Milestone Report

Hydrogeology of a Perched Aquifer in the Pantex Plant Region: Preliminary Results

INTRODUCTION

Significant progress has been made in the delineation, measurement, and description of a perched aquifer(s) in the region of the U.S. Department of Energy Pantex Plant, and in the determination of hydraulic characteristics of perched aquifers. Major areas of progress include documentation of the spatial extent of the perched aquifer and of mechanisms controlling directions and rates of ground-water flow.

New data have been collected from (1) aquifer tests performed in five perched aquifer monitoring wells at the Pantex Plant, (2) static water-level measurements in six new perched aquifer monitoring wells drilled at the Pantex Plant in the spring of 1992, (3) regional surveys conducted to locate domestic and agricultural wells producing from either the perched aquifer that extends under the Pantex Plant or from a possibly separate perched aquifer in the region of interest, and (4) extensive chemical and isotopic sampling of waters produced from the perched aquifer. Hydrologic results derived from these data will be discussed in this report, and chemical results will be reviewed in a separate report.

AQUIFER TEST RESULTS

Aquifer tests were conducted in the five existing perched aquifer monitoring wells, WR-19, WR-20, WR-38, WR-44, and WR-45, in October 1991, to determine hydrologic parameters for the perched aquifer. All aquifer tests were performed using Bennett Sample Pumps at discharge rates of less than 1.5 gallons per minute (gpm). Two primary factors affecting the validity of aquifer test results were discharge rates and test duration. First, the discharge rates, always less than 1.5 gpm (maximum rate achievable with a Bennett Pump at depths of approximately 300 ft), were too low to stress the aquifer during testing. Second, since all water produced during testing had to be drummed and disposed of as hazardous waste, the duration of the aquifer test was insufficient to define the late phase of the drawdown curve, which would be expected in an unconfined aquifer.

Despite these limitations, relatively consistent results were obtained from a suite of analyses performed on data collected from the five aquifer tests. The total range is less than 2 orders of magnitude (from 10 to 180 ft^2/d), whereas the range in transmissivities for uniform materials such as unconsolidated silty sandy aquifers is commonly bracketed over 4 orders of magnitude (Freeze and Cherry, 1979, for example). Nine different methods of analysis were used on both drawdown and recovery data for each of the five monitoring wells to establish mean transmissivities, both for individual wells and for the perched aquifer as a whole. Methods used include those for unconfined, confined, and leaky-confined aquifers. Solutions for unconfined aquifers require input data on the saturated thickness of the aquifer. This is problematic for the five wells in question because no defensible data exist on the saturated thickness in any of these five wells. The most probable scenario is that the perched aquifer is unconfined. Rather than make random assumptions regarding saturated thicknesses to employ Neuman's method for unconfined aquifers, we used only results from confined and leaky-confined methods. As data become available on saturated thickness for the perched aquifer, further analysis will be performed on these aquifer tests using Neuman's method for unconfined aquifers.

Analysis of aquifer tests, especially where the duration of the test was too short to document the later part of the drawdown curve, may be achieved with reasonable results using methods developed for confined and leaky-confined aquifers. The methods used and test results are listed in Table 1 and illustrated in Figure 1.

Table 1a. Transmissivity (ft^2/d) computed based on analysis of drawdown data using various methods.

Well ID	Theis curve	Jacob method (early)	Jacob method (late)	Hantush-Cooper	Hantush
WR-19	42.89	39.13	NA	35.47	42.16
WR-20	19.43	18.43	NA	14.94	20.04
WR-38	120.87	116.81	NA	155.52	126.58
WR-44	85.38	27.69	116.47	102.99	32.39
WR-45	122.69	188.01	NA	116.47	47.05

Table 1b. Transmissivity (ft^2/d) computed based on analysis of recovery data using various methods.

Well ID	Theis curve	Theis recovery method (early)	Theis recovery method (late)	Hantush-Cooper	Hantush	Mean - drawdown/ recovery
WR-19	57.92	25.47	NA	25.65	33.23	37.74
WR-20	20.77	14.84	68.19	NA	13.49	23.77
WR-38	128.74	40.82	NA	64.19	37.44	98.87
WR-44	48.16	28.23	NA	14.12	34.12	54.39
WR-45	40.74	13.91	90.89	20.77	10.23	72.31

The arithmetic mean transmissivity for the five monitoring wells ranges from 23 to 98 ft^2/d with an overall mean transmissivity is 57.41 ft^2/d. The range in transmissivity values overall is fairly uniform. This small range in transmissivities may be important in numerical simulations of flow and transport with respect to the presence or absence of relatively higher or lower permeability flow paths within the perched aquifer. Thus, prediction of ground-water flow rates using a relatively homogeneous transmissivity value may be a justifiable assumption. Further refinement of aquifer test results will be incorporated with new aquifer tests scheduled for recently completed perched monitoring wells and included in future reports.

Some if not all of the perched monitoring wells tested are probably not screened over the entire saturated section of the perched aquifer but are partially penetrating wells: they only test the upper or lower portion of the saturated section. The degree to which this has an impact on aquifer test results is a function of the degree or percentage of aquifer penetrated and screened.

Future efforts with respect to quantifying hydraulic parameters of the perched aquifers will focus on stressing the aquifer with higher discharge pumps, if possible, and on extending the drawdown phase of the aquifer test to a sufficient length to better define the late portion of the drawdown curve. Current plans include aquifer tests in two perched aquifer monitoring wells on-site and two to four aquifer tests in domestic, agricultural, and abandoned wells located in perched aquifer wells off-site.

