EVALUATION OF TRITIUM MIGRATION IN THE AQUIFER OF THE DONALD C. COOK NUCLEAR PLANT AND SURROUNDING COMMUNITIES

Indiana Michigan Power Company
Donald C. Cook Nuclear Plant

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EXECUTIVE SUMMARY

Groundwater samples obtained from environmental monitoring wells within the Donald C. Cook Nuclear Plant's site boundary have been found to contain levels of tritium greater than preoperational levels. The level of tritium in these samples raised a concern that offsite users of well water from the affected aquifer could be impacted and prompted an evaluation of this potential dose pathway to the offsite population. As part of the evaluation, an investigation to determine the source of the tritium detected in the environmental monitoring well samples was also initiated.

Eight active and two inactive offsite domestic wells were identified for sampling purposes to determine if the wells were subjected to the affected aquifer. All eight active wells and the two inactive wells were sampled and analyzed for tritium, iodine and gamma emitting radionuclides. In all but one case, no detectable radioactivity was found. The sample with detectable activity showed a tritium concentration consistent with documented preoperational groundwater tritium concentrations. The presence of tritium in the onsite environmental monitoring well samples is therefore concluded to have no impact on public health and safety.

The source of tritium in the environmental monitoring well samples was determined to be the onsite Absorption Pond which is upgradient from the wells and receives effluent from the Turbine Room Sump. Having determined the tritium source, the Radiological Environmental Monitoring Program (REMP) will be revised to include monitoring of additional wells. The locations of the added monitoring wells are based on a detailed hydrogeologic study of the groundwater system in the vicinity of the plant site and was performed as a part of the evaluation to determine the potential offsite impact.

Based on our investigation, the following is a summary of conclusions drawn:

- o Shallow groundwater movement at the Plant Site was clearly delineated, as a result of this evaluation.
- o Tritium migration has not resulted in adverse radiological impacts to the offsite population because:
    - Radiological Environmental Monitoring Program (REMP) radionuclide Reporting Levels were neither challenged nor exceeded, and
    - Radionuclides were not detected in offsite wells used for human consumption.
- o REMP modifications, designed to monitor this potential exposure pathway, will be implemented.

EVALUATION OF
TRITIUM MIGRATION IN THE AQUIFER OF
THE DONALD C. COOK NUCLEAR PLANT
AND SURROUNDING COMMUNITIES

I. INTRODUCTION

This study was performed to evaluate tritium migration in the aquifer of the Donald C. Cook Nuclear Plant and surrounding communities. This issue was raised due to concerns regarding the tritium concentration identified in onsite environmental monitoring wells located just west of the main plant buildings (environmental monitoring wells #4, 5 & 6). NRC concerns and comments relative to this matter, are documented in inspection reports 50-315/90012 (DRSS); 50-316/90012 (DRSS); 50-315/90014 (DRSS); 50-316/90014 (DRSS); 50-315/91008 (DRSS); 50-316/91008 (DRSS), as follows:

1. An Investigation of the human use of the groundwater aquifer should be performed.

2. An evaluation of the source of tritium found in the environmental monitoring wells should be performed.

3. The ODCM assumes that no drinking water wells draw from the affected aquifer. A review of the ODCM assumption regarding the basis for projecting waterborne dose will be required if the affected aquifer also affects drinking water wells.

4. The licensee will complete a hydrogeologic evaluation study of the aquifer.

5. An appropriate monitoring program for this pathway should be developed.

II. BACKGROUND

Hydrogeology - Covert Ridge is a groundwater barrier as well as a watershed boundary between the glacial plain to the east and the Grand Marais Embayment to the west.

Test borings and water level measurements at the site indicate that the groundwater system is unconfined. The base of the shallow aquifer is delineated as the stratigraphic contact between the dune sand or the sandy beach deposits and the lacustrine clay deposits. The surface of the lake clays slopes upward gradually.

Groundwater is recharged by precipitation infiltrating through the permeable, sandy surficial soils. Surface runoff is limited to minor quantities and is restricted to the northeast and eastern portion of the site. Basins of interior drainage and closed depressions characterize most of the site.

Groundwater Monitoring Programs - Two separate groundwater monitoring programs are active at the plant. The Radiological Environmental Monitoring Program is comprised of 7 monitoring wells for the plant and 4 monitoring wells for the temporary steam generator storage facility. These wells are used to monitor the shallow aquifer for radiological parameters.

The NPDES Groundwater Monitoring Program is composed of eight wells at four locations. Two wells are located at each site where one well is equipped with a submersible pump to obtain water samples and the other well is used to observe water levels. One aspect of the NPDES Ground Water Monitoring Program is to evaluate significant changes in groundwater quality and potentiometric levels which occur near the Absorption Pond. The Absorption Pond creates a groundwater mound and superimposes a radial flow pattern from the pond center on the regional flow regime.

The groundwater flow system was also indirectly modified by the installation of sheet piling in 1973-74 along Lake Michigan to control beach erosion. This piling was driven into the low permeable lacustrine deposits and created a barrier to groundwater flow. Ponding occurred behind this barrier and eventually spilled over the piling and flowed again to Lake Michigan. Several drains were cut into the piling in order to alleviate the ponding of ground water.

III. INVESTIGATION AND ACTION TAKEN

1. Human use of the affected ground water aquifer

Donald C. Cook Nuclear Plant's Environmental Section performed a well survey in 1990 of those residents with domestic wells located in Rosemary Beach (north of the plant) and Livingston Hills (south of the plant). The communities to the east of the plant were not involved in the well census due to the fact that they are located in a different groundwater basin and are beyond the potential influence of any plant activity associated with the absorption pond (see attached hydrogeologic evaluation).

Eight of the thirty-seven residences in the Rosemary Beach community were identified as having wells supplying potable water for human consumption. The eight residences are located between 2200 feet and 4100 feet from the Absorption Pond. All eight wells were sampled and analyzed for tritium, iodine and other gamma emitters. In all cases, analysis resulted in no detectable activity. Currently, Rosemary Beach domestic wells are used for potable and non-potable supplies, as opposed to Livingston Hills' residences, who obtain their potable water from the Lake Township Municipal water system.

Two of the inactive wells (Malmstadt and Scupham) in Livingston Hills, were temporarily repaired for the purpose of obtaining groundwater samples since these wells are located the closest to the plant. The Malmstadt well is located approximately 3200 feet from the plant center and 2450 feet from the Absorption Pond. The Scupham well is located approximately 3850 feet from the plant center and 3050 feet from the absorption pond. Duplicate samples were obtained from each well. Once again, these samples were analyzed for tritium, iodine and other gamma emitters. No detectable activity was identified for each Malmstadt sample. The iodine and gamma spectroscopy results for the Scupham samples showed no detectable activity. One sample analyzed for tritium from the Scupham area showed no detectable activity and the other, a concentration of 350 pCi/l. The concentration of 350 pCi/l is clearly within the preoperational (1974) tritium levels identified in groundwater which ranged from 150-710 pCi/l (as referenced in Annual Environmental Operating Reports). An additional well was drilled in 1990 between the plant and Livingston Hills. The well is located approximately 3100 feet from the plant center, and 2300 feet from the Absorption Pond. Initial tritium, iodine and gamma spectroscopy analyses of the well samples showed no detectable activity.

2. <u>The source of tritium found in the environmental monitoring wells</u>

Tritium has been detected in the downgradient environmental monitoring wells Nos. 4, 5, 6 and 7 and would indicate the Absorption Pond as the source. An increase in tritium concentration for effluent discharged from the Turbine Room Sump to the Absorption Pond is accompanied, at a consistent time interval, by an elevated peak concentration in the downgradient wells.

Tritium levels in the Absorption Pond over the past ten (10) years were evaluated. During this time period, eight major tritium concentration peaks in the Absorption Pond were identified.

The plant operational status when the peaks were observed is as follows:

Peak #1: Unit 1 refueling outage Cycle VI and VII

Peak #2: Unit 2 refueling outage Cycle III and IV

Peak #3: Unit 1 refueling outage - Cycle VII and VIII

Unit 2 force outage - Steam Generator (S/G) #23 tube leak repair

Peak #4: Unit 2 - S/G #23 leak repair

Peak #5: Unit 1 - Cycle VIII, 10 year ISI

Peak #6: Unit 2 - S/G #23 leak repair

Peak #7: Unit 2 - S/G tube leak (90% admin. limit)

Peak #8: Unit 1 - Cycle IX and X

As can be seen above, each major peak observed is associated with a unit outage. It should be noted that significant primary to secondary leakage was identified in the Unit 2 S/Gs in the mid 1980's. Further investigation showed that during this time, a leak from the S/G blowdown line (which runs through the Turbine Room Sump) occurred. This leak provided a pathway for S/G secondary side water to enter the Turbine Room Sump during S/G secondary side drains and S/G blowdown operation.

In 1987, the blowdown line was repaired and the Unit 2 S/Gs were replaced. As expected, there was a significant decrease in the concentration of tritium discharged to the Absorption Pond.

To continue this investigation, the tritium data from the Absorption Pond were then compared with the data from environmental monitoring wells #4, 5, and 6 (See figures 12, 13, 14, and 15 of Appendix 5 of the Hydrogeologic Evaluation Report for a graphical comparison of the tritium peaks in the Absorption Pond and the environmental monitoring wells). The purpose of this comparison was to determine the correlation between tritium levels in the wells as compared to that of the Absorption Pond. It was noted that whenever a rise in tritium concentration occurred in the Absorption Pond, approximately sixteen months later, there was a significant increase in the concentration of tritium environmental monitoring well samples.

The Auxiliary Boiler Fuel Oil Storage Tanks were also considered as a possible source for the tritium found in the environmental monitoring wells. These tanks were a concern because it is allowed, per Technical Specification 3.11.2, for waste oil to be added to the Auxiliary Boiler Oil Storage Tanks for incineration. Some of the waste oil was contaminated with radionuclides. However, a leak test recently performed on the tanks indicated no detectable leaks.

3. <u>ODCM assumptions regarding that no drinking water wells draw from the affected aquifer</u>

The hydrogeologic study supports the ODCM assumptions that offsite drinking water wells are not supplied by the affected aquifer. In addition, samples taken from offsite wells showed no activity greater than the baseline preoperational tritium levels presented earlier in this report. The assumption currently used in the ODCM for dose assessment are conservative, in that releases from the Turbine Room Sump to the Absorption Pond are considered releases to an unrestricted area.

4. <u>Hydrogeologic Evaluation of the Donald C. Cook Nuclear Plant</u>

A hydrogeologic study (Attachment 1 of this report) has also been prepared to evaluate the potential environmental impacts, if any, resulting from the discharge of the Turbine Room Sump effluent to the plant's Absorption Pond. This report defines the areal and vertical extent for the aquifer based upon a review of previous hydrologic studies. The baseline groundwater quality is derived from a review of the previous Dames & Moore environmental site study and the upgradient observation well of the current NPDES Groundwater Monitoring Program.

Initial site investigations observed static water levels ranging from 582 to 609 ft. A generalized potentiometric map which characterizes baseline conditions is depicted in Figure 5 of the "Hydrogeologic Evaluation Report". The groundwater static water level elevations reflect to some extent the irregular topography of the dunes and basin. The direction of the groundwater flow is toward the west to Lake Michigan.

5. <u>Modification to the REMP Program</u>

The Radiological Environmental Monitoring Program (REMP) will be modified to include the sampling of an additional four wells along Livingston Road, and EW#7 (See attached Hydrogeologic Evaluation report).

These wells will be used to monitor the groundwater along the south and north site property line. In addition, a new well near the visitor center will be drilled and made operable for sampling. Relative analyses and test results will be reviewed and evaluated as part of the quarterly analysis of the REMP data.

Based on current operational levels, an action level of 10,000 pCi/l will be implemented for Turbine Room Sump daily and weekly composite samples. Exceeding this action level will initiate a complete investigation of the cause of the increase in tritium concentration, any mitigating action to be taken and the effect it may have on the aquifer dose pathway.

IV. Conclusions

1. <u>Human use of the affected aquifer:</u>

The migration of tritiated water seeping from the Absorption Pond joins the regional flow and discharges into Lake Michigan. It is concluded that there has been no offsite impact to domestic wells located either north or south of the plant based on the environmental studies of the aquifer. However, the Donald C. Cook Nuclear Plant will continue to actively monitor this potential pathway.

2. <u>The source of tritium found in the environmental monitoring wells four, five, and six:</u>

It is concluded that the source of tritium found in the environmental monitoring wells originates from discharges to the Absorption Pond from the Turbine Room Sump and subsequent seepage from the Absorption Pond.

3. <u>ODCM assumptions regarding that drinking water wells do not draw from the affected aquifer:</u>

Based on the above conclusion that the affected aquifer does not impact the surrounding offsite watertables, the assumptions used in the ODCM are still valid. It should be noted that the Turbine Room Sump effluent is assessed for offsite dose and is reported in the Semi-annual Radioactive Effluent Release report.

4. <u>Hydrogeologic Evaluation:</u>

The Hydrogeologic Evaluation of the Donald C. Cook Nuclear Plant has been conducted and is attachment to this report. As previously assumed, this study confirmed that the migration of tritiated water seeping from the Absorption Pond joins the regional flow and discharges into Lake Michigan. The affected aquifer is confined within the site boundaries.

5. <u>Modification to the REMP Program:</u>

The following changes to the REMP program will be implemented by December 31, 1991:

- o Sampling and analysis of additional wells to monitor the groundwater along the south and north boundaries of the plant site.
- o An action level of 10,000 pCi/l identified by Turbine Room Sump composite sample analysis will initiate an investigation into the cause of the increase in tritium concentration and the effect it may have on the aquifer.

ATTACHMENT I

Hydrogeologic Evaluation

HYDROGEOLOGIC EVALUATION

OF THE

DONALD C. COOK NUCLEAR PLANT, BRIDGEMAN, MICHIGAN

Indiana Michigan Company

American Electric Power Service Corporation

April 1991

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Introduction

A hydrogeologic study has been prepared to evaluate the potential environmental impacts, if any, resulting from the discharge of the turbine room sump effluent to the plant's Turbine Room Sump Absorption Pond. This report defines the areal and vertical extent of the aquifer based upon a review of previous hydrologic studies. The baseline ground-water quality is derived from a review of the previous Dames & Moore environmental site study and the upgradient observation well of the current NPDES monitoring program.

The NPDES ground-water monitoring program does indicate an increase in total dissolved solids and sulfate concentrations above baseline quality concentrations downgradient of the Absorption Pond. These parameters are used as key indicator parameters to determine the areal extent of influence upon the shallow aquifer.

Topography

The site is located within a local physiographic area known as the Grand Marais Embayment. This area, 16 miles long and with an average width of about 1 mile, lies adjacent and parallel to the shoreline of Lake Michigan in western Berrien County. The area adjacent to the beach is characterized by high sand dunes of Pleistocene and Recent origin. The area is bounded on the east by a glacial moraine which parallels the shoreline and is known as Covert Ridge. The area east of Covert ridge is a glacial plain, with morainic ridges. (See enclosed 7.5 min. Bridgman Quadrangle Map)

Topographic elevations within the dune area range from about 580 Ft. NGVD, which is the elevation of Lake Michigan, to a high of slightly more than 800 Ft. NGVD (Figure No. 1). In the southern part of the embayment, the area of high dunes extends from the lake shore to the crest of Covert Ridge. To the north, however, the belt of high dunes is separated from Covert Ridge by Thornton Valley and the Grand Marais Lakes. The higher sand dunes extend inland about 3,000 feet from the beach. The eastern portion of the site is characterized by scattered lower dunes with broader intervening flat lowlands or basins, some of which contain small shallow ponds.

Geology

The site geology consists of a sequence of deposits composed of a surface deposit of dune sand which overlies older beach sand which in turn is underlain by glacial lake clays, glacial till and shale bedrock. The dune sands are light brown to tan, poorly graded, typically exhibit bimodel grain sizes distribution (fine and coarse sand grains). The dune sands are easily disturbed at or near the surface and become moderately compacted at depth. In the eastern half of the site the dune sands directly overlie glacial lake sediments. In this area, the upper 10 to 20 feet of lake sediments are often silty and sandy. Geologic cross- sections are illustrated in Figures 2, 3 and 4.

In the western portion of the site, the dune sands overlie beach sands which are generally medium to coarse grained and are moderately to well sorted. In places, the beach deposits contain a small percentage of fine gravel. The beach sands may be a bar-type of deposit, probably related to an old shoreline of Lake Michigan. The maximum thickness of the beach sand is about 52 feet in the southern portion

of the site. In the west-central portion of the property near the lake, the beach sands generally range from about 25 to 35 feet in thickness.

Underlying the beach sands and/or the dune sands is a thick sequence of glacial lake sediments. These glacio-lacustrine deposits, which are approximately 80 to 90 feet thick, consist generally of gray silty clay and sandy clay with occasional sand and silt partings. Varve-type bedding is not typical but does occasionally occur in places. The deposits exhibit considerable variation in detailed characteristics between borings and comprise an irregularly interbedded series of sediments.

The top few inches of the lake sequence often is marked by a considerable amount of organic material which in place is concentrated in peaty layers one or two inches in thickness. The layer immediately beneath the organic soil generally contains an abundance of gastropod shells. Throughout most of the site, the upper five to ten feet of lake deposits consists of silty or sandy soil with varying amounts of dispersed organic material and decayed vegetation. At greater depth, the lake deposits consists of silty clay with occasional zones containing scattered coarse sand grains and fine gravel. Lenses and pockets of silty fine sand and fine sandy silt are common. The deepest part of the lake sequence is commonly a clayey silt deposit.

A compact glacial till of silt and gravel with cobbles was encountered at an elevation of 474 Ft. NGVD. This stratum is about 22 feet and is believed to be fill in any depressions in the underlying bedrock. Bedrock was encountered at 452 Ft. NGVD and consists of gray, thin-bedded to fissile, calcareous shale containing thin interbeds of impure, shaley limestone. The shale is horizontally bedded and is cut by two sets of cemented

joints. The rock appears to correlate with the Berea-Bedford shale, a lower Mississippian formation.

Hydrogeology

Covert Ridge is a groundwater barrier as well as a watershed boundary between the glacial plain to the east and the Grand Marais Embayment to the west. Static groundwater levels east of the ridge are generally at an elevation of 650 Ft. NGVD. In contrast, static water levels west of the ridge occur generally at elevations of 580 to 610 Ft. NGVD.

Test borings and water level measurements at the site indicate that the groundwater system is unconfined. The base of the shallow aquifer is delineated as the stratigraphic contact between the dune sand or the sandy beach deposits and the lacustine clay deposits. The surface of the lake clays slopes upward gradually from elevations of about 555 to 560 Ft. NGVD along the beach to about elevation 589 Ft. NGVD at the location of Boring 14 in the southeast corner of the site (Figures 2, 3 and 4).

Ground water is recharged by precipitation infiltrating through the permeable, sandy surficial soils. Surface runoff is limited to minor quantities and is restricted to the northeast and eastern portion of the site. Basins of interior drainage and closed depressions charac-terize most of the site. The average annual precipitation for Benton Harbor Airport (located approximately 12 miles from the plant) is 36.04 inches/year (Table No. 1).

Initial site investigations observed static water levels ranging from 582 to 609 Ft. NGVD inside perforated plastic pipe installed in the 19 test borings (Table No. 2). A generalized potentiometric map which characterizes baseline conditions is depicted in Figure 5. The ground-water static

water level elevations reflect to some extent the irregular topography of the dunes and basins. The direction of ground-water flow is toward the west to Lake Michigan.

Short duration pumping tests were performed to determine values of permeability across the site. Analysis of the pumping test data indicated that aquifer permeabilities range from 115 to 196 ft/day assuming an aquifer thickness of 30 feet. This pump test data is referenced in Appendix No. 1. A value of 0.25 for effective porosity is assumed to be reflective of the site conditions.

Ground-Water Quality Baseline Conditions

The baseline ground-water quality reflects the solubility of minerals present in the aquifer and the residence time of the water in contact with various minerals. An analysis of the plant's two former drinking water wells in March 1972 (preoperational conditions) yielded a calcium bicarbonate type water with an average total dissolved solids concentration of 390 mg/l. Chloride and sulfate concentrations of the plant's former potable supply wells are also presented in Table 3 and reflect concentrations similar to baseline conditions reported by the previous Dames & Moore site investigation. It is reasonable to extrapolate the analysis of the former potable supply wells to establish the concentration of the dominant cations and anions (Ca, Mg, NA, HCO_3, SO_4 & Cl) in the ground-water quality baseline. Figure 6 illustrates the relationship between the dominant cations and anions for the March 1972 analysis.

The water quality of the upgradient Well (No. 8) provides a contrast in water quality between ground-waters upgradient of the TRS pond and ground-waters that are downgradient and have been influenced by the TRS pond.

Ground-Water Monitoring Programs

Two separate ground-water monitoring programs are active at the plant. The radiological protection monitoring program is comprised of 7 monitoring wells for the plant and 4 monitoring wells for the temporary steam generator storage facility. These wells are used to monitor the shallow aquifer for radiological parameters. The NPDES ground-water monitoring program is the other monitoring program and is composed of eight wells at four locations. Two wells are located at each site where one well is equipped with a submersible pump to obtain water samples and the other well is used to observe water levels. Well logs are contained in Appendix No. 2. Drawing No. CE-SK-3/25/91-1 depicts the location of the observation wells with respect to the plant's Absorption Pond, sanitary ponds and the plant's former potable supply wells. Additional well logs are also contained in Appendix No. 2. These wells were installed in 1989 under the direction of American Environmental Services, Inc. to reevaluate the potential environmental impacts, if any, resulting from a 1976 fuel oil spill.

Reference:

American Environmental Services Co. Inc., July 11, 1990, Subsurface Fuel Oil Contamination Assessment and Demonstration Recovery Technology at Indiana Michigan Power Company, Donald C. Cook Nuclear Plant, Bridgman, Michigan, AES Project No. AE964 AEPC741301-04/02.

Ground-Water Quality Michigan NPDES

The Michigan NPDES monitoring program is designed to evaluate significant changes in ground-water quality and potentiometric levels which occur near the Absorption Pond. The Absorption Pond creates a ground-water mound and superimposes a radial flow pattern from the pond center on the regional flow regime. The monthly average discharge to the Absorption Pond is listed in Table No. 4.

The ground-water flow system was also indirectly modified by the installation of sheet piling in 1973-74 along Lake Michigan to control beach erosion. This piling was driven into the low permeable lacustrine deposits and created a barrier to ground-water flow. Ponding occurred behind this barrier and eventually spilled over the piling and flowed again to Lake Michigan. Several drains were cut into the piling in order to alleviate the ponding of ground water.

Drawing No. CE-SK- 3/25/91-1 depicts an approximate configuration of the water table for March, 1986. The map should be considered as an approximation since it is based on static water level measurements observed in December 6 & 13, 1983; March 4, 1986, and October 26, 1990 for the ground-water monitoring programs. The configuration of the water table is also inferred from inundated dune swales observed from stereoscopic aerial photography taken March 24, 1986. The north to south direction of flow in the vicinity of RP Wells 4 and 5 is inferred from static water levels measured on November 30, 1989 in the AES, Inc. monitoring well and recovery well and the soil gas survey mapping of hydrocarbons (Figures 7 and 8).

Well hydrographs for observation wells Nos. 1A, 8, 11, and 12 are depicted in Figure No. 9. The well hydrographs

depict fluctuating water levels in response to a non-uniform discharge rate to the TRS pond, seasonal evapotranspiration, and precipitation etc. For example, field data recorded in 1983 depicts a decline in water levels and is probably due to a precipitation deficit of nearly 7 inches. A similar decline is observed in response to the 1988 drought.

The monitoring wells located downgradient of the TRS pond observe increased concentrations for the total dissolved solids and sulfate compared to the upgradient monitoring Well No. 8. Downgradient wells reflect a water quality similar to the water quality of the effluent discharged to the Absorption Pond. Time dependent graphs of sulfate (SO_4) and total dissolved solids (TDS) concentrations demonstrate the influence of the Absorption Pond on the shallow aquifer system.

Sulfate, TDS and static water level measurements for the period of record from 11/29/76 to 10/24/90 are listed in Table No. 5. In 1983, there was an operational change to improve the steam generater water quality by increasing blowdown and increasing the volume of makeup water. A result of this operation required an increase in the number of regenerations of the ion filter beds. The anion beds are recharged with a caustic solution (NaOH) and the cation beds are recharged with an acidic solution (H_2SO_4). This operational change is reflected in the NPDES ground-water monitoring program by the increase in total dissolved solids and sulfate concentrations. (Figure Nos. 10 and 11).

