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GROUNDWATER MODELING OF THE PROPOSED NEW PRODUCTION REACTOR SITE, SAVANNAH RIVER SITE, SOUTH CAROLINA (U)

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Publication Date: January 5, 1990

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Prepared for the U. S. Department of Energy under Contract DE-AC09-88SR18035

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report addresses groundwater modeling performed to support the Environmental Impact Statement (EIS) that is being prepared by the Department of Energy (DOE). The EIS pertains to construction and operation of a new production reactor (NPR) that is under consideration for the Savannah River Site (SRS). Three primary issues are addressed by the modeling analysis: (1) groundwater availability, (2) changes in vertical hydraulic gradients as a result of groundwater pumpage, and (3) migration of potential contaminants from the NPR site.

The modeling indicates that the maximum pumpage to be used, 1,000 gpm, will induce only minor drawdown across SRS. For example, drawdown will be limited to 2.5 ft in the Lower Cretaceous Aquifer at F, H, and P areas. Drawdown will not extend upward into the Tertiary water bearing zones due to confinement by low permeability beds.

Pumpage of this magnitude will have a limited effect on the upward gradient from the Cretaceous into the Tertiary near Upper Three Runs Creek. The simulations indicate that the boundary of the area of upward flow will move less than 2,000 ft toward Upper Three Runs Creek.

Potentiometric surface maps generated from modeled results indicate that horizontal flow in the water table is either towards Four Mile Creek to the north or to Pen Branch on the south. Because the NPR is located on a topographic ridge the ultimate flow path is highly dependent upon where a potential release actually occurs. Horizontal flow rates are relatively slow due to the relatively less permeable materials in this zone.

Particle tracking analysis indicates that the primary flow paths are vertical into the Lower Tertiary Zone, with very little lateral migration. Travel times to the Lower Tertiary Zone are on the order of 30 years. Once water reaches this zone, particle tracking analysis indicates relatively rapid horizontal flow toward the west to Upper Three Runs Creek and the Savannah River. Total travel times form the NPR site to the edge of the model (approximately 3 miles) is on the order of 50 years. The flow direction of water in the Lower Tertiary Zone is relatively well defined due to the regional extent of the flow system. The Pen Branch Fault does not influence contaminant migration for this particular site because it is in the opposite direction of Lower Tertiary Zone groundwater flow.

1 INTRODUCTION

The United States Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) as a part of the process of developing a new reactor (NPR) to produce special nuclear material. As required by the National Environmental Policy Act (NEPA), the NPR EIS will address the potential environmental consequences (to human health and the environment) of this major federal action. Some of the possible consequences are related to subsurface transport of contaminants and the impacts of using large amounts of subsurface water. Separate quantitative estimates of the potential impacts associated with groundwater and subsurface contamination are required for NEPA for each phase of the proposed project (construction, operation, and decommissioning) as well as for worst case accidents. Additionally, DOE intends to separately quantify the potential impacts of the three proposed reactor designs at the Savannah River Site (SRS) as part of the NPR EIS process. This EIS is being coordinated by Argonne National Laboratory (ANL) for DOE.

1.1 SCOPE OF PROJECT

Westinghouse Savannah River Company and GeoTrans Incorporated formed a team to perform numerical modeling of groundwater flow to evaluate potential hydrogeologic impacts of the NPR. The project was organized into phases: 1) data organization, 2) model construction, and 3) predictive simulations. The first phase of the investigation involved assimilation and interpretation of sitewide geohydrologic data needed for development of a model of the NPR site. New data collected as a part of reactor siting investigations were incorporated into the data base. The second phase involved adapting a previously developed regional groundwater model to fit the needs of this project. The model was then used to establish boundary conditions for a more localized model of the NPR site. The rationale for using two models is discussed in Section 2 of this report. The third phase involved running the models to assess the geohydrologic effects of various phases of the reactor life: construction, operation, and decommissioning. Potential accident scenarios may also be simulated with the model. Note that the scenarios defined by ANL and the specific information in the facility description documents indicate that there are no subsurface impacts (e.g., releases) or differences in water uses for the various phases of reactor life or possible accidents. The available data and guidance from ANL/DOE resulted in the following major assumptions:

1) Differences in water production are not discernable between reactor types or operating periods (a 200 gpm case and 1000 gpm worst case were used).

2) No subsurface source terms are identified for any reactor design, either during operation or accidents. All surface impoundments are lined, and the discharge canal at SRS is to be lined until the water reaches a gaining stream. Thus, issues associated with subsurface contamination will be addressed by evaluating head gradients, flow paths and flow times.

3) Existing reactors, fuel fabrication, chemical separation facilities, waste disposal facilities, and high level radioactive waste processing will continue to operate. Subsurface modeling of past waste disposal areas, existing waste disposal facilities, high level radioactive waste processing

has already been addressed in prior NEPA documentation. Additionally, the mix of reactor and support facilities will be operated to meet the national tritium goal. Because the support facilities for the various cases are operating at similar capacity for similar processes, and because NEPA for the waste management systems has been performed, subsurface modeling for this EIS is focused on the reactor area.

1.2 ISSUES ADDRESSED

Three primary issues are addressed by the modeling analysis: 1) groundwater availability, 2) changes in vertical hydraulic gradients as a result of groundwater pumpage, and 3) migration of potential contaminants from the NPR site.

Although the EIS deals with three types of nuclear reactors and must address three phases of reactor life, review of the reactor facility and support facility documents (EG&G, 1989; WHC, 1989; WSRC, 1989; ANL, 1989) indicate that the groundwater requirements for each type and phase are very similar. Therefore, the maximum quantity required, 1000 gpm, was simulated as a worst case scenario. A 200 gpm scenario was simulated to bound the possible range of groundwater use. Groundwater usage is generally low because surface water will be used for cooling purposes. The analysis of groundwater availability focused on regional drawdown effects resulting from the new withdrawals of the NPR. Effects on the productivity of wells off-site and at other SRS facilities was assessed using a regional model of the entire SRS.

An important aspect of the SRS groundwater flow system is a "head reversal," or area of upward flow from the deep water production aquifers into the shallower water bearing zones. This area is in the central part of the site adjacent to the Savannah River and Upper Three Runs Creek where deep incisement of Upper Three Runs has caused development of a lower head in overlying water bearing zones, resulting in upward leakage from the lower aquifers. Maintenance of the upward flow is desirable at SRS because it provides a naturally induced means of protection for the regionally extensive lower aquifers. Changes in vertical gradients resulting from the 200 gpm and 1000 gpm pumpage scenarios were assessed using the regional model. Localized changes in vertical hydraulic gradients near the NPR are also important, because, if significant, could cause a greater potential for contaminant migration.

Although the facility and facility support documents indicate that contaminant releases to the groundwater system were not selected as reasonable accident scenarios, there is a need to assess pathways of migration for contaminants. Directions of potential contaminant migration can be inferred from hydraulic head data and by interpretation of modeled results. This analysis was performed using the local NPR site model. Further quantification of particle trajectories, transit times, and receptors was obtained by application of a particle tracking program.

1.3 CONCEPTUAL DESCRIPTION OF SRS GROUNDWATER SYSTEM

The direction and rate of groundwater flow in a hydrologic system is governed by the hydrologic boundaries of the system (i.e., where water enters and leaves the system), and the nature of the subsurface materials, (i.e., hydraulic conductivity, heterogeneity, etc.). The resulting hydraulic heads and hydraulic gradients indicate the flow direction. Characterization of the subsurface materials and mathematical modeling allow estimation of flow rates and the potential for contaminant transport. A conceptual description of the groundwater system beneath SRS based on water level measurements in 1988 (Looney et al., 1990) is provided below to assist in understanding the models developed later. The maps are similar to those developed based on water level measurements from 1986 -1988 (Haselow et al., 1988) to support the Reactor Operations EIS. DOE (1989) develops a more complete description of the affected environment for the NPR EIS.

There are several water bearing zones beneath SRS that are separated by less permeable aquitards. Site streams and the Savannah River incise the various layers and serve as hydrologic boundaries. Water enters the system through recharge and flows downward and toward the streams in shallow zones and toward the Savannah River in deeper zones. The fact that each layer may be governed by a different hydrologic boundary results in different flow directions in the various units. Deep zones flow toward the Savannah River, the Lower Tertiary Zone flows toward Upper Three Runs Creek and the Savannah River, and the Water Table Zone flows in a complex pattern toward many site streams and rivers.

Potentiometric maps for the deep Cretaceous Aquifers are shown in Figures 1.1 and 1.2. In the Upper Cretaceous Aquifer, flow is predominantly toward the Savannah River, indicating that water flow into the river along the site boundary is the controlling hydrogeologic feature. Geologic and modeling studies suggest that relatively coarse grained sediments incise the aquitards in the vicinity of the Savannah River and provide a pathway between the Upper Cretaceous Aquifer and the river. Flow in the Lower Cretaceous Aquifer is generally toward the Savannah River, but diverges toward the west near the site boundary. This suggests that the hydrologic connection between the Savannah River and the Lower Cretaceous Aquifer is somewhat upstream of the site.

Figure 1.3 shows the potentiometric surface for the Lower Tertiary Zone. In the northwestern portion of the site, flow is toward Upper Three Runs Creek as exemplified by the equipotential lines curving around this feature. This flow is expected because Upper Three Runs Creek incises the Lower Tertiary Zone and acts as a drain. In the southern portion of SRS, flow in this zone is toward the Savannah River.

Figure 1.4 is a potential difference map between the Upper Cretaceous Aquifer and the Lower Tertiary Zone. In some areas, this gradient is upward because of the influence of Upper Three Runs Creek on the shallower zone. This head reversal prevents water from moving downward in those areas except in the immediate vicinity of high volume pumping wells tapping the deeper formation.

Flow in the Water Table Zone in the vicinity of the NPR reference site at SRS is toward local streams surrounding the site and downward into the Lower Tertiary Zone. A detailed Water Table map for the reference site area is presented in Figure 1.5.

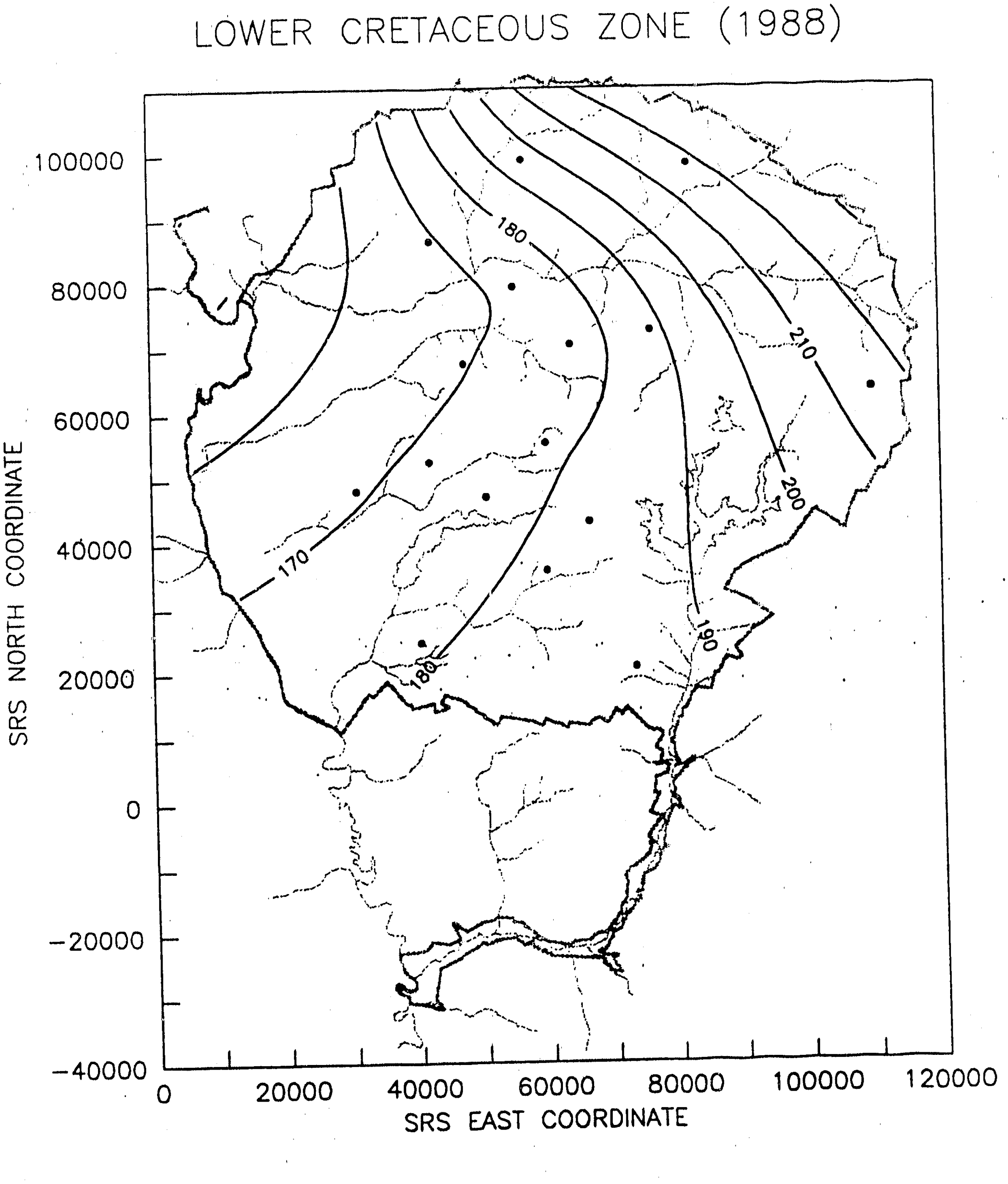

Figure 1.1. Potentiometric map for the Lower Cretaceous Aquifer; Elevations in feet above msl.

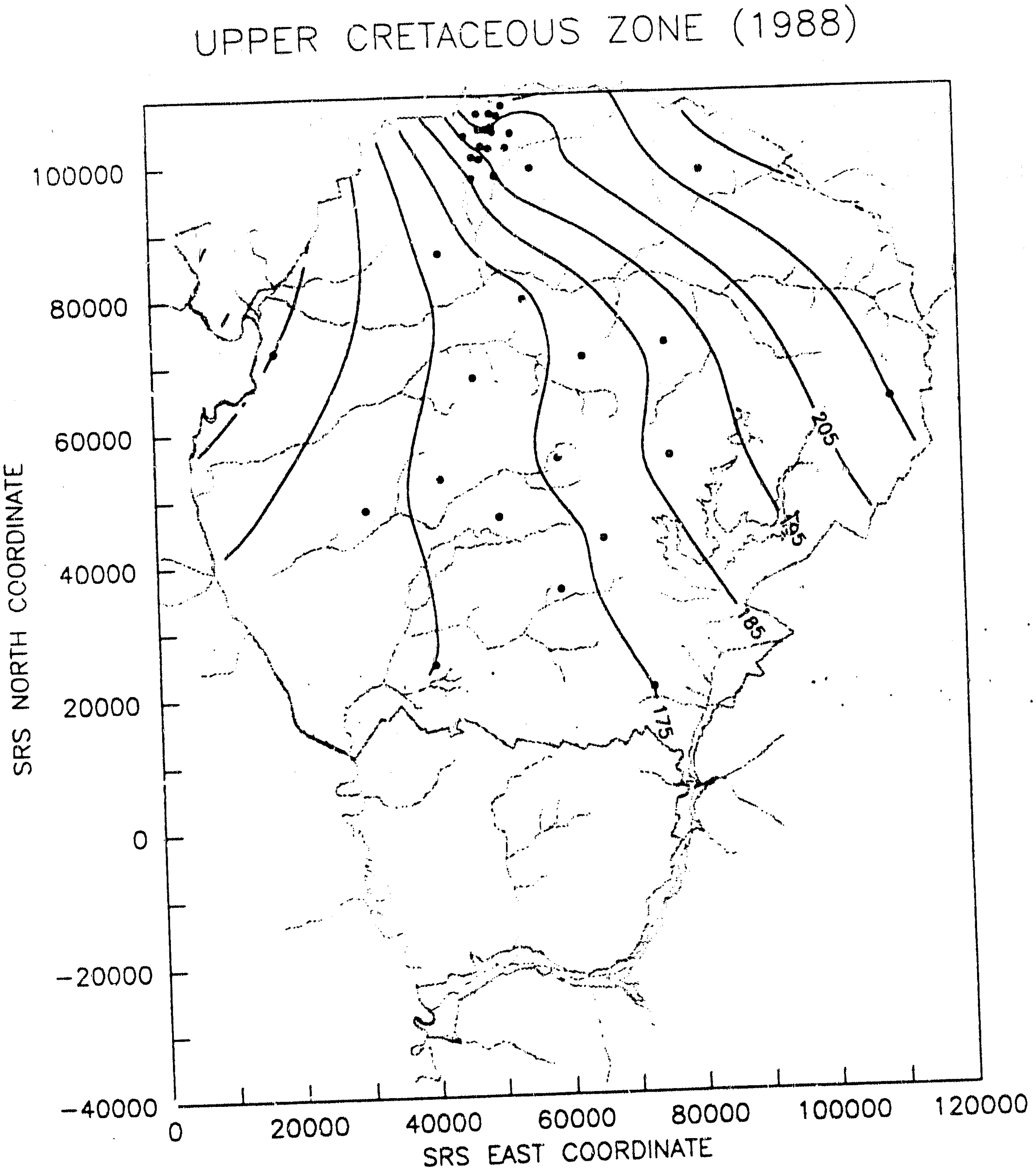

Figure 1.2. Potentiometric map for the Upper Cretaceous Aquifer; Elevations in feet above msl.

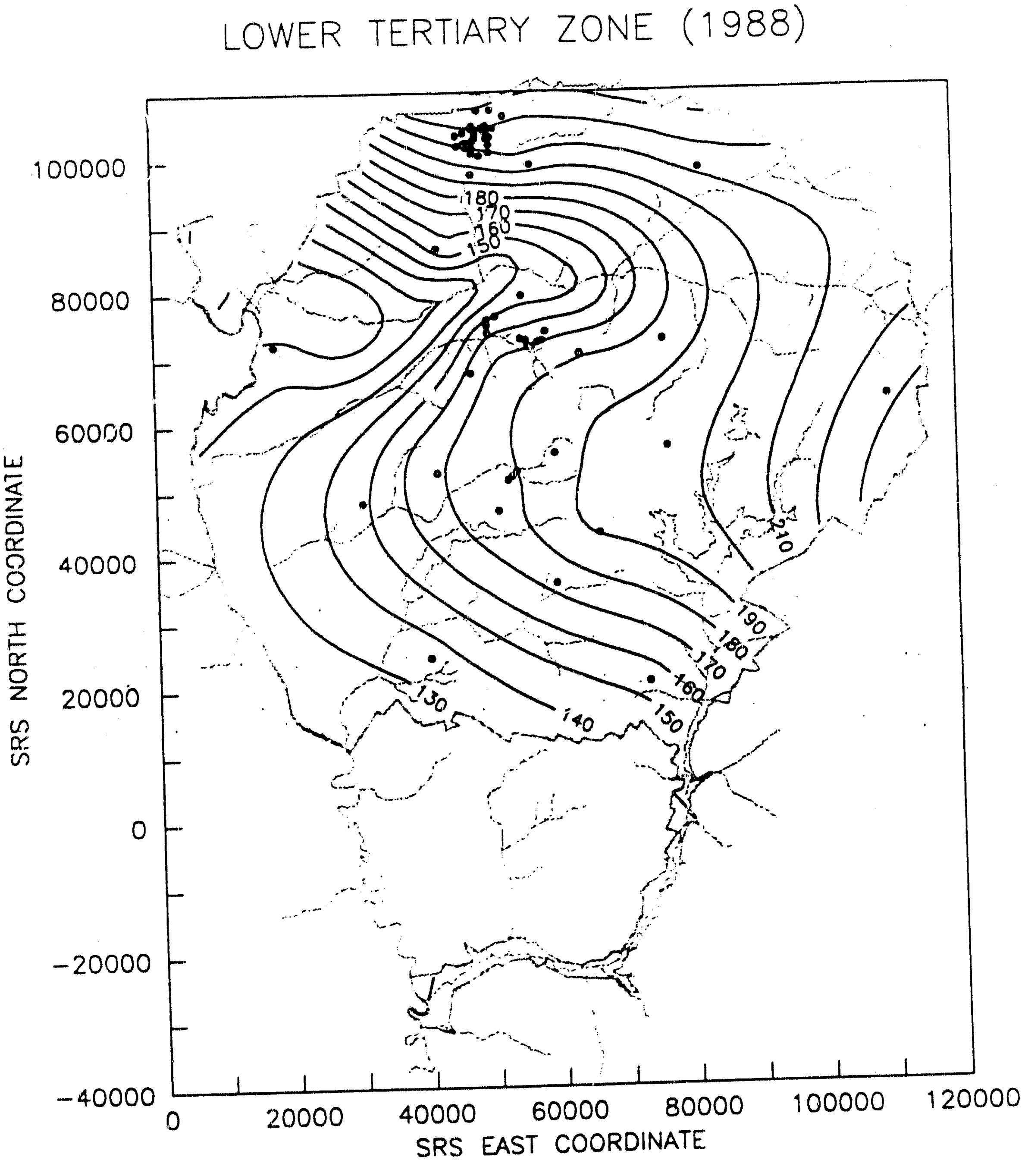

Figure 1.3. Potentiometric map for the Lower Tertiary Zone; Elevations in feet above msl.