WATER LEVELS AND THE POTENTIOMETRIC SURFACE

The Bureau's on-site drilling program at the Pantex Plant was completed on April 13, 1992. This effort and drilling programs subsequently undertaken by Battelle resulted in seven new monitoring wells that either were completed as perched aquifer monitoring wells or geophysical logs establishing the presence and depth of a perched aquifer have been completed.

Previous investigations concerning the perched aquifer at the Pantex Plant were based on the five monitoring wells described above: WR-19, WR-20, WR-38, WR-44, and WR-45. Based exclusively on these five wells, the potentiometric surface of the perched aquifer has been historically mapped as a relatively flat surface with a uniform hydrologic gradient from the northeast to the southwest. New water level data for six of the seven new perched aquifer wells have resulted in a new potentiometric surface (fig. 2) much different from that previously mapped. A static water level for the seventh well, located in the immediate area of WR-44, has not yet been released.

Assuming hydrologic connection between this BEG-PTX No. 3 and other perched aquifer wells at the Pantex Plant, the hydraulic head measured in this well demonstrates a reverse in hydrologic gradient of the perched aquifer. This reverse in gradient appears to be centered proximal to playa 1. Although the potentiometric surface may now be mapped as a closed mound centered under playa 1 (as opposed to previous interpretations of a relatively flat water table dipping from northeast to southwest), the final potentiometric surface will not be fully understood until additional hydraulic head measurements east and northwest of the plant area are obtained.

The two monitoring wells recently completed as part of the Bureau's drilling program, BEG-PTX No. 2 and BEG-PTX No. 3, provide significant hydrologic data from an extensive suite of geophysical logs, including litho-density, compensated neutron, and gamma-ray logs. Monitoring well BEG-PTX No. 2 indicates two perched saturated zones (fig. 3). The first saturated zone penetrated is located at a depth from 111 to 118 ft. The saturation of this interval, lithologically recorded as a fine-grained clay unit, is documented by the crossover of the litho-density and compensated neutron logs (fig. 3). The typical response in an unsaturated zone would be for the litho-density log to record normal porosities while the compensated neutron log, because of the absence of water (and presence of air), would record unrealistically low porosity values. This is the response recorded above and below the interval from 101 to 108 ft. However, because of the saturated nature of this clay unit, both the litho-density and the compensated neutron logs record realistic porosity values, the compensated neutron log typically reading 2 to 3 percent higher than the litho-density log.

The second saturated zone penetrated is also located above the regional Ogallala aquifer and at a depth of 308 to 320 ft. This zone can be correlated with the perched aquifer delineated in the area of the Pantex Plant. This well was completed as an Ogallala aquifer monitoring well because of the thinness of this saturated zone. Correlation of the saturated zone, as illustrated by the litho-density and compensated neutron logs (fig. 3), with the lithology interpreted from the gamma-ray log, documents that most of the saturated zone in this well is a fine-grained zone and that only approximately 2 to 3 ft of sand above the fine-grained zone is saturated. The difficulty in plugging back to this very thin zone and completing this well as a perched aquifer monitoring well led to the decision to complete the well as an Ogallala aquifer monitoring well.

Three saturated zones are observed on geophysical logs run in BEG-PTX No. 3 (fig. 4). The first zone penetrated extends from approximately 250 to 283 ft. Close inspection of the litho-density and compensated neutron logs indicates that the zone begins to approach saturation as shallow as 234 ft and that actual water level measurements in the well record static water level at approximately 265 ft. The exact reason for the discrepancy between log response to saturation and measured water levels is unknown. A possible explanation is that fluid invasion into the formation while drilling may have saturated the interval above 265 ft temporarily until the well was developed. The saturated zone from 265 to 282 ft correlates with the perched aquifer delineated in the area of the Pantex Plant.

Two additional saturated zones are also noted on geophysical logs below the perched aquifer. The interval between 308 to 315 ft is a saturated fine-grained layer, and the interval between 366 to 370 ft, a relatively coarse zone, also appears to be saturated.

Figure 1 does not adequately define the shape of the perched aquifer, and thus the direction of water movement away from playa 1 cannot be accurately predicted. Areas where additional hydraulic head measurements are critical for the accurate representation of the potentiometric surface are northwest and east of playa 1. These additional wells should be at least 1 mi away from playa 1 to delineate gradients on a regional scale. Additional measurements are also needed to the north in the Amarillo Well field.

REGIONAL SURVEY OF PERCHED AQUIFER WELLS

A preliminary survey of regional wells located off-site of the Pantex Plant and producing perched ground water was conducted in April 1992. The investigation was limited to the 7.5-minute quadrangle containing the Pantex Plant and the eight quadrangles bounding it. Locations of windmills indicated on the corresponding maps were highlighted, because windmills are often connected to relatively shallow wells, for which drillers' logs or completion reports are not generally available. Names of landowners and/or tenants of the properties on which the windmills were located were obtained from land records for parts of Carson, Potter, Armstrong, and Randall Counties. The study area is bounded on the west by Texas 136 and Loop 335, on the south by a section line 1 mi south of Interstate 40 and FM 2575, on the east by a section road 5 mi east of FM 2373, and on the north by FM 1342 and an adjoining section road (fig. 5). Texas 136 was chosen as a boundary because of its proximity to the southern edge of the escarpment of the Canadian River valley. Within that area, landowners and/or tenants were contacted and questionned about the depth, age, construction, and accessibility of the wells connected to their windmills. In addition, those persons were asked if they were aware of any shallow wells, whether connected to windmills or not, on nearby properties.