The water quality of observation Well No. 1A is very similar to baseline quality from July 1977 to March 1982. After March 1982, however, Observation Well 1A detected a steady increase in total dissolved solids and sulfate

concentrations as a result of the overflow from the Absorption Pond into the remaining portion of the dune swale.

Ground-Water Quality Radiological

A semi-annual sampling program has been initiated for the absorption pond sediments in addition to the current radiological monitoring program. A new procedure (12 THP 6010 ENV. 066) has been instituted to analyze these sediments. The test results will be reviewed and evaluated as part of the quarterly analysis of the REMP data.

Tritium has been detected in the downgradient radiological protection monitoring wells Nos. 4, 5, 6 and 7 and would indicate the TRS absorption pond as the source. Appendix No. 3 lists the tritium values for the monitoring program. A rise in tritium concentrations for effluent discharged to the absorption pond is accompanied by a detectable peak concentration in the downgradient wells. Figure No. 12 illustrates tritium activities for the TRS pond for the period of record from 1981 to 1990. Tritium activities for the downgradient RP monitoring wells are illustrated in Figures Nos. 13, 14 and 15. Table No. 6 provides a range of travel times from the absorption pond to the downgradient wells based on seepage velocities. The seepage velocities are derived from site specific hydrogeologic parameters of formation permeabilities, hydraulic gradients (rate and direction of ground-water flow) and an estimated value of specific yield.

Potable and Domestic Supply Wells

The Plant's Environmental Section performed a well survey in 1990 of those residents with domestic wells located in Rosemary Beach (North of the plant) and Livingston Hills

(south of the plant). The communities to the east of the plant were not involved in the well census due to the fact that they are located in a different ground-water basin and are beyond the potential influence of any plant activity.

Eight of the thirty-seven residences in the Rosemary Beach community were identified as having wells, previously used to supply water for human consumption. The eight residences are located between 2200 feet and 4100 feet from the absorption pond. (Figure No. 16). All eight wells were sampled and analyzed for tritium, iodine and other gamma emitters (Table No. 7). In all cases, there was no detectable activity identified. Currently, only the Rosemary Beach domestic wells are used for potable or non-potable supplies. (Liechner, 1991). The Livingston Hills residences obtain their potable water from Lake Township Municipal water system.

Two of the inactive wells (Malmstadt and Scupham), were temporarily repaired for the purpose of obtaining ground-water samples since these wells are located the closest to the plant. The Malmstadt well is located approximately 3200 feet from the plant center and 2450 feet from the absorption pond. The Scupham well is located approximately 3850 feet from the plant center and 3050 feet from the absorption pond. Duplicate samples were obtained from each well. Once again, these samples were analyzed for tritium, iodine and other gamma emitters. No detectable activity was identified for each Malmstadt sample. The iodine and gamma spectroscopy results for the Scupham samples showed no detectable activity. One sample taken for the Scupham area showed a tritium concentration of 350 pCi/l and the other showed no detectable activity. As a comparison, preoperational (1974) tritium levels in ground-water ranged from 150-710 pCi/l (as shown in Annual

Environmental Operating Reports). Tritium levels for lake water and drinking water samples collected in 1990 ranged from no detectable activity to 340 pCi/l.

An additional well has been drilled in 1990 between the plant and Livingston Hills to facilitate future groundwater sampling in this area. The well is located approximately 3100 feet from the plant center, and 2300 feet from the absorption pond. Initial tritium, iodine and gamma emitter analyses of the well samples showed no detectable activity.

The Plant's former potable supply wells are located approximately 1,400 feet north of the Absorption Pond. These wells served as a source of drinking water for plant personnel and the Energy Information Center from 1970 to 1987. (The plant is now served by municipal water from Lake Township). Former Potable Well No. 2 is located downgradient of the Absorption Pond based upon the existing flow regime depicted on Drawings No. CE-SK 3/25/91-1. Former Potable Well No. 1 is located about 300 feet further inland and was influenced to a lesser degree by the absorption pond.

The wells were sampled two to three times a year for several parameters (Table 8 and 9). Figures 17 and 18 depict time dependent graphs of Ca, Mg, Na, HCO_3, and Cl expressed in milliequivalents per liter (meq/l). A calcium bicarbonate type water characteristic of baseline conditions is exhibited by both wells from 1976 to early 1979. In August, 1979 potable Well No. 2 experienced a change in water quality to a sodium sulfate type water (Figure 17) and reflects the influence of the Absorption Pond. Former Potable Well No. 1 experienced a marginal shift in water quality (Figure 18) and is affected by the Absorption Pond to a lesser degree than former Potable Well No. 2.

Reference:

Liechner, J L; Feb. 28, 1991, Interoffice memo to D. R. Williams, Subject: "Preliminary Evaluation Regarding Tritium Migration Via the Groundwater Aquifer Within the Donald C. Cook Nuclear Plant Site Boundary".

Conclusions

The Cook Nuclear Power Plant is sited within a ground-water basin bounded by Lake Michigan to the west and Covert Ridge (a terminal end moraine) to the east. The aquifer is unconfined and is composed of beach sands overlain by sand dunes and underlain by low permeable lacustrine clays. Construction of the sheet piling and the Absorption Pond have modified existing ground-water flow directions. Discharge to Absorption Pond has created a ground-water mound which superimposed a radial flow pattern on the regional flow towards Lake Michigan.

Total dissolved solids and sulfate concentrations have increased above baseline conditions downgradient of the Absorption Pond as a result of the wastewater effluent migrating through the shallow aquifer towards Lake Michigan. Similar water quality changes are observed in the plant's former potable Well No. 2 and marginal changes are observed in former potable Well No. 1. The northern areal extent of the TRS effluent is bracketed between the plants former potable supply wells and radiological protection observation Wells No. 1 and No. 2 based on a review of the tritium analyses for ground water. The downgradient NPDES observation Wells Nos. 11 and 12 detect the influence of the TRS pond as ground water flows westward into Lake Michigan.

In the vicinity of R. P. Wells 4, 5 and 6, ground water flows from the north to the south. This direction of flow is confirmed by the tritium concentration gradient and a hydrogeologic site investigation conducted by American Environmental Services, Inc. The southern areal extent of the TRS effluent is bracketed by observation Wells 1A and the recently installed off-site monitoring well. It may be concluded that there has been no off-site impact to domestic wells located either north or south of the plant based on a review of the various monitoring programs and environmental site investigations. The migration of tritiated water seeping from the absorption pond eventually joins the regional flow and discharges into Lake Michigan.

Appendix No. 1

Aquifer Pump Test Data

Summary of

Aquifer Pump Test Data

OBS WELL No.	Q (gpm)	r (ft)	T (gpd/ft)	k (ft/day)	S	Analytical Method
8	10	10	58,666	196	1.22×10^{-6}	Jacob
1A	25	10	31,428	140	3.14×10^{-7}	Jacob
11	25	9.5	36,666	163	5.07×10^{-3}	Jacob
12	25	10	25,882	115	3.50×10^{-1}	Jacob
AVERAGE			38,160	153.5		

Notes:

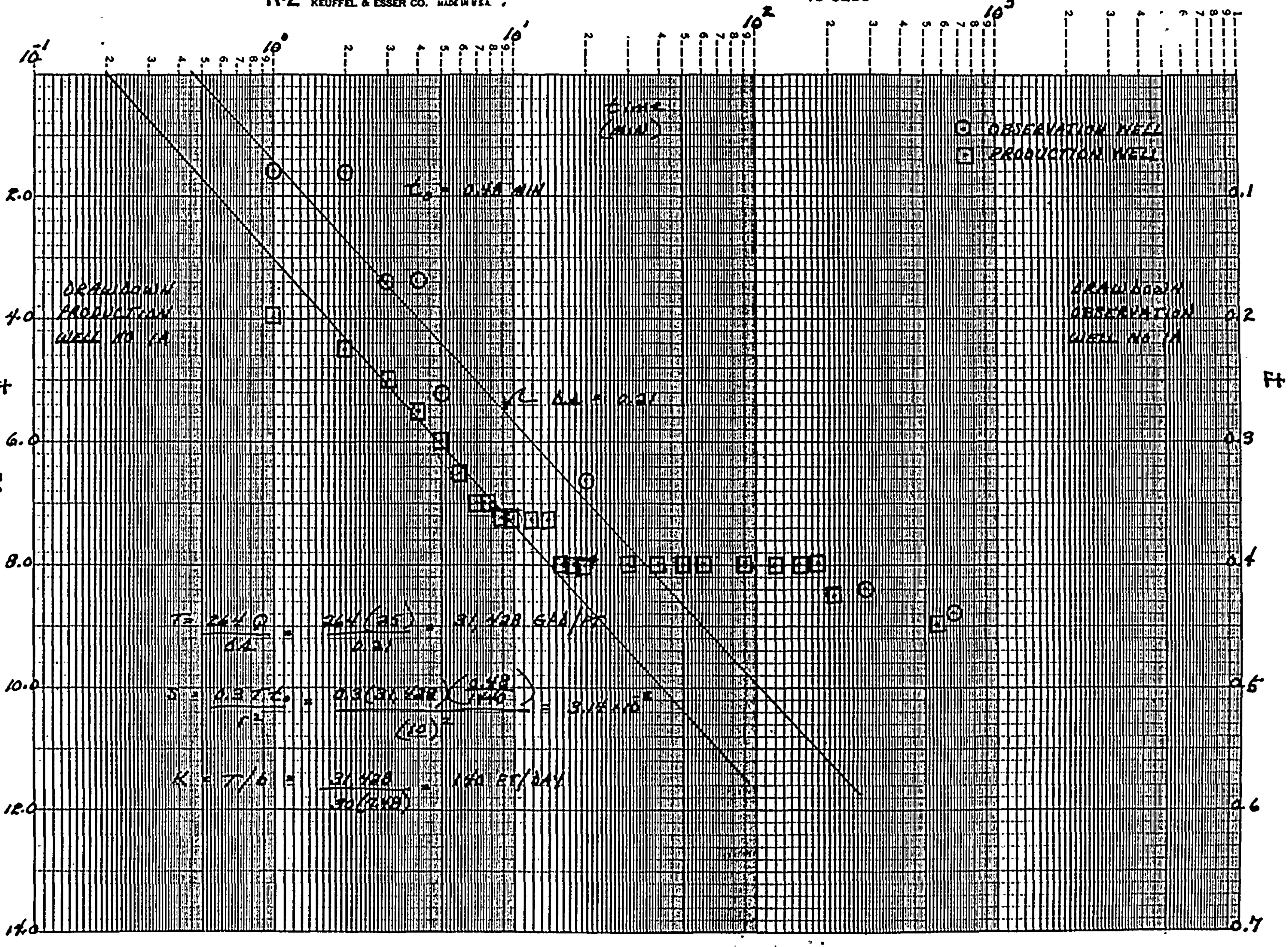
1. The drawdown for each production well is plotted on semi-logarithmic paper for comparison with the drawdown observed in the respective observation well.

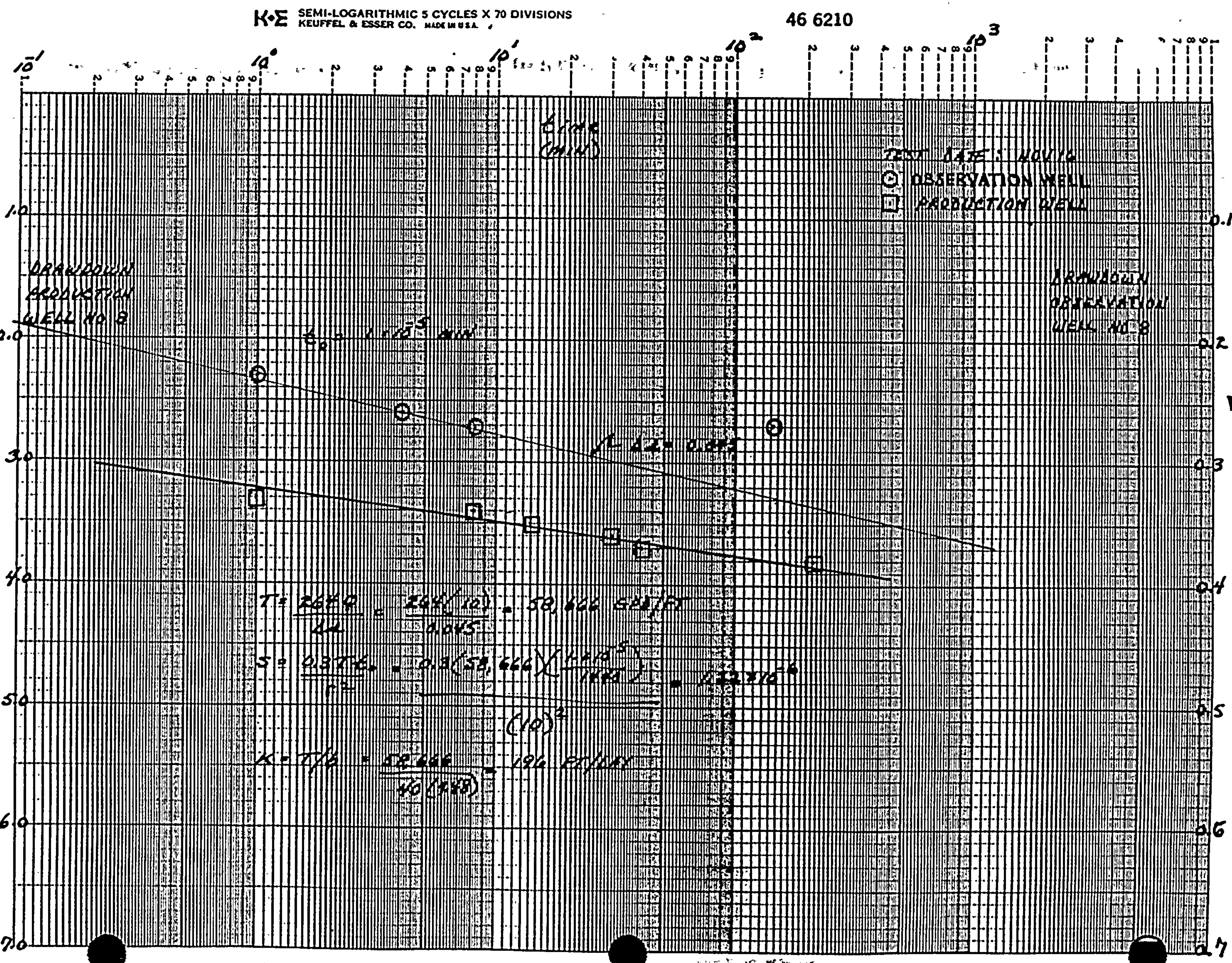
2. The permeability is derived from the transmissivity, T, divided by the aquifer thicknesses. The aquifer thickness at observation well No. 8 is estimated to be 40 ft. and 30 ft. for the remaining observation wells.

3. Data Source: Donald C. Cook Nuclear Plant, Annual Environmental Operating Report, 1981.

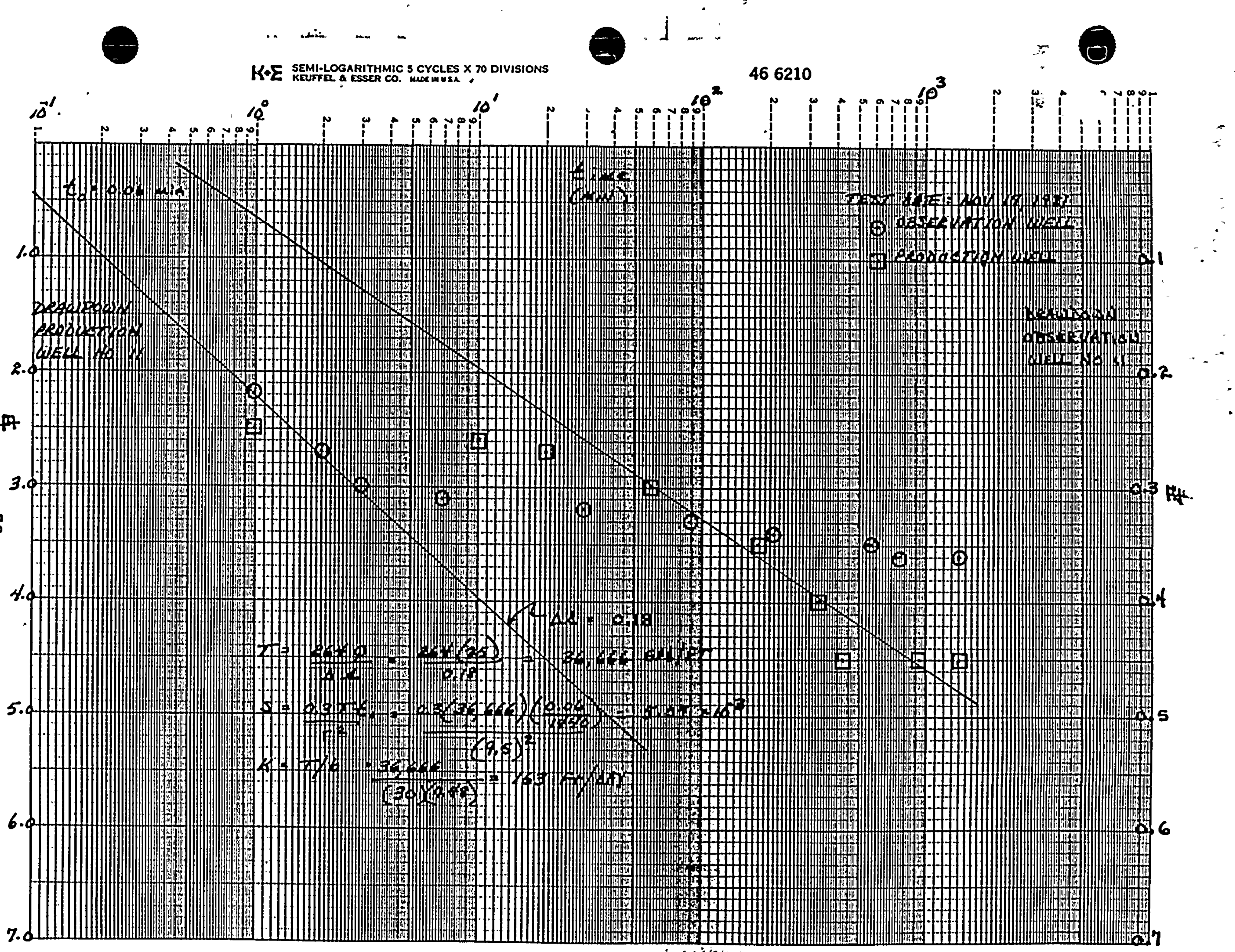
K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 6210

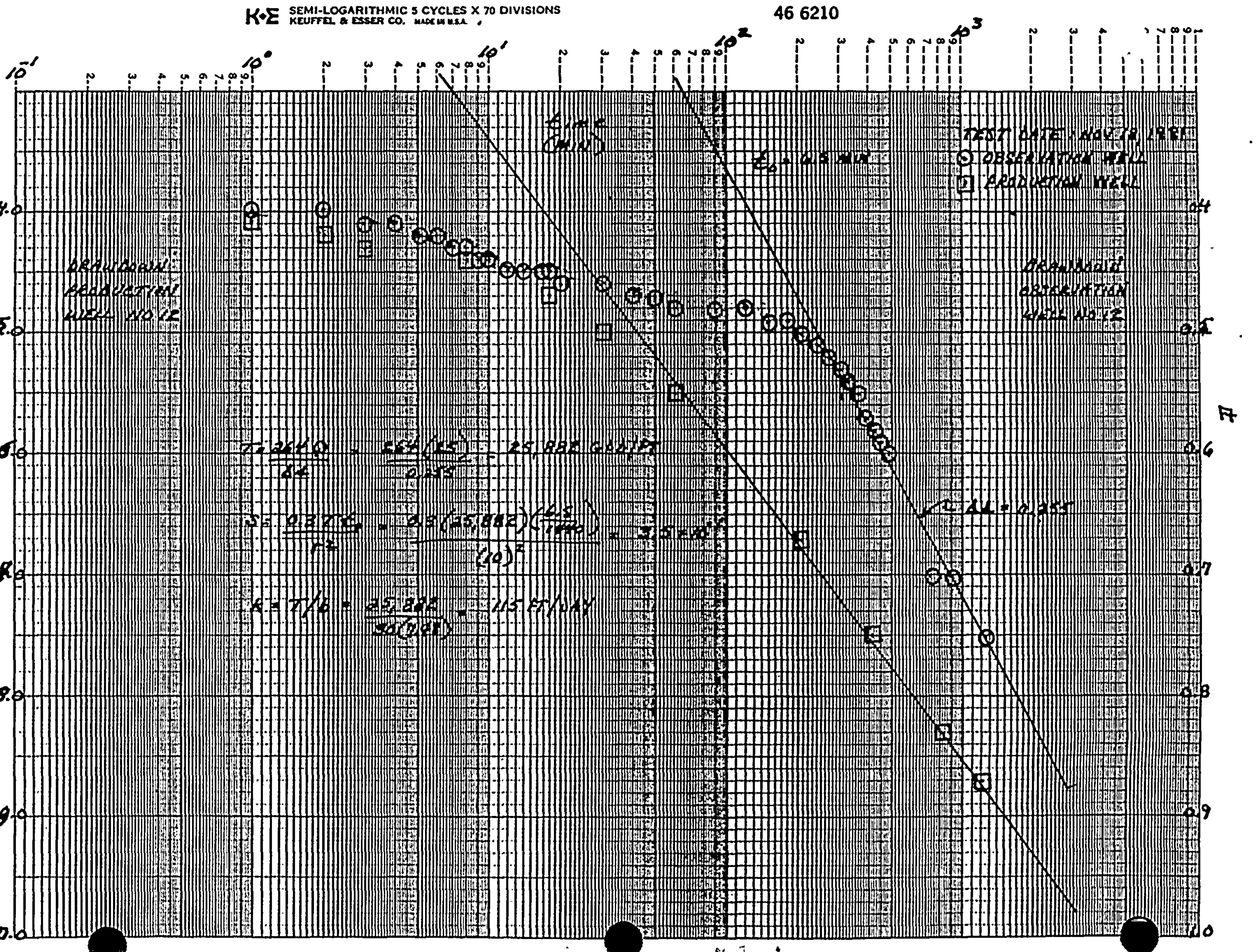




K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210
TIME (MIN)
OBSERVATION WELL
PRODUCTION WELL
DRAWDOWN PRODUCTION WELL NO. 8
DRAWDOWN OBSERVATION WELL NO. 8
Ft
Ft
(10)²


K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210
10⁻¹
10⁰
10¹
10²
10³
TIME (MIN)
TEST DATE: NOV 17, 1981
OBSERVATION WELL
PRODUCTION WELL
DRAWDOWN PRODUCTION WELL NO. 11
DRAWDOWN OBSERVATION WELL NO. 11
FT
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0.1
0.2
0.3 FT
0.4
0.5
0.6
0.7
Δh = 0.18
= 163 FT/DAY

-72-


K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210

Appendix No. 2

Well Logs

INDIANA MICHIGAN POWER

Date March 13, 1991

Subject Lake Township Monitoring Well

MAR 15 1991

From J. E. Oetken

To J. T. Massev-Norton

The following information pertains to the Lake Township monitoring well:

Well depth:	12 feet (approximate)
Screen length:	3.5 feet
Casing diameter:	2 inches
Casing tvpe:	Galvanized
Installation method:	Driven
Sealing method:	Bentonite
Backfill:	None

The ground and casing elevations have not been determined.

If you require any additional information in order to incorporate this well into vour hydrogeologic study, feel free to call me at X1326.

c: D. M. Fitzgerald

Intra-System

PIEZOMETER INSTALLATION REPORT

Project I+M D.C. Cook Steam Generator Storage SGR-5

Piez. Type observation well | Depth. 27.4 | Riser Desc. 2" PVC

Mat'l @ Tip sand | Sample # | Boring Dia. 4"

Method of Installation HW casing

Type of Grnd Protection 6" steel pipe set in grout

Grnd Elev. 621.90 | Riser Elev. 624.36 | Piez Tip Elev. 594.5

Filter Material Sand from Elev. 614.50 to Elev. 594.5

Seal Material No Seal from Elev. — to Elev. —

Installed By Roush - Bumgarner

Date Installed 9-1-87 | Date Tested 10-1-87

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

Valclay Grout 619.6 - 614.50

Water Elevation 604.90 9-2-87

" " 605.60 10-1-87

.01 Screen slot

No Bentonite Seal installed - Per. J.T. Massey-Norton

PIEZOMETER INSTALLATION REPORT

Project T+M D.C. Cook Steam Generator Storage SGR-4

Piez. Type observation well | Depth. | Riser Desc. 2" pvc

Mat'l @ Tip Sand | Sample # | Boring Dia. 4"

Method of Installation HW Casing

Type of Grnd Protection 6" steel pipe set in Grout

Grnd. Elev. 614.05 | Riser Elev. * 616.21 | Piez Tip Elev. 584.05

Filter Material Sand from Elev. 604.05 to Elev. 584.05

Seal Material Bentonite from Elev. 604.55 to Elev. 604.05

Installed By Roush + Bumgarner

Date Installed 9-2-87 | Date Tested 10-1-87

Method of Testing Piez.