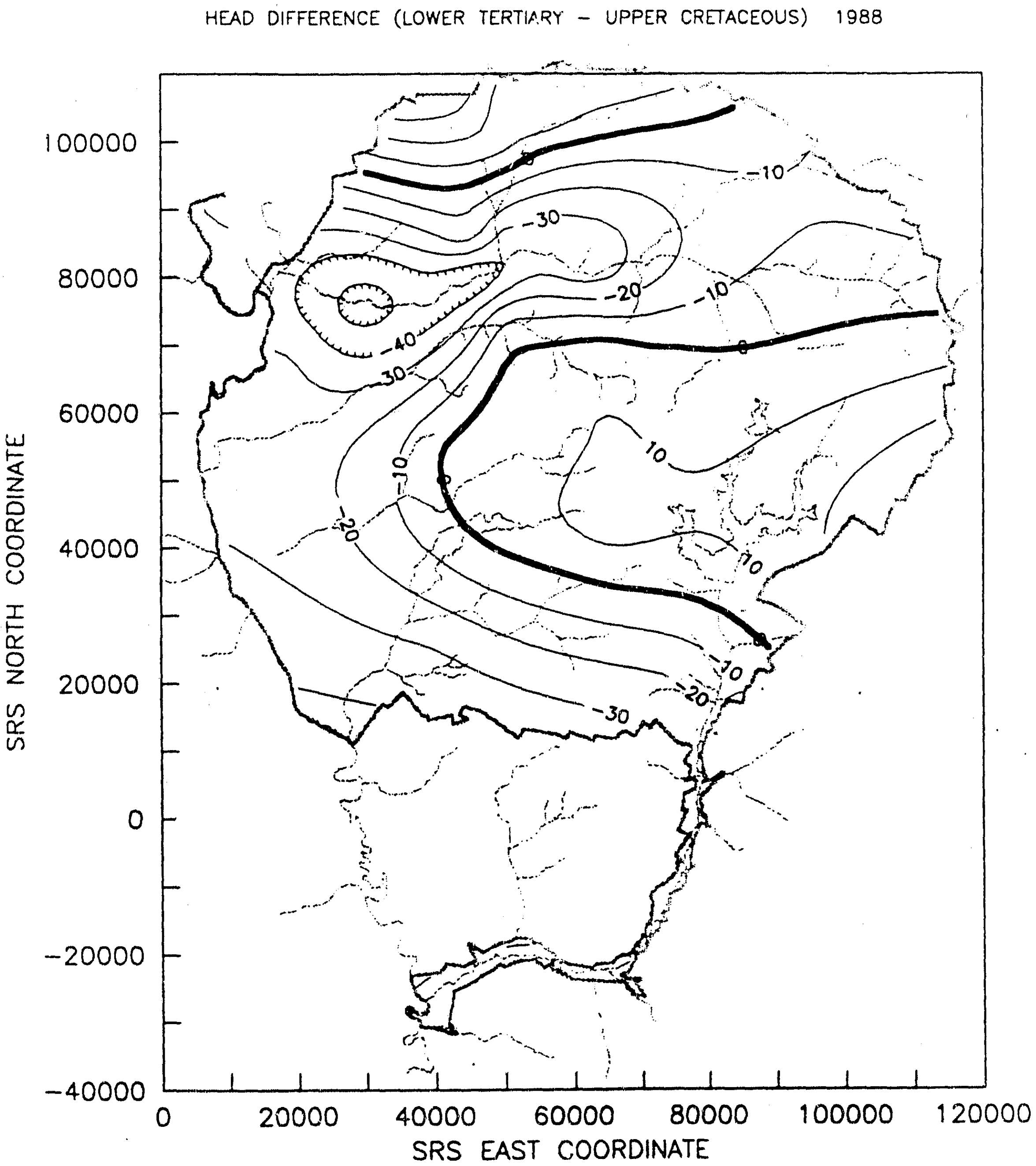

Figure 1.4. Potential difference map between the Lower Tertiary Zone and the Upper Cretaceous Aquifer; Head difference in feet. Negative values indicate the area of upward flow from the Cretaceous Aquifers into shallower zones.

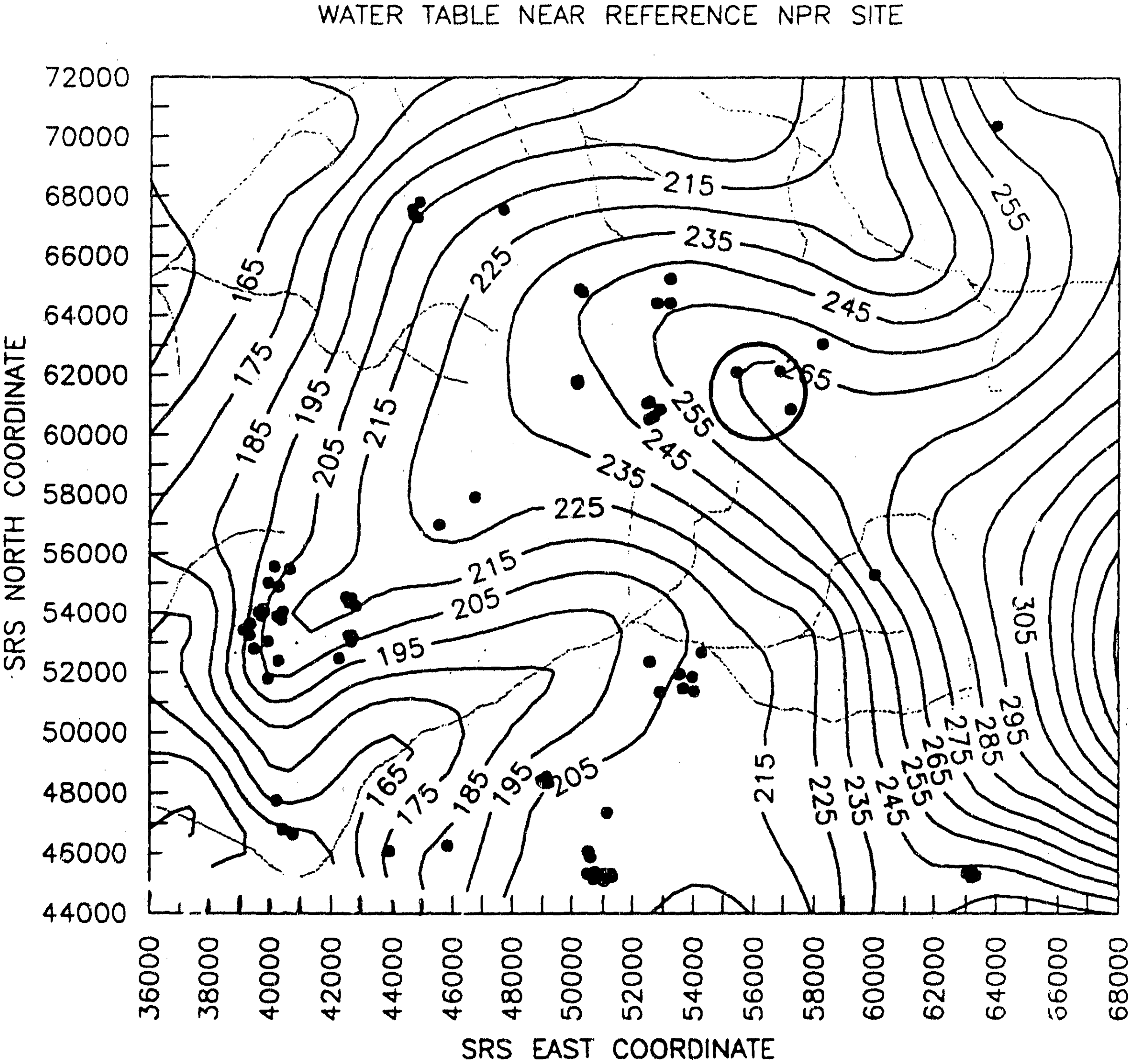

Figure 1.5. Water Table Map in the Vicinity of the New Production Reactor Reference Site; Elevations in feet above msl.

2 DESCRIPTION OF MODELS

The NPR reference site is shown in Figure 2.1. Also shown in this figure is the coverage of the two models used in this investigation. The models are described in the following sections.

2.1 REGIONAL SITEWIDE MODEL

A numerical model of the hydrogeological system underlying the Savannah River Site was developed as part of a comprehensive hydrogeological study by GeoTrans in 1989 (Andersen et al. 1989a). The model was based on existing data and incorporated currently held theories regarding the nature of the hydrostratigraphic units. The data and interpretations generally correspond to those of DOE (1989).

The modeled area covers approximately 500 square miles areally and extends vertically from the water table to bedrock. Where possible, the model uses permanent hydrologic features such as aquifer outcrops, large surface water bodies, and impermeable bedrock for boundary conditions. Elsewhere, hydrologic conditions such as flow lines, equipotentials, and groundwater divides are used for boundary conditions.

A finite-difference groundwater code was used to model the site. The code, FTWORK, has been documented (Faust, et al. 1989), benchmarked (GeoTrans, 1988a), and field tested for a number of applications including investigations at the Savannah River Site (GeoTrans, 1988b, GeoTrans, 1988c, GeoTrans, 1989). Sims, et al., (1989) describes the testing and benchmarking of FTWORK. The code is currently in the DOE review process for release to the public domain.

For input to the code, the modeled area was discretized into a uniformly spaced 30 by 30 finite difference grid. Each model cell measured 4000 ft on a side. Vertically, the model area was divided into six layers of non-uniform thickness. A cross-section, running north-south through the central part of SRS, is shown in Figure 2.2. Aquifers as well as major aquitards are included as layers in the model in order that transient effects and particle transit distances can be quantified. The various layers correspond to the Affected Environment Description written by DOE (1989) as follows: Aquifer 1 is the Lower Cretaceous Aquifer, Aquitard 1 is the Cretaceous Confining Unit, Aquifer 2 is the Upper Cretaceous Aquifer, Aquitard 2 is the Principle Confining Unit, Aquifer 3 is the Lower Tertiary Zone, and Aquifer 4 is the Water Table.

The sitewide model was calibrated by matching modeled hydraulic heads to observed water-levels at various points in the hydrogeologic system. A total of 67 calibration points were used, and included well clusters for which vertical hydraulic head data were available. The sitewide model generally matches observed flow directions, discharge and recharge relationships. This observation, as well as the uniqueness of vertical head profiles in the cluster wells, indicates that the factors and conditions considered in the model are key elements of the hydrogeologic system. Comparison of observed and calculated hydraulic heads indicates that the best match is obtained in the Cretaceous aquifers. This is a function of the coarseness of the model grid and lack of detailed characterization of the water-table aquifer.

The numerical model developed during the study serves as an important benchmark in understanding the hydrogeologic system underlying the Savannah River Site. The model is used in the current study to assess the regional effect of groundwater withdrawals resulting from the NPR and to generate boundary conditions for a site-specific local model of the NPR reference site.

2.2 LOCAL NPR SITE MODEL

Although the sitewide model is capable of addressing many of the regional groundwater issues, it is of limited utility for addressing issues pertaining to the local area near the NPR. These limitations result primarily from the coarse discretization used in the sitewide model. The 4000 ft grid spacing does not provide the resolution required to assess horizontal and vertical hydraulic gradients within the immediate area of the NPR. It was noted during the calibration of the sitewide model that the accuracy of the model is greatest in the lower layers. This is because the discretization is adequate for characterizing flow in the lower regional aquifers but not fine enough to accurately characterize the localized groundwater systems that are strongly influenced by topography and stream incisement. It was therefore necessary to develop a smaller scale, fine resolution model of the local area near the NPR to address local issues. The local model incorporates new data collected as a part of the siting investigation and local data that were not representative of conditions for the sitewide model (Andersen et al., 1989b)

The NPR model includes the area between Four Mile Creek and Pen Branch as shown in Figure 2.3. These hydrologic features, as well as the groundwater divide east of the NPR reference site, offer convenient boundary conditions for the water-table aquifer. Boundary conditions for the lower layers are based on equipotentials and streamlines as derived from the sitewide model. The model grid was rotated approximately 45° from that of the sitewide model in order to align with principal flow directions, to align with the strike of a fault running through the modeled area, to correspond to surface water features, and to take advantage of streamlines and equipotentials for boundary conditions in the lower layers. The alignment of the grid corresponds to the alignment of the SRS coordinate system.

Areally the grid spacing varies from 300 ft to 2000 ft. Fine grid spacing is used in the vicinity of the reference site, near hydrologic and geologic features, and in areas of expected steep hydraulic gradients. Coarse spacing is used at the model perimeter. Vertically the model includes the six layers used in the sitewide model. Layer thicknesses were interpolated from data used in the sitewide model.

Boundary conditions for the water-table aquifer (Aquifer 4) are shown in Figure 2.4. Specified head conditions derived from stream elevations on a topographic map were assigned to major surface water features: Four Mile Creek to the north and northwest, Pen Branch to the southeast, and Indian Grave Branch to the southwest. Several tributaries were also assigned specified head conditions. A head dependent flux condition, or drain, was assigned to the headwaters of most streams. This allowed greater control over the effect of the stream than did the specified head condition. To the northeast, a no-flow conditions was assigned to represent the groundwater divide. A specified flux of 15 in/yr, representing precipitation recharge, was assigned to all nodes of the water-table aquifer. A vertical conductance term representing the "Green Clay" and other localized clay units is used to connect the water table aquifer to the Lower Tertiary Zone.

Boundary conditions for the Lower Tertiary Zone are shown in Figure 2.5. Specified heads interpolated from a potentiometric surface map constructed from site specific data are assigned on three sides of the model grid. A no-flow condition is assigned on the southeast side to represent a flowline.

Placement of boundary conditions for all layers below the Lower Tertiary Zone is identical. Specified head conditions, corresponding to equipotentials, are used on the northeast and southwest sides. Because the grid aligns with flow directions, no-flow conditions representing flow-lines, are used on the other two sides. The Principle Confining Unit is explicitly modeled. Boundary conditions and observation points for the Upper Cretaceous Aquifer and Lower Cretaceous Aquifer are shown in Figures 2.6 and 2.7, respectively. In all cases, hydraulic head values are interpolated from the sitewide model. An individual layer, Aquitard 1, separates the Upper and Lower Cretaceous Aquifers.

Because the purpose of the NPR model is to improve the characterization of the water-table aquifer and Lower Tertiary Zone, calibration of the model involved adjustment of those parameters affecting the water-table configuration and Lower Tertiary Zone potentiometric surface. The characterization of flow in the lower aquifers from the sitewide model was assumed valid. Therefore, no adjustments were made to parameters in layers beneath the Lower Tertiary Zone, boundary heads and hydrologic parameters were used directly from the sitewide model.

Twenty-seven locations were chosen as calibration targets for the water-table aquifer (see Figure 2.4). More potential targets were identified, however, their proximity to model boundary conditions eliminated them from consideration. In some areas several wells were located within the same grid block. In this instance the average of water-levels was used. Generally good coverage across the model area was attained with the twenty-seven targets. During the calibration procedure, adjustments were made to the hydraulic conductivity of the water-table and the Lower Tertiary Zone and leakance of the intervening confining bed. Shown in Figure 2.8 is the modeled potentiometric surface of the water-table aquifer. Also shown in the figure are model residuals for each calibration target. Generally the match is quite good, particularly near the NPR reference site. Zonation of hydraulic conductivity could result in a better match between modeled and observed, however, further adjustment of parameters is unjustified given the limited data base.

Thirteen locations were chosen as calibration targets for the Lower Tertiary Zone as shown in Figure 2.5. Coverage of the model area is generally good, except in the western (upper left) corner of the model. Shown in Figure 2.9 is the modeled potentiometric surface of the Lower Tertiary Zone. Model residuals at the thirteen calibration targets are also shown. The match is generally good, particularly beneath the NPR site. Some discrepancy on the northeastern side is present but is upgradient of the NPR and does not effect conclusions drawn from the modeling.

Calibration statistics and model residuals are given in Table 2.1. Inspection of the table indicates that model residuals are generally within ±5 feet of observed. The small mean residual (-0.10083) indicates minimal bias in model errors.

Modeled potentiometric surface maps for the Upper and Lower Cretaceous Aquifers are given in Figures 2.10 and 2.11, respectively. Also shown on these figures are observed hydraulic heads at various wells. Comparison of modeled to observed heads in these aquifers is also generally good. Some discrepancies may be due to observation well test. It does appear, however, that the fault would only affect water-levels locally and does not have regional significance on water-levels.placement. In the coarsely gridded sitewide model, calibration targets are probably within ± 2000 ft of actual. Well placement is much more accurate in the local model.

Aquifer parameters used in the model are given in Table 2.2. Note that the hydraulic conductivity of the water-table aquifer and leakance of the underlying confining bed are in general agreement with values obtained from calibration of models of the General Separations Area (Duffield, et al. 1986).

The Pen Branch Fault is a northeast-southwest trending growth fault located along the northwest border of the Dunbarton Basin. Within the SRS boundaries, the fault trends northeast along the central portion of the plant striking from N45E to N65E (Snipes et al. 1989). It is believed that movement along the fault began in the late Triassic, and sediments of Cretaceous, Paleocene, and Eocene age have been cut by the fault. Locally, the throw of the Pen Branch Fault decreases from about 100 - 120 ft at the base of the Cretaceous to about 20 ft at the base of the upper Eocene Dry Branch Formation. The hydrogeologic significance of the fault was tested using a series of sensitivity simulations. The fault was incorporated into the model by specifying a zone of high vertical hydraulic conductivity in each of the aquitards in the area cut by the fault. Due to model discretization, this zone was one grid block, or generally 300 ft, wide. Vertical hydraulic conductivities of twice the original value and one order of magnitude greater than the original value were tested in the sensitivity analysis. The simulations indicate that there is little effect in all layers except the water-table aquifer. Hydraulic heads decrease locally by approximately 20 ft for the order of magnitude increase in hydraulic conductivity (Figure 2.12). Inclusion of the fault generally worsens the calibration of the model within the water-table, particularly near K area. The effects are not as significant in the other layers due to higher transmissivities which damp out the source/sink effect of the fault. The hydrologic effect of the fault cannot be determined given the lack of a dense water-level monitoring network or direct groundwater flow data such as a tracer test. It does appear, however, that the fault only affects water levels locally, and does not have regional significance on water levels.

Table 2.1. Calibration statistics for the NPR site model.

NODE ID	I	J	K	OBSERVED	CALCULATED	RESIDUAL
KAB 2	5	29	1	214.86	210.72	4.14
P25D	7	29	1	210.17	214.57	-4.40
T18N-1	11	19	1	230.30	237.44	-7.14
T18N-2	13	18	1	232.13	243.33	-11.2
P18D	14	5	1	219.21	229.94	-10.7
LRP 1-4	16	32	1	206.80	211.01	-4.21
P15D	18	33	1	227.26	217.90	9.36
M12-3	25	13	1	261.75	259.86	1.89
M12-1	27	13	1	270.98	260.17	10.8
M12-4	27	14	1	269.82	261.86	7.96
M12-2	29	11	1	259.28	254.74	4.54
P27D	34	2	1	265.29	256.32	8.97
KAB3	4	30	1	207.85	203.43	4.42
KAB4	4	29	1	207.81	206.18	1.63
KAC 1-7	8	28	1	217.13	219.23	-2.10
KRP 1-2	8	26	1	217.32	221.36	-4.04
KRP 3-4	8	27	1	216.75	220.92	-4.17
KDB 1-3	5	27	1	209.67	210.92	-1.25
KAB1,KCB 1	4	28	1	208.05	206.75	1.30
KSB1-4A	4	27	1	206.66	205.67	0.995
KRB 14-15	5	23	1	204.81	204.06	0.754
KRB 13	4	24	1	206.08	199.82	6.26
KRB 1	4	25	1	208.14	201.92	6.22
KRB 8	5	25	1	209.84	207.73	2.11
KSS 1D	5	33	1	170.91	174.80	-3.89
T18 S1	9	34	1	178.49	180.71	-2.22
CSA 1	17	13	1	246.80	252.33	-5.53
P25A	7	29	2	171.40	163.42	7.98
T18S-1A	9	34	2	170.58	165.78	4.80
T18N-1A	11	19	2	173.71	168.25	5.46
P18B	14	5	2	167.85	162.18	5.67
M12-1A	27	13	2	184.19	185.10	-0.907
CMP-8A	23	29	2	181.17	185.67	-4.50
P19A	32	24	2	185.79	191.64	-5.85
P27B	34	2	2	178.92	178.18	0.740
P15B	19	33	2	176.88	181.17	-4.29
LAW-3B	20	34	2	174.77	182.62	-7.85
LAW-2B	17	34	2	172.72	178.01	-5.29
LAW-1C	18	35	2	173.28	179.48	-6.20
CMP-5A,12A	21	30	2	179.40	183.69	-4.29

NUMBER OF OBSERVATIONS = 40

RESIDUAL SUM OF SQUARES = 1286.1
RESIDUAL MEAN = -0.10083
RESIDUAL VARIANCE = 32.976

Table 2.2. Aquifer parameters used in the NPR site model.

