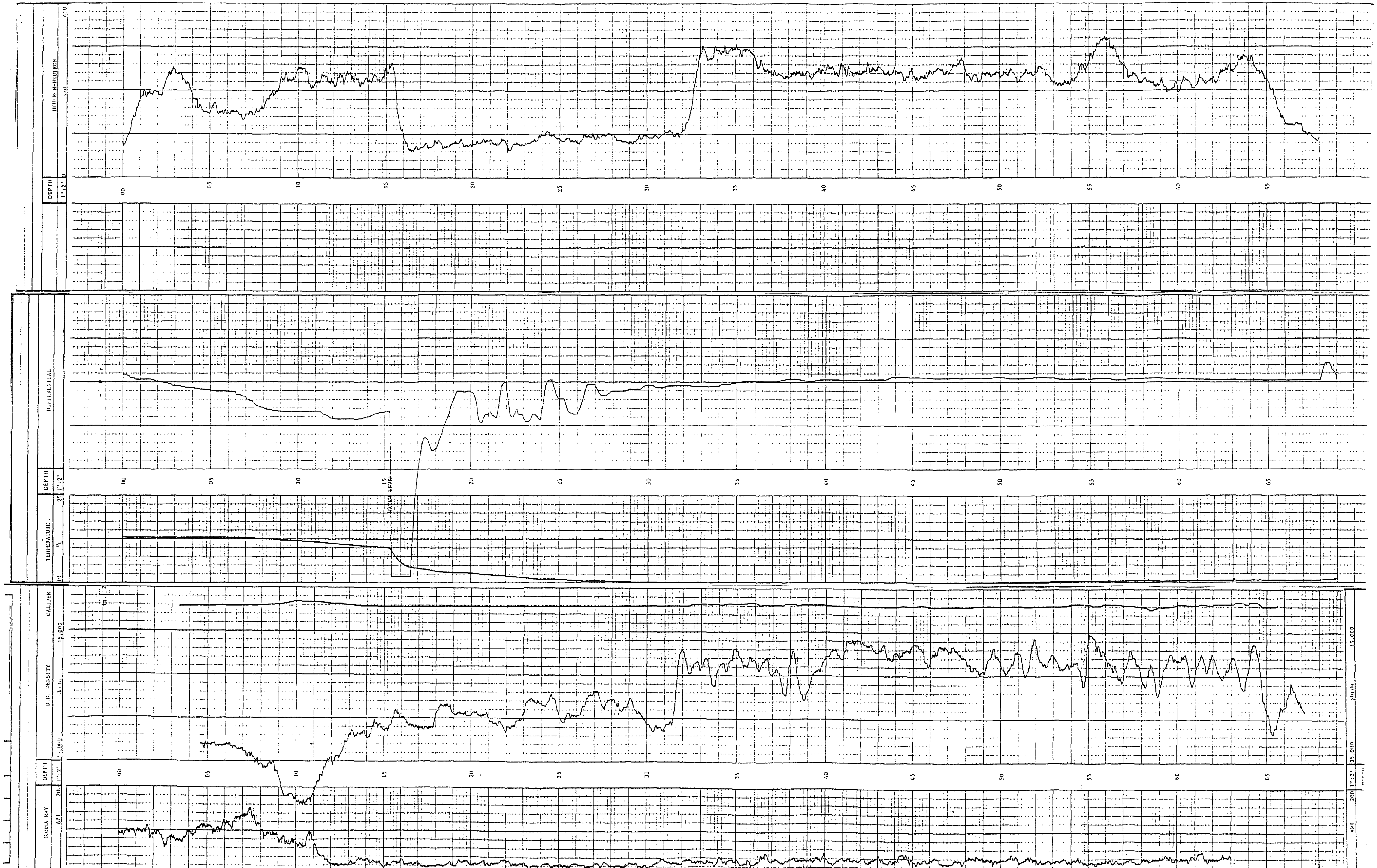

DEPTH
NEUTRON-NEUTRON
1":2'
0 snu 200
00
05
10
15
1":2'
0 snu 200
DEPTH
NEUTRON-NEUTRON
BOREHOLE PZ 18
CLIENT HATCHER (FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA