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

Valclay Grout 611.65 - 604.55

Water Elevation 606.05 one (1) Hr after installation

" " 10-1-87 606.01

.01 Screen. Slot

* Riser Elevation taken from top of steel protector

PIEZOMETER INSTALLATION REPORT

Project I+M D.C. Cook Steam Generator Storage SGR-2

Piez. Type Observation well | Depth. | Riser Desc. 2" PVC

Mat'l @ Tip Sand | Sample # | Boring Dia. 4"

Method of Installation HW Casing

Type of Grnd Protection 6" Steel Pipe Set in Grout

Grnd Elev. 614.82 | Riser Elev. 617.32 | Piez Tip Elev. 584.82

Filter Material Sand from Elev. 604.82 to Elev. 584.82

Seal Material Bentonite from Elev. 605.32 to Elev. 604.82

Installed By Roush - Bumgarner

Date Installed 8-27-87 | Date Tested 10-1-87

Method of Testing Piez. Pump Test

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

Volclay Grout 612.52 - 605.32

Water Elevation 9-2-87 606.32

.01" Screen Slot " 10-1-87 605.78

PIEZOMETER INSTALLATION REPORT

Project I&M D.C. Cook Steam Generator Storage SGR-1		
Piez. Type observation well	Depth. 30.0	Riser Desc. 2" pvc
Mat'l @ Tip Sand	Sample #	Boring Dia. 4"
Method of Installation HW casing		
Type of Grnd Protection 6" Steel Pipe Set in Grout		
Grnd Elev. 616.46	Riser Elev. 618.18	Piez Tip Elev. 586.46
Filter Material Sand	from Elev. 606.46	to Elev. 586.46
Seal Material Bentonite	from Elev. 606.96	to Elev. 606.46
Installed By Roush - Bumgarner		
Date Installed 8-25-87	Date Tested 10-1-87	
Method of Testing Piez. Pump Test		

Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water	Time	Elapsed Time	Depth to Water

REMARKS

Volclay Grout 614.16 to 606.96

.01 Screen Slot

Water Elevation 8-27-87 - 607.46

" " 9-2-87 607.46

" " 10-1-87 606.54

INDIANA & MICHIGAN POWER COMPANY
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

GROUND WATER MONITORING

6" MONITORING WELL # 1A	3" OBSERVATION WELL # 1A
LOCATION: 600' SOUTH OF INFILTRATION BASIN	LOCATION: 10' S.W. OF MONITORING WELL
WELL TOP ELEVATION: 660.74	WELL TOP ELEVATION: 661.54'
GROUND ELEVATION: 659.5' APPROX.	GROUND ELEVATION: 660.5' APPROX.

WATER TABLE ELEVATIONS

ON 6-19-75 604.87'
ON 4-25-75 603.43'
ON 10-25-75 601.82

LOG OF GEOLOGICAL FORMATION

DESCRIPTION	THICKNESS	DEPTH TO BOTTOM
DUNE SAND	50'	50'
WATER BEARING SAND	25'	75'

T.V. 8-5-75

INDIANA & MICHIGAN POWER COMPANY
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

GROUND WATER MONITORING

4" MONITORING WELL # 8	2" OBSERVATION WELL # 8
LOCATION: 2400' EAST OF INFILTRATION BASIN	LOCATION: 10' S.W. OF MONITORING WELL
WELL TOP ELEVATION: 615.20'	WELL TOP ELEVATION: 615.66'
GROUND ELEVATION: 614.' APPROX.	GROUND ELEVATION: 614.5' APPROX.

WATER TABLE ELEVATIONS

ON 6-19-75 : 609.33'
ON 4-25-75 : 608.60'
ON 10-25-75 : 607.03'

LOG OF GEOLOGICAL FORMATION

DESCRIPTION	THICKNESS	DEPTH TO BOTTOM
TOP SOIL	1'	1'
DARK YELLOW SAND	5'	6'
LIGHT SAND	12'	18'
WATER BEARING SAND	14½'	32½'
CLAY	1'	33½'

INDIANA & MICHIGAN POWER COMPANY
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

GROUND WATER MONITORING

6" MONITORING WELL # 11	2" OBSERVATION WELL # 11
LOCATION: 200' N.W. OF INFILTRATION BASIN	LOCATION: 10' WEST OF MONITORING WELL
WELL TOP ELEVATION: 609.47'	WELL TOP ELEVATION: 608.37'
GROUND ELEVATION: 608.5' APPROX	GROUND ELEVATION: 607.5' APPROX.

WATER TABLE ELEVATIONS
ON 6-19-75 : 599.33'
ON 4-25-75 : 597.08'
ON 10-25-75 601.72'

LOG OF GEOLOGICAL FORMATION

DESCRIPTION	THICKNESS	DEPTH TO BOTTOM
DUNE SAND	16'	16'
WATER BEARING SAND	10'	26'

T.K. 8-5-75

INDIANA & MICHIGAN POWER COMPANY
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

GROUND WATER MONITORING

6" MONITORING WELL #12	2" OBSERVATION WELL #12
LOCATION: 700' WEST OF INFILTRATION BASIN	LOCATION: 10' SOUTH OF MONITORING WELL
WELL TOP ELEVATION: 610.45'	WELL TOP ELEVATION: 610.97'
GROUND ELEVATION: 609.5 APPROX	GROUND ELEVATION: 610.0 APPROX

WATER TABLE ELEVATIONS

ON	6-19-75	593.45'
ON	4-25-75	594.70'
ON	10-25-75	595.28'

LOG OF GEOLOGICAL FORMATION

DESCRIPTION	THICKNESS	DEPTH TO BOTTOM
GRAVEL	1'	1'
DUNE SAND	12'	13'
BLACK PEAT SAND	3	16'
GRAVEL W/ SAND	6'	22'
SAND W/ GRAVEL	10'	32'

GEOLOGICAL SURVEY SAMPLE No. ______ #2

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Berrien	Lake	NW¼ NE¼ SE¼	6	6 S.	20 W.

Distance And Direction from Road Intersections

Street address & City of Well Location

Locate with "X" in section below — Sketch Map:

3 OWNER OF WELL: I&M Power Co
Address: D.C. Cook Plant, Bridgman, Mi

4 WELL DEPTH: (Completed) 96 ft. Date of Completion 19 June 74

5 ☐ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☒ Jetted ☐ Bored ☐ ______

6 USE: ☐ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☒ MONITOR WELL

7 CASING: Threaded ☒ Welded ☐ Diam. 3 in. to ___ ft. Depth; ___ in. to ___ ft. Depth; Height: Above Surface 2 ft.; Weight ___ lbs./ft.; Drive Shoe? Yes ☒ No ☐

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top soil	1	1
dune sand	70	71
H_2O Sand	16	87
H_2O gravel	9	96

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: SS Dia.: 2" Gauze 80 Length 8' OA; Set between 90 ft. and 96 ft.; Fittings: neck + K packer

9 STATIC WATER LEVEL 75' ft. below land surface APPX

10 PUMPING LEVEL below land surface plunger tested 40+ g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ___ Chlorides (Cl) ___ Hardness ___ Other ___

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☐ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☐ Yes ☒ No ☐ Neat Cement ☐ Bentonite ☐ ___ Depth: From ___ ft. to ___ ft.

14 Nearest Source of possible contamination None (Direction) None Type; Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: ☒ Not Installed; Manufacturer's Name ___; Model Number ___ HP ___ Volts ___; Length of Drop Pipe ___ ft. capacity ___ G.P.M.; Type: ☐ Submersible ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.
Well @ Top of Hill near old 2" well pit site
MONITOR WELL # 1 (located @ S. end of I&M property)

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
George Cole & Son — REGISTERED BUSINESS NAME; 0213 — REGISTRATION NO.
Address: RR3, Box 240 B.H
Signed: Robert J. Cole — AUTHORIZED REPRESENTATIVE Date 6 July 74

D67d 100M (Rev. 12-68)

IMPORTANT: File with deed.

WELL OWNER COPY

GEOLOGICAL SURVEY SAMPLE No.

#3

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Berrien	Lake	W½ NW SE	6	6 N/S.	20 E/W.

Distance And Direction from Road Intersections

Street address & City of Well Location

Locate with "X" in section below — Sketch Map:

W — E — 1 MI. — S — 1 MILE

3 OWNER OF WELL: I&M Power Co.
Address: Cook Plant, Bridgman, Mi

4 WELL DEPTH: (completed) 49 ft. Date of Completion 3 June 74

5 ☐ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☒ Jetted ☐ Bored ☐

6 USE: ☐ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☒ Test Well ☐

7 CASING: Threaded ☒ Welded ☐ Diam. 2 in. to 45 ft. Depth; ___ in. to ___ ft. Depth. Height: Above/Below Surface 1 ft. Weight ___ lbs./ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: SS 131½ Dia.: 1¼" Slot/Gauze 80 Length 5' OA. Set between 45 ft. and 49 ft. Fittings: Check valve

9 STATIC WATER LEVEL 14 ft. below land surface

10 PUMPING LEVEL below land surface plunger pump Heavy tail 12+ g.p.m. ___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ___ Chlorides (Cl) ___ Hardness ___ Other ___

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☐ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☐ Yes ☒ No ☐ Neat Cement ☐ Bentonite ☐ Depth: From ___ ft. to ___ ft.

14 Nearest Source of possible contamination: None; Direction: Area; Type ___. Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: ☒ Not installed. Manufacturer's Name ___ Model Number ___ HP ___ Volts ___ Length of Drop Pipe ___ ft. capacity ___ G.P.M. Type: ☐ Submersible ☐ Jet ☐ Reciprocating

2

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
fill & gravel	1	1
dune sand	19	20
H_2O sand	29	49

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
Used as test well — pulled & plugged. For Water Well #3 (2" Pilot Well)

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

George Cole & Son — 0213
REGISTERED BUSINESS NAME — REGISTRATION NO.

Address 3946 Evergreen Lane B. H.

Signed Robert L. Cole — Date 6 July 74
AUTHORIZED REPRESENTATIVE

D67d TOOM (Rev. 12-68)

IMPORTANT: File with deed.

WELL OWNER COPY

GEOLOGICAL SURVEY SAMPLE No.

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

LOCATION OF WELL

County: Berrien
Township Name: Lake
Fraction: NE¼ NE¼ SE¼
Section Number: 6
Town Number: 6 N/S
Range Number: 20 E/W.

Distance And Direction from Road Intersections

Street address & City of Well Location

Locate with "X" in section below — Sketch Map:

W — E — 1 MI. — 1 MILE

3 OWNER OF WELL: I & M Power Co
Address: D.C. Cook Plant
Bridgman, Mi

4 WELL DEPTH: (completed) 47 ft. Date of Completion: 20 June 74

5 [X] Cable tool [X] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ]

6 USE: [ ] Domestic [X] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [ ]

7 CASING: Threaded [X] Welded [ ] Diam. 6 in. to 42 ft. Depth; ___ in. to ___ ft. Depth
Height: Above/Below Surface 1½ ft. Weight 19 lbs./ft. Drive Shoe? Yes [ ] No [X]

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top soil & gravel fill	1	1
dune sand	19	20
H_2O sand	27	47
drinking water well #1 (construction parking)		

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type: Red Brass Dia.: 6" ID
Slot/Gauge 16 Length 5' 6"
Set between 42 ft. and 47 ft.
Fittings: 6" riser + 6" plug bottom

9 STATIC WATER LEVEL
14 ft. below land surface

10 PUMPING LEVEL below land surface
40 ft. after 24 hrs. pumping 80 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ___ Chlorides (Cl) ___
Hardness ___ Other ___

12 WELL HEAD COMPLETION: [ ] In Approved Pit [X] Pitless Adapter [ ] 12" Above Grade

13 Well Grouted? [X] Yes [ ] No
[ ] Neat Cement [X] Bentonite [ ] ___
Depth: From 10 ft. to 0 ft.

14 Nearest Source of possible contamination
None Observed Type
Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not Installed
Manufacturer's Name DEMING
Model Number 2361212000 HP 5 Volts 575-3ph
Length of Drop Pipe → ft. capacity 50 G.P.M.
→ 2" x 29'
Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.
[illegible]
7 [illegible]
GF [illegible] I-1-74
Well Water #3

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
George D. Cole & Son — 0213
REGISTERED BUSINESS NAME — REGISTRATION NO.
Address 3946 Evergreen Lane B.H.
Signed Robert J. Cole — Date 6 July 74
AUTHORIZED REPRESENTATIVE

367d 100M (Rev. 12-68)

IMPORTANT: File with ...

GEOLOGICAL SURVEY SAMPLE No. ___ #6

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

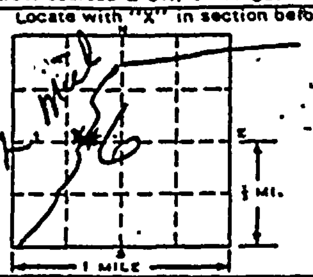
1 LOCATION OF WELL

Co	Township Name	Fraction	Section Number	Town Number	Range Number
		SE¼ SW¼ NW¼	6	6 N/S.	19 E/W.

Distance And Direction from Road Intersections: Along Lake Bluff @ N. W. Part of Property. - Appx 95' from Lake Shore

Street Address & City of Well Location

Locate with "X" in section below — Sketch Map:



3 OWNER OF WELL: American Elec Power Co.

Address: Donald C Cook Plant, Bridgman, Michigan

4 WELL DEPTH: (completed) 93 ft. **Date of Completion** 4 JAN 77

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ] ___

6 USE: [ ] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [X] Monitor Well

7 CASING: Threaded [X] Welded [ ] Diam. 6 in. to 88 ft. Depth; ___ in. to ___ ft. Depth. Height: Above/Below Surface 3½ ft. Weight 19 lbs./ft. Drive Shoe? Yes [X] No [ ]

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Fill Gravel	2	2
Dune sand, brown	70	72
Clay & gravel	1	73
H2O Sand	20	93

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: Red Brass Dia.: 6" Nom. Slot/Gauze 10 Length 16'-8" OA. Set between 88' ft. and 93 ft. Fittings: K Packer - 6'-4" Sump

9 STATIC WATER LEVEL Appx 76 ft. below land surface

10 PUMPING LEVEL below land surface ___ ft. after ___ hrs. pumping ___ g.p.m. Pumped 30 gpm. ___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ___ Chlorides (Cl) ___ Hardness ___ Other ___

12 WELL HEAD COMPLETION: [ ] In Approved Pit [ ] Pitless Adapter [X] 12" Above Grade

13 Well Grouted? [ ] Yes [X] No [ ] Neat Cement [ ] Bentonite [ ] ___ Depth: From ___ ft. to ___ ft.

14 Nearest Source of possible contamination None ___ Direction ___ Type. Well disinfected upon completion [ ] Yes [X] No

15 PUMP: [X] Not installed. Manufacturer's Name Red Jacket - Electric. Model Number 6CC HP 1½ Volts 230. Length of Drop Pipe ___ ft. capacity 45 G.P.M. Type: [X] Submersible 1¼" x 91' [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

NORTH OB. WELL REPLACES " which WAS PULLED, PLUGGED & BACK FILLED. (#6 WELL)

17 WATER WELL CONTRACTOR'S CERTIFICATION: This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

George D. Cole & Son — 0213

REGISTERED BUSINESS NAME — REGISTRATION NO.

Address 5946 Evergreen Lane, B.H.

Signed [signature] AUTHORIZED REPRESENTATIVE Date 10 March 77

D67d 100M (Rev. 12-68)

IMPORTANT: File with deed.

WELL OWNER COPY

GEOLOGICAL SURVEY SAMPLE No. ______

WATER WELL RECORD

ACT 294 PA 1965

#7

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County: [illegible] | Twp.: Lake | Fraction: ¼ ¼ ¼ | Section No.: 6 | Town: 6 N/S. | Range: 19-20 E/W.

Distance And Direction from Road Intersections: 8" Drinking Water Well #1 Donald C. Cook Nuclear Power Plant

OWNER No. ______

Street address & City of Well Location: Bridgman, Mich.

3 OWNER OF WELL: Indiana & Michigan

Address: Power Company, Bowling Green St., New York

2

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
dune sand	20	20
water sand	20	40
real clean gray sand	7	47
muddy sand w/clay	4	51

4 WELL DEPTH: (Completed) 49 ft. Date of Completion: Feb 19, 1969

5 ☑ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ___

6 USE: ☐ Domestic ☑ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ______

7 CASING: Threaded ☑ Welded ☐ Diam. 8 in. to 39 ft. Depth; ___ in. to ___ ft. Depth. Height: Above/Below surface 1 ft. Weight ___ lbs/ft. Drive Shoe? Yes ☑ No ☐

8 SCREEN: Type: COOK Dia.: 7 3/4 OD. Slot/Gauge: 11 Length: 6'. Set between 39 ft. and 49 ft. Fittings: 2-2" neat & packer; 3-2" Anchor Pipe

9 STATIC WATER LEVEL 20-2 ft. below land surface

10 PUMPING LEVEL below land surface 37 ft. after 24 hrs. pumping 75 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ___ Chlorides (Cl) ___ Hardness ___

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☑ Pitless Adapter ☐ 12" Above Grade

13 GROUTING: Well Grouted? ☐ Yes ☑ No. Material: ☐ Neat Cement ☐ ___. Depth: From ___ ft. to ___ ft.

14 SANITARY: Nearest Source of possible contamination 1500 feet W Direction TANK Type. Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: Manufacturer's Name: Deming. Model Number ___ HP 3. Length of Drop Pipe 40 ft. capacity 50 G.P.M. Type: ☑ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

Pump and Pitless adapter be installed later — type to be used listed.

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

George B. Cole & Son — REGISTERED BUSINESS NAME; 0213 — REGISTRATION NO.

Address: RR#3, Box 240 Benton Harbor

Signed: Robert G. Cole — AUTHORIZED REPRESENTATIVE. Date: 3-24-69

D67D 100M 6-66

IMPORTANT: File with deed.

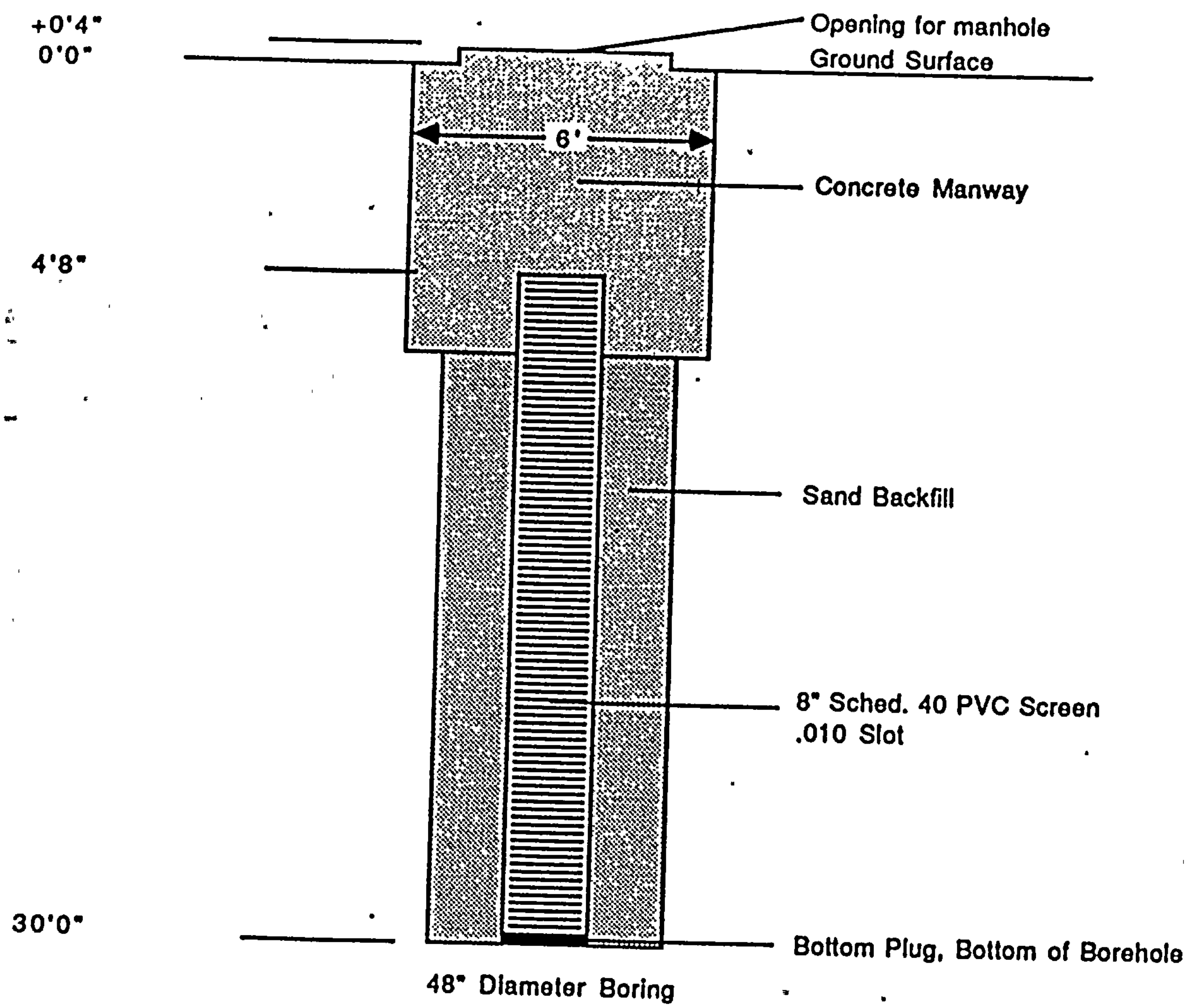
WELL OWNER COPY #1

AMERICAN
ENVIRONMENTAL
SERVICES CO., INC.

Well Detail Summary
American Electric Power
D.C. Cook Nuclear Plant
Bridgeman, Michigan
AE-964 - 7/7/89

Well Detail Summary

RW



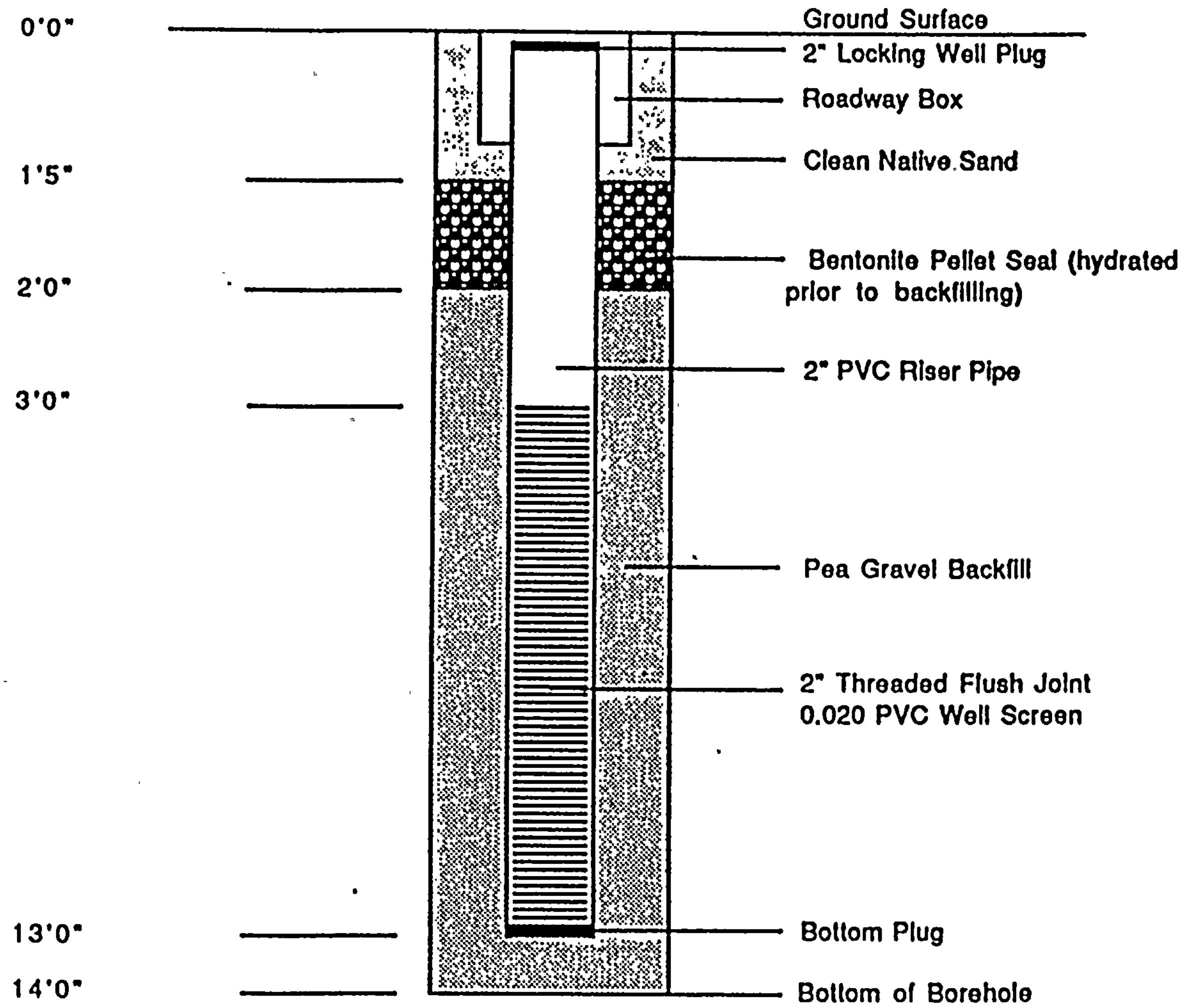
Note: Drawing Not to Scale.