Model Layer	Horizontal Hydraulic Conductivity (ft/d)	Thickness (ft)	Transmissivity (ft^2/d)	Vertical Hydraulic Conductivity (ft/d)
Lower Cretaceous Aquifer (Aquifer 1)	81.7	100-160	8200-13120	8.17
Cretaceous Confining Unit (Aquitard 1)	2.2	110-215	242-473	0.022
Upper Cretaceous Aquifer (Aquifer 2)	40.0	130-200	5200-8000	4.0
Principal Confining Unit (Aquitard 2)	0.075	125-185	10-15	7.5×10^{-4}
Lower Tertiary Zone (Aquifer 3)	130.0	60-160	7800-20800	13.0
Water-Table Aquifer (Aquifer 4)	2.77	20-230	40-460	3.856×10^{-5}*

*A leakance term (k/b) is specified for the water-table aquifer

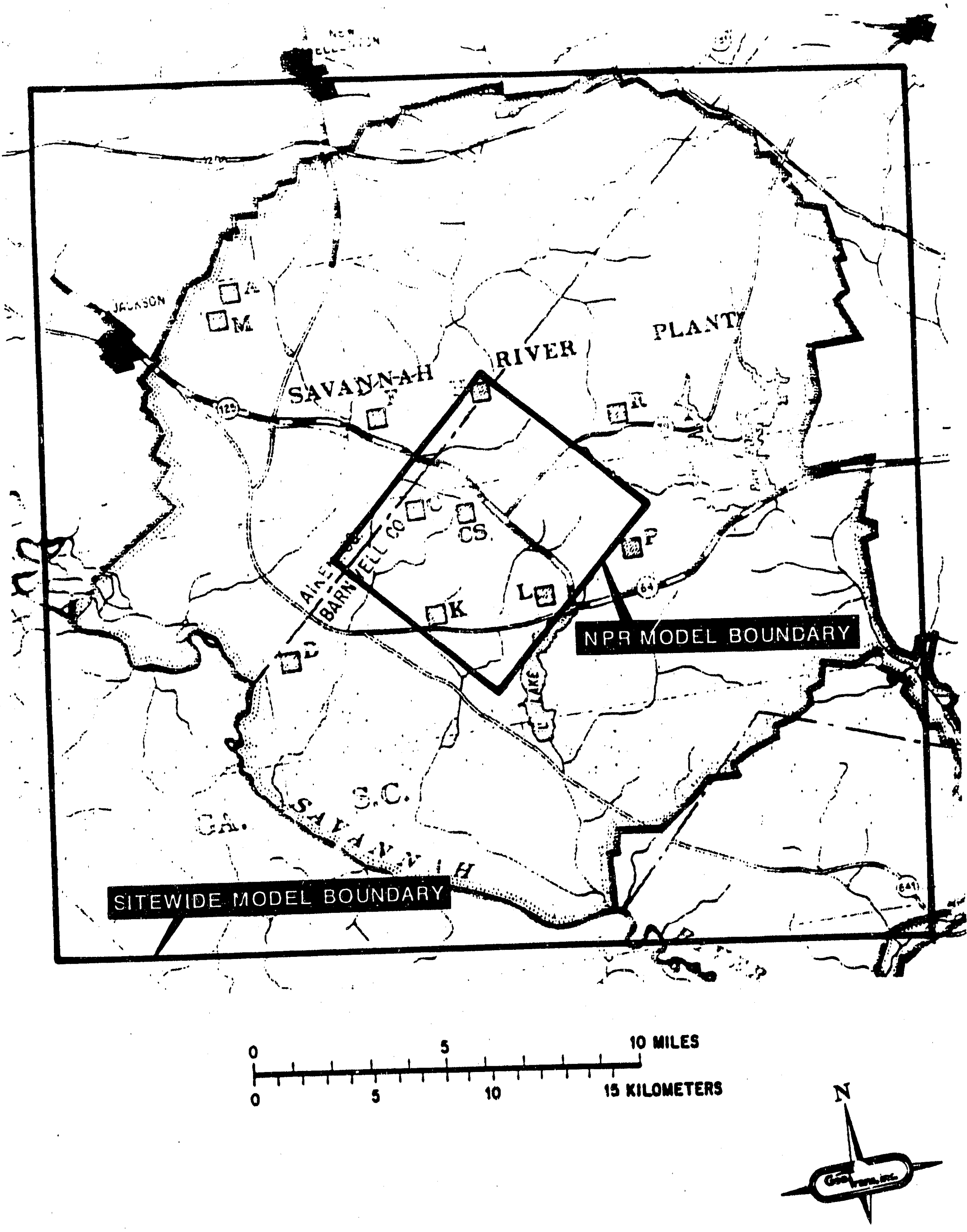

Figure 2.1. Site location map showing the NPR reference site and coverage of the regional and local models.

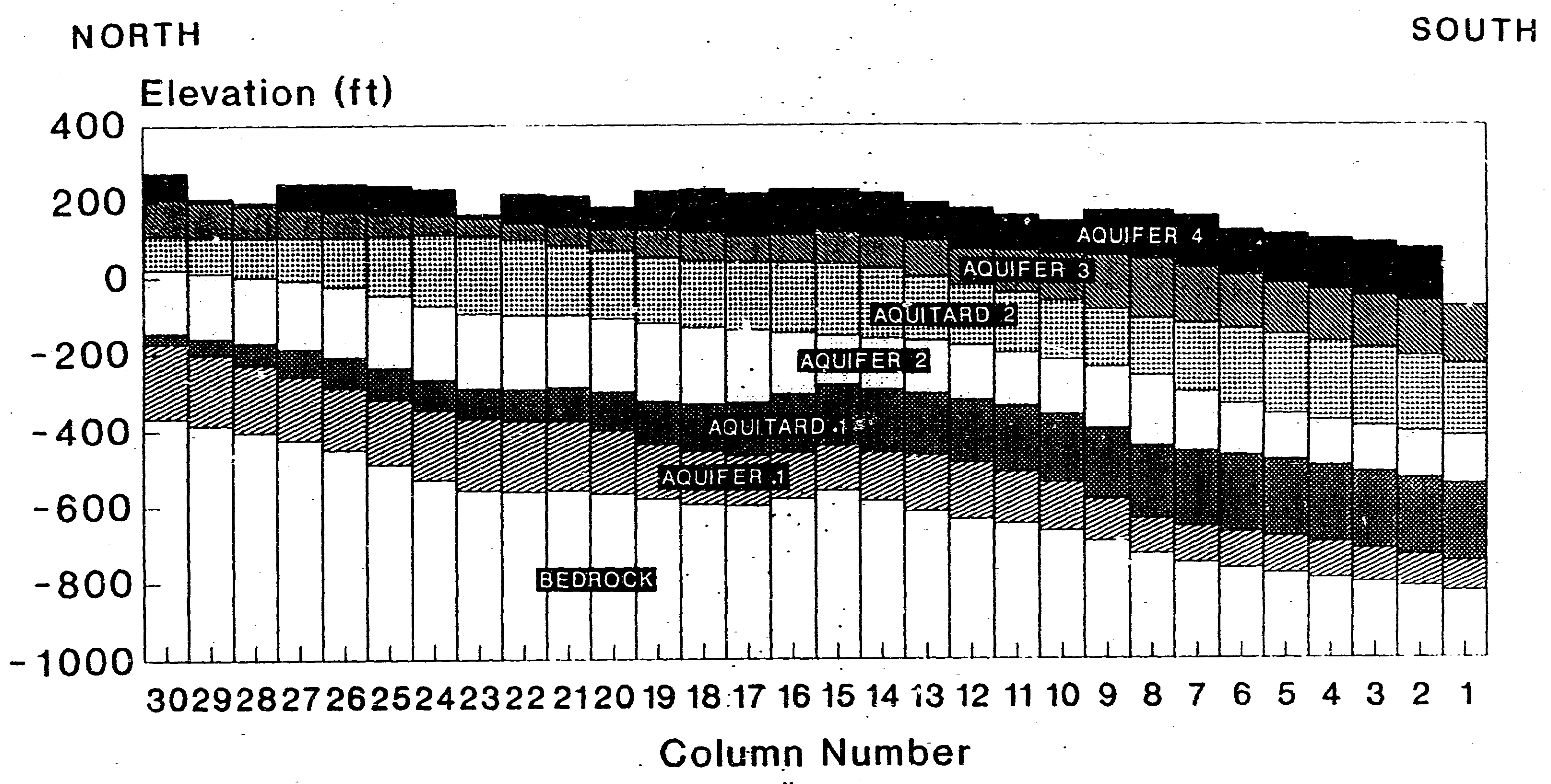

Figure 2.2. Configuration of model layers for the regional and local models. The vertical section corresponds to the N-S line along row 15 of the regional model.

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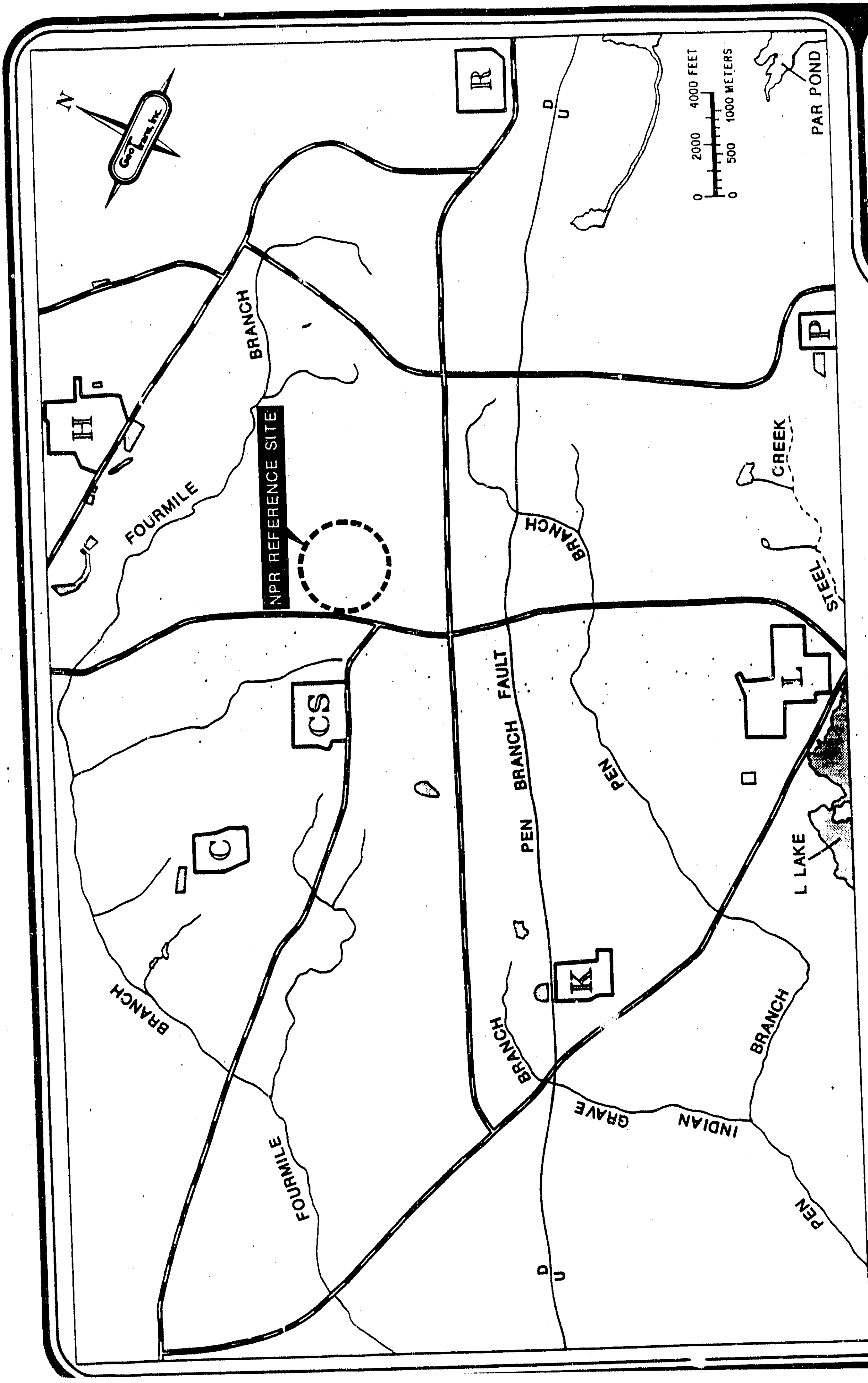

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Figure 2.3. Site map showing the location of the proposed NPR facilities and various hydrologic features.

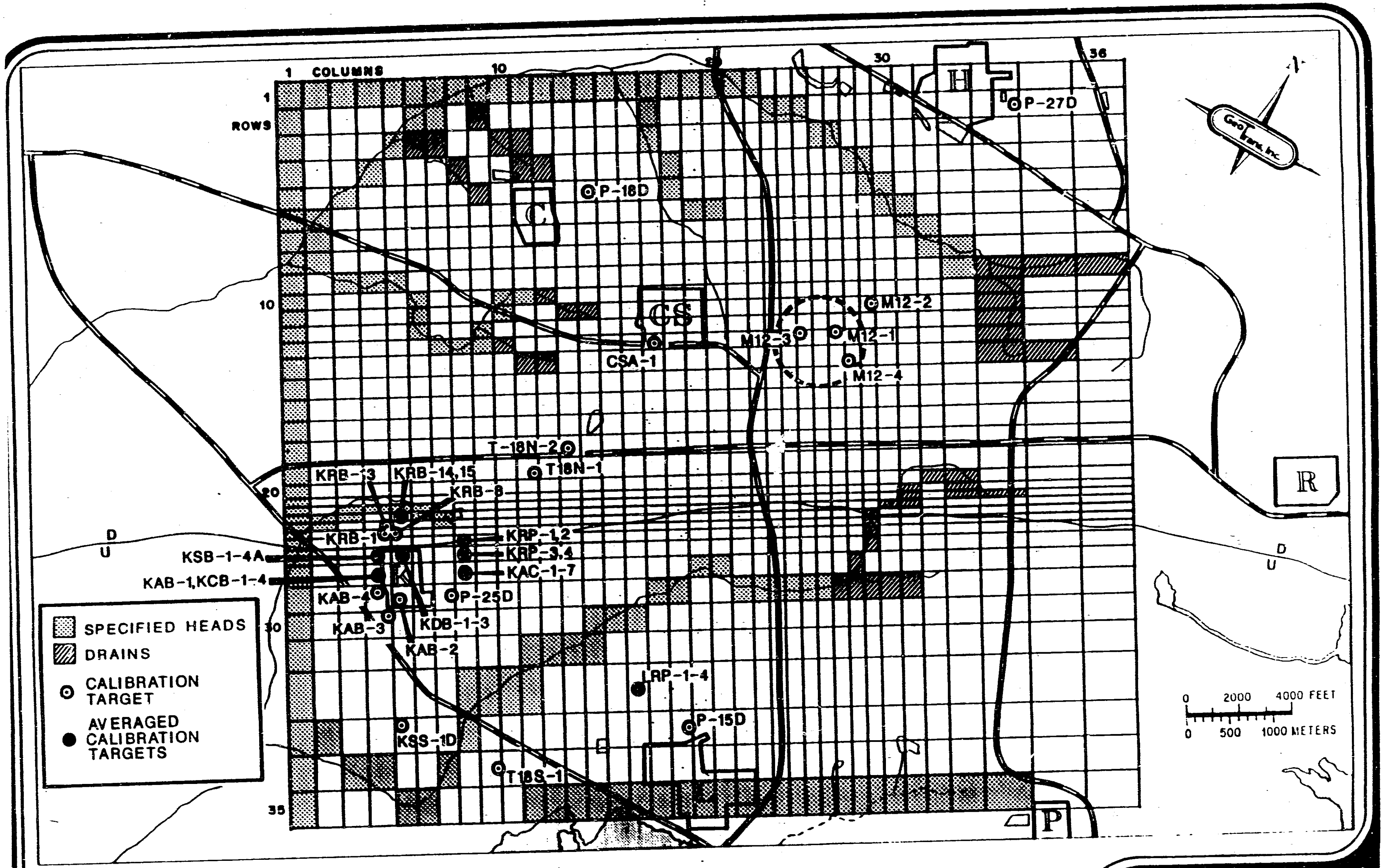

Figure 2.4. Finite difference grid for the local model showing boundary conditions and calibration targets in the water-table aquifer (Aquifer 4).

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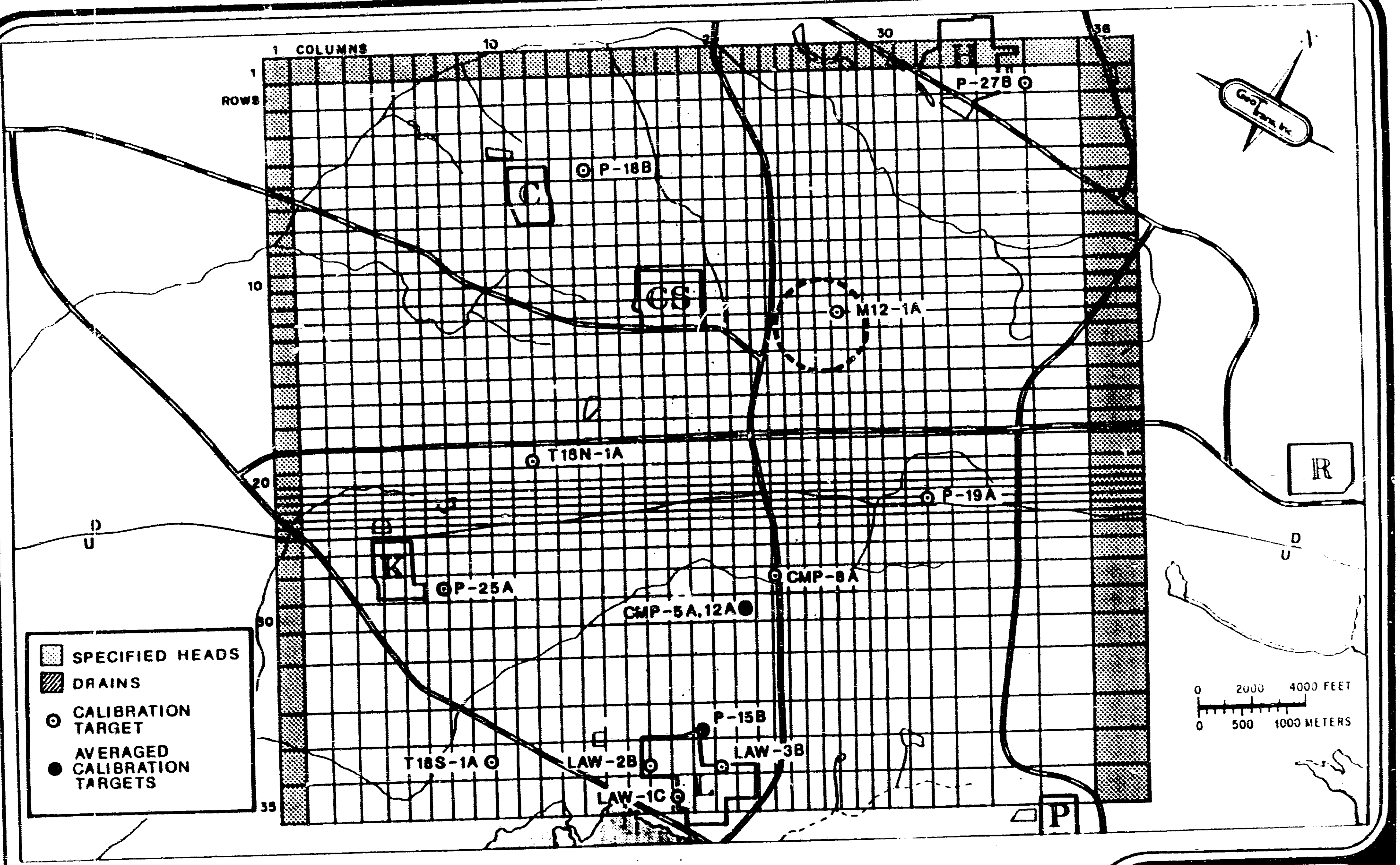

Figure 2.5. Finite difference grid for the local model showing boundary conditions and calibration targets in the Lower Tertiary Zone (Aquifer 3).