TEMPERATURE
DEPTH
DIFFERENTIAL
10
25
00
05
10
WATER LEVEL
10
°C
25
TEMPERATURE
DEPTH
DIFFERENTIAL

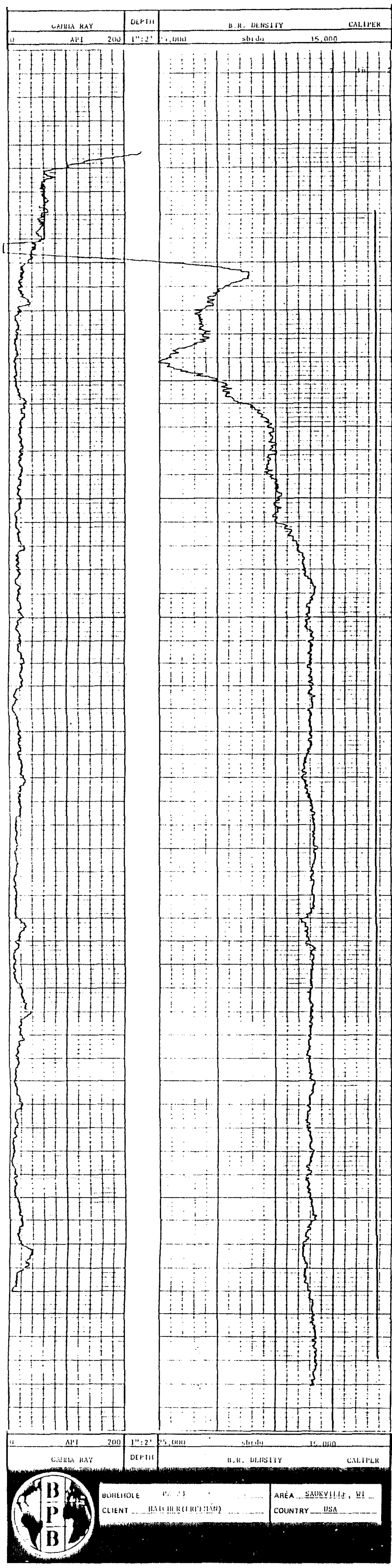

GAMMA RAY
DEPTH
B R DENSITY
CALIPER
0 API 200
1":2'
25,000 sbrdu 15,000 7 in 2
00
05
10
15
20
BOREHOLE PZ 12
AREA SAUKVILLE, WI
CLIENT HATCHER (FREEMAN)
COUNTRY USA