AMERICAN ENVIRONMENTAL SERVICES CO., INC.

Well Detail Summary
American Electric Power
D.C. Cook Nuclear Plant
Bridgeman, Michigan
AE-964 - 6/6/89

Well Detail Summary

OW-3



20" Diameter Boring

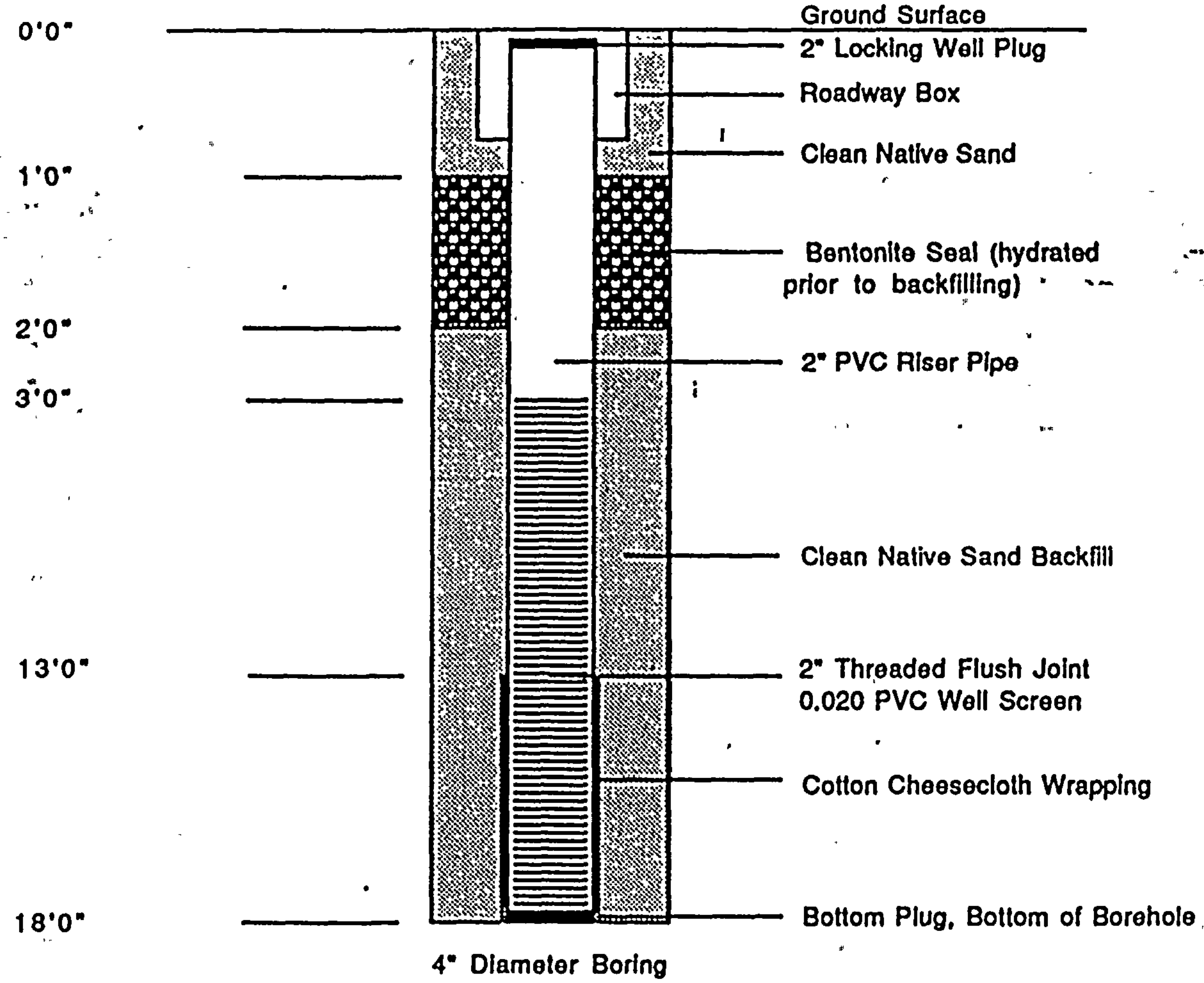
Note: Drawing Not to Scale.

AMERICAN
ENVIRONMENTAL
SERVICES CO., INC.

Well Detail Summary
American Electric Power
D.C. Cook Nuclear Plant
Bridgeman, Michigan
AE-964 - 6/6/89

Well Detail Summary

OW-2



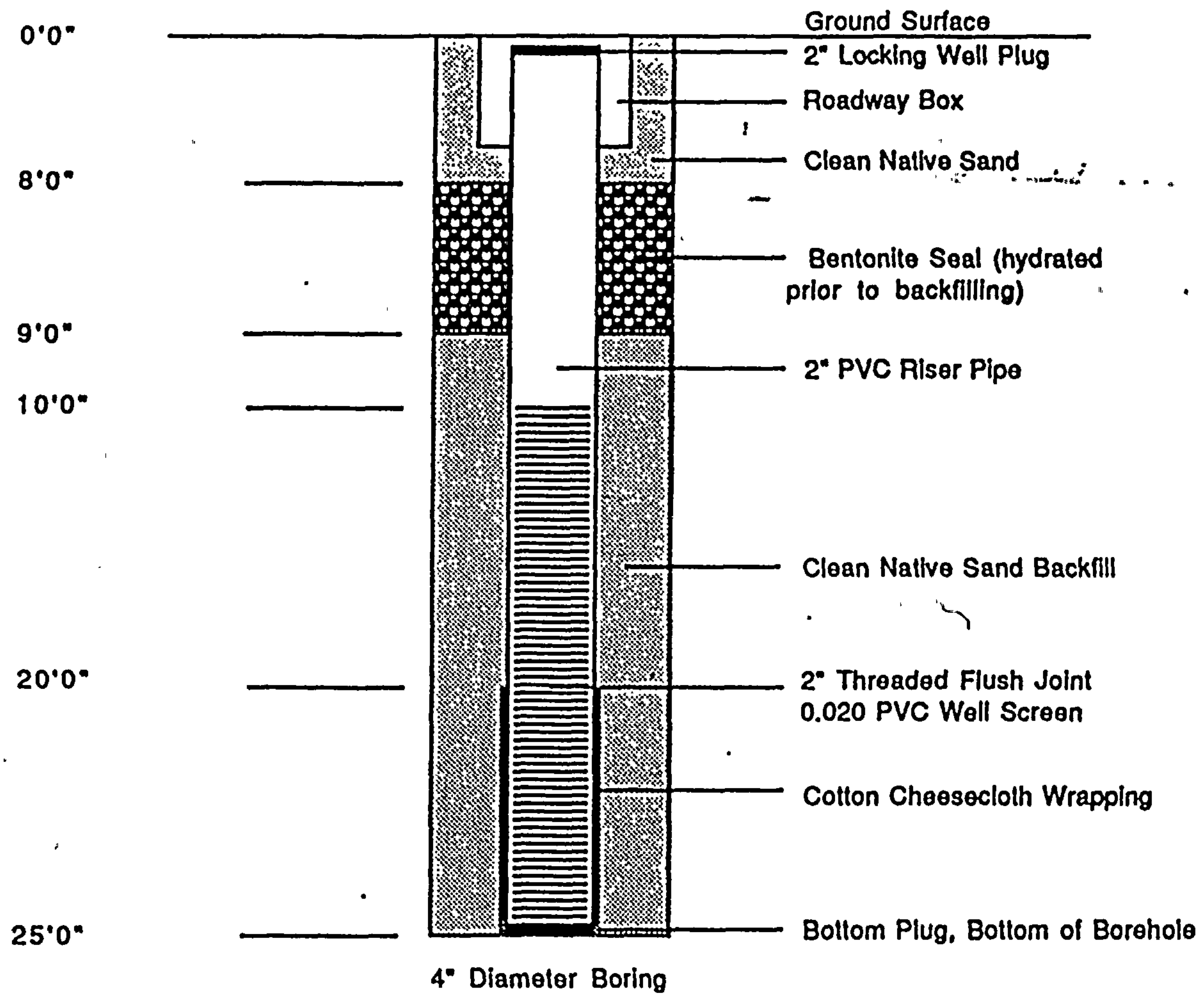
Note: Drawing Not to Scale.

AMERICAN ENVIRONMENTAL SERVICES CO., INC.

Well Detail Summary
American Electric Power
D.C. Cook Nuclear Plant
Bridgeman, Michigan
AE-964 - 6/6/89

Well Detail Summary

OW-1



Note: Drawing Not to Scale.

Appendix 3

Tritium Analysis

Tritium Activities (pCi/l)

Date	#1	#2	#3	#4	#5	#6	#7
7/72	N.D. →	→	→	→	N/T	N.D.	N/T
1/74	N/T	590	710	600	390	580	N/T
5/74	660	560	150	540	250	350	670
9/74	<1000 →	→	→	→	→	→	→

Tritium Activities (pCi/l)

Date	#1	#2	#3	#4	#5	#6	#7
3/77	<1000	→	→	→	→	→	→
7/77	<1000	→	→	→	→	→	→
11/77	<1000	<1000	<1000	640	680	9000	<1000
4/78	500	400	500	6800	2900	3900	500
8/78	<1000	→	→	7800	1400	<1000	<1000
12/78	<1000	→	→	2400	1700	<1000	<1000
4/79	<1000	→	→	17,000	12,000	<1000	<1000
8/79	700	850	<1000	5100	2100	2100	2500
12/79	<1000	→	→	3600	3500	<1000	<1000
4/80	<1000	→	→	2300	<1000	→	→
9/80	<1000	→	→	1400	700	<1000	<1000
1/81	<1000	<1000	1200	1100	1500	1100	<1000
5/81	800	<1000	<1000	1400	1200	1200	600
9/81	800	<1000	<1000	1400	1200	1200	600
2/82	<1000	<1000	<1000	2100	2100	1100	<1000
6/82	<1000	→	→	→	→	→	→
10/82	<1000	→	→	→	→	→	→
2/83	<1000	→	→	3200	<1000	2200	<1000
6/83	<1000	→	→	→	→	→	→
8/83	<1000	→	→	2600	1500	4100	600
11/83	<1000	700	<1000	8400	3300	2800	600
2/84	<330	→	→	5190	4340	1710	<330
5/84	<330	→	→	4700	3170	900	<330

Tritium Activities (pCi/l)

Date	#1	#2	#3	#4	#5	#6	#7
8/84	1170	<330	<330	5280	5700	5690	1720
11/84	1190	1030	1260	7890	5110	3470	2000
2/85	<330 →	→	→	4750	4240	2120	1570
4/85	<330 →	→	→	7440	1810	650	200
5/85	<330 →	→	→	7430	3460	1300	450
8/85	<330 →	→	→	3040	2600	<330	1070
12/85	<500 →	→	→	<500	<500	<500	<500
3/86	<300 →	→	→	→	→	→	449
6/86	<300 →	→	→	1249	1466	<300	717
8/86	<300 →	→	→	2500	4734	965	1530
10/86	<300 →	→	→	2274	2167	<300	2412
1/87	<300 →	→	→	4444	2631	755	3930
4/87	<300 →	→	→	3462	1946	816	5192
7/87	<300 →	→	→	2477	1060	<300	5563
10/87	<300 →	→	→	1655	896	<300	1889
2/88	<300 →	→	→	1588	929	1548	1320
5/88	602	<300 →	→	3419	2075	2165	2155
8/88	<300	<300	435	6033	3141	1554	1329
9/88	<300 →	→	→	5204	2920	841	1146
11/88	<300 →	→	→	2752	2536	1108	1165
2/89	<330 →	→	→	1247	1200	926	854
5/89	<330 →	→	→	2725	1596	1766	1145
8/89	<330 →	→	→	1615	<330	<330	<330
11/89	* 2400	2400	<2000	3600	3000	2000	<2000

TRITIUM ACTIVITIES (pCi/l)

Date	#1	#2	#3	#4	#5	#6	#7
2/90	<100	130	<200	1400	1700	1300	210
5/90	<200	<200	<200	320	700	260	<200

Appendix 4

Tables

TABLE NO. 1

PRECIPITATION DATA

BENTON HARBOR AIRPORT, MICHIGAN

(inches)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
JAN	2.43	2.04	5.34	3.73	2.61	2.33	3.32	N/A	0.42	.48	N/A	.89	.64
FEB	2.14	.85	1.37	2.70	3.48	1.96	0.84	N/A	0.91	3.55	N/A	1.01	1.40
MAR	3.57	2.57	5.22	2.29	4.23	3.17	1.27	N/A	1.78	1.48	N/A	2.42	1.17
APR	3.57	4.18	4.49	5.86	5.01	2.72	3.73	3.89	2.71	4.23	.23	4.42	3.91
MAY	1.96	4.43	5.39	3.94	4.25	0.92	2.58	1.55	2.88	4.64	6.24	3.91	6.14
JUN	3.77	4.89	3.79	4.50	3.26	4.02	4.32	3.34	3.85	4.68	1.74	1.38	1.54
JUL	2.68	4.59	.89	2.34	3.06	1.54	3.93	2.56	3.36	2.01	3.60	1.33	3.46
AUG	3.33	1.65	1.79	6.21	0.61	5.11	3.35	2.18	7.10	2.40	1.81	1.67	2.44
SEP	7.00	3.41	3.48	1.56	1.74	6.88	6.91	N/A	5.81	5.08	3.36	4.46	8.44
OCT	3.27	4.04	2.29	1.19	1.78	3.47	2.69	N/A	2.71	2.88	0.98	1.92	2.92
NOV	2.67	2.48	3.72	3.78	2.36	2.58	1.48	N/A	1.41	2.28	5.15	2.68	2.46
DEC	6.04	4.82	2.27	3.64	1.45	2.85	2.83	2.98	1.64	2.37	5.90	2.98	2.37
ANNUAL	41.93	39.95	40.04	41.74	33.84	37.55	37.25	N/A	34.58	36.08	N/A	29.07	36.89
DEPART. FROM NORMAL	5.89	3.91	4.00	5.70	−2.20	1.51	1.21	N/A	−1.46	.04	N/A	−6.97	0.48

N/A = Not Available

TABLE NO. 1 CONTINUED
PRECIPITATION DATA
BENTON HARBOR AIRPORT, MICHIGAN

(Inches)

	1985	1986	1987	1988	1989	1990
JAN	2.61	1.28	1.28	1.54	0.63	1.28
FEB	2.64	2.49	0.0	0.87	0.67	2.70
MAR	5.61	1.23	0.93	2.64	2.39	2.51
AP	2.61	2.47	1.59	4.22	2.49	3.87
MAY	2.62	4.76	2.46	1.67	2.20	5.84
JUN	2.59	4.88	2.46	0.15	4.73	2.78
JUL	3.84	4.87	3.22	0.99	6.94	2.94
AUG	3.40	2.74	8.19	2.41	5.16	5.16
SEP	1.89	9.92	2.55	2.84	3.62	5.74
OCT	4.29	3.73	2.73	5.44	1.27	
NOV	7.15	1.21	1.80	5.92	2.16	
DEC	2.06	0.95	2.42	1.44	1.85	
ANNUAL	41.31	40.53	29.63	30.13	34.11	
DEPART. FROM NORMAL	4.90	N.A.	-6.78	-6.28	-2.30	

TABLE No. 2

BASELINE
WATER TABLE ELEVATIONS

(National Geodetic Vertical Datum 1929)

BORING NO.	SURFACE ELEVATION (feet)	GROUND WATER DEPTH (feet)	DATE	GROUND WATER ELEVATION (feet)
1	601.4	11.0	7-21-66	590.4
2	664.4	62.0	7-28-66	602.4
3	641.6	53.3	11-23-66	588.3
4	621.8	37.3	11-23-66	584.5
5	605.2	18.2	11-23-66	587.0
6	584.3	1.5	11-23-66	582.8
7	583.5	2.2	7-23-66	581.3
8	605.8	9.8	7-23-66	596.0
9	596.8	8.7	11-23-66	588.1
10	600.1	9.2	11-23-66	590.9
11	625.4	23.0	11-23-66	602.4
12	625.5	24.5	7-25-66	601.0
13	605.6	3.5	11-23-66	602.1
14	616.7	7.9	11-23-66	608.8
15	603.8	7.2	11-23-66	596.6
16	658.4	51.5	7-23-66	606.9
17	588.5	6.0	11-23-66	582.5
18	613.0	6.2	11-23-66	606.8
19	592.7	10.0	8-4-66	582.7

TABLE 3

BASELINE WATER QUALITY

(mg/1)

DAMES & MOORE SAMPLE SURVEY

SOURCE	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	Total Hard.	Total Solids	Fe
9 Wells (40-60 Ft. Deep)	12						24	10			245	306	1.2
17 Wells (60-160 Ft. Deep)	13						38	20			256	327	0.9
10 Wells (160 Ft. Deep)	13						25	17			262	307	0.5
Weighted Average	13						30	16			255	316	0.86
D.C. Cook's Potable Well No. 1 March 21, 1972	8	73	22	10	4.0	257	28	50	0.29	0.7	275	398	
Well No. 2 March 21, 1972	11.2	67	21	10	3.2	249	28	44	0.29	0.8	255	383	
Upgradient Observation Well No. 8				47			9.5	76		0.2	219.5	406	

Note: Values for observation well No. 8 are median values for period of monitoring from July 1, 1977 to December 31, 1984

TABLE NO. 4

DISCHARGE TO THE TRS POND

(AVERAGE DAILY DISCHARGE PER MONTH)

OUTFALL 374

FLOW, MGD

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
JAN		0.33		0.56	0.44	0.36	0.51	0.50	0.47	0.51	0.44	0.55	0.39	0.34	0.45	0.82
FEB		0.31	0.42	0.43	0.50	0.61	0.33	0.48	0.49	0.38	0.51	0.64	0.36	0.35	0.38	0.84
MAR		0.36	0.44	0.42	0.48	0.61	0.55	0.51	0.54	0.40	0.41	0.58	0.37	0.49	0.45	
AP		0.38	0.42	0.25	0.48	0.59	0.49	0.63	0.39	0.62	0.44	0.72	0.38	0.35	0.39	
MAY		0.19	0.36	0.46	0.53	0.59	0.50	0.67	0.35	0.63	0.41	0.26	0.24	0.28	0.36	
JUN		0.33	0.45	0.51	0.37	0.53	0.58	0.68	0.39	0.43	0.68	0.25	0.14	0.50	0.61	
JUL	0.40	0.44	0.63	0.81	0.37	0.50	0.39	0.61	0.44	0.34	0.68	0.39	0.13	0.47	0.58	
AUG	0.47	0.39	0.54	0.84	0.47	0.40	0.42	0.33	0.35	0.40	0.59	0.39	0.31	0.42	0.51	
SEP	0.44	0.35	0.68	0.48	0.44	0.50	0.53	0.33	0.39	0.35	0.61	0.45	0.29	0.34	0.64	
OCT	0.42	0.33	0.62	0.45	0.44	0.42	0.48	0.40	0.38	0.42	0.57	0.60	0.28	0.27	0.71	
NOV	0.34	0.48	0.58	0.44	0.27	0.42	0.46	0.41	0.49	0.50	0.49	0.60	0.33	0.39	0.75	
DEC	0.39	0.47	0.70	0.40	0.30	0.53	0.37	0.42	0.47	0.49	0.44	0.48	0.30	0.39	0.62	

TABLE NO. 5

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

SAMPLE		WELL 1A			WELL 8			WELL 11			WELL 12		
DATE	QUARTER	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL
11/29/76	4Q76	0	200	609.1	4.9	422	608.06	169.5	634	598.93			
2/25/77	1Q77	74.9	150	600.8	42.7	548	607.72	241.6	598	597.23	244.2	688	592.17
7/24/77	2Q77	1.1	176	603.6	1.3	496	608.72		688	599.18		680	593.72
8/19/77	3Q77	4.1	174	602.35	9.9	292	607.89	265.8	682	604.18	304.5	678	598.72
11/14/77	4Q77	8	162	602.29	9.5	604	608.89	329.2	598	599.18	283.1	570	593.72
2/11/78	1Q78	0	110	603.6	49.4	414	609.05	257	694	599.93	229	548	595.97
5/12/78	2Q78	12.4	214	604	0	210	609.72	293.8	638	600.63	307.8	618	594.17
8/11/78	3Q78	27.1	350	609.6	6.6	290	609.72	255	320	603.43	332	640	607.67
11/8/78	4Q78	11.5	180	607.6	0.8	356	608.72	277	716	602.43	265	666	598.97
3/6/79	1Q79 (1)	0	134	602.6	0	464	609.72	247	600	604.43	257	624	592.97
3/26/79	1Q79 (2)	0	244	608.6	0	408	609.72	173	556	605.43	234	608	598.97
6/25/79	2Q79	0	144	608.24	1.8	246	608.7	151	462	604.97	169	452	595.78
8/4/79	3Q79	0	176	605.74	0	272	608.2	216	428	606.17	111	478	596.95
12/4/79	4Q79	20	234	616.74	21	370	608.2	229	750	602.97	163	494	596.95
3/4/80	1Q80	0	220	604.66	0	564	608.2	248	694	602.64	301	738	592.15
6/2/80	2Q80	3	170	604.74	29	312	608.37	310	718	602.8	272	654	599.68
8/3/80	3Q80	0	308	602.24	0	488	608.7	279	786	602.85	312	698	593.95
12/2/80	4Q80	0	94		0	602		333	606		82.5	296	594.14
3/3/81	1Q81	1	186	604.54	0	358	608.58	285	700	601.85	295	688	596.53
6/2/81	2Q81	35	570	612.6	11	398	609.47	205	660	602.18	236	688	596.36
8/3/81	3Q81	98.2	292	609.1	8	364	608.72	176	410	603.73	112	422	599.23
12/10/81	4Q81	117	298	609.6	0	342	608.72	157	390	602.43	174	450	598.03
3/4/82	1Q82	28.8	81	605.6	31	412	610.72	190.9	456	602.6	221.3	434	599.53
6/2/82	2Q82(1)	170	398	610.77	24	670	609.3	170	414	599.85	152	342	596.11
7/7/82	2Q82(2)				71	334	609.81						
8/31/82	3Q82	186	420	611.6	13	272	609.47	121	444	602.93	158	454	595.53
12/7/82	4Q82	151	320	605.6	1	514	608.72	221.4	594	601.26	74	410	595.53
3/8/83	1Q83	202.5	456	606.1	18.1	780	609.7	228	546	599.43	216.5	306	597.53
6/9/83	2Q83	0	386	605.68	17.3	438	610.53	242	538	601.93	118.5	410	596.03
9/6/83	3Q83	10	268	605.5	3	566	607.95	345	422	601.68	225	504	597.78
12/6/83	4Q83	149	464	604.77	16	406	607.22	234	694	599.43	77	525	593.78
3/6/84	1Q84	269	604	606.1	200	518	609.94	209	842	599.93	239	754	595.53
6/18/84	2Q84	383	760	606.52	10	480	609.22	370	672	599.85	398	744	593.66
9/4/84	3Q84	139	620	604.93	25	350	607.3	242	1018	599.93	159	760	593.86
12/4/84	4Q84	421	900	606.43	4	454	608.3	243	1088	598.51	244	1008	593.61
3/7/85	1Q85	370	1044	606.93	2	510	610.47	405	1174	599.56	290	1150	594.2
6/14/85	2Q85	256.7	576	607.97	0	340	609.3	294	1052	601.35	364.5	882	593.7
9/3/85	3Q85	125	396	607.1	16	476	607.72	316	762	600.18	446	786	594.28
12/5/85	4Q85	388	652	608.43	32	546	609.55	349	690	600.35	366	698	594.45
3/10/86	1Q86	419	660	607.6	90	438	609.22	444	726	600.18	362	700	594.95
6/2/86	2Q86	537	888	607.6	43	700	609.14	410	876	600.35	462	786	594.03
9/3/86	3Q86	210	524	609.52	19	486	608.55	280	768	601.6	250	734	595.45
12/10/86	4Q86	320	633	606	35	475	609.61	370	365	601.23	460	728	594.93
1/10/87	1Q87	440	720	606.1	49	646	603.82	440	841	596.43	390	763	592.23
5/13/87	2Q87				48	478		400	714	601.01	350	721	594.78
8/27/87	3Q87	360	677	601.6	13	430	607.42	78	280	599.23	340	658	593.23