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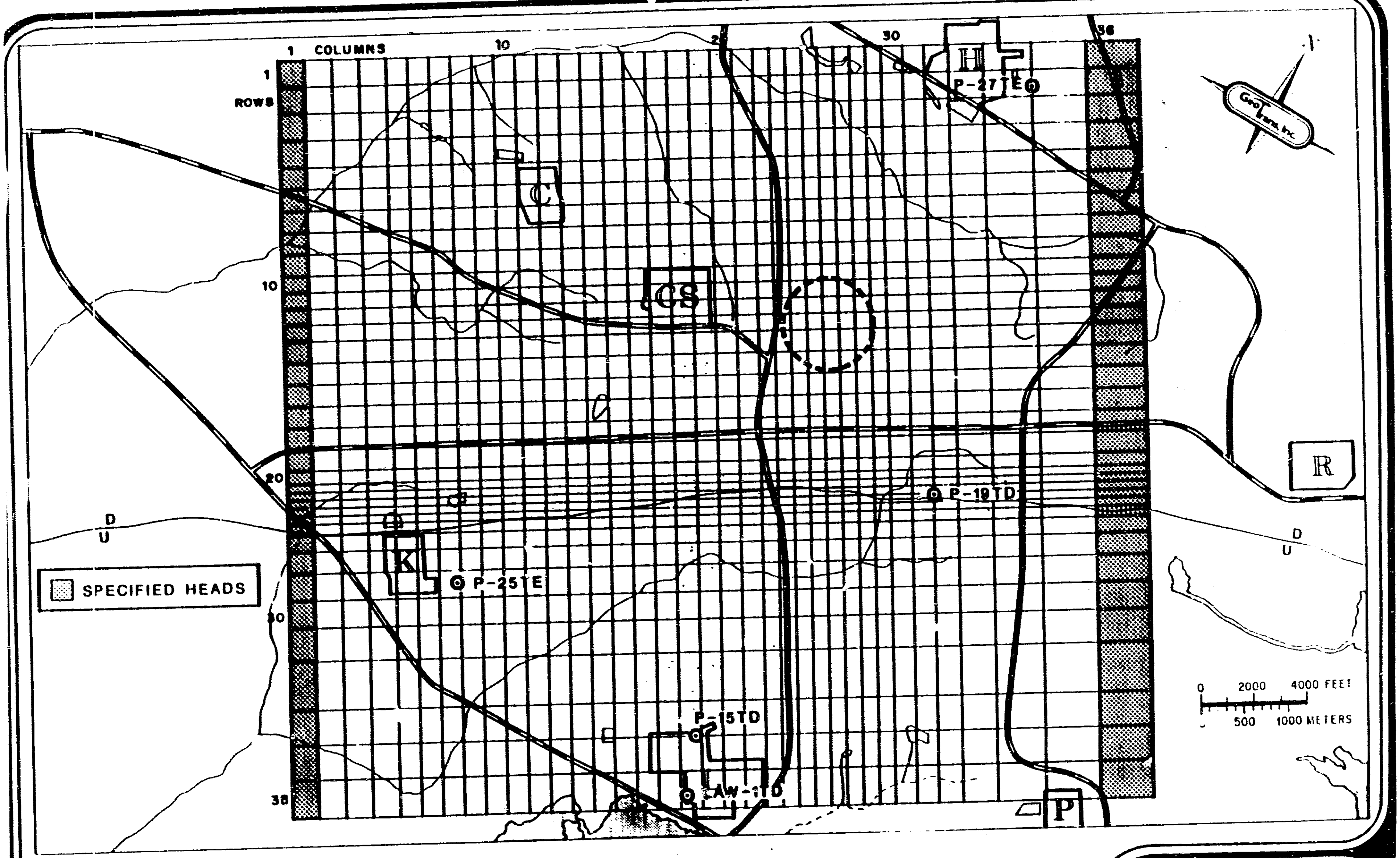

Figure 2.6. Finite difference grid showing boundary conditions and observation points in the Upper Cretaceous Aquifer (Aquifer 2).

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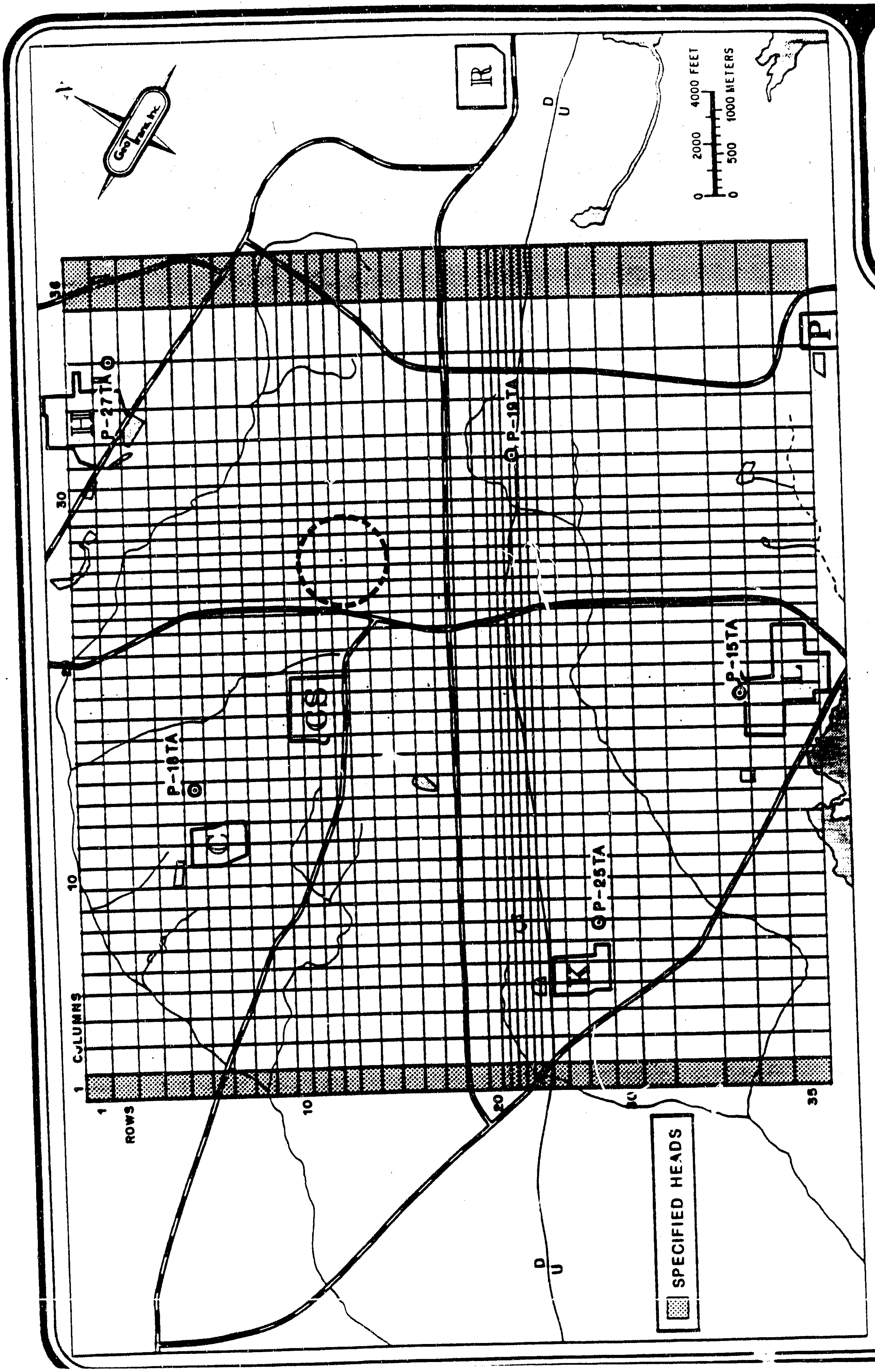

Figure 2.7. Finite difference grid showing boundary conditions and observation points in the Lower Cretaceous Aquifer (Aquifer 1).

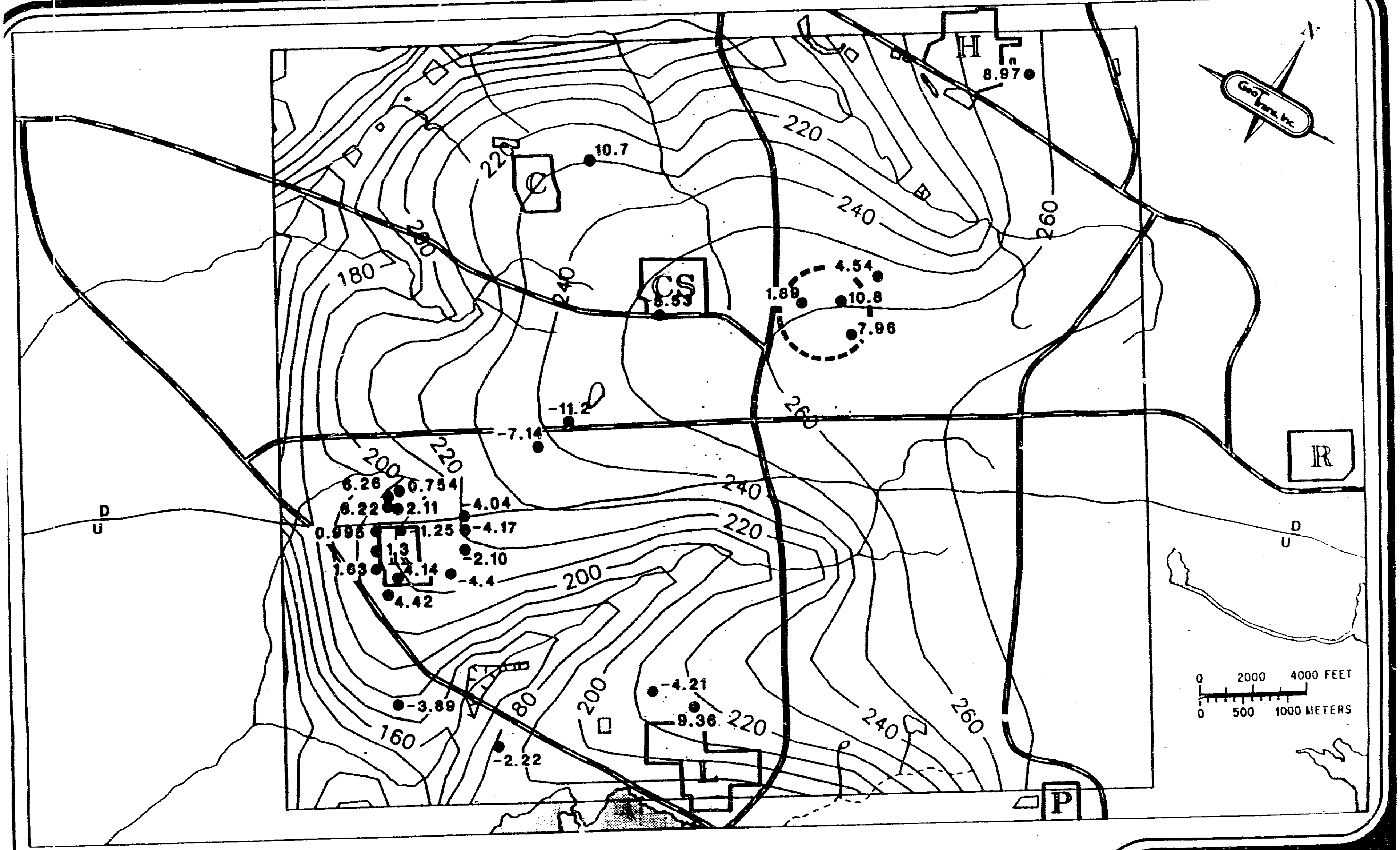

Figure 2.8. Modeled hydraulic heads (ft, msl) for the water-table aquifer (Aquifer 4). Model residuals (observed - modeled) are shown at calibration points.

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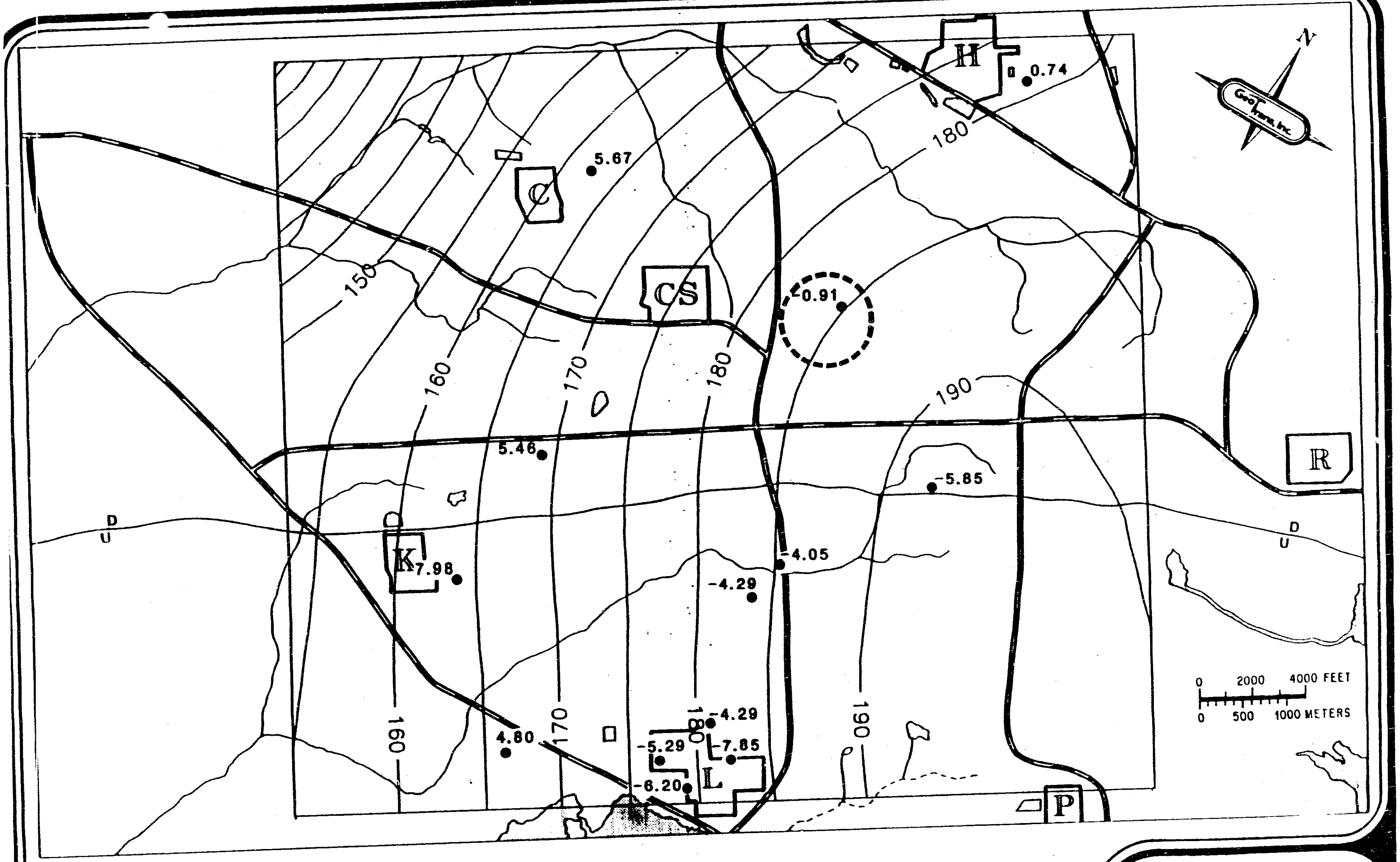

Figure 2.9. Modeled hydraulic heads (ft, msl) for the Lower Tertiary Zone (Aquifer 3). Model residuals are shown at calibration points.

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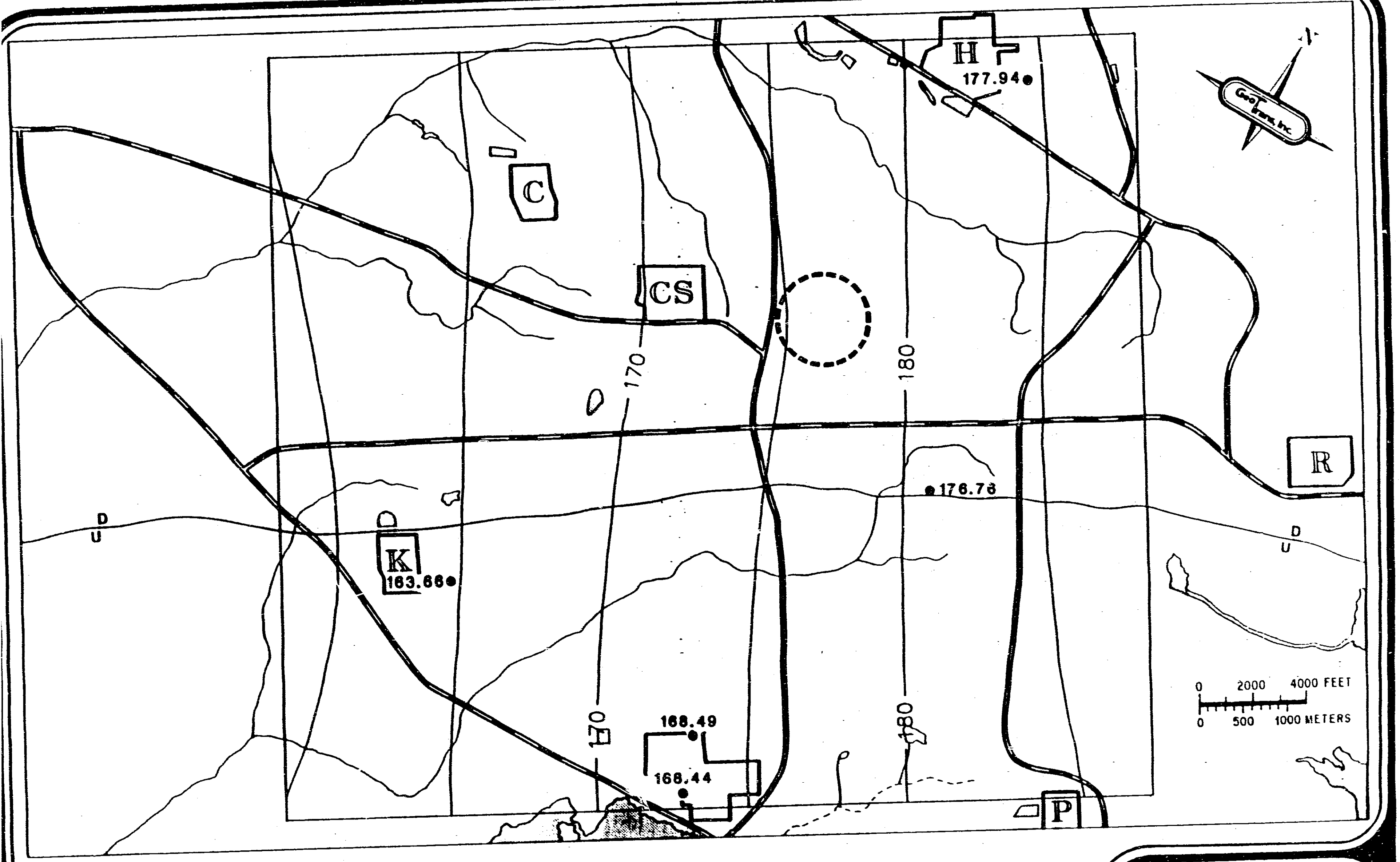

Figure 2.10. Modeled hydraulic heads (ft, msl) for the Upper Cretaceous Aquifer (Aquifer 2). Actual water levels are shown at observation points.

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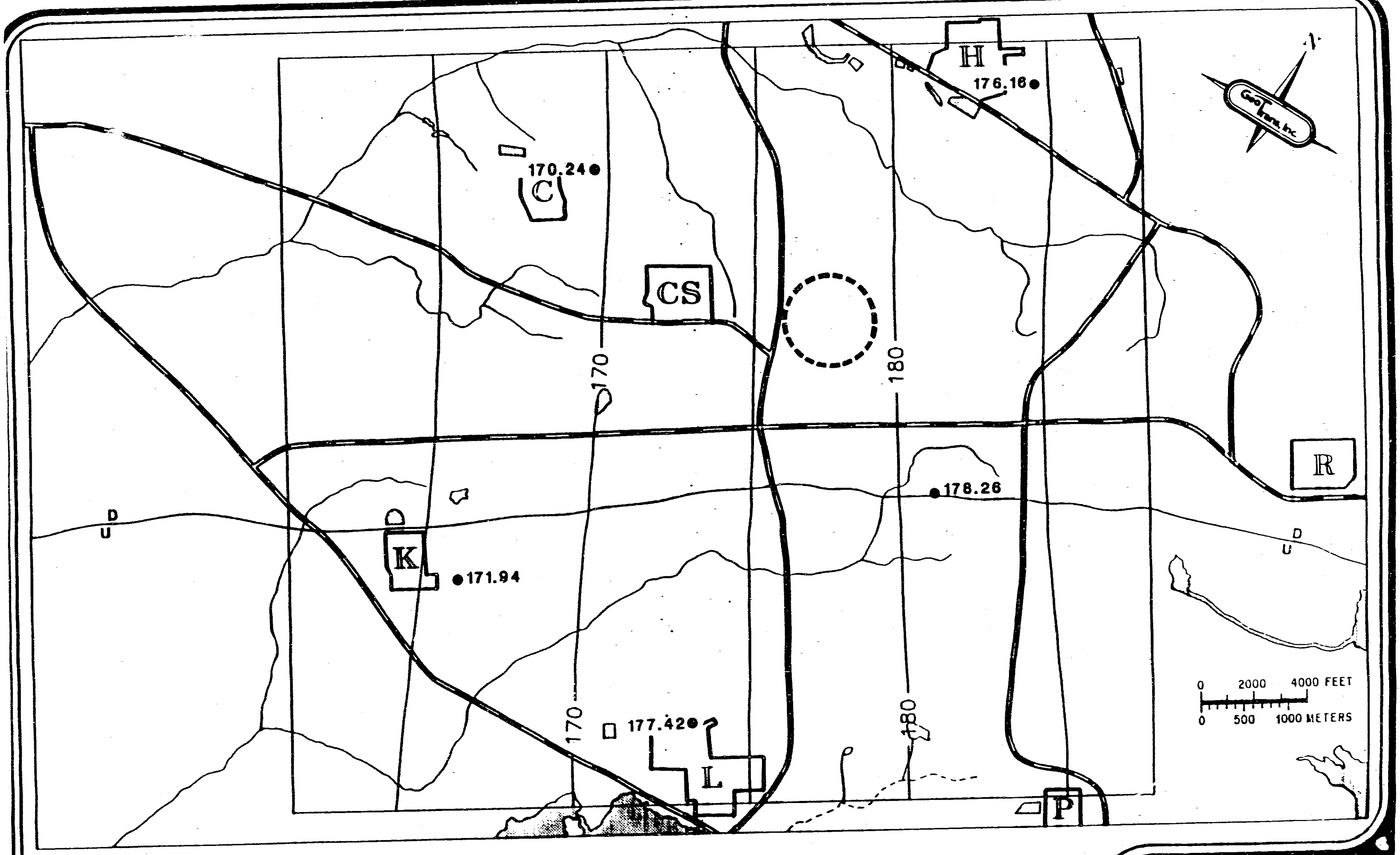

Figure 2.11. Modeled hydraulic heads (ft, msl) for the Lower Cretaceous Aquifer (Aquifer 1). Actual water levels are shown at observation points.