Screening criteria for potential perched wells included the depth of the well or the depth to water relative to the level of the main Ogallala water table in 1980 (as mapped by the Panhandle Groundwater Conservation District No. 3) and whether the well had been drilled through a water-bearing zone and into an underlying unsaturated zone. On the basis of these criteria, two wells were identified as probable and six more as possible perched wells (fig. 5). However, more perched wells may exist; only those wells for which water level data could be gathered have been included. Water levels lie between approximately 3242 and 3286 ft above sea level (a.s.l.), except for the well southwest of Pantex belonging to B. E. Kinzer (water level at approximately 3470 ft a.s.l.). That well is considered as a possible perched well because of its shallow depth relative to nearby wells. The well to the west of Pantex belonging to Clarence Wink is an abandoned household well unconnected to a windmill. Only Mr. Wink was able to provide information on an unsaturated zone underlying a perched zone, which was encountered during the recent drilling of a deeper, adjacent well. The well to the north of Pantex, on property owned by Ethel Pratt and rented by Mr. and Mrs. Claude Swindle, has a pumpjack and is for household use; its water level is approximately 150 ft above the main water table. The five wells shown to the south of Pantex are deemed to be possibly, rather than probably, perched because their estimated water levels are within 50 ft of the Ogallala water table.

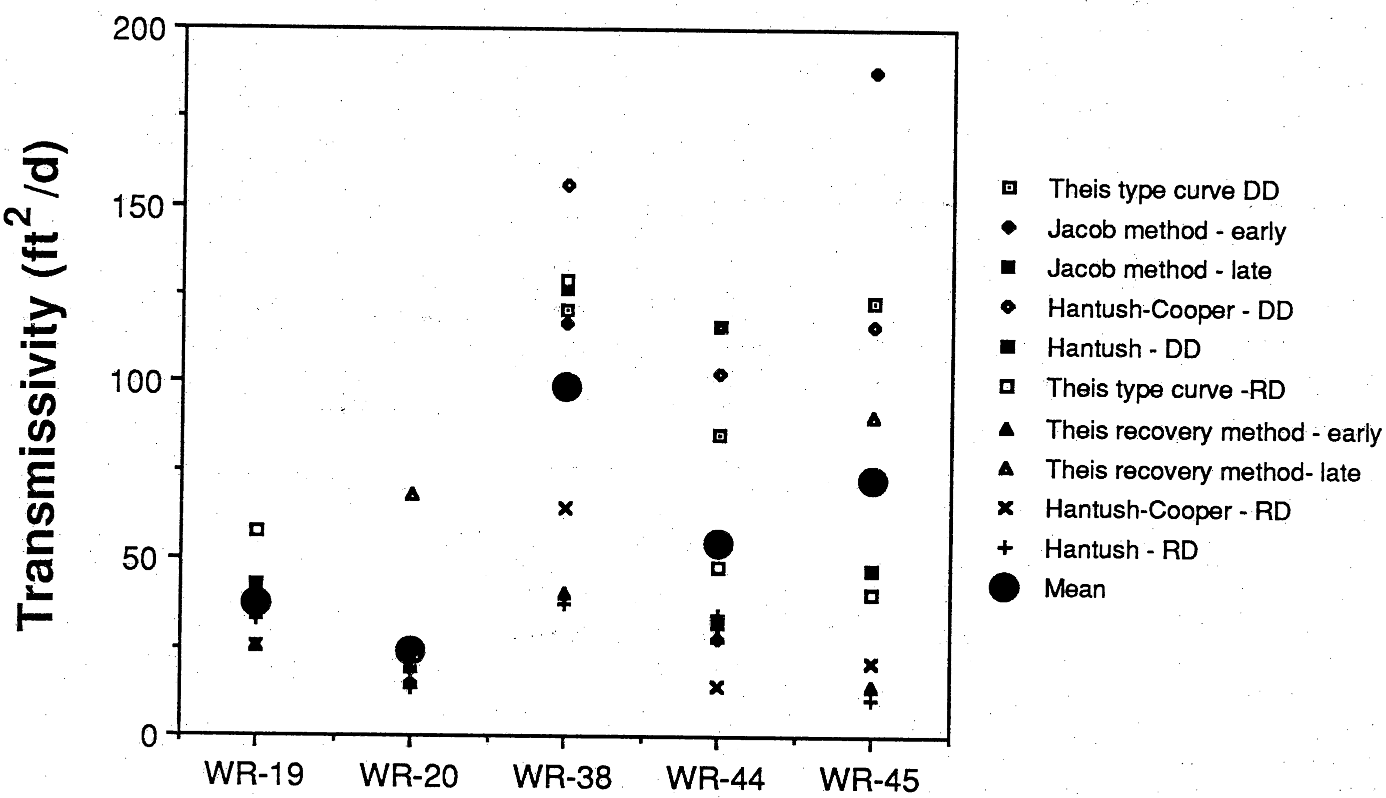


Figure 1. Plot of transmissivities for aquifer tests conducted in the five perched aquifer monitoring wells.