TABLE NO. [illegible] CONTINUED

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

SAMPLE		WELL 1A			WELL 8			WELL 11			WELL 12		
DATE	QUARTER	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL	SULFATE	TDS	LEVEL
11/23/87	4Q87	360	588	606.7	33	387	608.62	390	715	601.23	390	738	594.23
2/24/88	1Q88	380	640	608.6	8	370	614.91	1100	2250	598.53	1100	2260	598.23
6/1/88	2Q88	340	620	604.6	29	390	609.62	560	1140		400	700	593.53
9/1/88	3Q88	98	220	601.7	31	182	609.92	200	439	598.63	710	982	594.93
12/6/88	4Q88	29	175	602.6	38	273	603.92	520	722	598.63	190	361	593.03
2/16/89	1Q89	5	290	603.3	11	320	607.92	390	941	598.03	300	658	592.53
4/20/89	2Q89	18	182	603.93	16	382	607.72	800	856	596.93	580	922	589.86
8/1/89	3Q89	48	274	605.7	74	275	609.97	410	764	600.43	530	962	594.73
10/3/89	4Q89	140	58	605	15	445	608.55	520	1030		450	848	593.86
1/8/90	1Q90	420	780	605.2	13	470	609.32	470	950	598.53	390	850	593.73
4/16/90	2Q90	480	740	607.5	26	490	609.7	460	770	599.41	560	970	594.93
7/10/90	3Q90	450	750	607.7	33	460	609.61	420	790	602.38	510	880	595.95
10/24/90	4Q90	230	390	609.6	13	370	609.92	270	540	604.03	260	530	598.58

TABLE NO. 6

HYDRAULIC GRADIENT DATA REDUCTION SPREADSHEET
DEVELOPED BY: GSS
DATE: 04/22/91

COOK PLANT TRITIUM FLOW PATH STUDY

WELL NO.	UPGRADIENT STATIC WATER LEVEL	WELL NO.	DOWNGRADIENT STATIC WATER LEVEL	DISTANCE BETWEEN MONITORING WELLS	HYDRAULIC GRADIENT	FORMATION PERMEABILITY CM/SEC	FORMATION POROSITY	RATE OF GROUND-WATER FLOW (SEEPAGE VELOCITY) CM/SEC	FT/DAY	TIME OF TRAVEL BETWEEN WELLS DAYS	YRS.	COMMENTS
SEE NOTE 1	607.00	PT1	605.00	620.00	0.0032	5.42E-02	0.25	6.99E-04	1.9824	312.7	0.86	TRS POND TO WELL RP4
PT1	605.00	PT2	590.00	720.00	0.0208	5.42E-02	0.25	4.52E-03	12.8032	56.2	0.15	
PT2	590.00	RP4	581.96	800.00	0.0101	5.42E-02	0.25	2.18E-03	6.1762	129.5	0.35	TOTAL 16.32 MONTHS
SEE NOTE 2	607.70	RP7	602.06	1380.00	0.0041	5.42E-02	0.25	8.86E-04	2.5116	549.4	1.51	OVERFLOW POND TO
RP7	602.06	LMICH	582.00	1070.00	0.0187	5.42E-02	0.25	4.06E-03	11.5214	92.9	0.25	LAKE MICHIGAN
												TOTAL 21.12 MONTHS

NOTES:

1. THE LOCATION OF THE UPGRADIENT POINT IS THE 607 FT. POTENTIOMETRIC CONTOUR ALONG AN IMAGINARY FLOW PATH PERPENDICULAR TO THE POTENTIOMETRIC HEADS TO DOWNGRADIENT POINT 1. POINT 1, AT THE 605 FT. POTENTIOMETRIC CONTOUR, IS THE UPGRADIENT POINT WHILE POINT 2 IS THE DOWNGRADIENT POINT AT THE 590 FT. POTENTIOMETRIC CONTOUR. POINT 2 IS THEN USED AS THE UPGRADIENT POINT ALONG THE REMAINING SEGMENT OF THE FLOW PATH. A UNIFORM GRADIENT IS ASSUMED AND THE TRAVEL TIME IS RECALCULATED WITH THE APPROPRIATE GRADIENT. AN EXAMPLE CALCULATION IS PROVIDED AS FOLLOWS.

   V(S) = KI(1/Φ) = (5.43E-02 CM/SEC)(607-605)/(620)/(0.25) = 6.99E-04 CM/SEC
   T(1) = D/V(S) = 620 FT/[(6.99E-02 CM/SEC)(1 FT/30.48 CM)] =2.70E+07 SEC = 312.7 DAYS

   THE TOTAL TRAVEL TIME IS THE SUM OF T(1), T(2), AND T(3), WHERE T(1) IS THE TRAVEL TIME BETWEEN THE TRS POND TO POINT 1, T(2) IS THE TRAVEL TIME BETWEEN POINT 1 AND POINT 2, AND T(3) IS THE TRAVEL TIME BETWEEN POINT 2 AND WELL RP4.

   [T(TOTAL) = 312.7+56.2+129.5 = 498.4 DAYS = 16.3 MONTHS]

2. THE LOCATION OF THE UPGRADIENT POINT IS THE OVERFLOW POND. THE FIRST DOWNGRADIENT POINT IS WELL RP7, LOCATED ALONG AN IMAGINARY FLOW PATH PERPENDICULAR TO THE POTENTIOMETRIC HEADS. THE FLOW PATH IS THEN FOLLOWED FROM UPGRADIENT WELL RP7 TO DOWNGRADIENT LAKE MICHIGAN. A SIMILAR CALCULATION WAS DONE FOR THIS FLOW PATH.

   (REF. DWG. CE-SK-3/25/91-1)

TABLE NO. 7

OFFSITE WELL ANALYSIS RESULTS
(pCi/l)

Well	Date	H-3	I-131	Gamma Spec
ROSEMARY BEACH				
Armstrong	8/29/90	<200	<0.2	<LLD
Burke	8/29/90	<200	<0.2	<LLD
Halstead	8/29/90	<100	<0.2	<LLD
Tengerstrom	8/31/90	<100	<0.1	<LLD
Scott	8/31/90	<100	<0.1	<LLD
Cone	9/11/90	<100	<0.2	<LLD
MaCiloon	9/19/90	<200	<0.2	<LLD
Maracich	9/19/90	<200	<0.2	<LLD
LIVINGSTON HILLS				
Swamp Water	9/10/90	<200	<0.1	<LLD
Malmstadt	9/26/90	<100	<0.1	<LLD
Duplicate	9/26/90	<200	<0.1	<LLD
Scupham	11/12/90	<200	<0.2	<LLD
Duplicate	11/12/90	350	<0.2	<LLD
New Well	11/29/90	<100	<0.1	<LLD
Duplicate	11/29/90	<200	<0.2	<LLD

TABLE NO. 8

MONITORING DATA

POTABLE SUPPLY WELL NO. 2

(mg/l)

DATE	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard $CaCO_3$	PH	Sp. Cond. A 25°C
3/21/72	11.2	67	21.4	10	3.2	249	27.6	43.7	0.29	0.8	383	255	7.68	570
1/31/76	8.0	57	16.4	8.6	2.1	202	31.3	25.2	0.1	0.8	298	210	7.4	491
8/3/76	7.4	63	16.4	13.0	1.7	233	25.4	22.4	0.14	0.07	326	228	7.1	447
1/31/77	5.4	60	16.6	12	2.3		29		0.36	0.07	293	218		
3/16/77	7.3	57	15.9	10.4	2.6	198	29	22	0.4	2.4	300	207	6.8	386
8/1/78	7.8	65	16.9	13	2.5	199	50	25	0.34	0.0	392	232	7.1	491
1/5/79	7.0	66	16.5	12	3.3	239	30	20.6	0.2	0.0	337	232	7.3	370
8/2/79	8.7	82	18.3	76	4.1	199	195	18.7	0.4	5.6	604	280	7.4	747
2/13/80	3.6	58	18	74	2.1	190	200	17.5	0.36	1.3	566	218	7.1	625
8/5/80	8.3	57	16	56	2.4	203	130	14.9	0.34	6.0	476	208	7.5	573
2/3/81	8.2	60	14	83	2.9	147	240	19.4	0.32	1.6	578	207	7.2	743
8/3/81	7.9	62	14.6	171	5.0	139	460	40	0.1	0.18	881	215	7.0	779
12/17/81	8.3	54	15.5	105	1.5	142	305	14.6	0.1	0.37	627		7.5	695
2/1/82	7.5	62	16.1	80	3.3	187	185	18.8	0.1	0.01	539		5.9	555
5/3/82	5.7	52	14.2	115	2.0	144	320	17.9	0.13	0.03	666		6.6	753
8/3/82	9.0	45	12.9	115	2.5	145	260	18	0.11	0.17	608		6.4	610

TABLE NO. 8 CONTINUED

CONTINUED

DATE	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard $CaCO_3$	pH	Sp. Cond. @ 25°C
2/8/83	8.8	44	13	75.5	1.4	156	180	13.82	0.14	0.06	424	163.6	7.6	412
5/2/83	8.9	51	14	69.1	1.3	149	195	14.82	0.17	0.10	504	-	7.3	453
8/2/83	8.1	55	17	93.9	2.6	184	205	23.93	0.15	0.17	579	205.6	7.1	481
11/11/83	7.8	59	17	44.9	0.1	208	142	22.27	ND	0.14	460	216	7.4	375
2/7/84	9.4	54	17	79.3	2.6	191.4	248	19.02	ND	ND	574	205	7.7	661
5/1/84	8.3	54	17	77.1	1.5	220	201	17.3	ND	0.08	571	204	7.2	652
8/1/84	7.1	72	19	73.1	3.1	219	180	17.0	0.20	0.01	574	258	7.8	780

* None Detected <0.1 mg/l Fl

None Detected <0.1 mg/l NO

TABLE NO. 9

MONITORING DATA

POTABLE SUPPLY WELL NO. 1

(mg/l)

DATE	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard $CaCO_3$	PH	Sp. Cond. A 25°C
3/21/72	8.0	73	22.4	10	4	257.3	27.6	49.5	0.29	0.7	398	274.5	7.55	597
1/31/76	8.0	70.2	18.2	8.5	1.7	253.2	44.7	19.9	0.1	1.8	344	250	7.3	563
8/3/76	6.7	56	15.6	11.5	2.1	199.4	28.6	22	0.14	0.07	305	204	7.4	397
1/31/77	3.7	67	18.8	12.5	2.1		26		0.4	0.07	308	244		
3/16/77	8.2	66	18.5	14.3	2.7	243.5	24	30.1	0.64	0.02	350	241	7.0	445
1/31/78	10	61	19	16	2.9	236	22.5	32	0.32	0.0	334	230	7.1	465
8/1/78	10	63.5	15.8	12.1	2.3	232.3	48	23.2	0.32	0.0	344	223	7.4	385
1/6/79	7.5	64	14.9	17.5	3.3	204.2	70	36.4	0.2	0.0	361	221	7.4	392
8/1/79	7.2	78	17.9	42	3.2	226.8	114.0	17.4	0.38	5.8	457	268.5	7.2	584
2/2/80	7.1	54.	18	13	1.7	242.6	42	15.3	0.28	1.6	378	209	7.1	424
8/4/80	5.6	65	17.4	62	2.5	198.5	135	15.2	0.34	2.4	490	233	7.5	564
2/11/81	9.1	60	17	19	1.9	236	67.5	15.4	0.32	3.6	416	219	7.0	495
8/3/81	8.2	61	15.6	28.5	2.4	238	55	55	0.1	0.15	389	217	7.0	429
12/17/81	11	59	17.3	18.1	0.8	232	67.5	20	0.1	0.29	354		7.4	415
2/2/82	8.1	68	16.8	17.9	3.2	234	30	23	0.1	0.04	430		6.5	373
5/4/82	4.9	66	18.3	19.3	2.5	227	70	28	0.1	0.01	410		6.5	475
8/2/82	9.9	68	18.7	64	2.2	313	80	19	0.1	0.17	512		6.6	506

TABLE NO. 9 CONTINUED

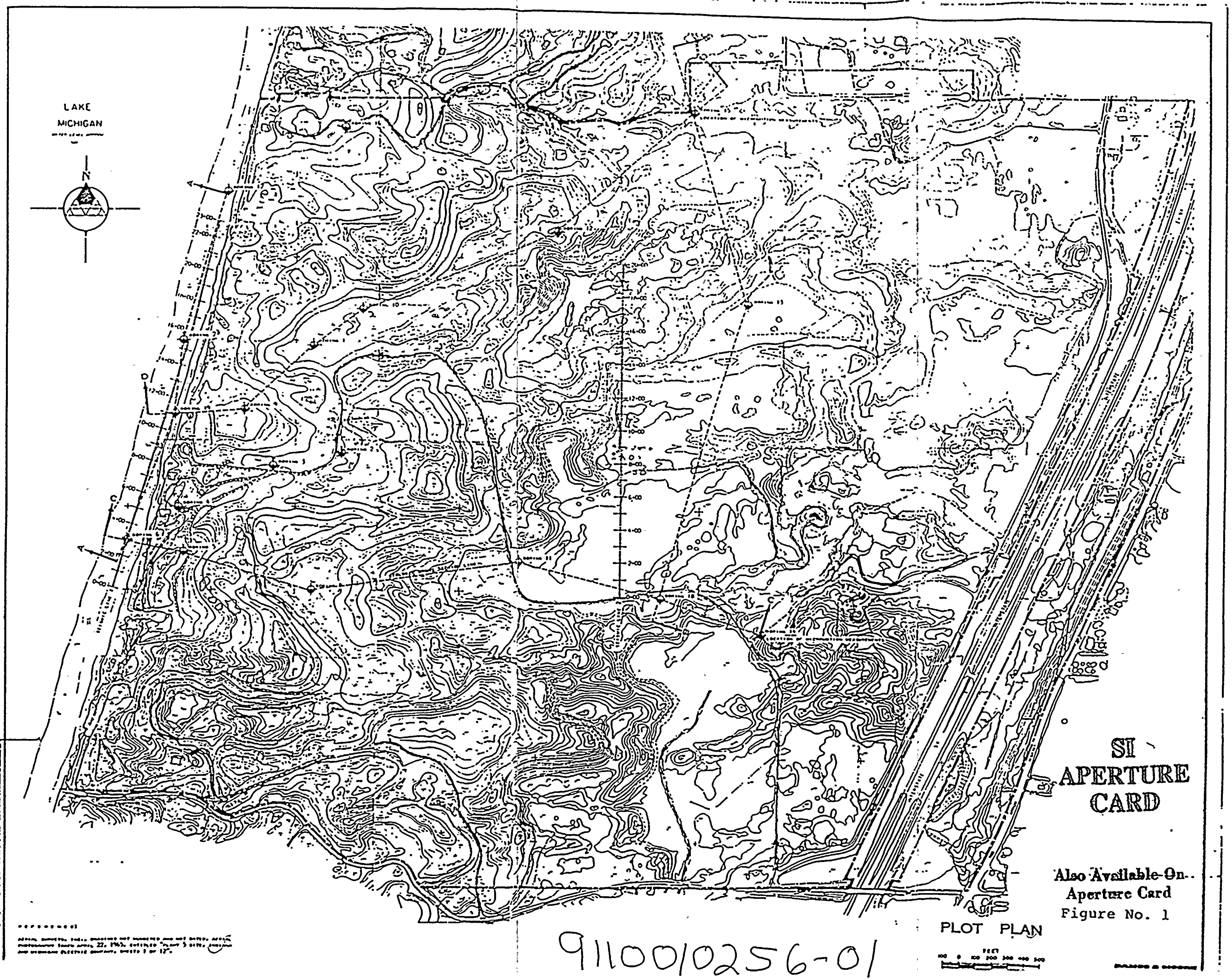
CONTINUED

Date	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	TDS	Hand $CaCO_3$	PH	Sp. Cond. @ 25°C
2/7/83	9.8	44	13.7	77.5	1.6	252	28	29.23	ND*	0.04	338	110	7.5	3.00
5/2/83	7.4	51	14.2	68.7	1.3	149	205	16.42	0.19	0.05	527	-	7.1	451
8/2/83	9.5	73	18.5	23.0	1.3	229	68	28.23	ND	0.14	426	258	6.9	358
11/11/83	9.8	60	16.7	29.2	1.4	219	92	23.23	ND	0.13	406	217	7.4	324
2/6/84	10.9	59	14.9	20.9	2.1	233	10	26.83	ND	0.28	325	207	7.5	428
4/30/84	9.5	50	15.8	20.4	1.1	234	23	35.0	ND	ND	348	190	7.0	376
7/30/84	9.4	71	15.7	16.2	22	236	17	33.7	0.20	0.03	382	241	7.7	520

* ND - None Detected < 0.1 mg/l Fl

Appendix 5

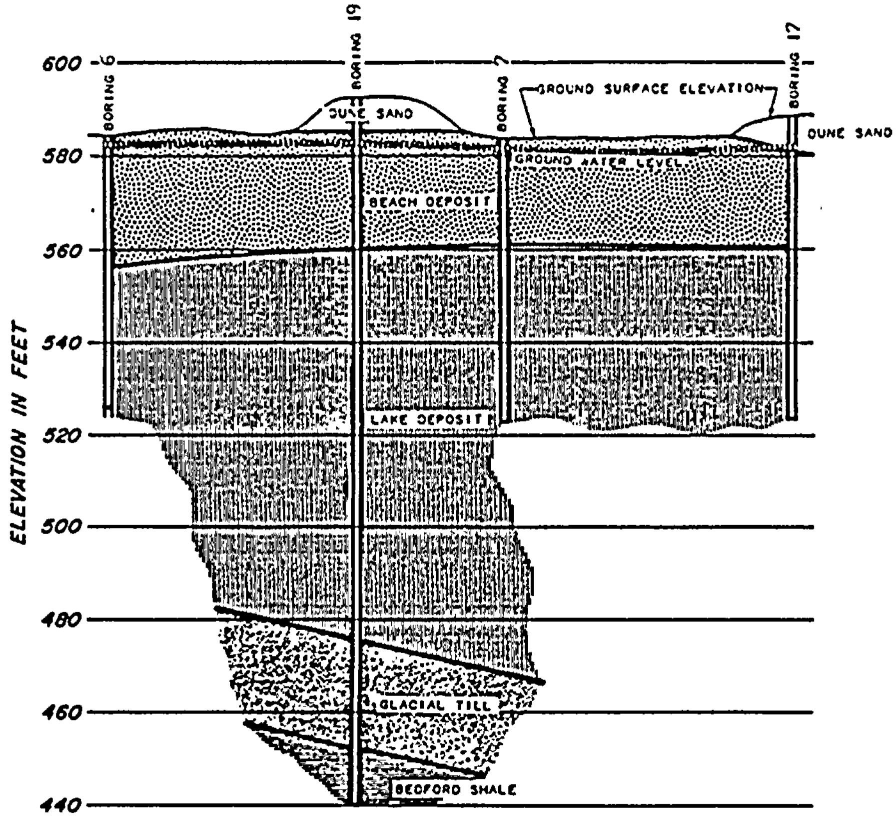
Figures



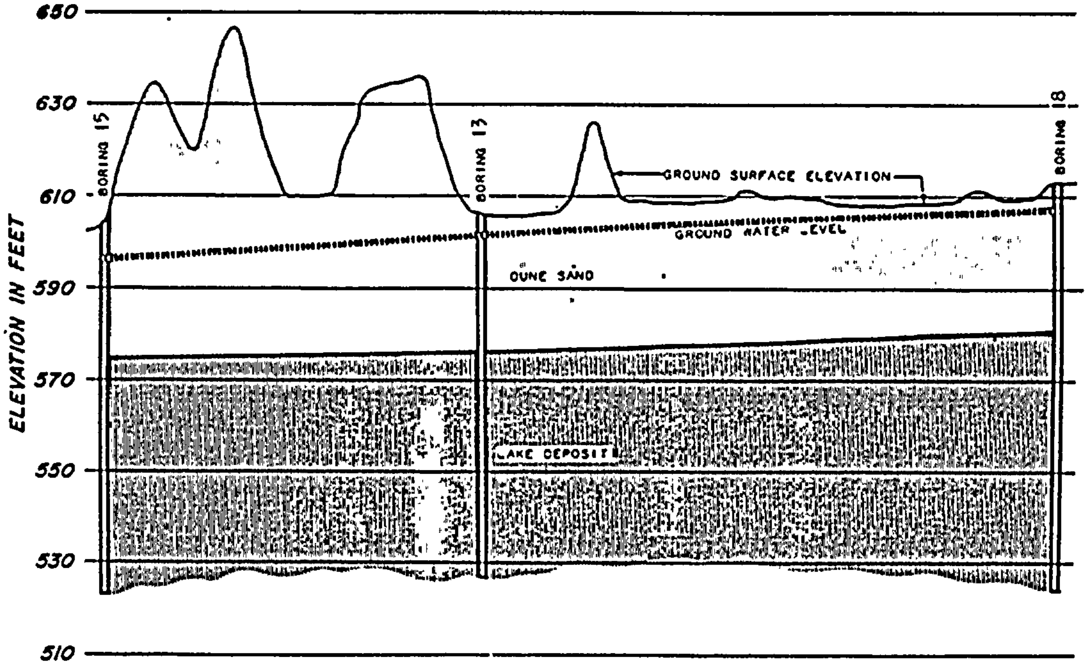
SI
APERTURE
CARD

Also Available On
Aperture Card
Figure No. 1

9110010256-01



SECTION A—A



SECTION B—B

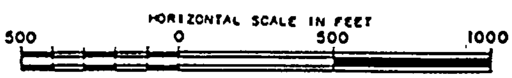


Figure No. 2

GEOLOGIC CROSS-SECTIONS

NOTE:

SUBSURFACE CONDITIONS ILLUSTRATED ABOVE WERE OBTAINED BY INTERPOLATION BETWEEN BORINGS. CONSEQUENTLY, VARIATIONS WHICH ARE NOT INDICATED BY THE CROSS-SECTION CAN BE EXPECTED BETWEEN BORING LOCATIONS.

DAMES & MOORE

PLATE IIA-10a

FILE 4853-001
BY D. J. [illegible] DATE 2-20-67
CHECKED BY [illegible] DATE [illegible]

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

NOTE:
SUBSURFACE CONDITIONS ILLUSTRATED ABOVE WERE OBTAINED BY INTERPOLATION BETWEEN BORINGS. CONSEQUENTLY, VARIATIONS WHICH ARE NOT INDICATED BY THE CROSS-SECTION CAN BE EXPECTED BETWEEN BORING LOCATIONS.