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P3010-005/OA/12A

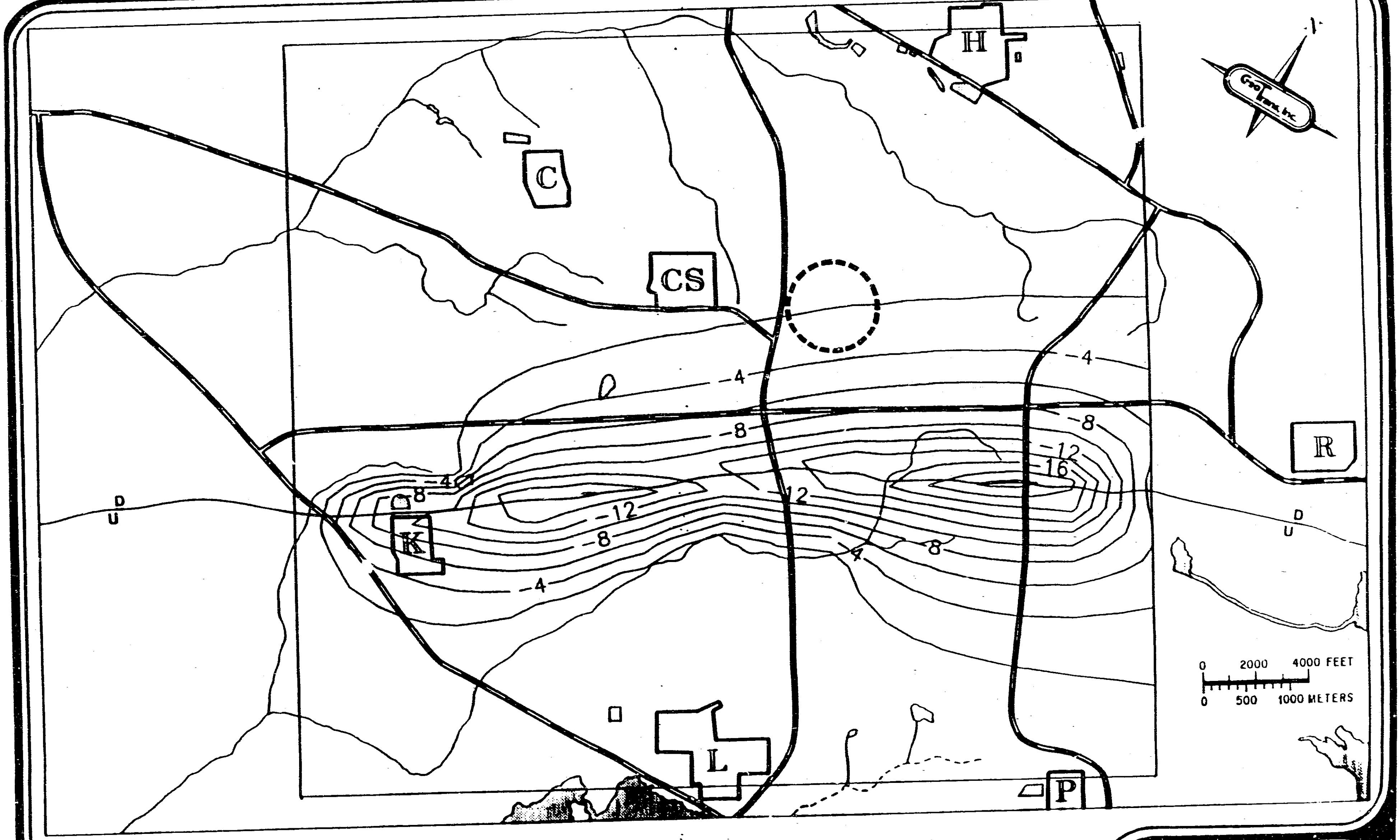

Figure 2.12. Head difference map for the water-table aquifer showing the independent effect of the Pen Branch Fault included as a zone of higher leakance (1 order of magnitude).

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3 MODEL RESULTS

3.1 ANALYSIS OF GROUNDWATER AVAILABILITY

Three scenarios were simulated using the sitewide model to analyze the regional effect of pumpage resulting from construction and operation of the NPR. The first is the base case and represents current steady-state conditions. A 1000 gpm discharge from the Lower Cretaceous Aquifer (Aquifer 1, layer 6) was specified at the NPR reference site (column 16, row 15) for the second scenario. This represents a maximum case for construction and operation phases of all three reactor designs. The third scenario is similar to the second, except a 200 gpm discharge is specified. This quantity represents an average or likely quantity that would be used. Comparison of these three scenarios shows the net effect of pumpage from the NPR.

Drawdown within the Lower Cretaceous Aquifer is shown for the 1000 gpm discharge in Figure 3.1. A maximum drawdown of 10.5 ft occurs in the 4000 ft^2 finite difference block underlying the NPR. Drawdowns decrease radially from the site, resulting in drawdowns of 2.5 ft at F, H, and P areas. Drawdown of 1 ft is noted across much of the site, however, drawdowns do not exceed 2 ft off SRS boundaries. Drawdowns within the Upper Cretaceous Zone (Figure 3.2) are similar to those of the Lower Cretaceous Aquifer except maximum drawdown directly above the pumping well is less. Drawdown in the Lower Tertiary Zone is almost totally damped by the confining nature of the Principal Confining Unit. Drawdowns within the Lower and Upper Cretaceous Aquifers are shown for the 200 gpm discharge in Figure 3.3 and 3.4, respectively. In this case drawdown is one-fifth that of the previous case and results in a very limited cone of depression around the NPR site. The one foot drawdown contour extends only about 2 miles radially from the pumpage center within the Lower Cretaceous Aquifer.

Based on these computations, an additional withdrawal of 1000 gpm at this particular site does not cause significant drawdown impact or reduction in groundwater availability for other parties.

3.2 ANALYSIS OF CHANGES IN VERTICAL HYDRAULIC GRADIENTS

The sitewide model was also used to assess changes in vertical hydraulic gradients. Of particular interest is the change in the area of upward head that would result from pumpage at the NPR.

Figure 3.5 is a head profile which runs west to east across the entire SRS and approximately through the NPR site. Shown in this figure are hydraulic heads for the Lower Tertiary Aquifer and Upper Cretaceous Aquifer for pumping (1000 gpm) and non-pumping conditions. The head reversal is apparent in this figure, upward flow from the Upper Cretaceous Aquifer to the Lower Tertiary Zone is present generally west of Upper Three Runs; flow is downward in the eastern portion of SRS. The decline in heads in the Upper Cretaceous Aquifer due to pumping causes a westward shift of the head reversal interface (the intersection of the potentiometric surfaces). This shift in shown in an areal sense in Figure 3.6. The largest movement of the head reversal interface is less than 2000 ft. For the 200 gpm scenario, the shift in the head reversal interface is much more limited. As shown in Figure 3.7, the movement as a result of the additional pumpage is nearly imperceptible.

3.3 ANALYSIS OF POTENTIAL CONTAMINANT MIGRATION PATHWAYS

Contaminant migration is addressed qualitatively in this study through analysis of potentiometric surface maps and quantitatively using a particle tracking routine. Particle tracking provides trajectories, transit times, and receptor locations resulting from a hypothetical release from the NPR site. Particle tracking assumes conservative solute transport controlled exclusively by the advection process. This type of analysis may be considered worst-case because the important processes of dispersion (which would tend to decrease concentrations) and adsorption (which would tend to increase transit times) are not considered. Inclusion of these processes would require a knowledge of the properties of specific contaminants.

It was noted in the previous sections that drawdowns resulting from pumpage at the NPR would be minimal in the water-table and Lower Tertiary Aquifer. Contaminant transport analysis therefore uses current conditions for calculation of velocity and transit times. Similarly, localized changes to the flow system resulting from NPR construction, such as reduction or redistribution of recharge in covered areas is assumed negligible.

Inspection of water-table maps and water-level data indicate that there is the potential for migration within the water-table aquifer along a 180° angle downgradient of the NPR site. This is because the reference site straddles a topographic ridge. The direction of migration within the water-table aquifer is therefore heavily dependent on the exact location of the release. Contaminants have the potential of flowing toward Four Mile Creek to the north and Pen Branch to the south. It seems unlikely that contaminants could bypass these surface water bodies and discharge directly to the Savannah River. Based on modeled gradients and hydraulic parameters, it appears that the most rapid migration to surface water would occur from the NPR to Four Mile Branch and this would be on the order of several hundred years. This slow transit time assumes that contaminants remain within the relatively less permeable water-table aquifer.

The eighty to ninety foot head difference between the water-table and Lower Tertiary Zone suggests potential for downward migration. In order to quantitatively assess three-dimensional contaminant migration, a particle tracker was used to compute flow paths and velocities. Particle tracking uses the modeled head distributions to derive internodal flow rates and velocities. Particles are then tracked along the generated streamlines.

The U.S.G.S. particle tracker MODPATH (Pollock, 1989), developed for the MODFLOW code (McDonald and Harbaugh, 1984), was modified for application with FTWORK (Srinivasan, 1989). Particles were placed at five locations within the NPR reference site and tracked through time. As shown in Figure 3.8, the vertical hydraulic gradient dominates, and particles "sink" into the Lower Tertiary Aquifer with very little lateral movement. Once the particles enter this aquifer they move relatively rapidly to the west, toward Upper Three Runs Creek and the Savannah River. Particles take approximately 28 years to enter the Lower Tertiary Zone and 50 years to exit the modeled area.

The downward movement of particles appears reasonable given the large head difference that exists between the water-table aquifer and the Lower Tertiary Zone. Local gradients within the water-table are also present as evidenced by the varying water-levels with depth observed in clusters of wells. Other more localized models constructed in the General Separations Areas support movement into the Lower Tertiary Zone.

Because the particle tracking is relatively sensitive to the location of the entry point to the Lower Tertiary Zone, alternate locations of particle entry were analyzed. Particles were assumed to enter the Lower Tertiary Zone along a semicircle 5000 ft downgradient of the center of the NPR reference site. Figure 3.9 shows the movement of particles resulting from this scenario. Particle migration is basically the same in this case, except they follow a wider band and exit the modeled area faster.

The sensitivity of particle migration to variations in the hydraulic conductivity was assessed in two separate simulations. Because the combination of hydraulic conductivity and recharge is non-unique, it is possible to generate identical head distributions by increasing or decreasing these two parameters by the same factor. Using this methodology, particle migration was assessed for a 50% decrease in hydraulic conductivity (Figure 3.10) and a 2 fold increase in hydraulic conductivity. As expected, the travel times are linear and inversely related to hydraulic conductivity. A 50% decrease in hydraulic conductivity doubles the transit time.

The particle tracking indicates that flow is slow in the water-table aquifer and relatively fast in the Lower Tertiary Zone. Flow directions in the water-table are variable and highly dependent upon proximity to surface features. Once water enters the Lower Tertiary Zone, its destination becomes more predictable due to the regional nature of the flow system. Because flow in the Lower Tertiary Zone is toward the west, the effect of the fault is unimportant for this particular site (i.e., flow is away from the fault). The modeling suggests that from a geohydrologic point of view, siting the NPR north of the Pen Branch Fault is desirable because it minimizes the potential for downward migration of water through fault related discontinuities into the Cretaceous Age Aquifers.

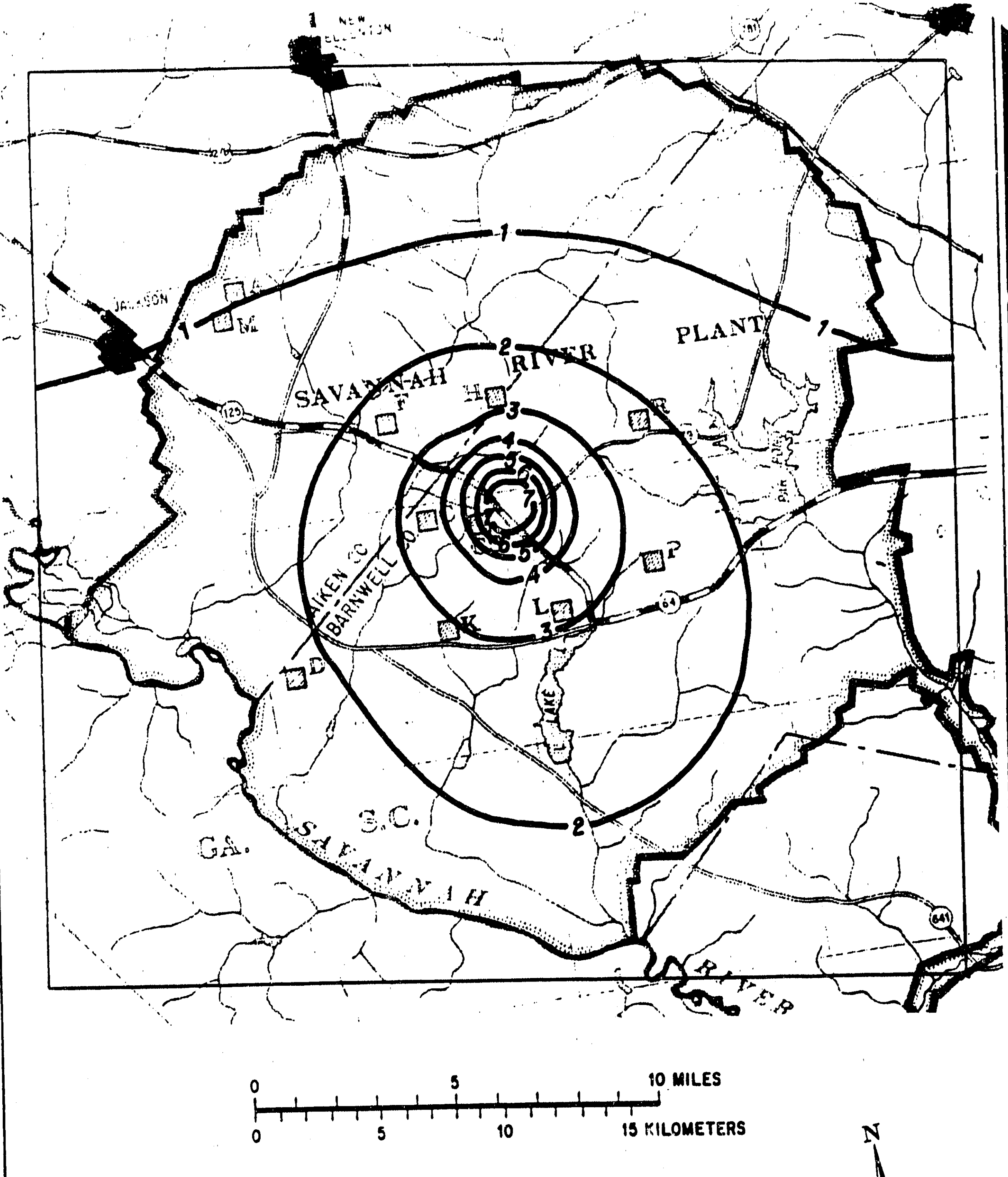

Figure 3.1. Drawdown (ft) in the Lower Cretaceous Aquifer (Aquifer 1) as a result of pumping 1000 gpm at the proposed NPR site.

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P3010-005/OA/14

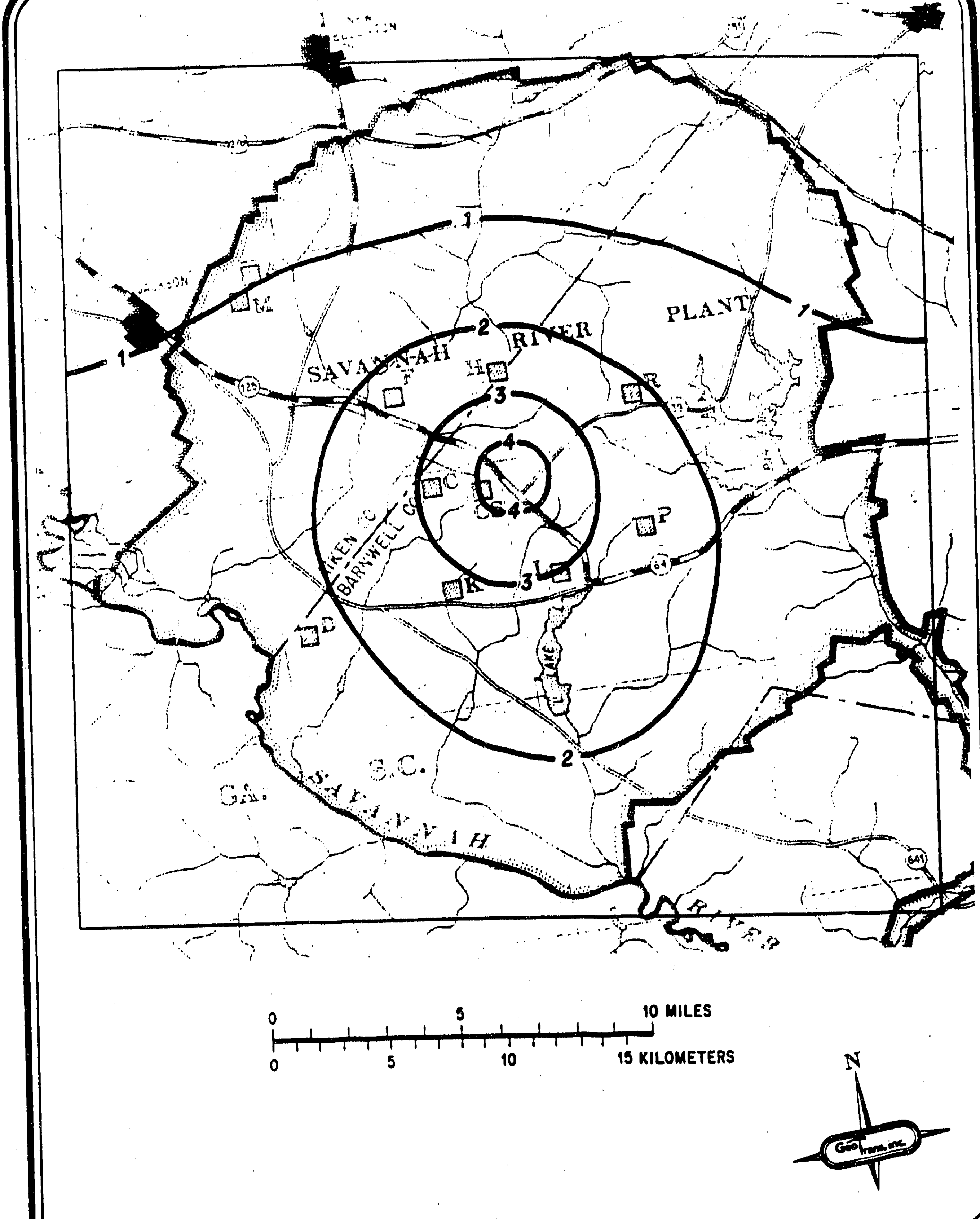

Figure 3.2. Drawdown (ft) in the Upper Cretaceous Aquifer (Aquifer 2) as a result of pumping 1000 gpm at the proposed NPR site.