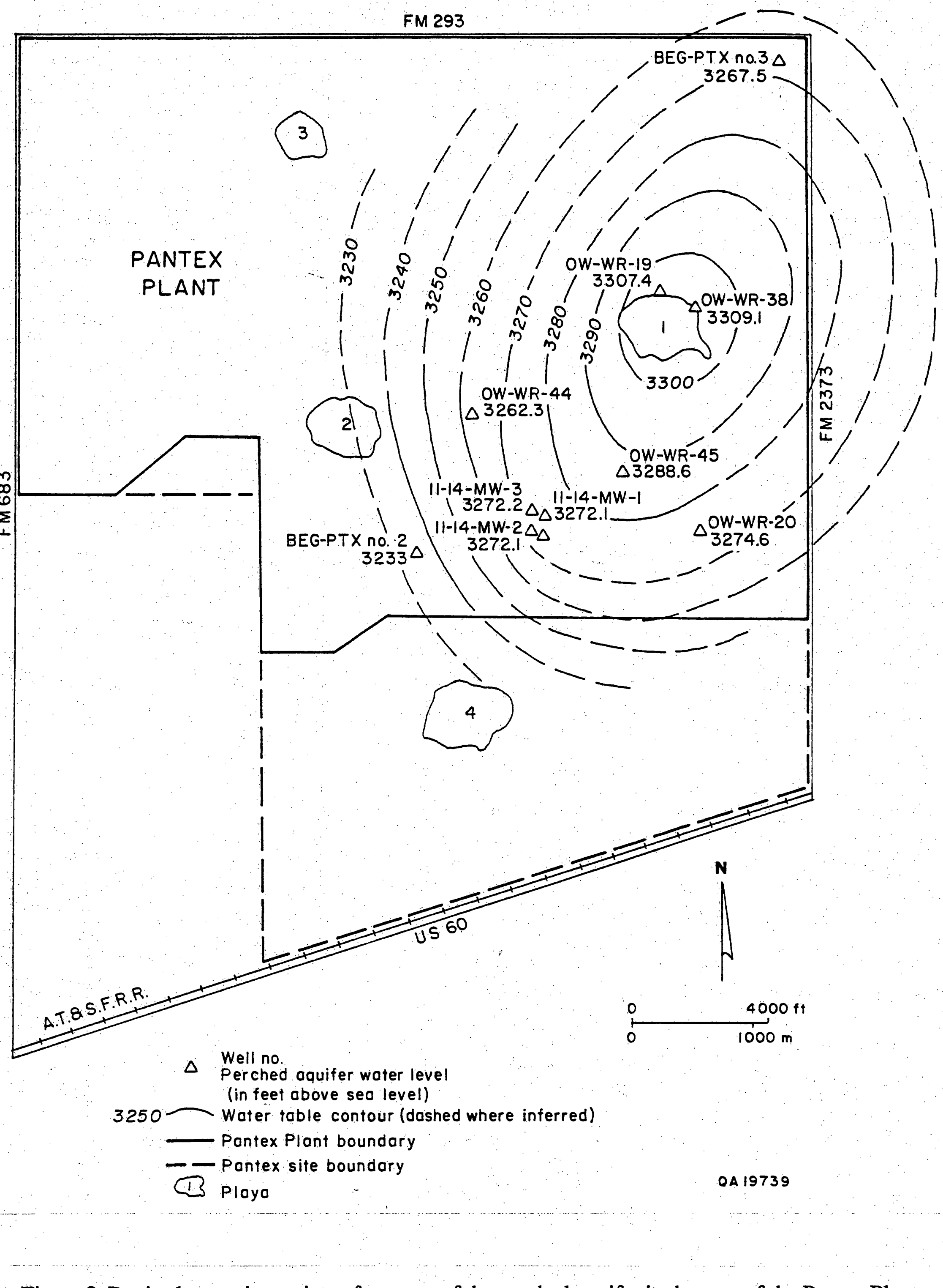


Figure 2. Revised potentiometric surface map of the perched aquifer in the area of the Pantex Plant.