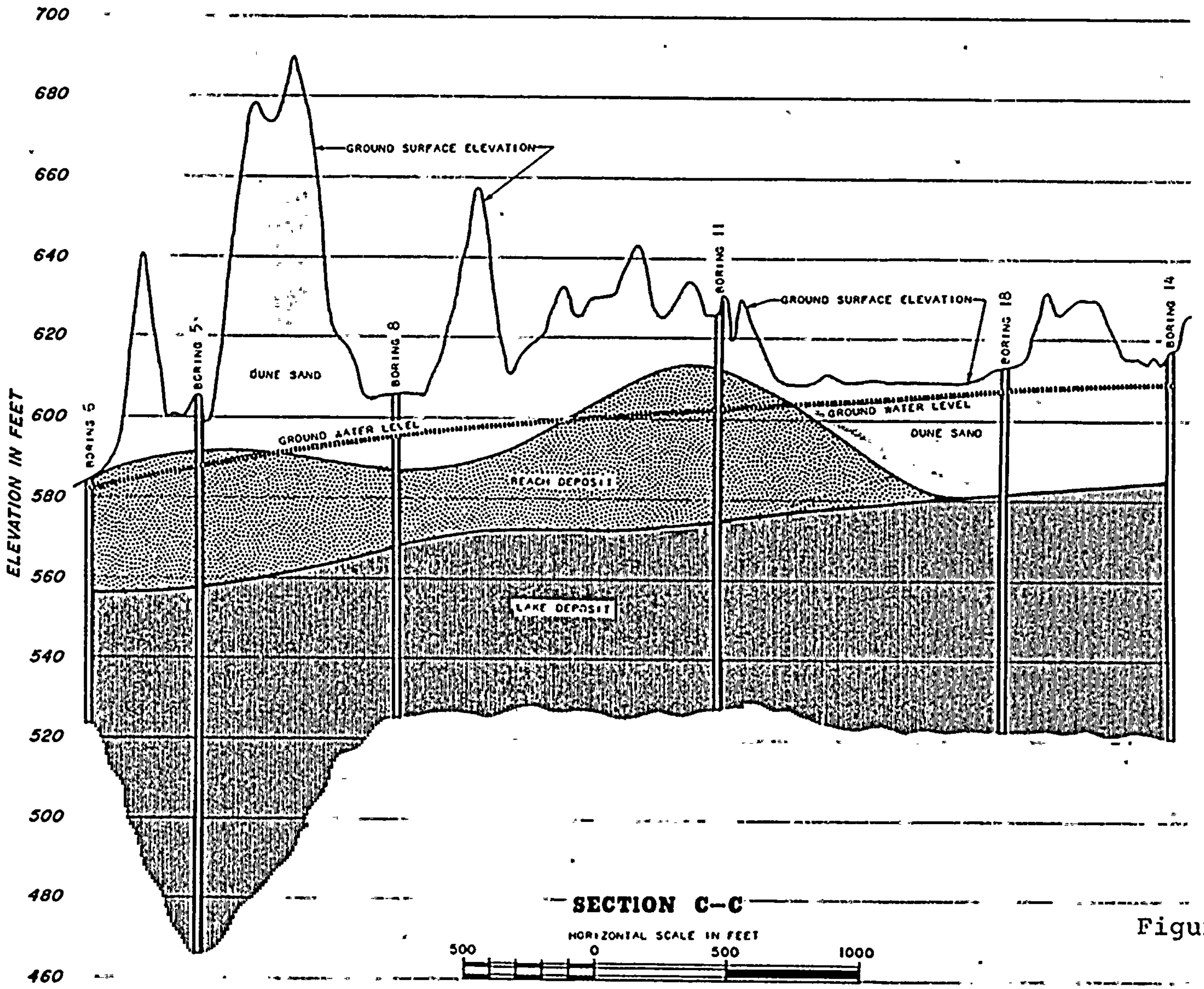
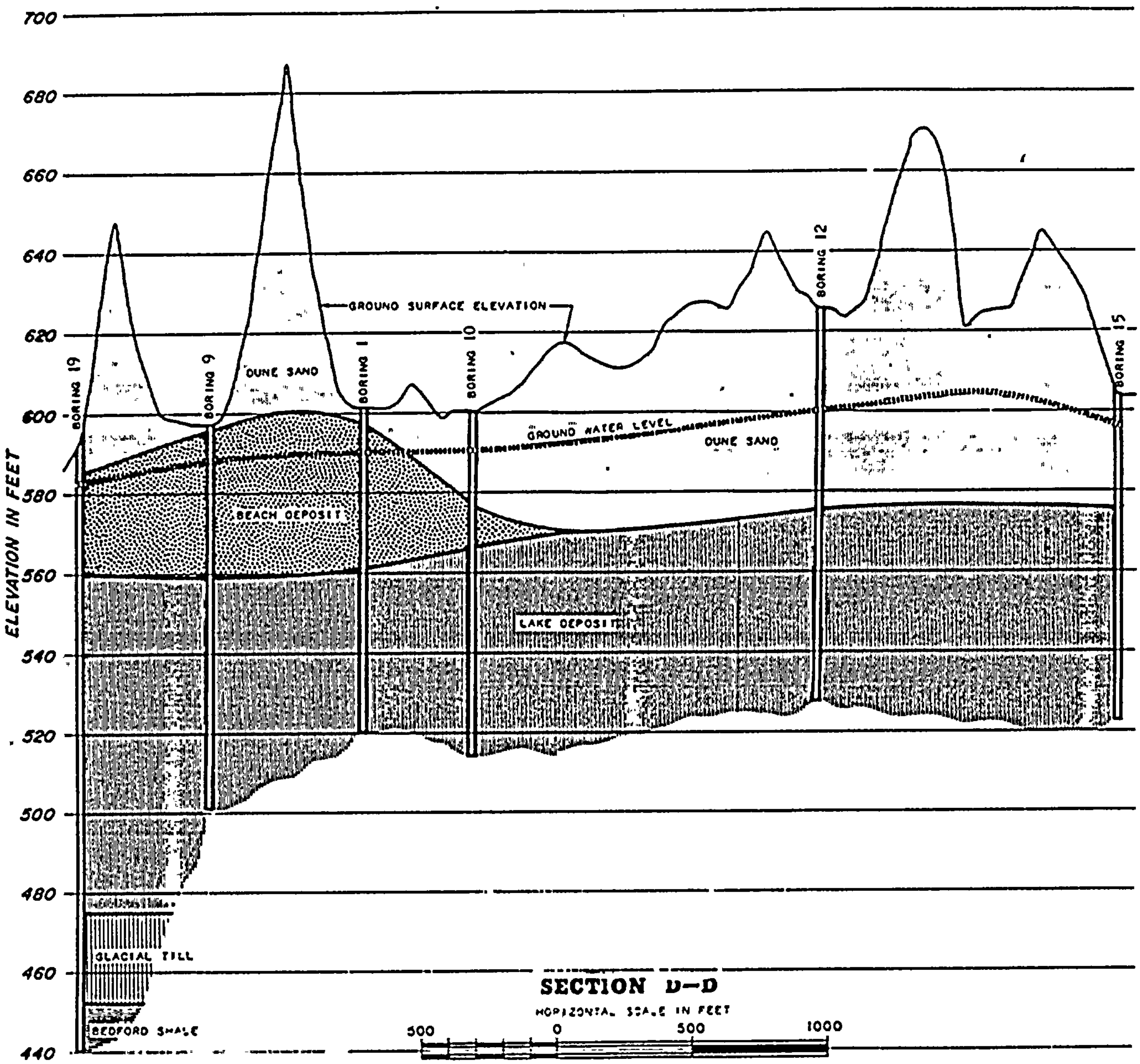


Figure No. 3

GEOLOGIC CROSS-SECTION

DAMES & MOORE

PLATE IIA-10b



NOTE:

SUBSURFACE CONDITIONS ILLUSTRATED ABOVE WERE OBTAINED BY INTERPOLATION BETWEEN BORINGS. CONSEQUENTLY, VARIATIONS WHICH ARE NOT INDICATED BY THE CROSS-SECTION CAN BE EXPECTED BETWEEN BORING LOCATION.

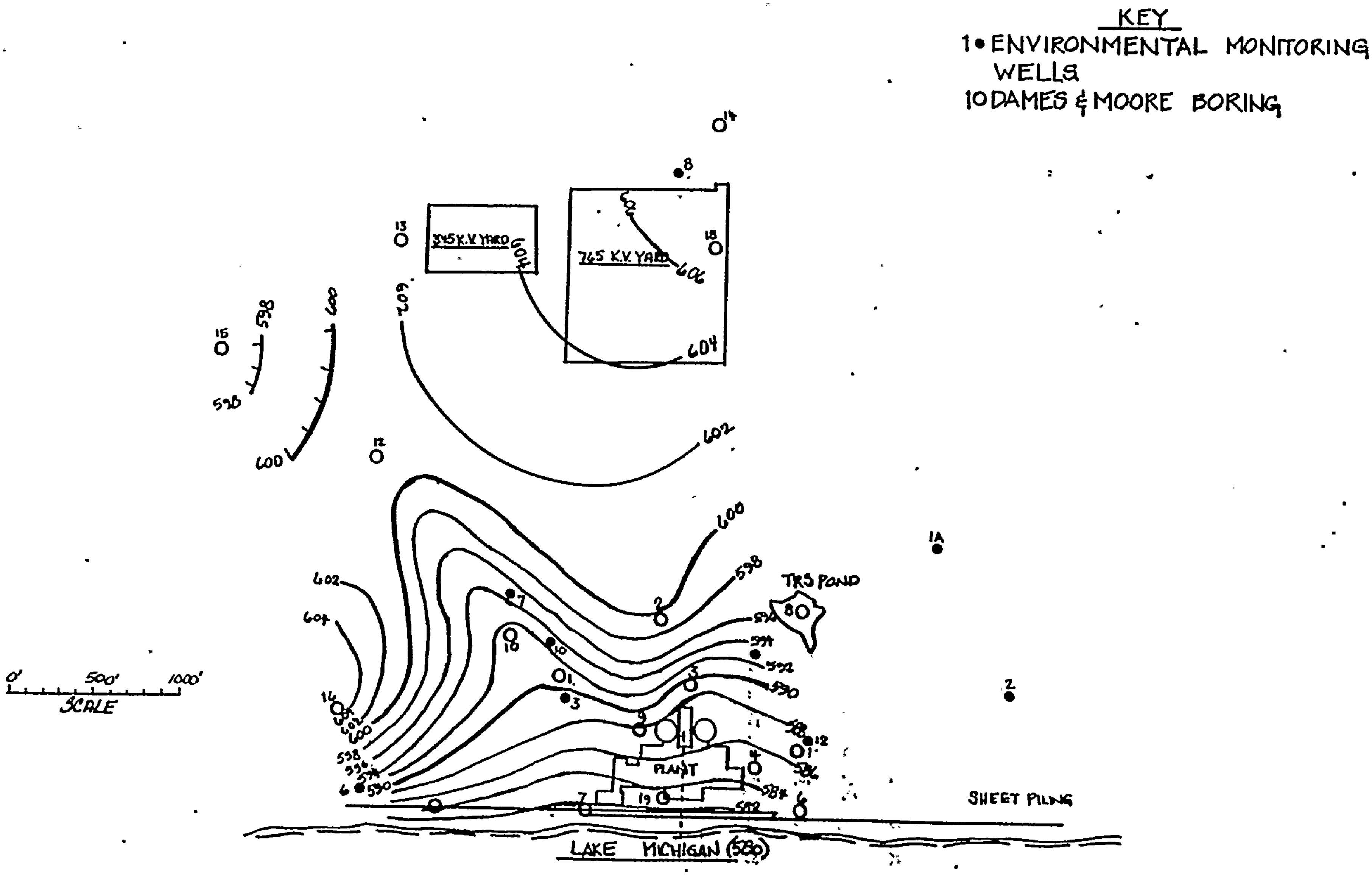
GEOLOGIC CROSS-SECTION Figure No. 4

DAMES & MOORE

PLATE IIA-10c

FIGURE 5

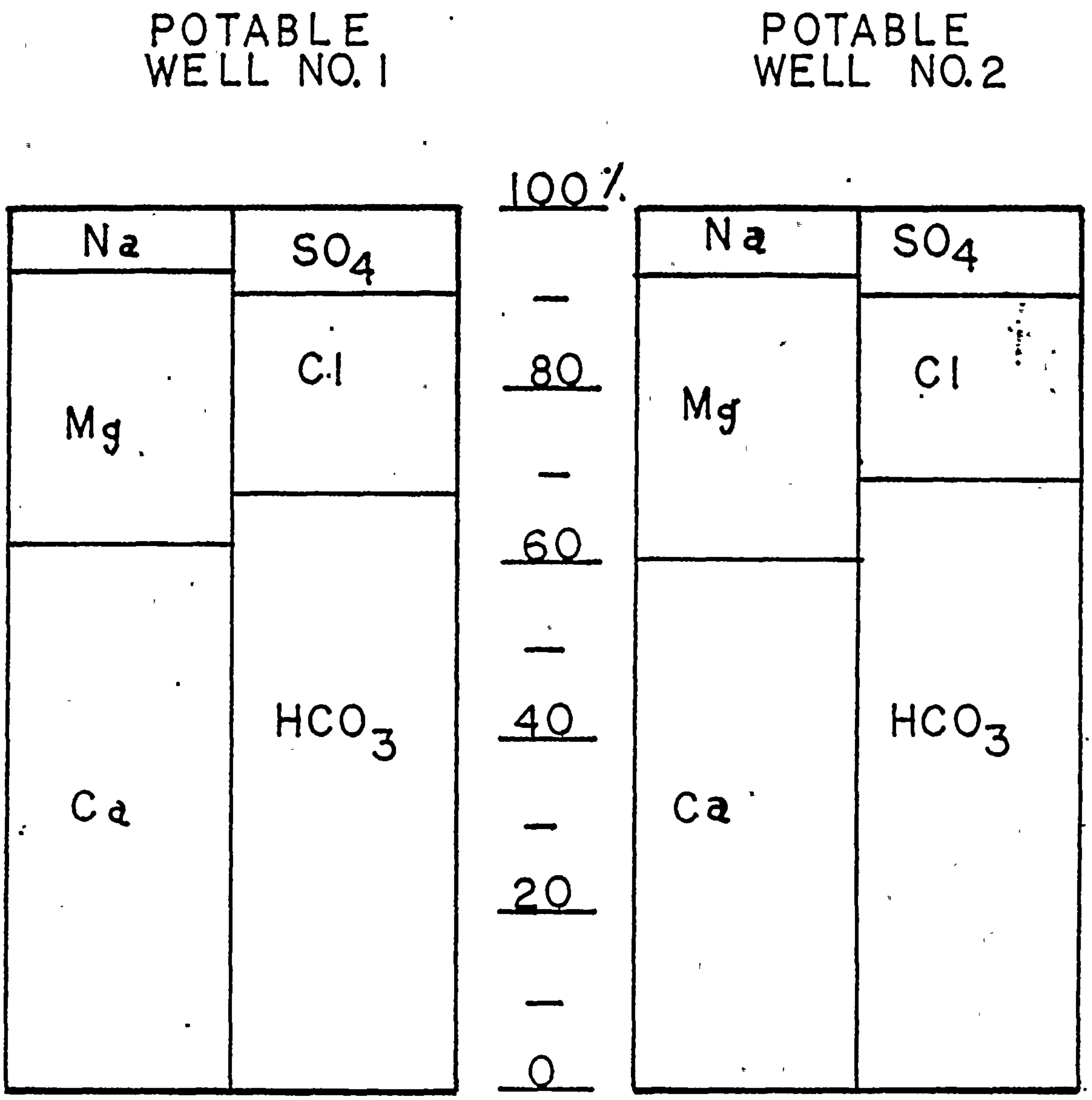
GENERALIZED PRECONSTRUCTION GROUNDWATER TABLE



Note: Obs. Wells 2, 3, 6, and 7 were discontinued after August, 1978.

Figure 6

Mass Balance of Baseline Water Quality



NOTE: Total percentage of the ions is based on the March, 1972 analysis

Figure No. 7
Water Table Map

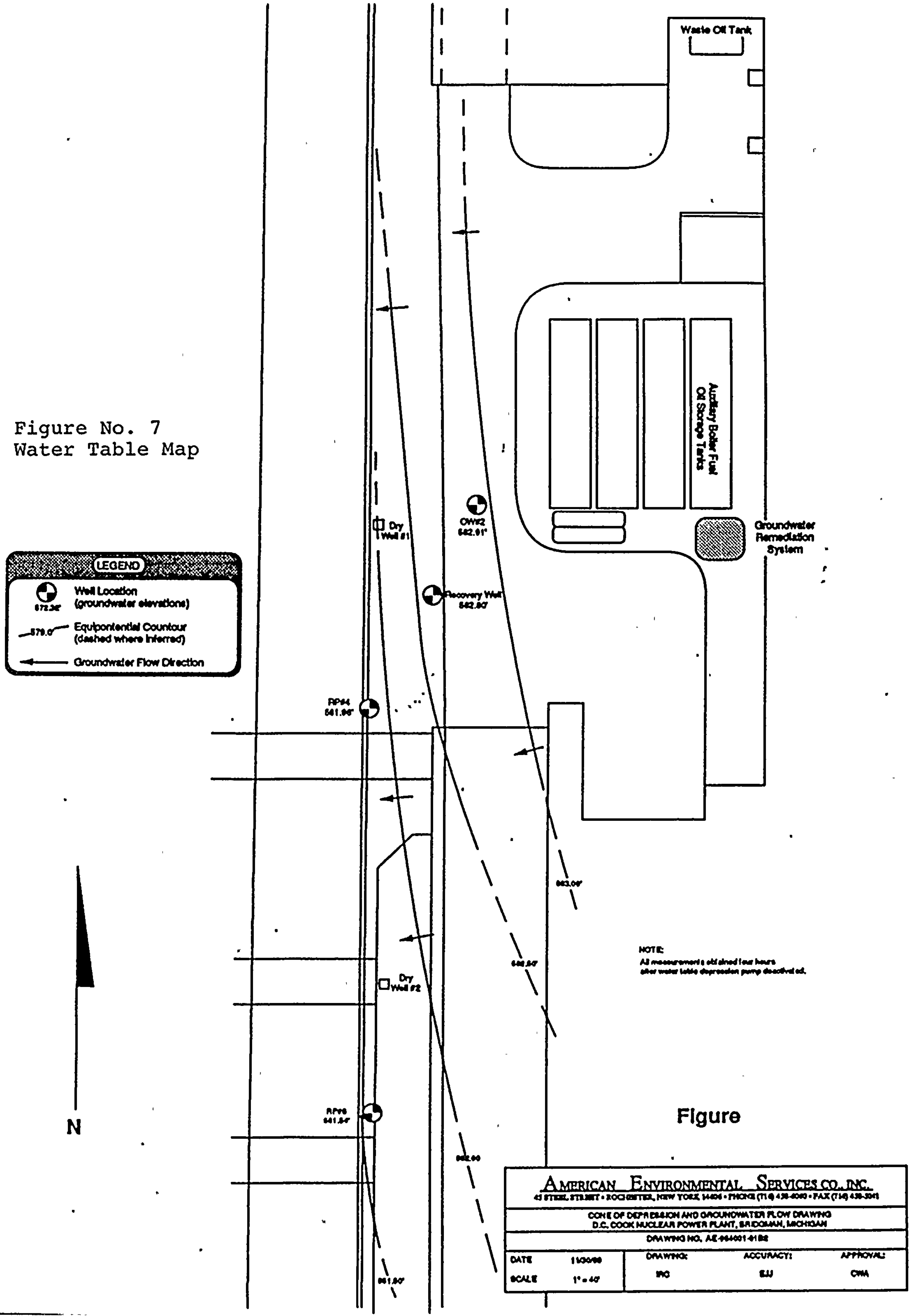
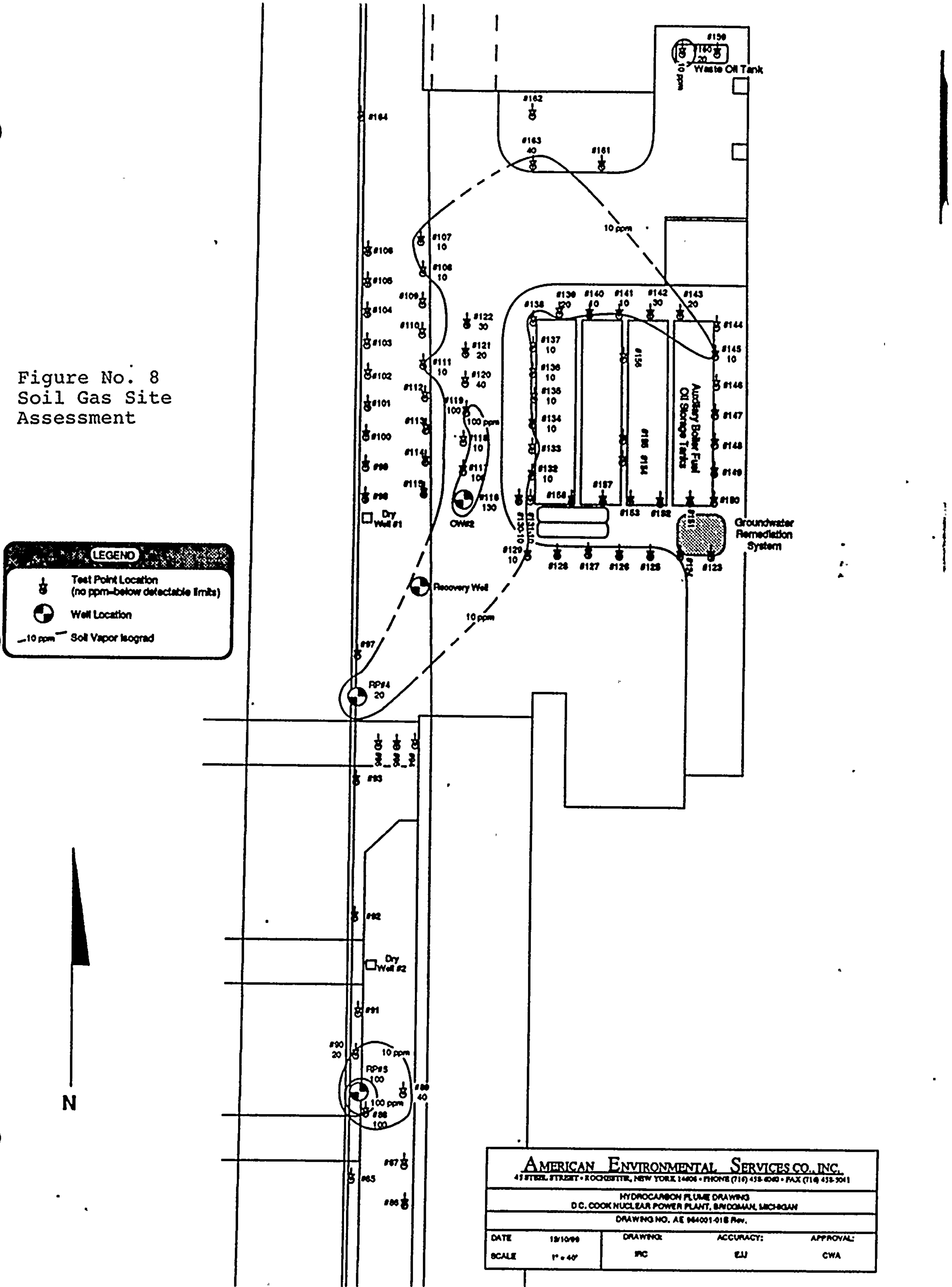


Figure No. 8
Soil Gas Site Assessment



AMERICAN ENVIRONMENTAL SERVICES CO., INC.			
HYDROCARBON PLUME DRAWING D.C. COOK NUCLEAR POWER PLANT, BRIDGMAN, MICHIGAN			
DRAWING NO. AE			
DATE	DRAWING:	ACCURACY:	APPROVAL:
SCALE 1" = 40'	RC	EJJ	CWA