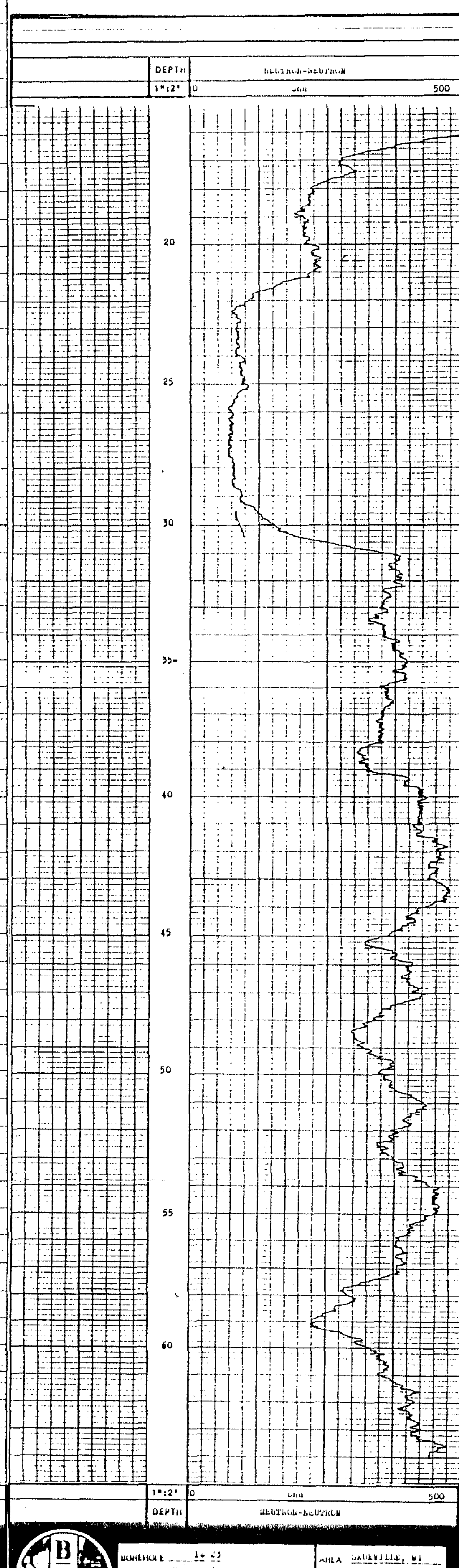

1":2'
0 API 200
25,000 sbrdu 15,000
in. 2
00
05
10
15
20
25
GAMMA RAY
DEPTH
B R DENSITY
CALIPER
BOREHOLE PZ 19
AREA SAUKVILLE, WI
CLIENT HATCHER (FREEMAN)
COUNTRY USA


DEPTH
NEUTRON-NEUTRON
1":2'
0
200
05
10
15
20
25
WATER LEVEL
°C
1":2'
TEMPERATURE
DEPTH
DIFFERENTIAL
BOREHOLE PZ 19
CLIENT HATCHER(FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA



NEUTRON-NEUTRON
DEPTH
1":2'
00
05
10
15
20
25
30
35
40
45
50
55
60
65
DIFFERENTIAL
TEMPERATURE
°C
WATER LEVEL
CALIPER
15,000
G.R. DENSITY
25,000
GAMMA RAY
API
200