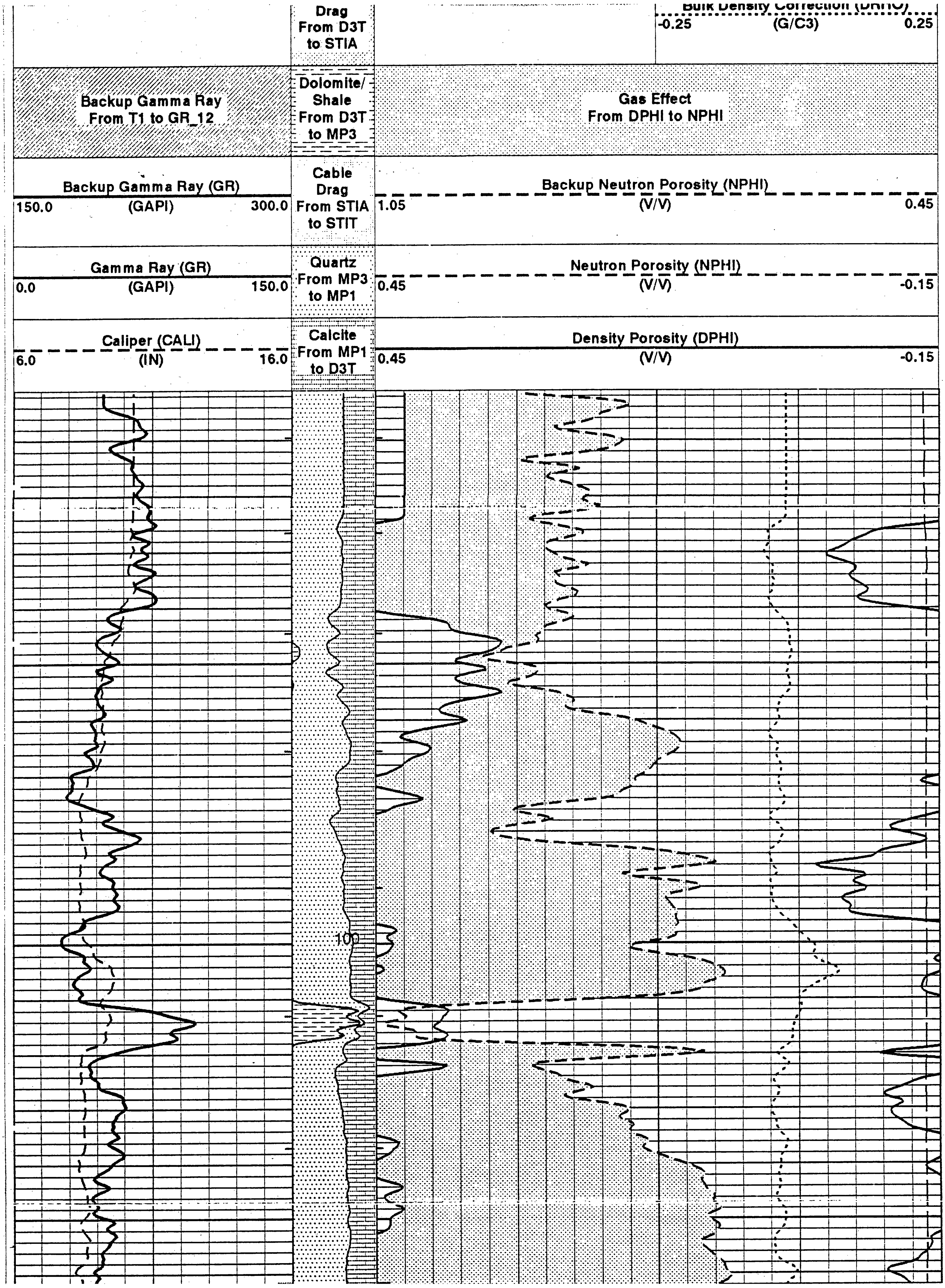


Figure 3. Segment of geophysical log suite run in BEG-PTX No. 2.

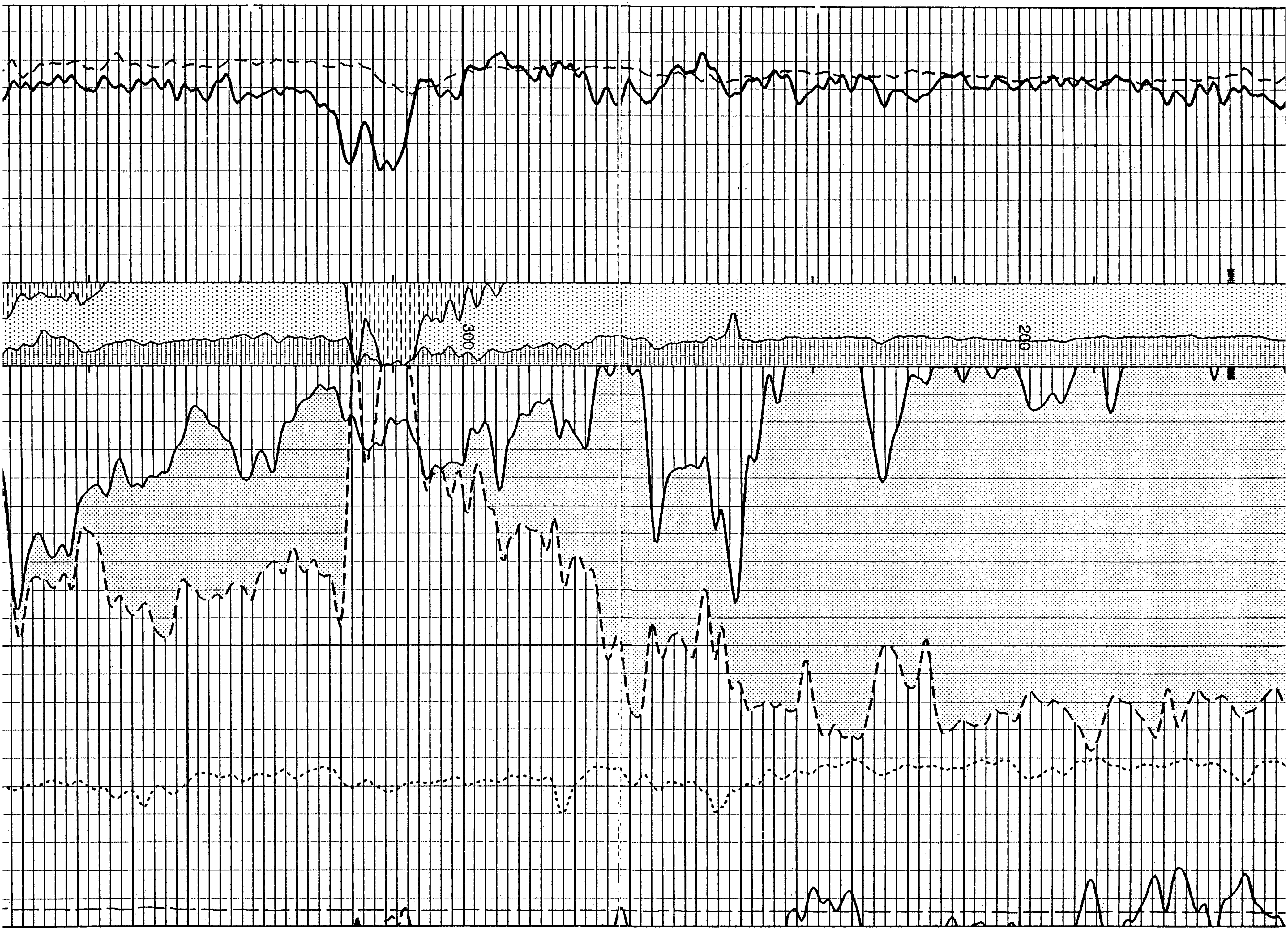
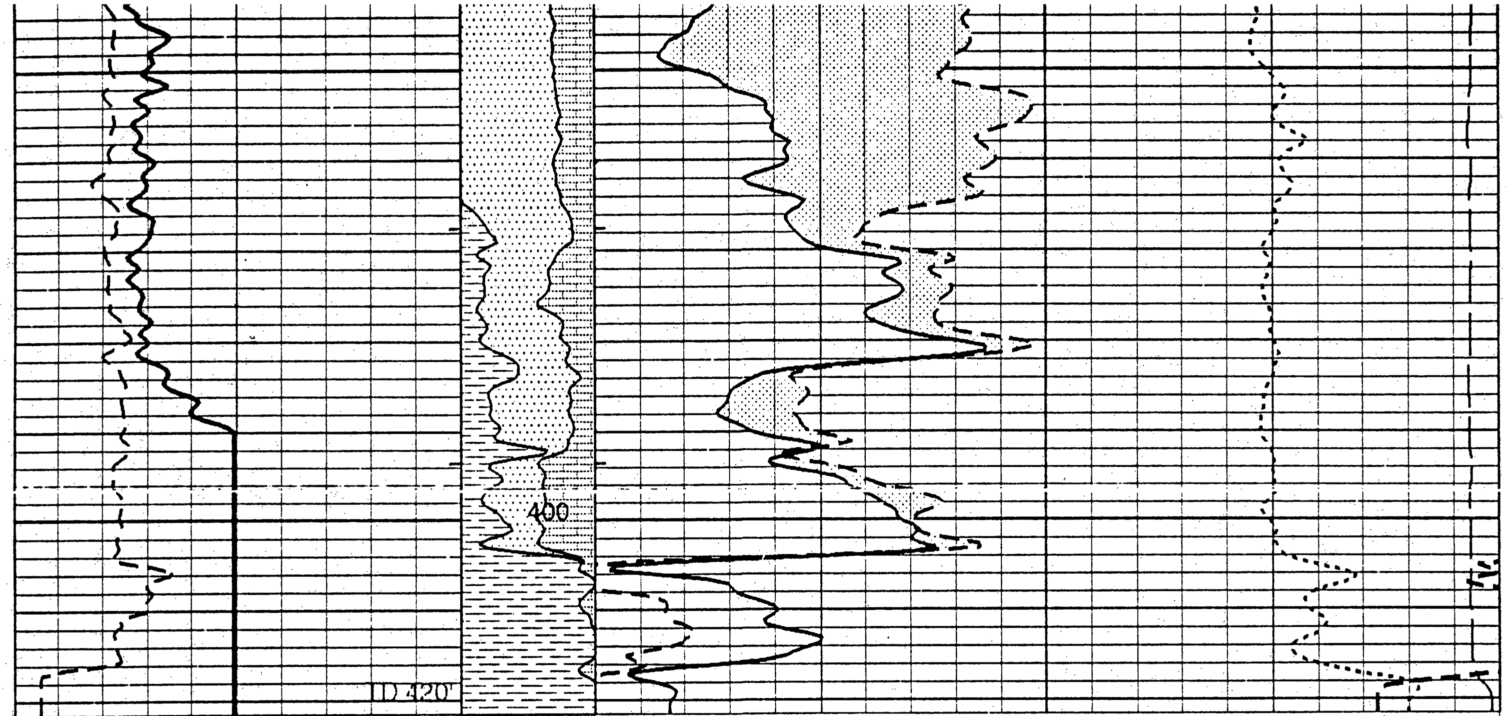