Figure No. 9

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

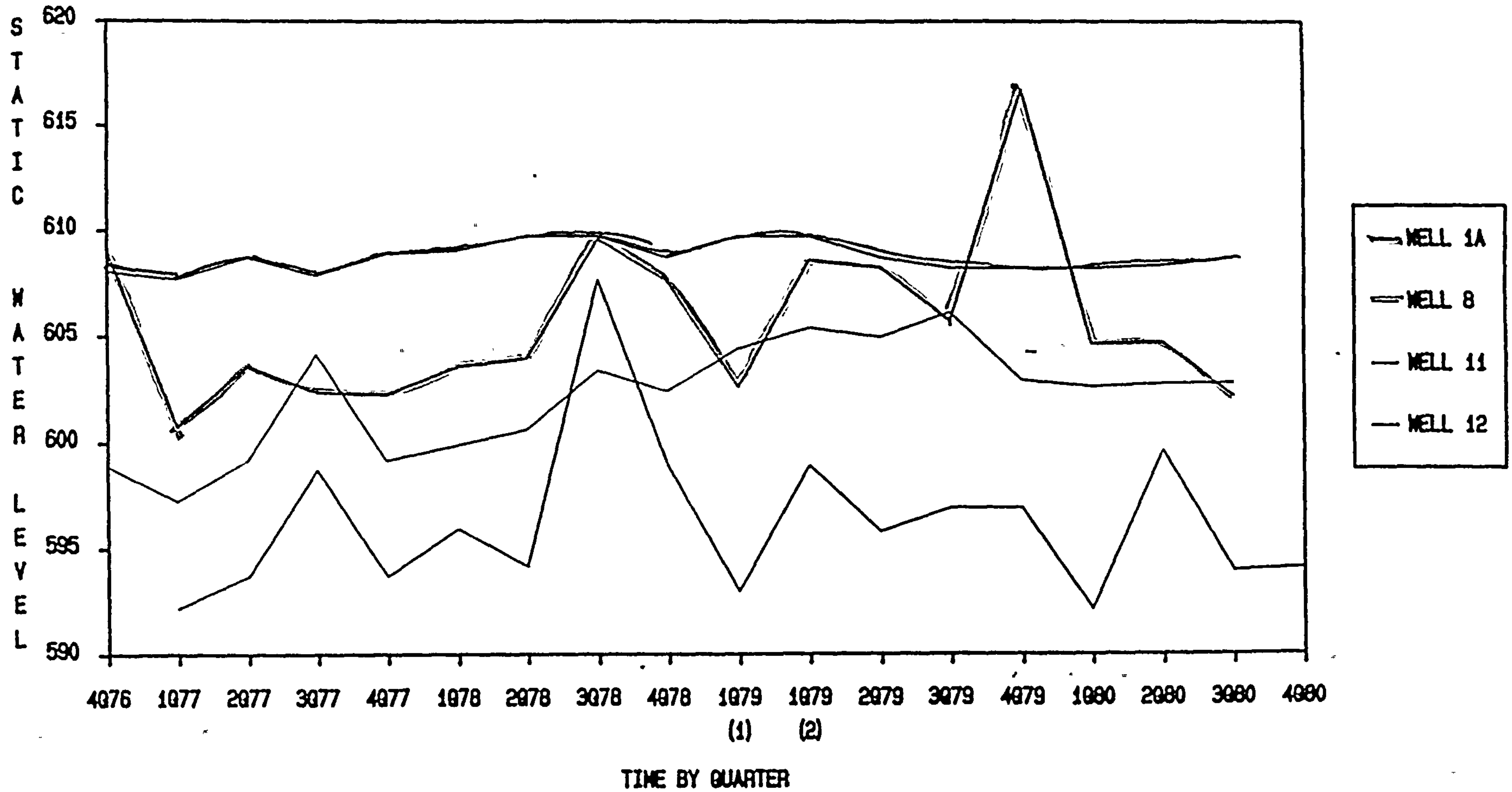


Figure No. 9
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

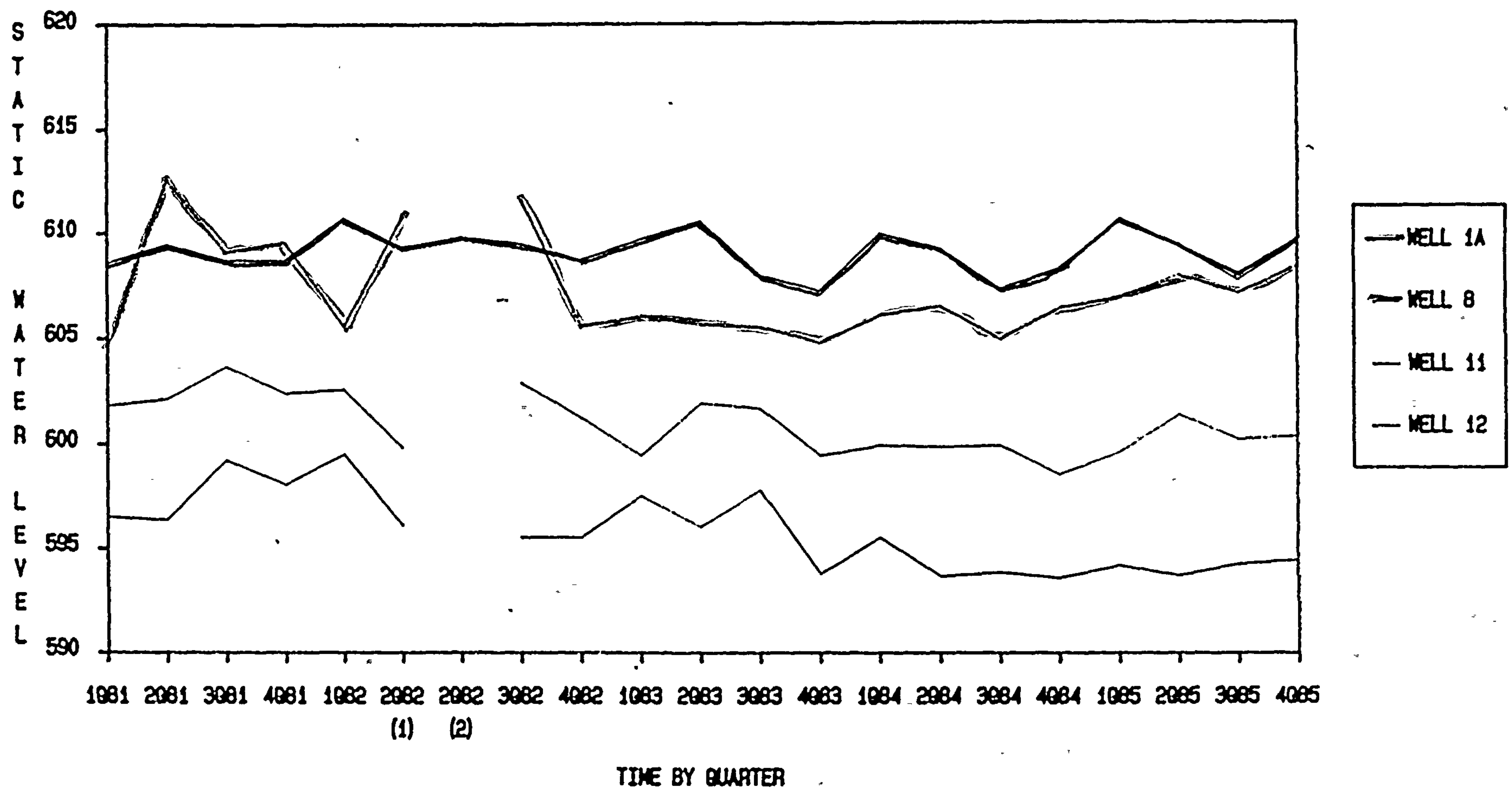


Figure No. 9
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

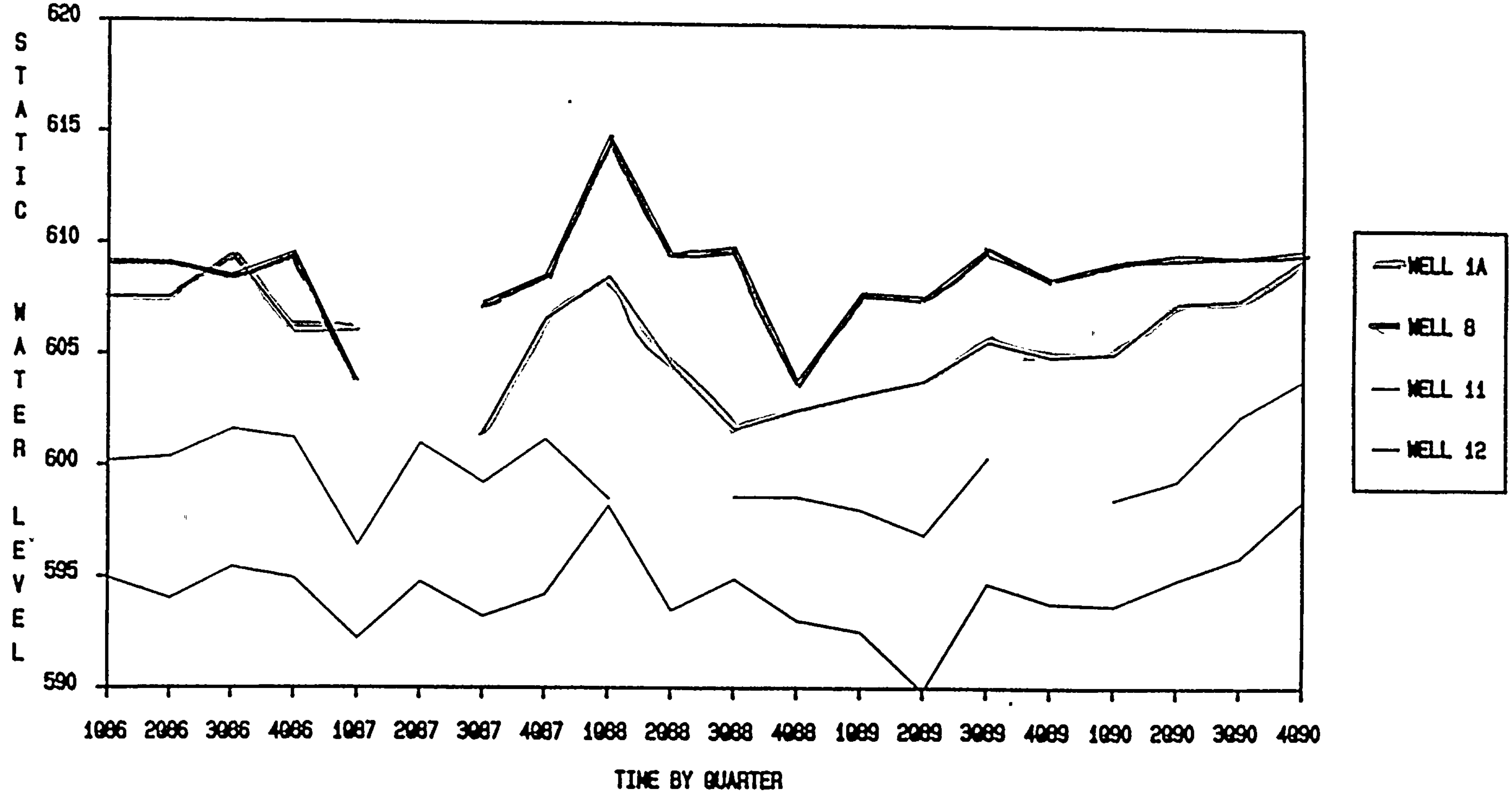


Figure No. 10

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

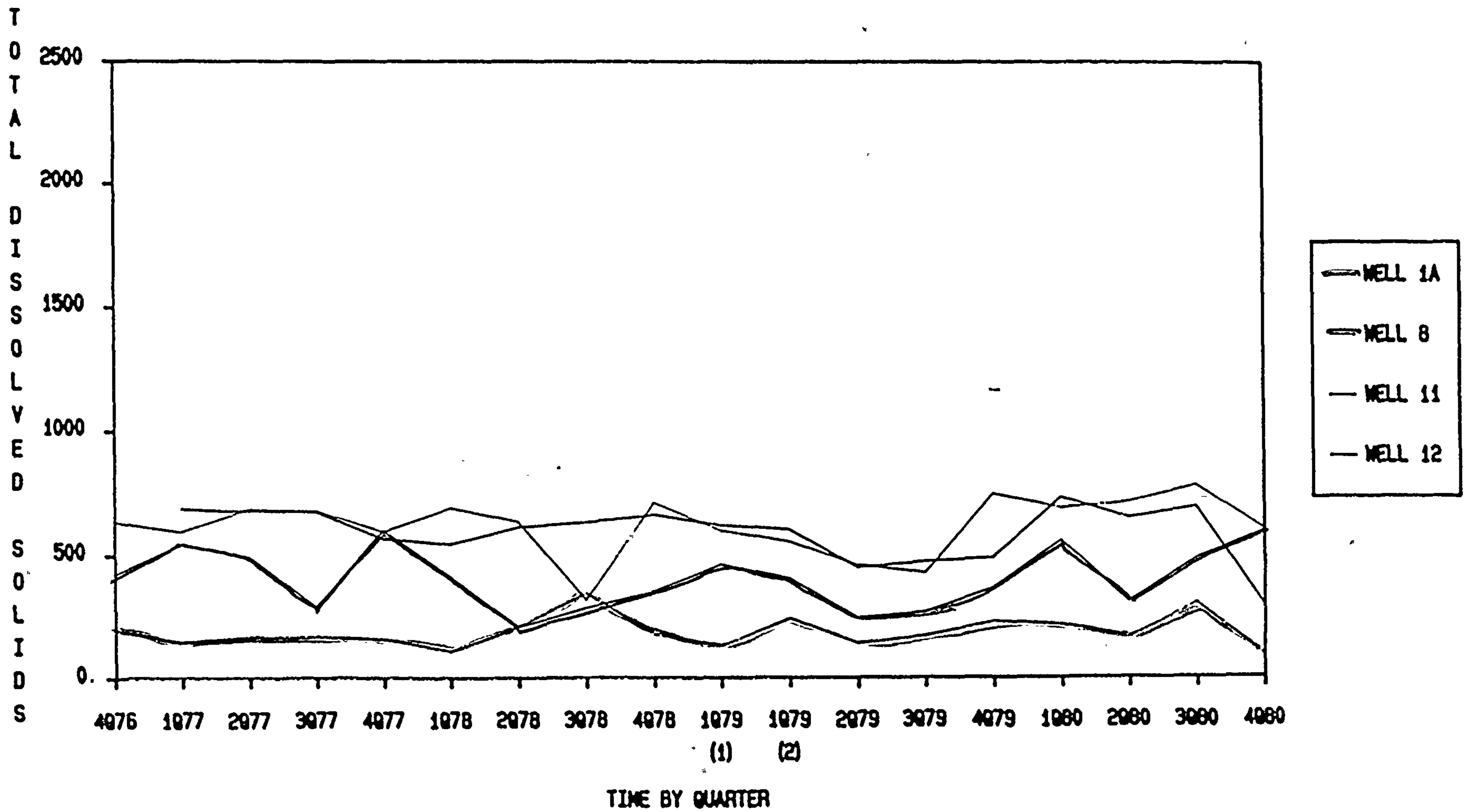


Figure No. 10
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

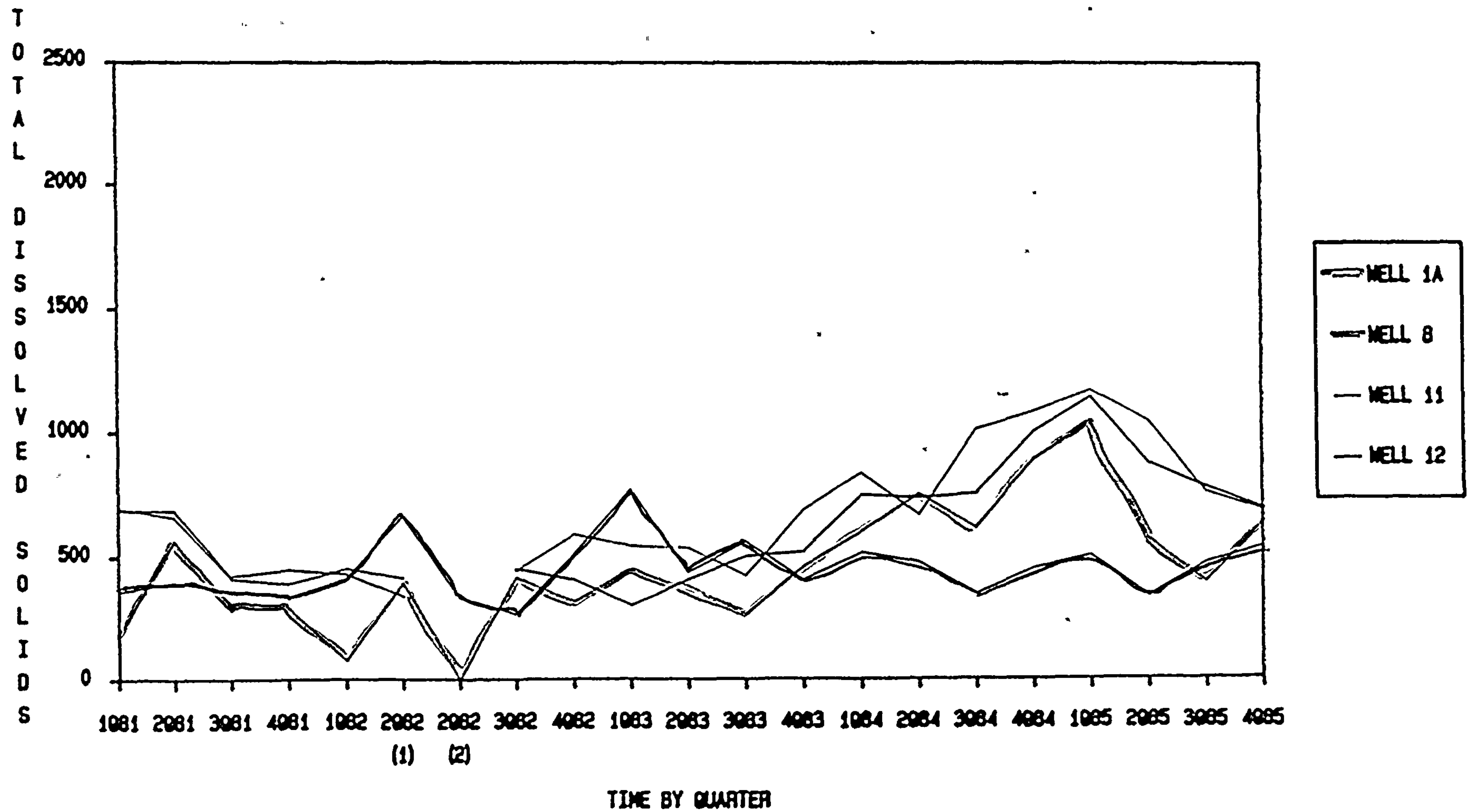


Figure No. 10
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

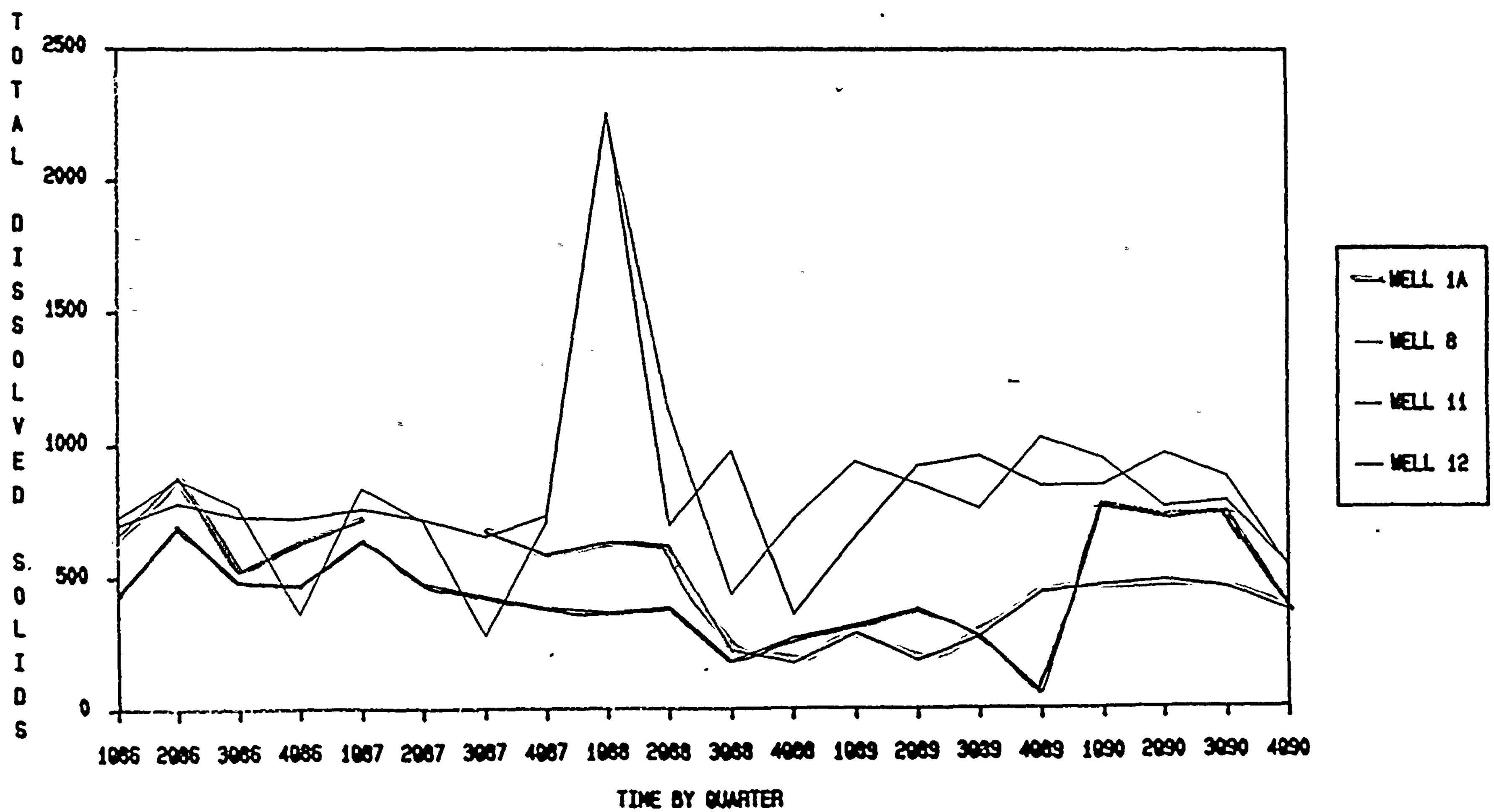


Figure No. 11

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

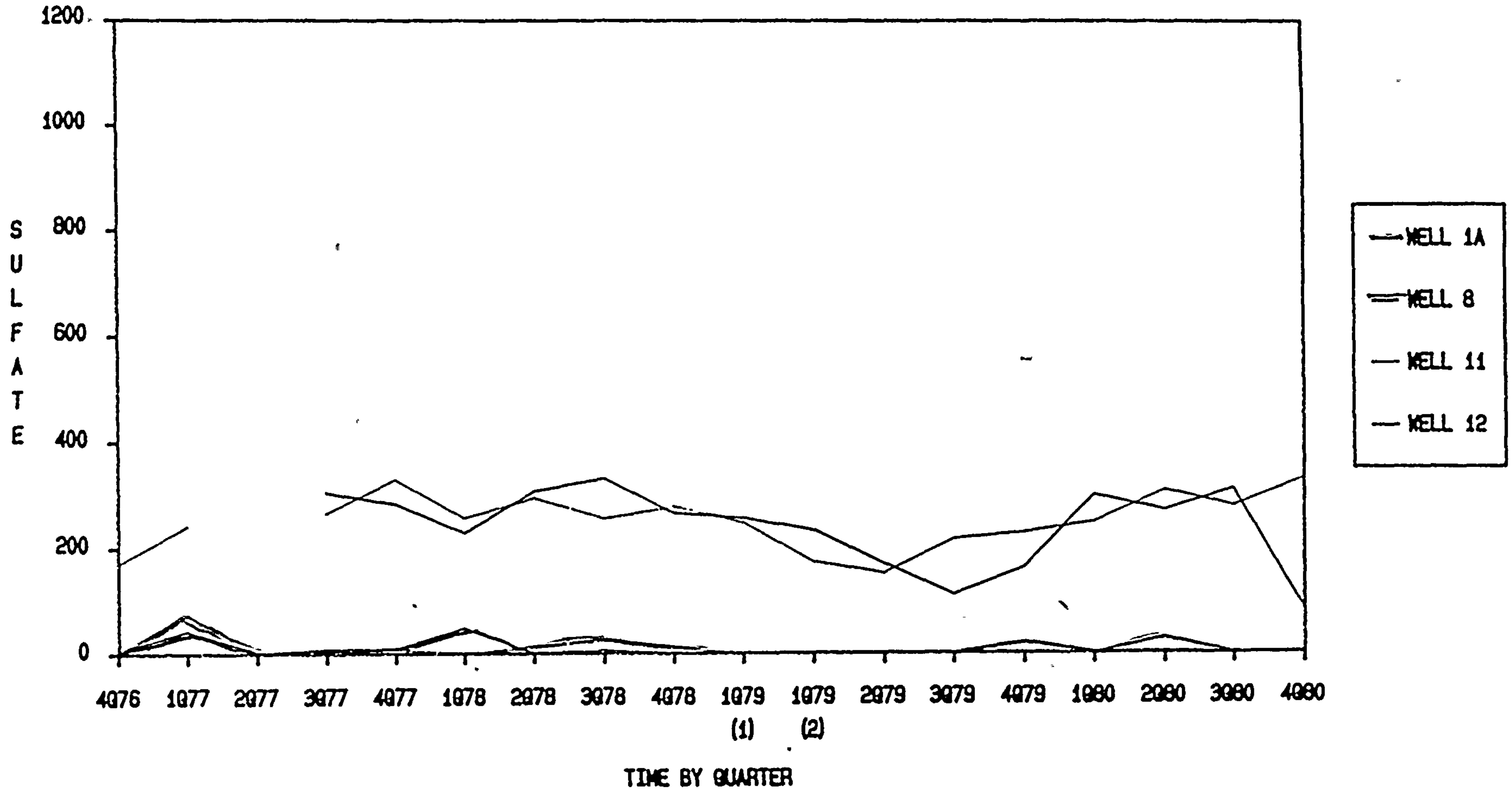