GAMMA RAY
DEPTH
B.R. DENSITY
CALIPER
API 200
1":2'
BOREHOLE
CLIENT
AREA SAUKVILLE, WI
COUNTRY USA


DEPTH
NEUTRON-NEUTRON
1":2'
0
500
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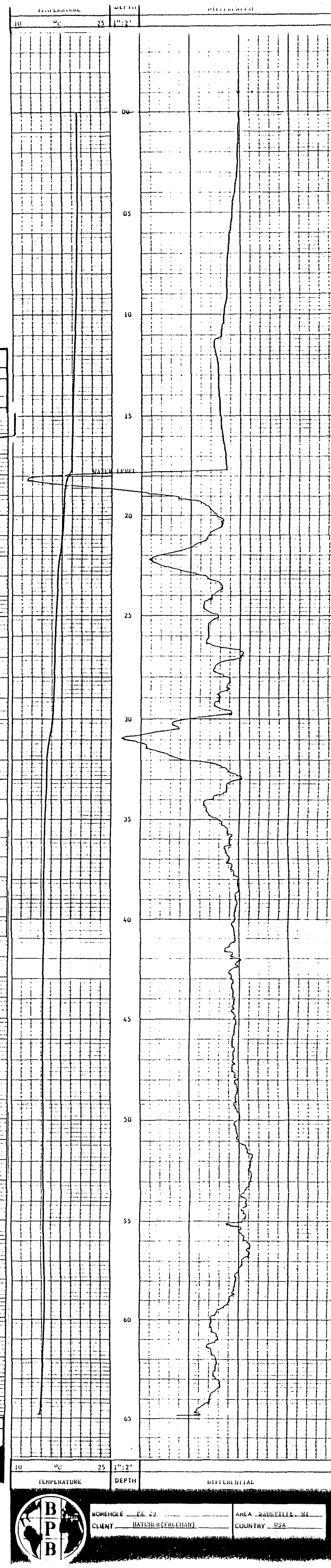
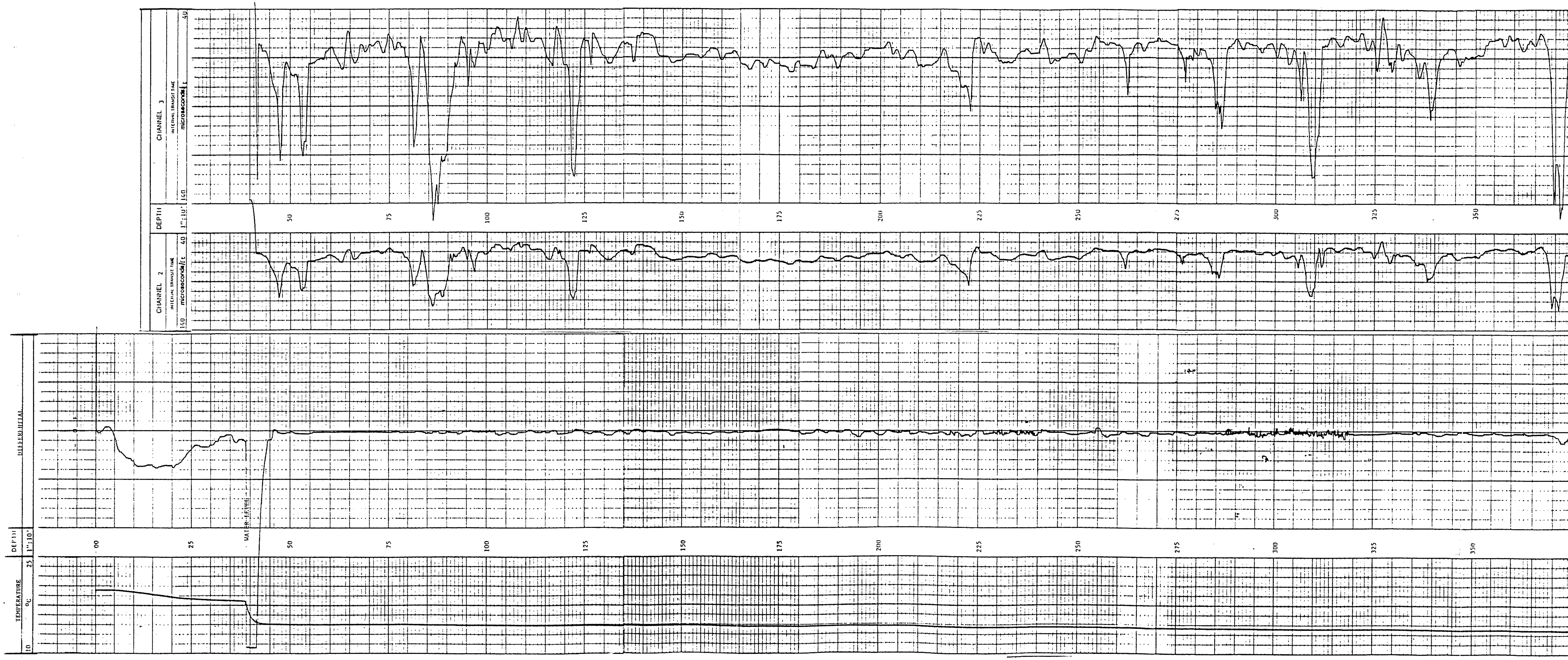
60
BOREHOLE
CLIENT HATCHER(FREEMAN)
AREA SAUKVILLE, WI


10
°C
25
1":2'
05
10
15
WATER LEVEL
20
25
30
35
40
45
50
55
60
65
TEMPERATURE
DEPTH
DIFFERENTIAL
BOREHOLE
CLIENT HATCHER(FREEMAN)
AREA SAUKVILLE, WI
COUNTRY USA



CHANNEL 3
INTERVAL TRANSIT TIME
microseconds/ft
40
140
DEPTH
1":10'
50
75
100
125
150
175
200
225
250
300
325
350
375
CHANNEL 2
INTERVAL TRANSIT TIME
microseconds/ft
DIFFERENTIAL
WATER LEVEL
00
25
275
TEMPERATURE
°C
10