Figure 3. (continued)



Caliper (CALI)	Calcite From MP1 to D3T	Density Porosity (DPHI)
6.0 (IN) 16.0		0.45 (V/V) -0.15
Gamma Ray (GR) 0.0 (GAPI) 150.0	Quartz From MP3 to MP1	Neutron Porosity (NPHI) 0.45 (V/V) -0.15
Backup Gamma Ray (GR) 150.0 (GAPI) 300.0	Cable Drag From STIA to STIT	Backup Neutron Porosity (NPHI) 1.05 (V/V) 0.45
Backup Gamma Ray From T1 to GR_12	Dolomite/ Shale From D3T to MP3	Gas Effect From DPHI to NPHI
	Tool/Tot. Drag From D3T to STIA	Bulk Density Correction (DRHO) -0.25 (G/C3) 0.25
	Stuck Stretch (STIT) (F) 0.0 50.0	Tension (TENS) 10000.0 (LBF) 0.0

PIP SUMMARY

⊣ Integrated Hole Volume Minor Pip Every 10.0 F3
Integrated Hole Volume Major Pip Every 100.0 F3
⊢ Integrated Cement Volume Minor Pip Every 10.0 F3
Integrated Cement Volume Major Pip Every 100.0 F3

Time Mark Every 60.0 S

Format: PORO Vertical Scale: 5.0" per 100.0' Graphics File Created: 9-APR-1992 17:51

OP System Version: 5B0-231

Input DLIS Files

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Figure 3. (continued)