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P3010-005/OA/15

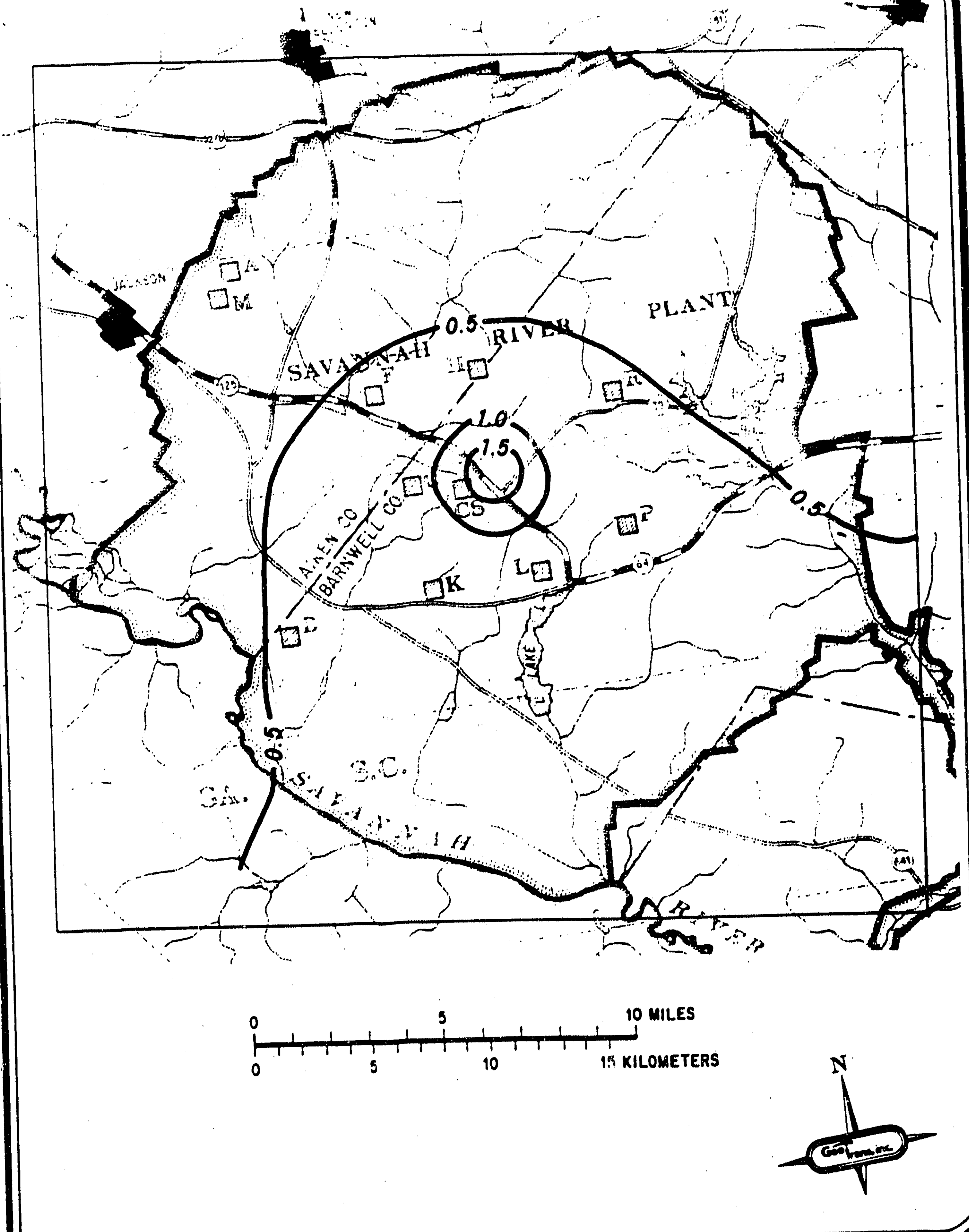

Figure 3.3. Drawdown (ft) in the Lower Cretaceous Aquifer (Aquifer 1) as a result of pumping 200 gpm at the proposed NPR site.

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P3010-005/OA/22

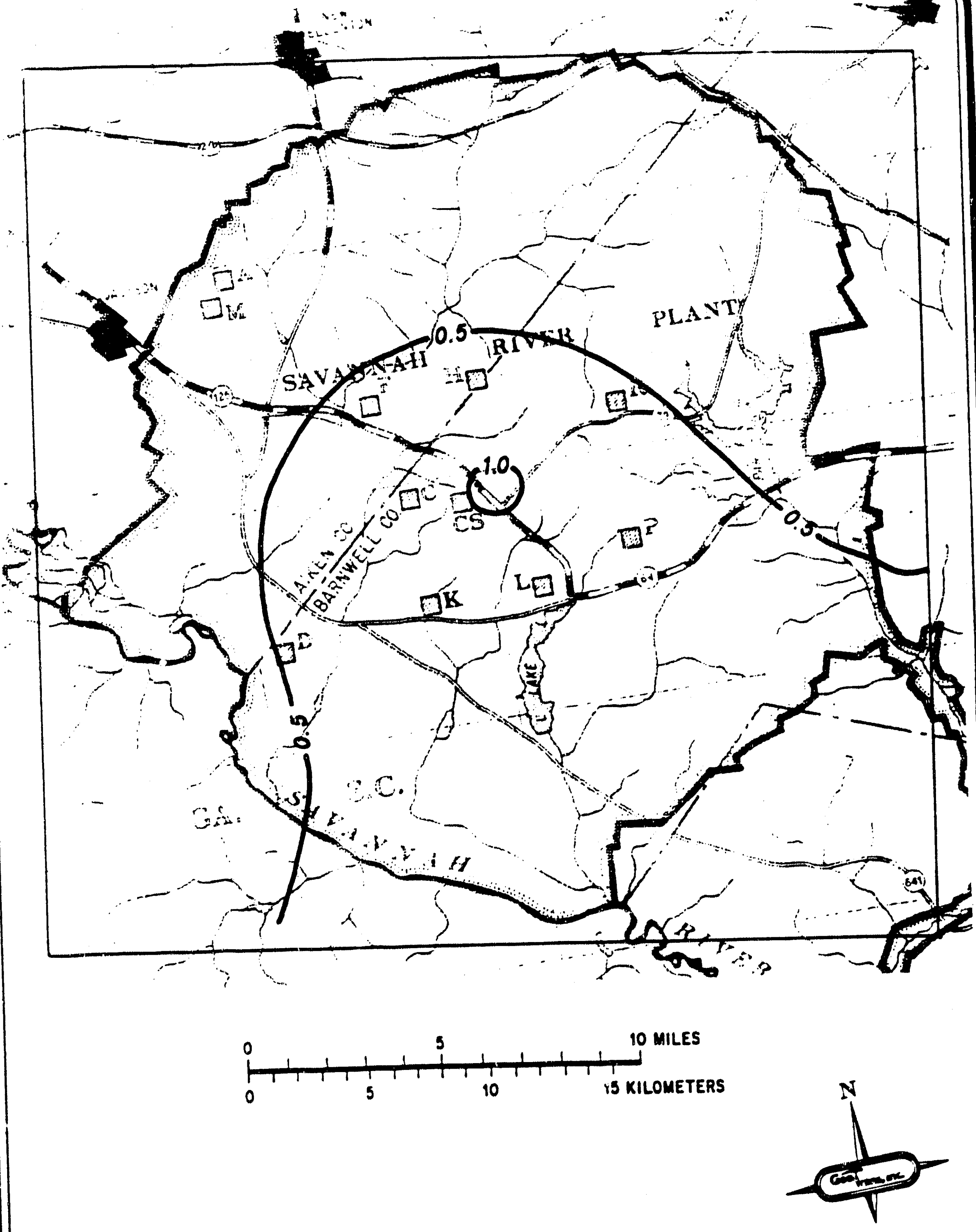

Figure 3.4. Drawdown (ft) in the Upper Cretaceous Aquifer (Aquifer 2) as a result of pumping 200 gpm at the proposed NPR site.

GeoTrans, inc.

P3010-005/OA/20

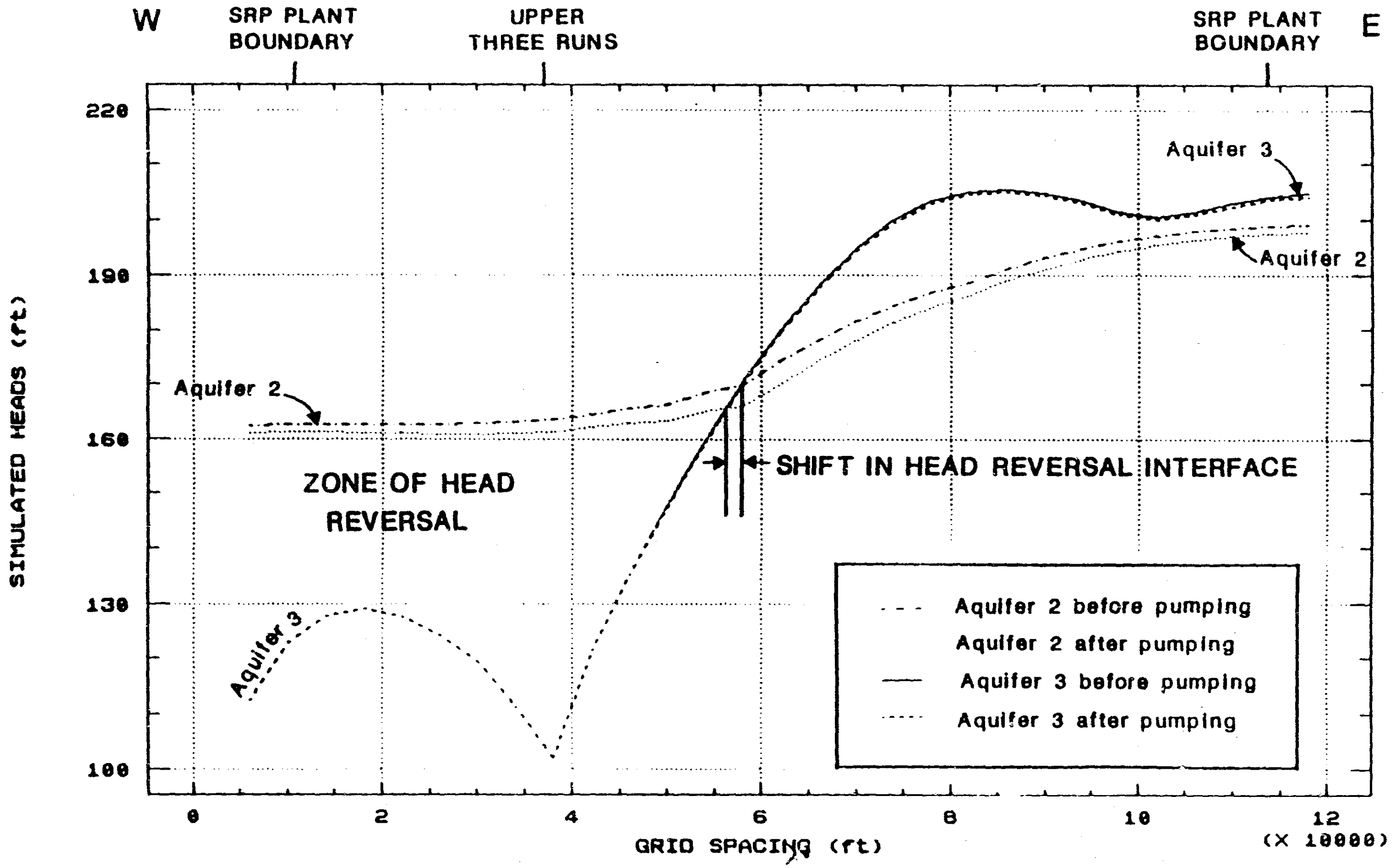

Figure 3.5. Cross-section showing vertical hydraulic heads (ft) with and without pumpage of 1000 gpm at the proposed NPR site. Section is along column 15 of the regional model.

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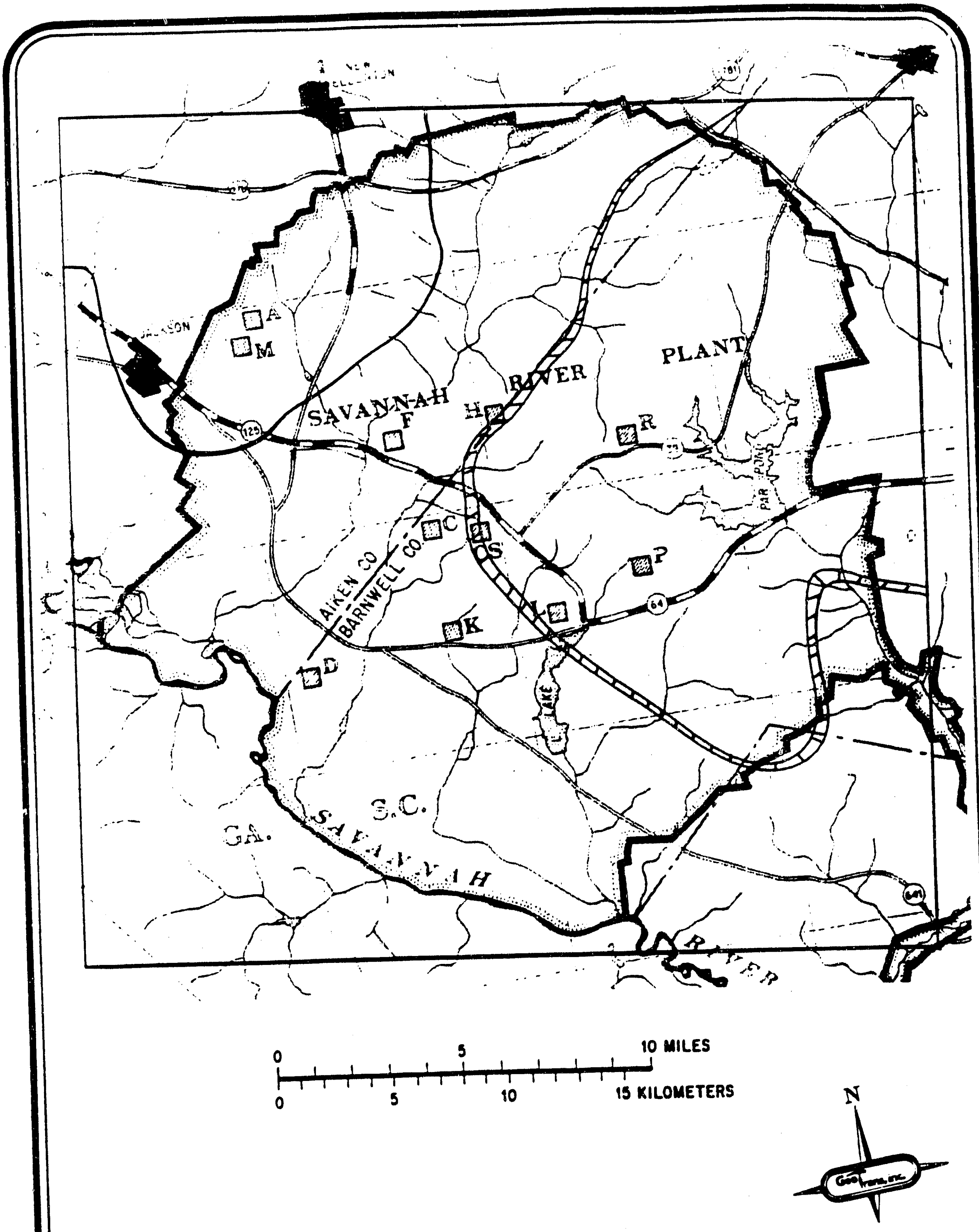

Figure 3.6. Movement of the zero vertical head gradient contour (head reversal interface) as a result of 1000 gpm pumpage from the NPR.

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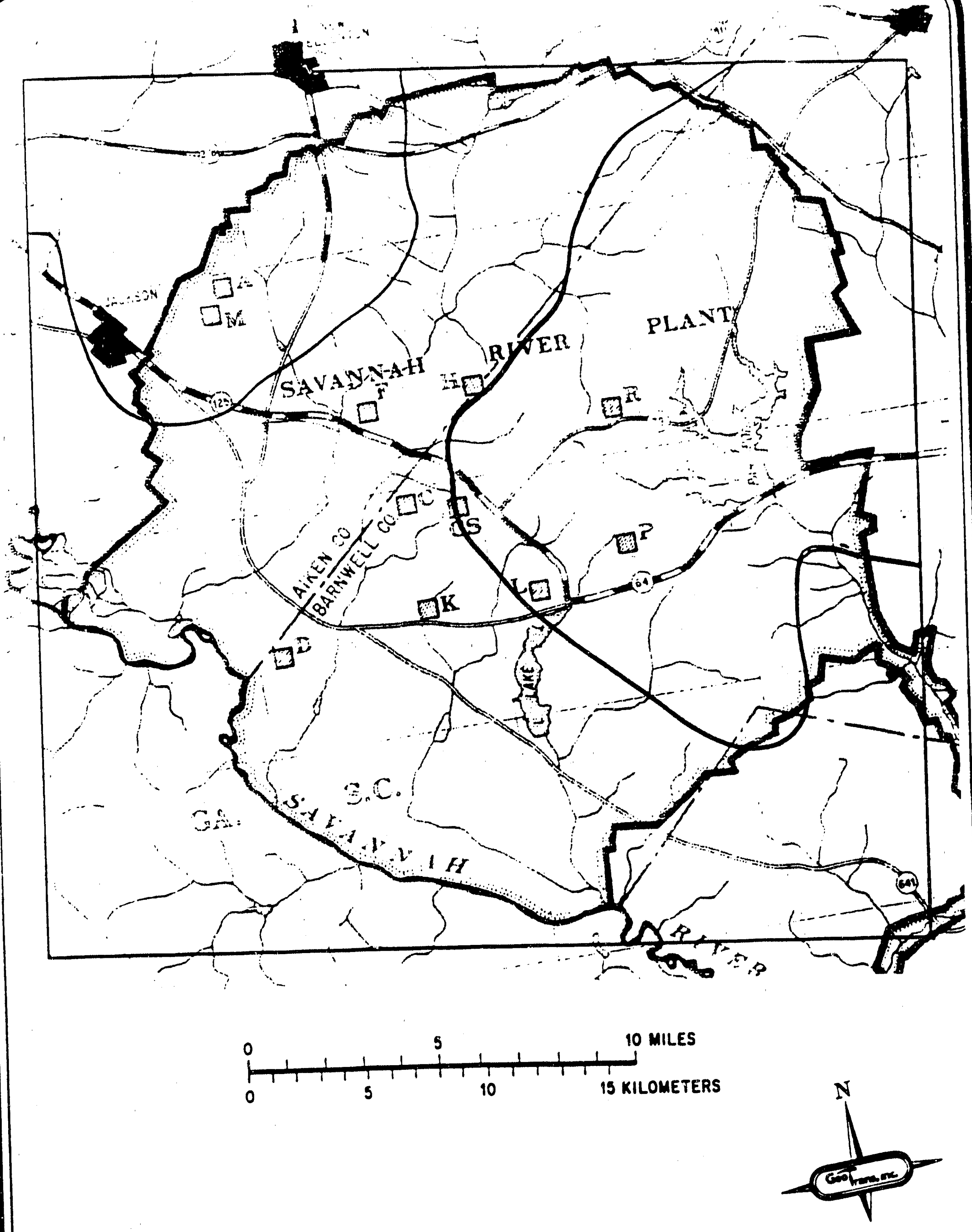

Figure 3.7. Movement of the zero vertical head gradient contour (head reversal interface) as a result of 200 gpm pumpage from the NPR.

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P3010-005/OA/21

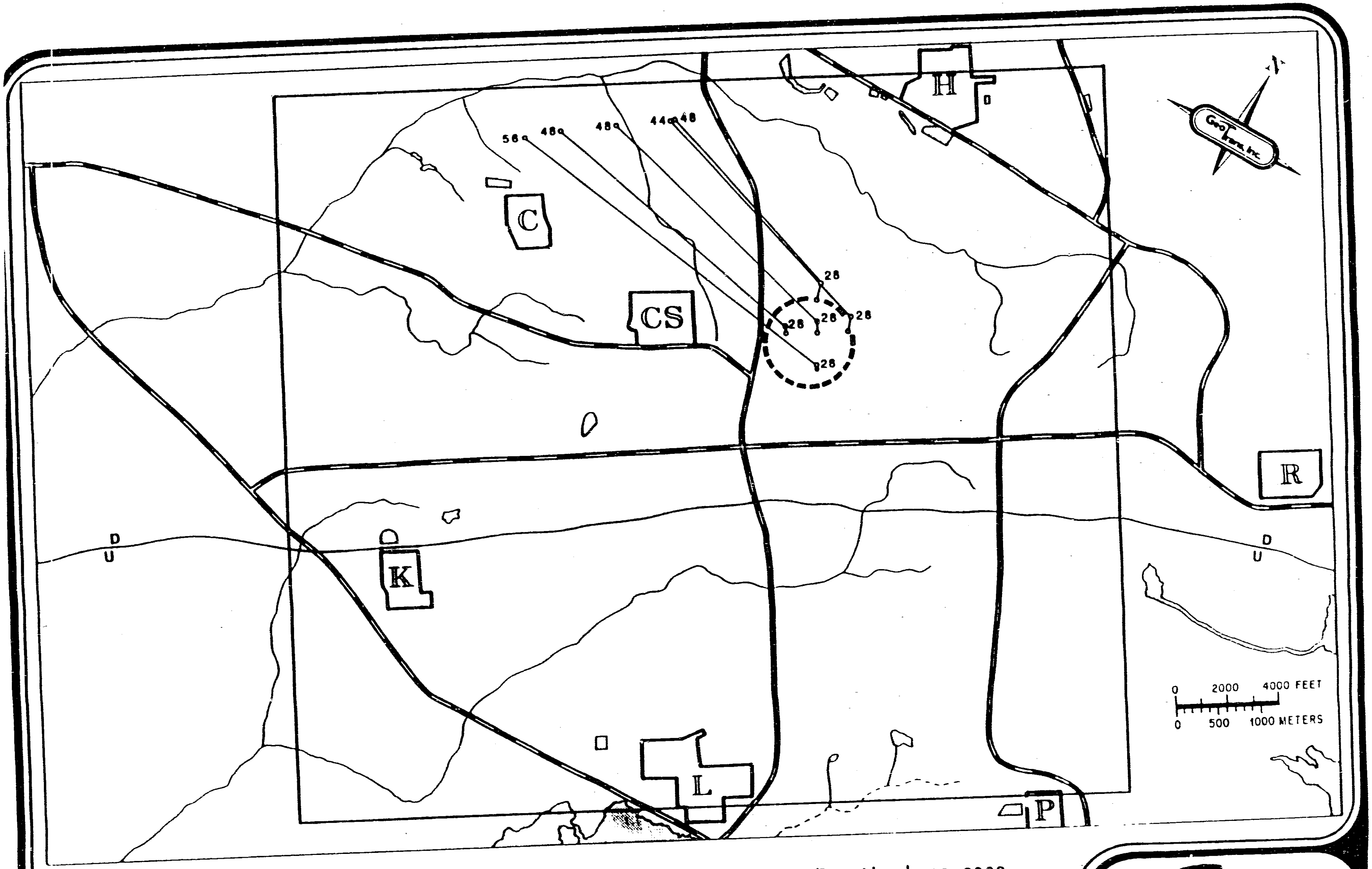

Figure 3.8. Movement of particles released from the NPR site for the base case. Numbers indicate cumulative travel times to the Lower Tertiary Zone and model boundary.

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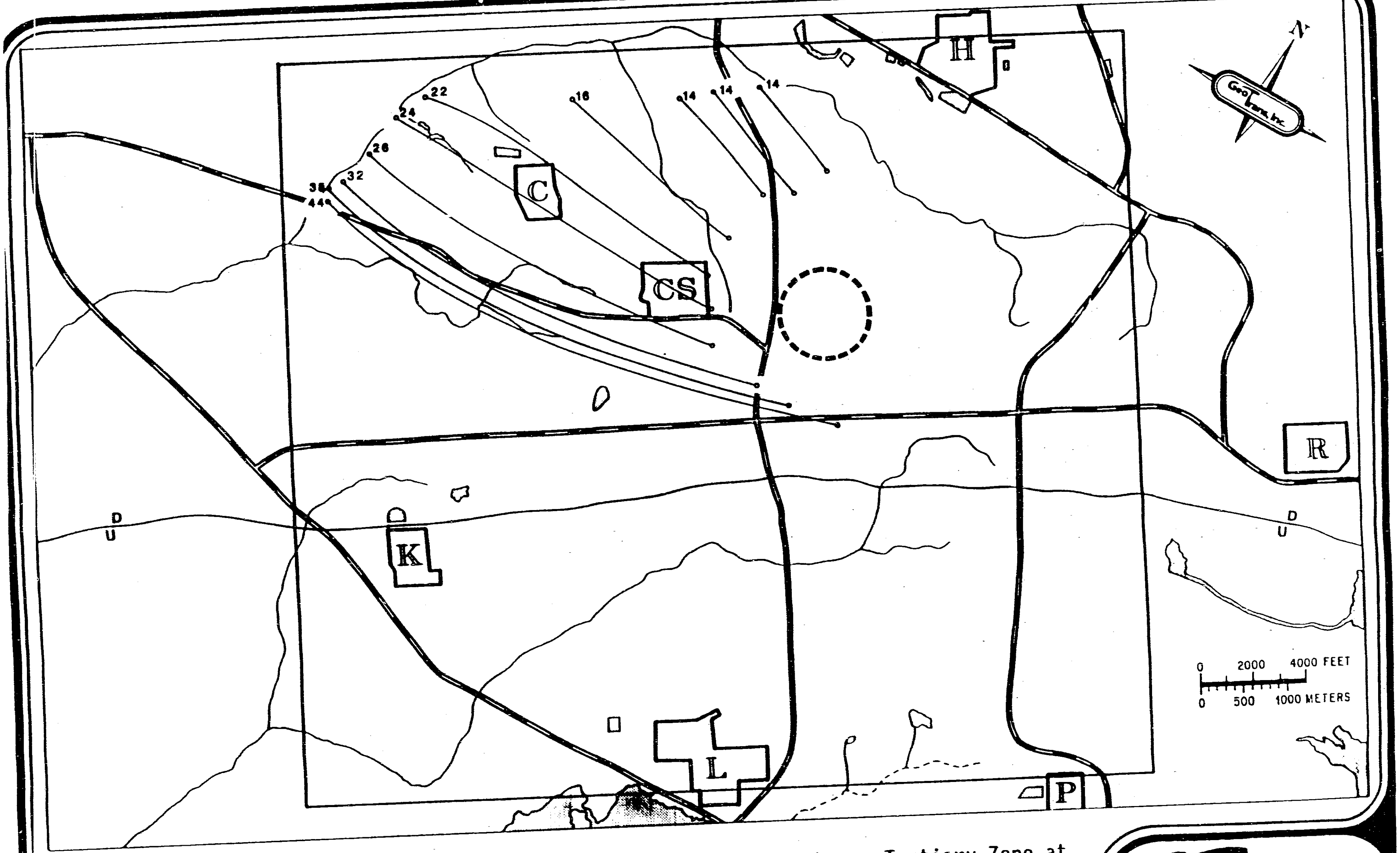

Figure 3.9. Movement of particles that have entered the Lower Tertiary Zone at a distance of 5000 ft from the center of the NPR site. Numbers indicate cumulative travel times to the model boundary.

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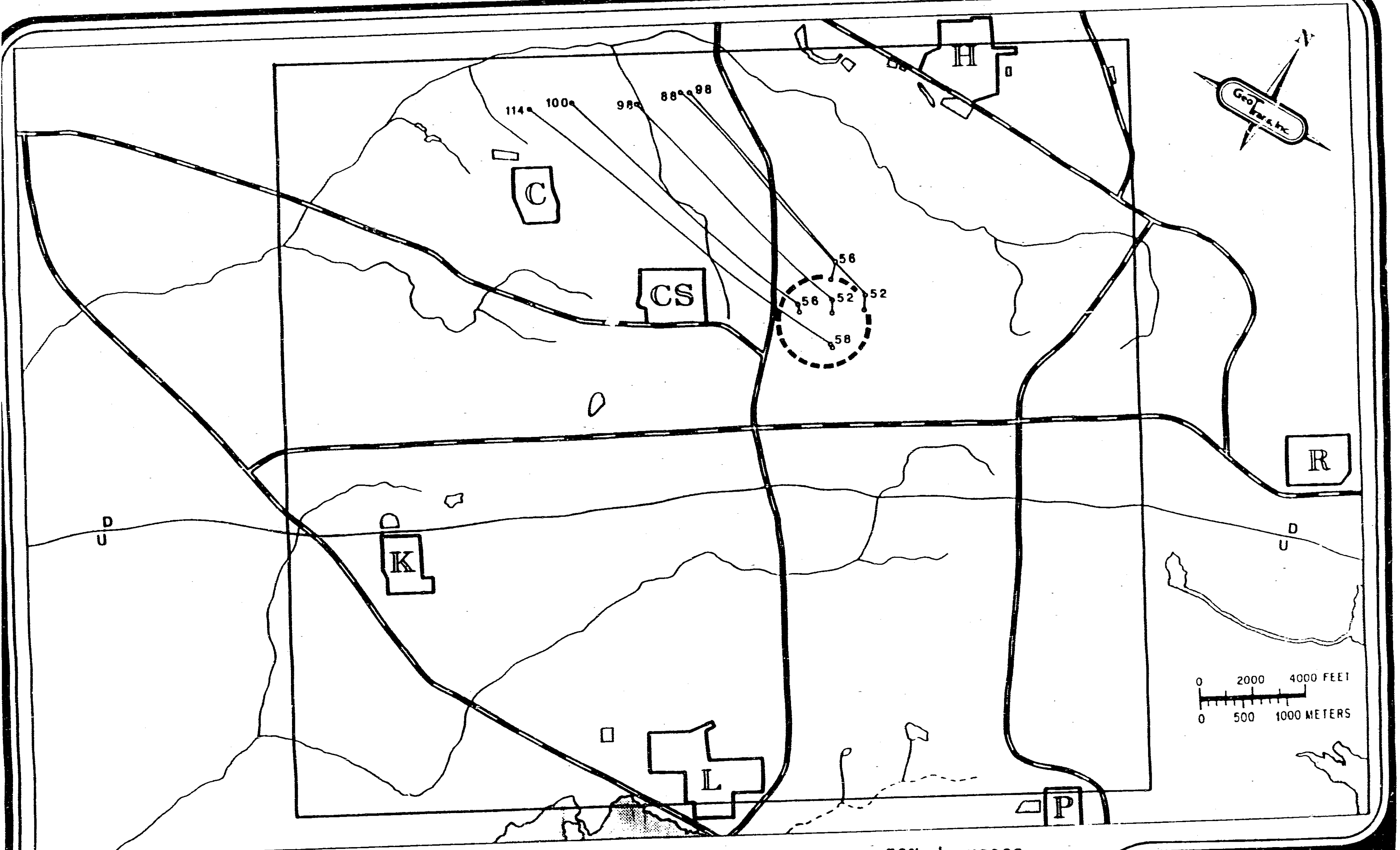

Figure 3.10. Movement of particles released from the NPR site for a 50% decrease in hydraulic conductivity (and recharge). Numbers indicate cumulative travel times to the Lower Tertiary Zone and model boundary.

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APPENDIX A: DATA BASE OF WELLS USED IN THE NPR STUDY

Wells Within NPR Model Grid
(Modwells.db)

Well Name	Northing Coord.	Easting Coord.	Screened Zone Elevation (ft MSL)	Unit	Average Water Elev. (ft MSL)	1986 First Quarter Water Elevation (ft MSL)	1986 Second Quarter Water Elevation (ft MSL)	1986 Third Quarter Water Elevation (ft MSL)	1986 Fourth Quarter Water Elevation (ft MSL)	1987 First Quarter Water Elevation (ft MSL)	1987 Second Quarter Water Elevation (ft MSL)
CMP 10B	51380.7	54005.9	147.4-137.4	Water Table	194.39	194.30	194.50	194.00	194.10	195.16	195.82
CMP 10C	51390.4	54006.5	218.8-188.8	Water Table	219.01	218.90	219.50	218.40	217.00	218.45	219.76
CMP 11	51481.3	53640.6	215.2-185.2	Water Table	210.96	212.30	211.60	209.90	209.90	210.25	211.89
CMP 11B	51456.6	53661.9	149.7-139.7	Water Table	194.45	194.30	194.70	193.80	194.00	195.16	195.82
CMP 12	51956.4	53518.9	223.6-193.6	Water Table	209.49	209.60	208.40	207.30	208.90	208.94	209.92
CMP 12A	51949.2	53524.6	32.1- 22.1	Congaree	179.92	180.20	178.90	180.30	180.00	180.73	181.38
CMP 12B	51943.3	53517.7	158.0-148.0	Water Table	193.38	193.90	190.20	193.40	193.40	194.18	194.50
CMP 13	51862.0	53945.5	212.7-182.7	Water Table	206.92	207.50	207.30	206.20	206.00	206.31	207.62
CMP 13B	51855.5	53937.8	144.2-134.2	Water Table	193.64	193.90	193.60	193.30	193.30	194.18	193.19
CMP 14B	52376.4	52587.3	140.0-130.0	Water Table	193.69	193.90	193.70	193.20	193.30	193.85	194.50
CMP 14C	52371.7	52579.6	215.1-185.1	Water Table	212.38	211.60	211.60	211.20	211.30	211.56	214.18
CMP 15A	51357.2	52896.8	24.2- 14.2	Congaree	178.88	178.90	178.50	178.80	179.00	179.74	180.40
CMP 15B	51349.5	52904.7	155.1-145.1	Water Table	203.26	204.60	204.00	203.80	204.10	201.39	205.33
CMP 16B	51576.7	53849.9	151.7-141.7	Water Table	193.59	194.60	189.90	193.70	192.30	194.50	195.82
CMP 8	52681.4	54272.4	214.0-184.0	Water Table	202.16	202.50	202.30	201.20	201.30	203.03	203.69
CMP 8A	52671.2	54270.2	23.5- 13.7	Congaree	181.17	181.00	181.20	181.20	181.20	182.04	182.70
CMP 8B	52674.6	54280.2	166.6-156.6	Water Table	197.44	197.90	197.70	196.10	197.10	197.46	198.44
CMP 9B	51691.6	53842.3	159.0-149.0	Water Table	193.78						
HSB 139A	71127.4	57365.4	97.6- 87.6	Congaree	171.63						
HSB 68A	71526.9	56892.1	58.0- 47.5	Congaree	170.52	170.60	170.70	169.90		171.22	171.22
HSB 69A	71549.4	56465.1	93.1- 83.1	Congaree	170.40						
HSB 83A	71638.3	58604.1	76.0- 65.2	Congaree	171.71	171.80	171.90	171.40	171.60	172.20	171.87
HSB 84A	71592.9	56351.0	75.6- 64.4	Congaree	171.06	171.60	171.80	170.60	170.90	171.54	171.22
KAB 1	53055.6	39919.7	224.0-194.0	Water Table	210.51	207.60	208.00	208.80	209.60	210.25	212.22
KAB 2	52410.8	40277.9	228.6-198.6	Water Table	214.86	212.30	212.70	213.40	212.60	213.86	217.46
KAB 3	51807.7	39918.4	223.0-193.0	Water Table	207.85	205.20	205.10	204.90	205.10	206.97	209.59
KAB 4	52807.1	39457.0	217.0-187.0	Water Table	207.81	204.80	204.40	206.20	206.70	207.62	209.92
KAC 1	53167.0	42614.8	229.0-199.0	Water Table	216.18	217.10	216.80	215.10	214.90	216.48	218.78
KAC 2	53255.5	42677.2	225.4-195.4	Water Table	216.96	217.60	216.90	215.90	215.10	219.43	220.09
KAC 3	53201.8	42723.9	225.8-195.8	Water Table	218.09	219.40	218.90	216.40	216.10	219.43	220.42
KAC 4	53053.5	42676.4	208.0-178.0	Water Table	215.16	215.80	215.90	214.20	213.50	215.82	217.46
KAC 5	53161.7	42716.3	224.3-204.3	Water Table	219.18						
KAC 6	53139.9	42693.5	224.6-204.6	Water Table	218.74						
KAC 7	53252.9	42574.5	223.0-203.0	Water Table	215.62						
KCB 1	53453.0	39523.1	213.6-183.6	Water Table	208.73	205.80	205.50	208.80	208.30	208.28	210.25
KCB 2	53634.4	39337.1	217.7-187.7	Water Table	206.85	204.40	204.80	206.50	207.20	206.31	208.28
KCB 3	53440.5	39139.2	214.1-184.1	Water Table	205.77	203.30	203.60	205.50	205.90	205.66	207.30
KCB 4	53256.1	39315.6	218.9-188.9	Water Table	208.40	205.70	206.30	207.20	208.10	207.95	209.92

Wells Within NPR Model Grid
(Modwells.db)

Well Name	Northing Coord.	Easting Coord.	Screened Zone Elevation (ft MSL)	Unit	Average Water Elev. (ft MSL)	1986 First Quarter Water Elevation (ft MSL)	1986 Second Quarter Water Elevation (ft MSL)	1986 Third Quarter Water Elevation (ft MSL)	1986 Fourth Quarter Water Elevation (ft MSL)	1987 First Quarter Water Elevation (ft MSL)	1987 Second Quarter Water Elevation (ft MSL)
KDB 1	54050.5	40425.9	205.8-184.8	Water Table	209.97					209.59	210.90
KDB 2	53907.3	40241.4	203.5-182.5	Water Table	209.07					208.61	209.92
KDB 3	53794.6	40393.7	205.4-184.2	Water Table	209.98					209.59	210.90
KRB 1	55015.3	39952.1		Water Table	208.14	208.40	213.00	207.40	206.90	206.97	209.59
KRB 13	55344.2	39986.6		Water Table	206.08	206.90	206.80	205.90	205.20	205.66	207.30
KRB 14	55566.7	40158.5		Water Table	204.03	204.90	203.10	203.90	203.20	204.02	205.98
KRB 15	55476.3	40669.3		Water Table	205.58	206.20	205.30	209.50	204.20	205.98	206.64
KRB 8	54893.6	40302.1		Water Table	209.84	211.80	210.30	211.00	208.80	208.94	211.23
KRP 1	54544.0	42471.2	237.0-207.0	Water Table	217.34	217.80	217.80	216.80	216.50	216.81	219.10
KRP 2	54503.6	42681.6	229.2-199.2	Water Table	217.29	218.00	218.10	216.50	216.30	216.15	221.07
KRP 3	54248.7	42814.3	237.5-207.5	Water Table	217.01	217.90	217.90	216.90	216.60	218.12	
KRP 4	54362.9	42590.3	218.7-188.7	Water Table	216.48	217.00	216.90	215.90	216.00	217.14	218.78
KSB 1	54044.4	39806.8	205.6-175.6	Water Table	207.12	206.70	205.70	206.40	206.50	205.66	208.94
KSB 2	53927.6	39703.4	203.8-173.8	Water Table	206.88	205.90	205.30	205.00	206.50	205.33	208.61
KSB 3	54040.2	39625.3	199.7-169.7	Water Table	206.40	205.40	205.00	205.90	206.50	205.00	207.95
KSB 4A	54140.4	39756.7	199.6-169.6	Water Table	206.23	205.90	205.40	204.20	206.60	205.33	208.28
KSS 1D	47758.9	40220.2	177.5-157.4	Water Table	170.91						
KSS 2D	46803.9	40438.3	164.7-144.6	Water Table	160.65						
KSS 3D	46644.4	40749.3	159.3-139.3	Water Table	159.98						
LAC 1	45238.8	51318.8	221.1-191.1	Water Table	213.50	213.80	214.20	212.70	211.90	217.14	217.79
LAC 2	45330.4	51270.2	223.4-193.4	Water Table	213.96	214.20	214.90	212.90	212.20	216.81	218.12
LAC 3	45201.9	51186.8	220.7-190.7	Water Table	213.48	213.80	214.10	212.50	212.10	217.79	218.12
LAC 4	45213.1	51270.4	215.3-185.3	Water Table	213.54	213.60	214.30	212.50	211.60	217.79	217.79
LAW 1A	44563.6	50628.0	(157.2-162.2)	Ellenton	170.71						
LAW 1B	44562.5	50615.6	(93.6- 98.6)	Ellenton	172.14						
LAW 1C	44562.4	50603.6	(29.0- 34.0)	Congaree	173.29						
LAW 1D	44562.0	50595.6	11.6- 6.6	Congaree	173.23						
LAW 1E	44561.2	50579.0	95.1- 90.1	Santee	201.00						
LAW 1F	44562.1	50567.1	185.9-165.9	Water Table	199.46						
LAW 1TD	44564.1	50640.5	(212.9-217.9)	Steel Creek	168.44						
LAW 2A	45626.5	49637.6	(147.2-152.2)	Ellenton	169.98						
LAW 2B	45641.0	49635.5	(4.8- 9.8)	Congaree	172.72						
LAW 2C	45610.9	49638.7	191.2-171.2	Water Table	204.47						
LAW 3A	45585.8	52266.2	(159.0-164.0)	Ellenton	171.88						
LAW 3B	45600.7	52269.5	4.0-(1.0)	Congaree	174.77						
LAW 3C	45616.1	52272.9	214.9-194.9	Water Table	228.92						
LCO 1	45198.2	50957.7	225.8-195.8	Water Table	211.82	211.30	212.70	211.10	210.30	215.82	215.50
LCO 2	45317.8	51043.4	226.6-196.6	Water Table	213.59	213.70	214.40	211.70	212.00	215.50	217.79
LCO 3	45203.0	51113.2	226.3-196.3	Water Table	213.29	213.40	214.40	212.50	211.70	216.15	217.46

Wells Within NPR Model Grid
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Well Name	Northing Coord.	Easting Coord.	Screened Zone Elevation (ft MSL)	Unit	Average Water Elev. (ft MSL)	1986 First Quarter Water Elevation (ft MSL)	1986 Second Quarter Water Elevation (ft MSL)	1986 Third Quarter Water Elevation (ft MSL)	1986 Fourth Quarter Water Elevation (ft MSL)	1987 First Quarter Water Elevation (ft MSL)	1987 Second Quarter Water Elevation (ft MSL)
LCO 4	45087.4	51036.1	222.3-192.3	Water Table	209.72	210.80	211.10	209.10	207.80	215.82	213.53
LDB 1	46067.3	50530.6	215.0-185.0	Water Table	215.17	215.20	215.60	213.10	212.80	216.48	217.79
LDB 2	45886.5	50590.5	214.5-184.5	Water Table	214.97	213.00	212.90	213.50	212.70	217.14	218.12
LRP 1	48548.6	49128.7	215.8-185.8	Water Table	206.53	205.90	205.80	204.90	204.70		207.95
LRP 2	48352.9	49214.4	214.7-184.7	Water Table	207.53	202.50		206.30	205.70	207.62	210.58
LRP 3	48333.6	49057.7	221.4-191.4	Water Table	206.93	205.30		205.20	204.90	205.98	209.59
LRP 4	48440.2	48964.7	203.3-173.3	Water Table	206.22	205.30	205.60	204.60	204.80	205.66	208.61
LSB 1	45153.1	50700.9	222.7-192.7	Water Table	208.86	210.10	208.80	208.20	206.50	215.50	212.22
LSB 2	45224.0	50824.5	225.0-195.0	Water Table	209.48	211.00	209.80	208.90	207.40	216.48	213.20
LSB 3	45388.7	50729.7	226.6-196.6	Water Table	213.79	214.20	213.00	213.00	211.20	220.74	217.79
LSB 4	45321.6	50513.0	221.5-191.5	Water Table	213.78	215.90	213.80	214.10	210.70	222.38	219.43
M12-1	62146.0	56871.0	276.5-256.5	Water Table							270.98
M12-1A	62163.0	56840.0	23.3-13.3	Congaree							184.19
M12-2	63049.0	58272.0	263.4-243.4	Water Table							259.28
M12-3	62102.0	55437.0	266.4-246.4	Water Table							261.75
M12-4	60875.0	57234.0	276.2-256.2	Water Table							269.82
M12-4DD	60885.0	57238.0	306.2-296.2	Perched Zone							304.65
PRP 1A	45349.8	63032.7	262.9-232.9	Water Table	248.55	247.90	248.30	246.60	246.20	251.58	251.58
PRP 2	45389.5	63229.0	264.1-234.1	Water Table	254.46	259.80	252.70	251.40	250.60	260.10	259.45
PRP 3	45200.7	63165.5	258.6-228.6	Water Table	253.49	246.90	253.90	252.10	250.70	259.12	258.79
PRP 4	45270.9	63341.0	262.9-232.9	Water Table	257.24	256.90	256.90	255.60	255.00	261.09	261.42
P-10A	55280.0	60049.0	(544-554)	Middendorf	178.26						
P-15A	46755.3	51376.3	(87- 97)	Ellenton	175.52						
P-15B	47023.2	51532.1	58- 48	Congaree	176.88						
P-15C	47293.6	51408.4	103- 93	Santee/tc	213.34						
P-15D	47350.2	51130.3	240-219	Water Table	227.26						
P-15TA	47007.9	50863.7	(617-638)	Middendorf	177.42						
P-15TB	47304.9	50975.5	(456-467)	Black Creek	177.34						
P-15TC	47381.9	51271.0	(356-367)	Black Creek	170.83						
P-15TD	46737.8	51053.5	(197-207)	Steel Creek	168.49						
P-18A	67592.8	47688.1	21- 11	Congaree	170.97						
P-18B	67578.9	47680.9	76- 66	Congaree	167.85						
P-18D	67552.8	47666.6	226-206	Water Table	219.21						
P-18TA	67578.5	47652.8	(534-554)	Middendorf	170.24						
P-18TB	67592.7	47660.6	(370-380)	Black Creek	169.88						
P-18TC	67605.8	47669.6	(258-268)	Black Creek	169.46						
P-18TD	67618.1	47678.0	(180-190)	Black Creek	169.67						
P-19A	55347.1	60031.3	(28- 38)	Congaree	185.79						
P-19B	55336.4	60050.7	78- 58	Santee	261.33						