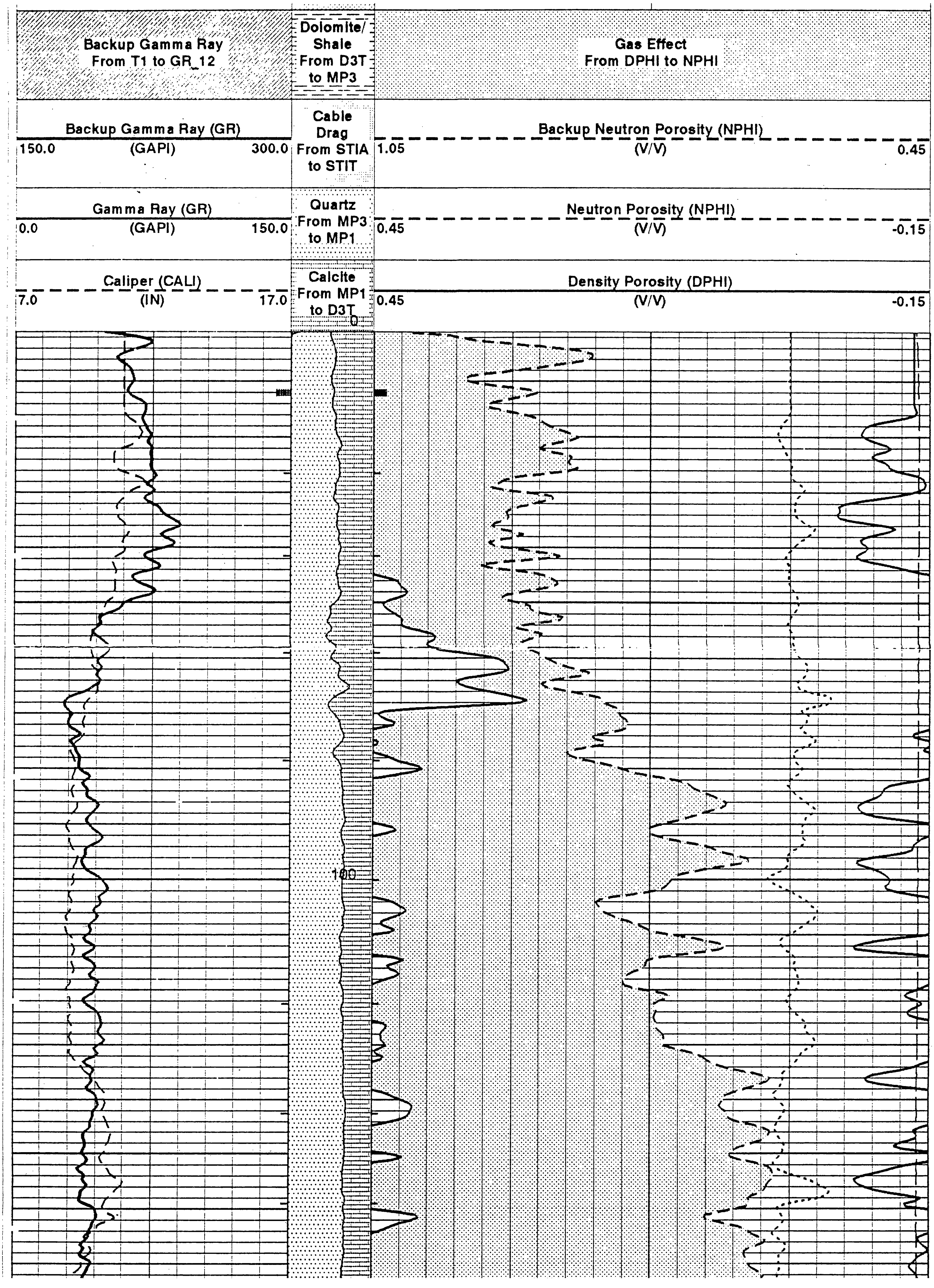

Figure 4. Segment of geophysical log suite run in BEG-PTX No. 3.