Wells Within NPR Model Grid
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P-19C	55321.5	60056.1	125-115	Water Table	258.58						
P-19D	55301.9	60048.7	272-252	Water Table	261.80						
P-19TA	55295.9	60034.6	(458-469)	Middendorf	178.26						
P-19TB	55309.8	60029.4	(316-326)	Black Creek	178.02						
P-19TC	55328.2	60022.2	(230-240)	Black Creek	176.88						
P-19TD	55342.1	60016.8	(128-138)	Steel Creek	176.76						
P-25A	52535.8	42240.0	(34- 44)	Ellenton	170.96						
P-25B	52521.4	42241.9	90- 80	Congaree	183.44						
P-25C	52506.1	42244.1	110-100	Santee	196.71						
P-25D	52491.9	42246.1	225-205	Water Table	210.17						
P-25TA	52493.6	42261.0	(583-605)	Middendorf	171.94						
P-25TB	52508.3	42259.1	(454-465)	Black Creek	170.75						
P-25TC	52523.3	42257.1	(309-320)	Black Creek	166.34						
P-25TD	52538.2	42254.9	(194-205)	Black Creek	166.13						
P-25TE	52552.7	42253.5	(134-145)	Steel Creek	163.66						
P-27B	70405.9	64000.3	94- 74	Congaree	178.92						
P-27C	70391.7	64004.9	144-139	Santee	247.02						
P-27D	70376.9	64008.9	219-199	Water Table	265.29						
P-27TA	70382.0	64022.9	(533-543)	Middendorf	176.16						
P-27TB	70396.7	64018.5	(406-416)	Black Creek	177.70						
P-27TC	70410.8	64014.5	(286-296)	Black Creek	177.99						
P-27TD	70425.4	64010.2	(206-216)	Black Creek	177.66						
P-27TE	70439.7	64006.0	(106-116)	Steel Creek	177.94						
T18N-1	56994.0	45562.0	232.6-212.6	Water Table							230.30
T18N-1A	57015.0	45553.0	-44.1- -54.1	Congaree							173.71
T18N-2	57935.0	46735.0	227.3-207.3	Water Table							232.13
T18S-1	46082.0	43894.0	184.2-164.2	Water Table							178.49
T18S-1A	46111.0	43898.0	-16.6- -26.6	Congaree							170.58
T18S-2	46263.0	45825.0	193.7-173.7	Water Table							188.90

Wells Within NPR Model Grid
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Well Name	1987 Third Quarter Water Elevation (ft MSL)	1987 Fourth Quarter Water Elevation (ft MSL)	1988 First Quarter Water Elevation (ft MSL)	1988 Second Quarter Water Elevation (ft MSL)	1988 Third Quarter Water Elevation (ft MSL)	1988 Fourth Quarter Water Elevation (ft MSL)	9/84 Water Elevation (ft MSL)	5/85 Water Elevation (ft MSL)	3/86 Water Elevation (ft MSL)	7/87 Water Elevation (ft MSL)
CMP 10B	194.18	194.50	194.65	194.39	194.20	192.84				
CMP 10C	220.42	220.42	219.76	219.44	218.62	217.50				
CMP 11	212.87	211.56	211.39	210.78	209.94	209.15				
CMP 11B	195.82	194.18	194.61	194.36	193.94	192.73				
CMP 12	210.90	210.90	210.55	209.97	209.29	209.22				
CMP 12A	180.40	179.74	180.36	180.10	179.14	177.82				
CMP 12B	193.19	193.85	194.16	193.91	193.40	192.43				
CMP 13	208.28	207.30	207.44	206.90	206.08	206.07				
CMP 13B	194.50	193.85	194.19	193.92	193.46	192.29				
CMP 14B	193.52	193.85	194.05	193.92	193.23	193.27				
CMP 14C	213.53	213.86	213.13	212.68	212.18	211.75				
CMP 15A	180.73	178.43	178.83	178.84	177.73	176.68				
CMP 15B	204.67	203.69	202.99	202.22	201.35	201.01				
CMP 16B	193.19	194.18	194.07	194.21	193.97	192.63				
CMP 8	202.70	202.38	202.25	202.19	201.32	201.08				
CMP 8A	181.06	180.73	181.23	181.11	180.52	180.09				
CMP 8B	197.46	197.78	197.76	197.33	197.15	197.06				
CMP 9B		193.85	194.43	194.16	193.92	192.55				
HSB 139A				172.26	171.44	171.18				
HSB 68A	171.22	170.56	170.46	170.38	169.86	169.56				
HSB 69A				170.79	170.38	170.02				
HSB 83A	172.53	171.87	171.71	171.66	171.15	170.80				
HSB 84A	171.54	170.89	171.11	170.84	170.42	170.24				
KAB 1	213.53	211.23	212.15	211.97	210.44	210.38				
KAB 2	217.79	215.50	212.50	217.73	216.05	216.38				
KAB 3	210.58	208.61	210.79	210.73	208.31	208.30				
KAB 4	210.58	208.61	209.87	209.54	207.87	207.63				
KAC 1	217.14	216.81	215.60	214.60	215.24	215.65				
KAC 2	217.46	216.81	215.69	215.19	216.28	217.02				
KAC 3	218.45	217.79	216.50	216.32	218.35	219.05				
KAC 4	216.48	215.50	214.61	213.57	214.33	214.70				
KAC 5						219.18				
KAC 6						218.74				
KAC 7						215.62				
KCB 1	211.89	210.58	209.87	209.48	208.16	207.80				
KCB 2	209.59	209.26	207.75	207.11	205.67	205.36				
KCB 3	208.28	207.95	206.64	206.12	204.62	204.42				
KCB 4	210.90	210.25	209.68	209.15	207.90	207.76				

Wells Within NPR Model Grid
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Well Name	1987 Third Quarter Water Elevation (ft MSL)	1987 Fourth Quarter Water Elevation (ft MSL)	1988 First Quarter Water Elevation (ft MSL)	1988 Second Quarter Water Elevation (ft MSL)	1988 Third Quarter Water Elevation (ft MSL)	1988 Fourth Quarter Water Elevation (ft MSL)	9/84 Water Elevation (ft MSL)	5/85 Water Elevation (ft MSL)	3/86 Water Elevation (ft MSL)	7/87 Water Elevation (ft MSL)
KDB 1	211.56	210.90	209.80	209.61	209.09	208.33				
KDB 2	210.90	209.92	209.00	208.78	208.05	207.41				
KDB 3	211.89	210.90	209.77	209.62	209.01	208.14				
KRB 1	209.59	208.28	207.24	207.08	206.67	206.51				
KRB 13	207.30	206.31	205.36	205.37	204.75					
KRB 14	205.33	204.02	203.60	203.72	203.43	203.22				
KRB 15	205.66	205.00	204.67	204.76	204.75	204.33				
KRB 8	210.90	209.92	209.15	208.84	208.68	208.50				
KRP 1	219.10	218.45	217.47	216.32	215.12	215.78				
KRP 2	218.45	218.12	216.93	216.16	216.08	215.67				
KRP 3		218.45	217.20	216.54	214.45	216.00				
KRP 4	216.15	217.46	216.41	215.45	215.47	215.07				
KSB 1	208.94	208.61	207.73	207.33	206.78	206.11				
KSB 2	208.94	208.61	207.59	208.22	206.68	205.91				
KSB 3	208.28	207.95	206.93	206.62	206.05	205.25				
KSB 4A	207.95	208.28	204.12	206.82	206.32	205.54				
KSS 1D						170.91				
KSS 2D						160.65				
KSS 3D						159.98				
LAC 1	215.82	215.82	213.77	213.81	213.33	212.68				
LAC 2	216.15	216.48	214.31	214.24	213.82	213.31				
LAC 3	212.54	216.15	212.96	213.91	213.51	213.06				
LAC 4	215.82	216.15	213.78	213.95	213.36	212.89				
LAW 1A								174.01		
LAW 1B								175.37		
LAW 1C								175.52		
LAW 1D								175.45		
LAW 1E								199.06		
LAW 1F								199.63		
LAW 1TD								171.31		
LAW 2A								173.21		
LAW 2B								174.83		
LAW 2C								203.70		
LAW 3A								177.13		
LAW 3B								177.40		
LAW 3C								231.27		
LCO 1	213.86	214.18	212.09	212.33	211.62	211.12				
LCO 2	216.15	216.48	214.09	214.11	213.30	213.16				
LCO 3	215.50	215.82	213.69	213.67	213.12	212.75				

Wells Within NPR Model Grid
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Well Name	1987 Third Quarter Water Elevation (ft MSL)	1987 Fourth Quarter Water Elevation (ft MSL)	1988 First Quarter Water Elevation (ft MSL)	1988 Second Quarter Water Elevation (ft MSL)	1988 Third Quarter Water Elevation (ft MSL)	1988 Fourth Quarter Water Elevation (ft MSL)	9/84 Water Elevation (ft MSL)	5/85 Water Elevation (ft MSL)	3/86 Water Elevation (ft MSL)	7/87 Water Elevation (ft MSL)
LCO 4	211.23	211.89	209.85	210.62	209.50	208.57				
LDB 1	217.14	215.82	214.80	215.17	214.75	213.41				
LDB 2	217.46	216.15	214.81	215.52	214.79	213.49				
LRP 1	208.61	208.28	207.40		206.23	205.56				
LRP 2	209.59	209.59	208.58	208.07	207.44	206.88				
LRP 3	209.26	208.61	207.78	207.13	206.54	205.93				
LRP 4	208.61	208.28	205.18	206.54	206.01	205.45				
LSB 1	209.92	210.58	208.63	209.27	208.42	207.35				
LSB 2	210.90	211.56	209.37	210.08	209.24	208.12				
LSB 3	215.50	215.82	214.26	214.26	214.08	212.48				
LSB 4	215.50	216.15	213.91	214.62	214.11	211.49				
M12-1										
M12-1A										
M12-2										
M12-3										
M12-4										
M12-4DD										
PRP 1A	249.61	249.61	248.23	248.98	247.77	246.28				
PRP 2	255.84	254.20	252.94	253.84	252.20	250.49				
PRP 3	254.36	253.87	253.23	255.10	252.82	250.46				
PRP 4	258.79	257.48	256.64	256.89	255.71	254.45				
P-10A									178.49	
P-15A							178.00			
P-15B							179.00			
P-15C							218.00			
P-15D				226.40			234.00			
P-15TA							179.00			
P-15TB							179.00			
P-15TC							170.00			
P-15TD							170.00			
P-18A									178.82	
P-18B									168.98	
P-18D									223.58	
P-18TA									169.92	
P-18TB									168.98	
P-18TC									168.95	
P-18TD									168.87	
P-19A									187.17	
P-19B									264.09	

Wells Within NPR Model Grid
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Well Name	1987 Third Quarter Water Elevation (ft MSL)	1987 Fourth Quarter Water Elevation (ft MSL)	1988 First Quarter Water Elevation (ft MSL)	1988 Second Quarter Water Elevation (ft MSL)	1988 Third Quarter Water Elevation (ft MSL)	1988 Fourth Quarter Water Elevation (ft MSL)	9/84 Water Elevation (ft MSL)	5/85 Water Elevation (ft MSL)	3/86 Water Elevation (ft MSL)	7/87 Water Elevation (ft MSL)
P-19C									255.97	
P-19D									264.50	
P-19TA									178.03	
P-19TB									177.74	
P-19TC									176.21	
P-19TD									176.46	
P-25A										171.60
P-25B										190.00
P-25C										198.90
P-25D										212.30
P-25TA										171.70
P-25TB										170.10
P-25TC										164.20
P-25TD										163.60
P-25TE										156.10
P-27B										179.40
P-27C										264.80
P-27D										266.70
P-27TA										175.30
P-27TB										177.70
P-27TC										177.10
P-27TD										178.00
P-27TE										177.60
T18N-1										
T18N-1A										
T18N-2										
T18S-1										
T18S-1A										
T18S-2										

Wells Within NPR Model Grid
(Modwells.db)

Well Name	8/18/88 Water Elevation (ft MSL)	9/15/88 Water Elevation (ft MSL)	10/17/88 Water Elevation (ft MSL)	11/29/88 Water Elevation (ft MSL)	12/20/88 Water Elevation (ft MSL)	1/25/89 Water Elevation (ft MSL)	2/13/89 Water Elevation (ft MSL)	5/23/89 Water Elevation (ft MSL)	6/29/89 Water Elevation (ft MSL)
CMP 10B									
CMP 10C									
CMP 11									
CMP 11B									
CMP 12									
CMP 12A									
CMP 12B									
CMP 13									
CMP 13B									
CMP 14B									
CMP 14C									
CMP 15A									
CMP 15B									
CMP 16B									
CMP 8									
CMP 8A									
CMP 8B									
CMP 9B									
HSB 139A									
HSB 68A									
HSB 69A									
HSB 83A									
HSB 84A									
KAB 1									
KAB 2									
KAB 3									
KAB 4									
KAC 1									
KAC 2									
KAC 3									
KAC 4									
KAC 5									
KAC 6									
KAC 7									
KCB 1									
KCB 2									
KCB 3									
KCB 4									

Wells Within NPR Model Grid
(Modwells.db)

Well Name	8/18/88 Water Elevation (ft MSL)	9/15/88 Water Elevation (ft MSL)	10/17/88 Water Elevation (ft MSL)	11/29/88 Water Elevation (ft MSL)	12/20/88 Water Elevation (ft MSL)	1/25/89 Water Elevation (ft MSL)	2/13/89 Water Elevation (ft MSL)	5/23/89 Water Elevation (ft MSL)	6/29/89 Water Elevation (ft MSL)
KDB 1									
KDB 2									
KDB 3									
KRB 1									
KRB 13									
KRB 14									
KRB 15									
KRB 8									
KRP 1									
KRP 2									
KRP 3									
KRP 4									
KSB 1									
KSB 2									
KSB 3									
KSB 4A									
KSS 1D									
KSS 2D									
KSS 3D									
LAC 1	213.41	213.28	213.20	212.20	211.99	211.12	210.95	212.35	212.28
LAC 2	213.99	213.78	213.65	212.99	212.53	211.82	211.61	212.78	212.62
LAC 3	213.59	213.34	213.21	212.55	212.13	211.55	211.30	212.51	212.26
LAC 4	213.64	213.39	213.22	212.43	211.85	210.93	210.77	212.34	212.27
LAW 1A	170.16	169.65	170.15	169.88	170.00	170.25	170.37	171.55	171.11
LAW 1B	171.87	171.60	171.70	171.50	171.50	171.70	171.80	171.80	172.53
LAW 1C	173.12	173.08	172.77	172.68	172.55	172.82	172.92	173.85	173.62
LAW 1D	173.05	173.00	172.68	172.57	172.54	172.77	172.85	173.80	173.60
LAW 1E	201.82	201.98	201.58	200.99	200.75	200.45	200.42	201.35	201.56
LAW 1F	199.70	200.26	199.55	198.55	198.30	198.08	198.05	200.55	201.89
LAW 1TD	167.32	168.78	167.74	167.57	167.66	168.25	167.87	169.20	168.66
LAW 2A	169.22	169.43	169.25	169.03	169.25	169.53	169.68	170.85	170.37
LAW 2B	172.55	172.38	172.35	172.00	172.06	172.24	172.35	173.35	173.07
LAW 2C	205.36	205.67	205.12	204.03	203.60	203.32	203.00	205.00	205.93
LAW 3A	171.17	171.08	170.95	170.86	170.73	171.13	171.30	172.40	172.05
LAW 3B	174.52	174.52	174.32	174.10	174.04	174.30	174.40	174.95	175.15
LAW 3C	230.75	231.08	230.18	227.05	226.18	225.85	225.30	230.35	231.20
LCO 1	211.74	211.49	211.41	210.53	210.16	209.37	209.99	210.87	210.70
LCO 2	213.77	213.35	213.39	212.60	212.19	211.60	211.19	212.64	212.31
LCO 3	213.48	213.02	212.90	212.02	211.65	211.15	210.86	211.90	211.90

Wells Within NPR Model Grid
(Modwells.db)

Well Name	8/18/88 Water Elevation (ft MSL)	9/15/88 Water Elevation (ft MSL)	10/17/88 Water Elevation (ft MSL)	11/29/88 Water Elevation (ft MSL)	12/20/88 Water Elevation (ft MSL)	1/25/89 Water Elevation (ft MSL)	2/13/89 Water Elevation (ft MSL)	5/23/89 Water Elevation (ft MSL)	6/29/89 Water Elevation (ft MSL)
LCO 4	209.49	209.49	208.95	207.79	207.28	206.87	206.61	208.66	209.24
LDB 1									
LDB 2									
LRP 1									
LRP 2									
LRP 3									
LRP 4									
LSB 1	208.33	208.45	207.78	206.78	206.16	205.91	210.53	208.16	208.41
LSB 2	209.32	209.20	208.74	207.66	207.16	206.53	206.24	208.80	209.28
LSB 3	213.65	214.32	213.32	211.77	211.23	210.65	210.32	213.40	214.65
LSB 4	213.25	214.21	212.87	210.33	209.58	209.09	208.83	214.04	215.17
M12-1									
M12-1A									
M12-2									
M12-3									
M12-4									
M12-4DD									
PRP 1A									
PRP 2									
PRP 3									
PRP 4									
P-10A								178.49	177.79
P-15A								174.44	174.13
P-15B								175.94	175.69
P-15C								211.13	210.88
P-15D								224.37	224.25
P-15TA								176.81	176.46
P-15TB								176.69	176.34
P-15TC								171.45	171.04
P-15TD								167.75	167.72
P-18A								167.07	167.02
P-18B								167.28	167.28
P-18D								217.02	217.04
P-18TA								170.88	169.92
P-18TB								170.78	169.88
P-18TC								170.20	169.24
P-18TD								170.98	169.17
P-19A								185.34	184.87
P-19B								260.04	259.85

Wells Within NPR Model Grid
(Modwells.db)

Well Name	8/18/88 Water Elevation (ft MSL)	9/15/88 Water Elevation (ft MSL)	10/17/88 Water Elevation (ft MSL)	11/29/88 Water Elevation (ft MSL)	12/20/88 Water Elevation (ft MSL)	1/25/89 Water Elevation (ft MSL)	2/13/89 Water Elevation (ft MSL)	5/23/89 Water Elevation (ft MSL)	6/29/89 Water Elevation (ft MSL)
P-19C								259.99	259.78
P-19D								260.21	260.69
P-19TA								178.75	178.00
P-19TB								178.53	177.78
P-19TC								177.89	176.54
P-19TD								177.33	176.48
P-25A								170.72	170.57
P-25B								180.22	180.10
P-25C								195.66	195.56
P-25D								209.12	209.10
P-25TA								172.25	171.87
P-25TB								171.27	170.88
P-25TC								167.64	167.19
P-25TD								167.65	167.15
P-25TE								167.61	167.26
P-27B								178.91	178.44
P-27C								237.28	238.98
P-27D								265.05	264.13
P-27TA								177.82	175.35
P-27TB								178.22	177.17
P-27TC								179.00	177.88
P-27TD								178.06	176.93
P-27TE								178.63	177.58
T18N-1									
T18N-1A									
T18N-2									
T18S-1									
T18S-1A									
T18S-2									

END

DATE FILMED

02 / 26 / 91