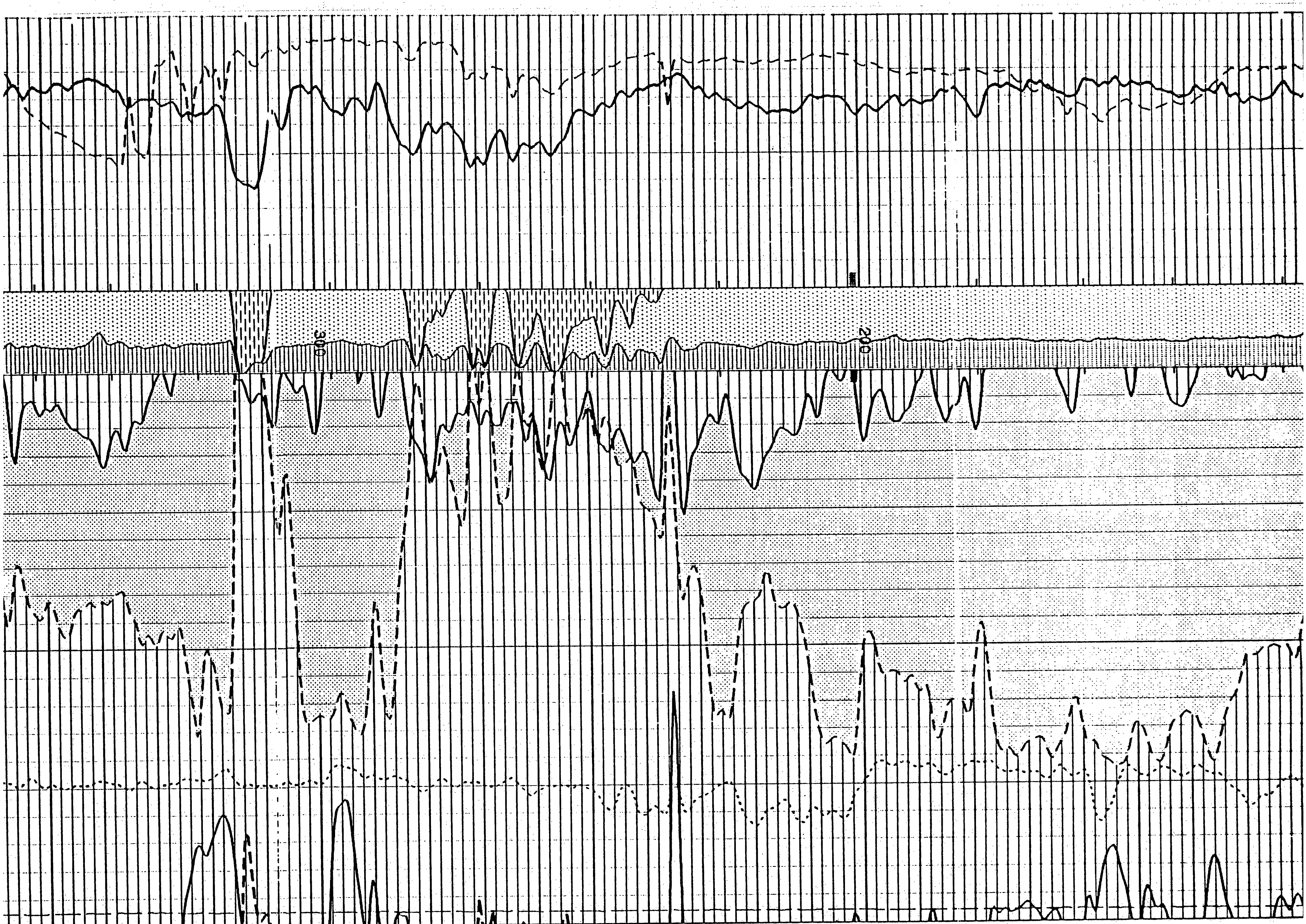

Figure 4. (continued)

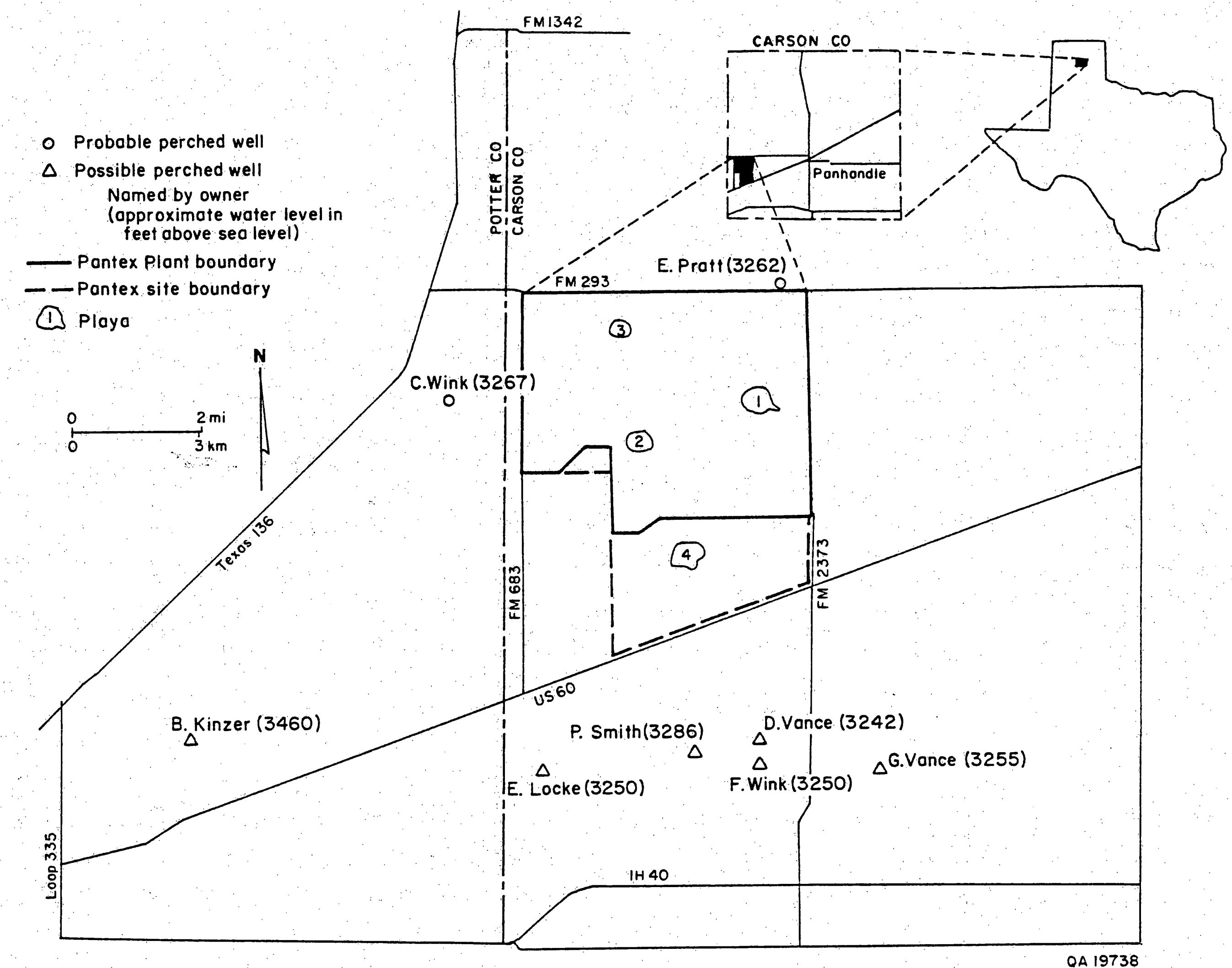

Figure 5. Map illustrating locations of possible and probable perched aquifer wells in the Pantex Plant area.