Figure No. 11
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

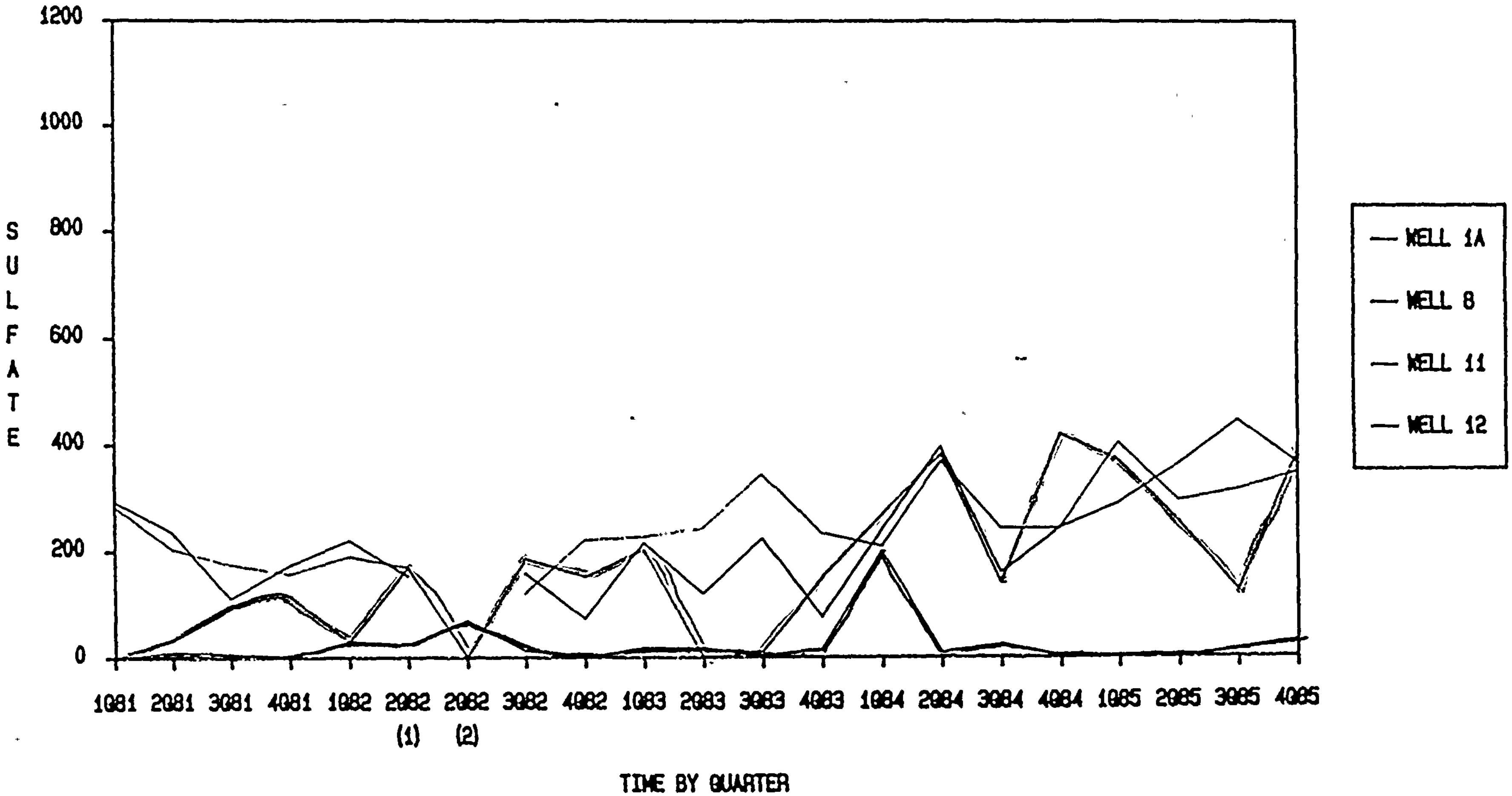


Figure No. 11
Continued

DONALD C. COOK NUCLEAR PLANT GROUNDWATER DISCHARGE MONITORING

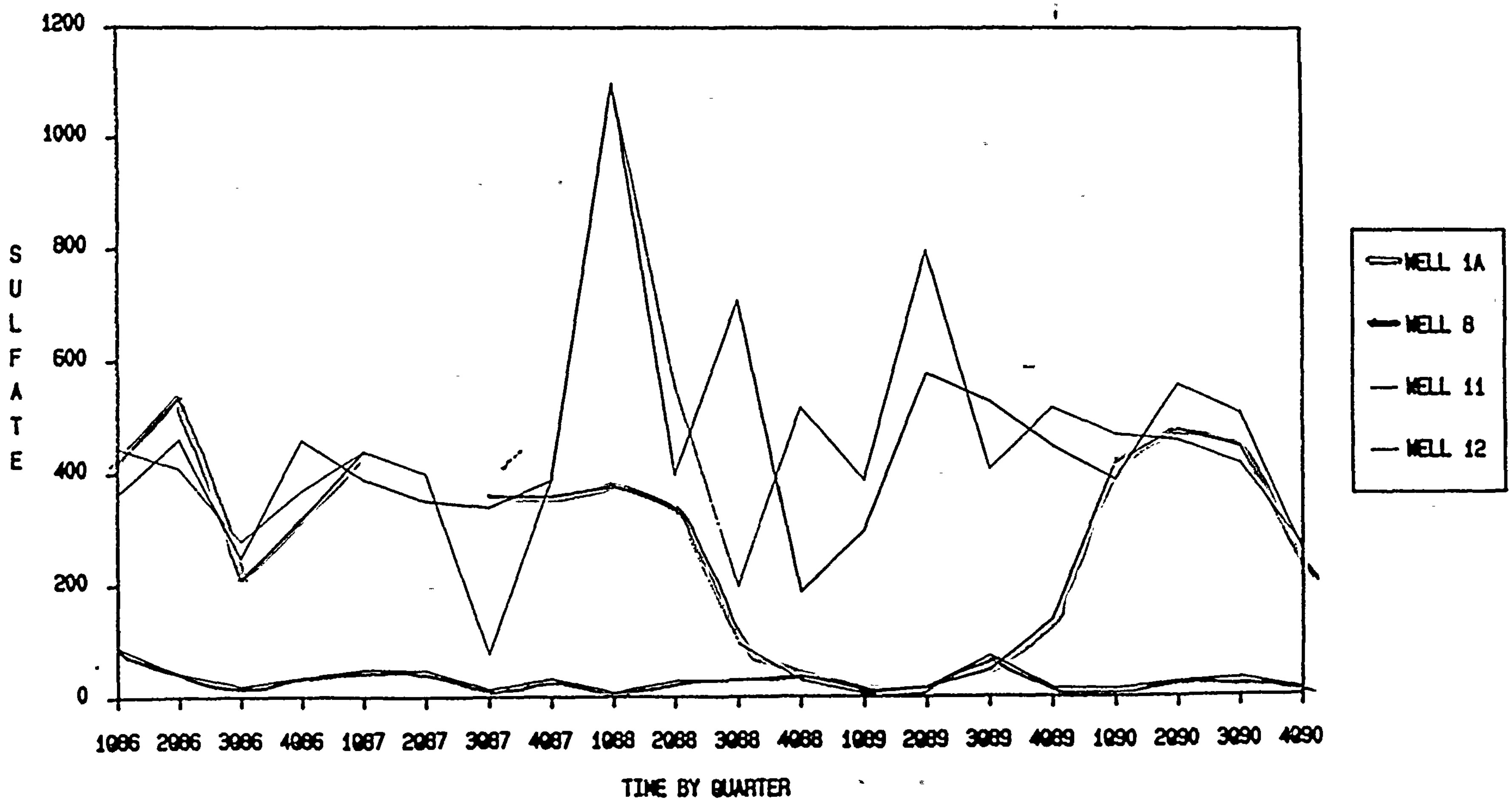


Figure No. 12

Tritium Activities
1981-1990

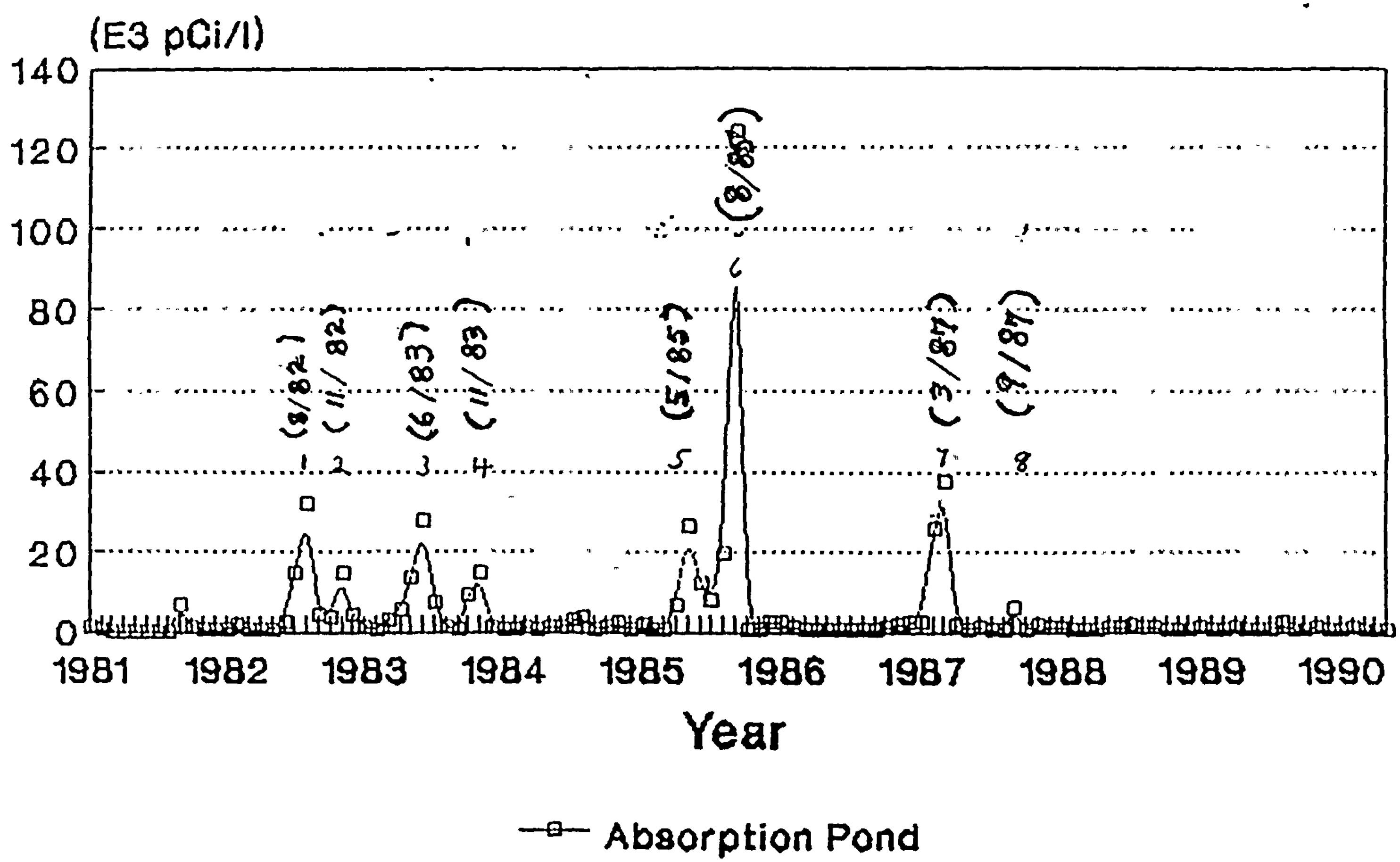


Figure No. 13

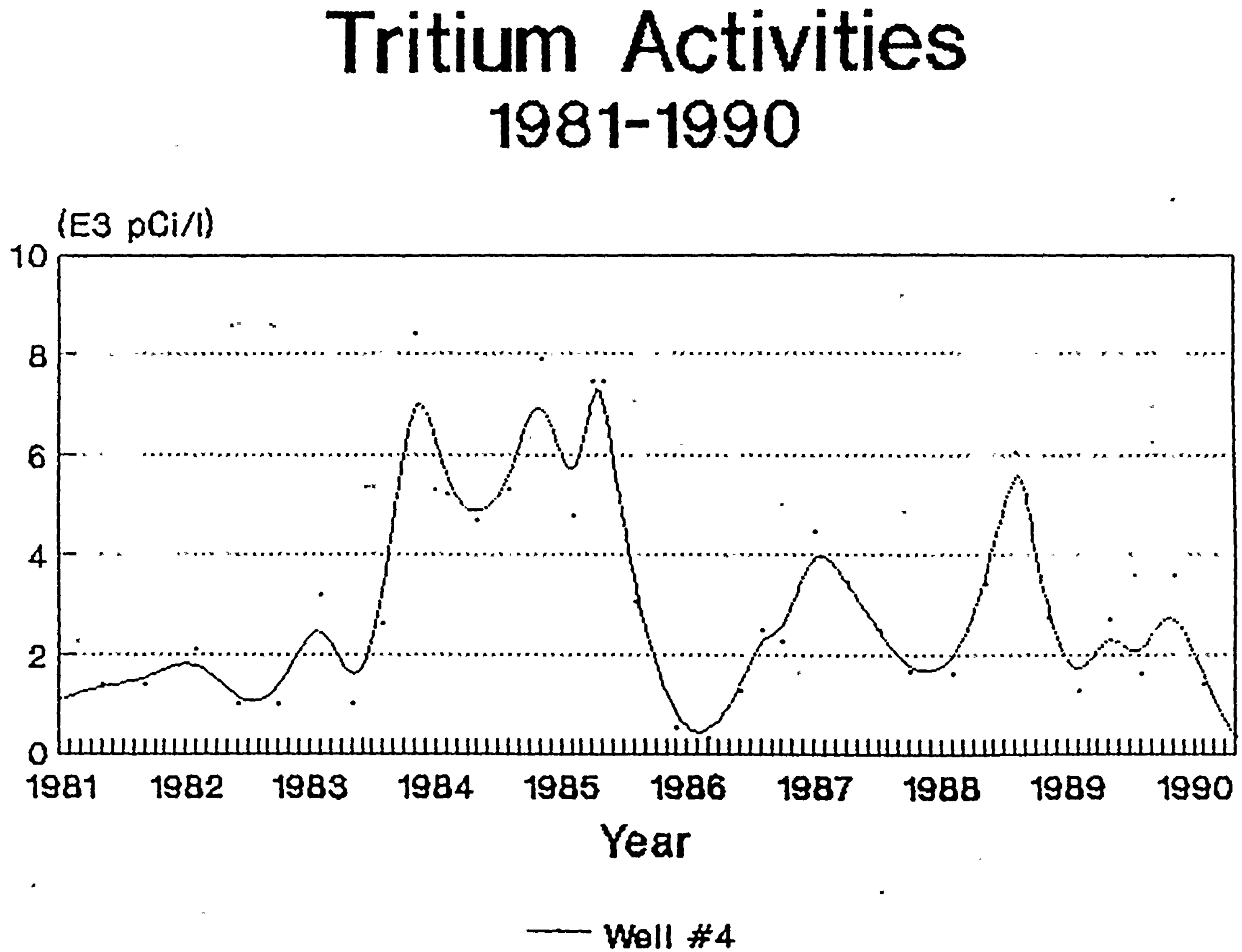

Tritium Activities
1981-1990
(E3 pCi/l)
10
8
6
4
2
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Year
Well #4

Figure No. 14

Tritium Activities
1981-1990

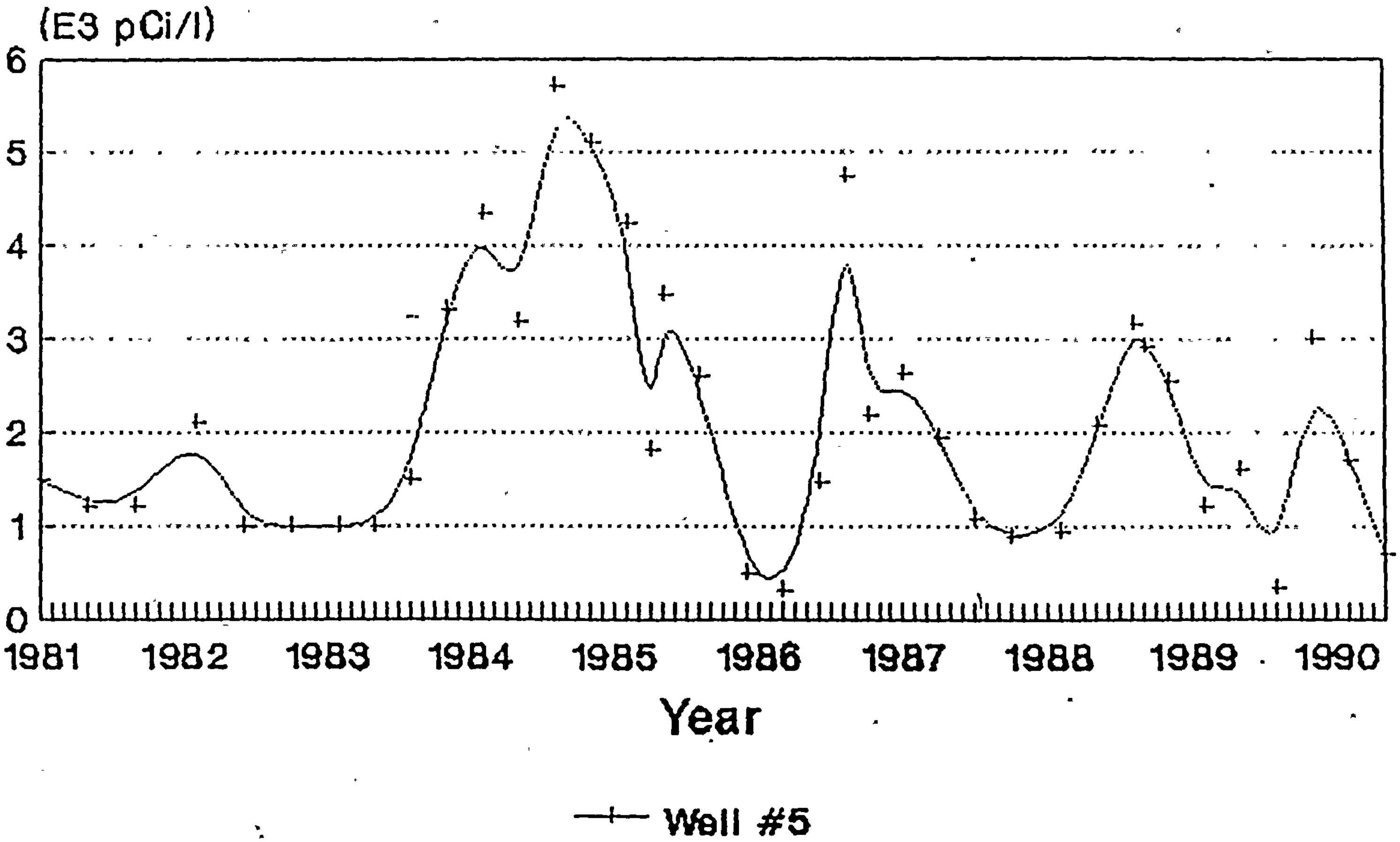


Figure No. 15

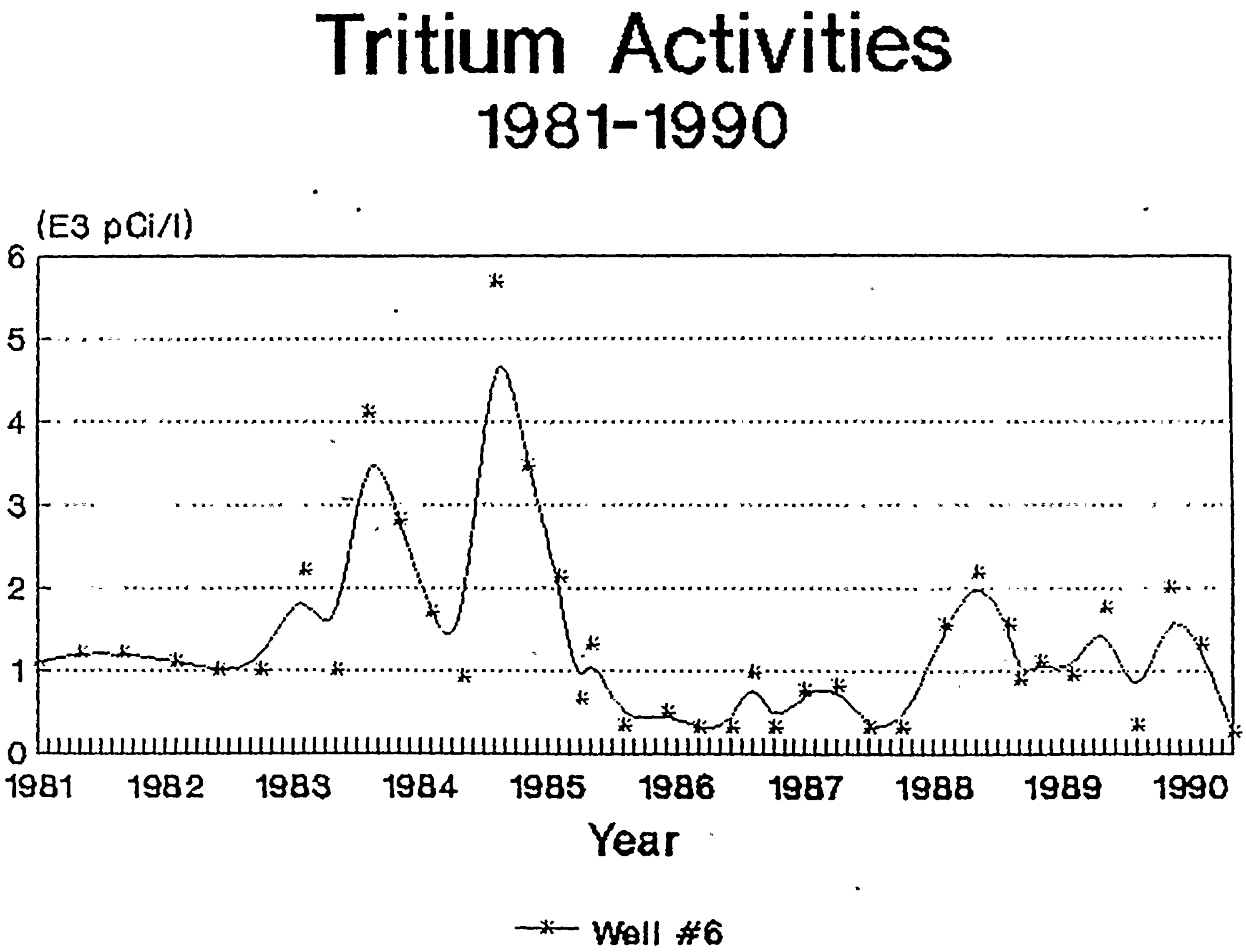

Tritium Activities
1981-1990
(E3 pCi/l)
6
5
4
3
2
1
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
Year
Well #6

Figure 16a.

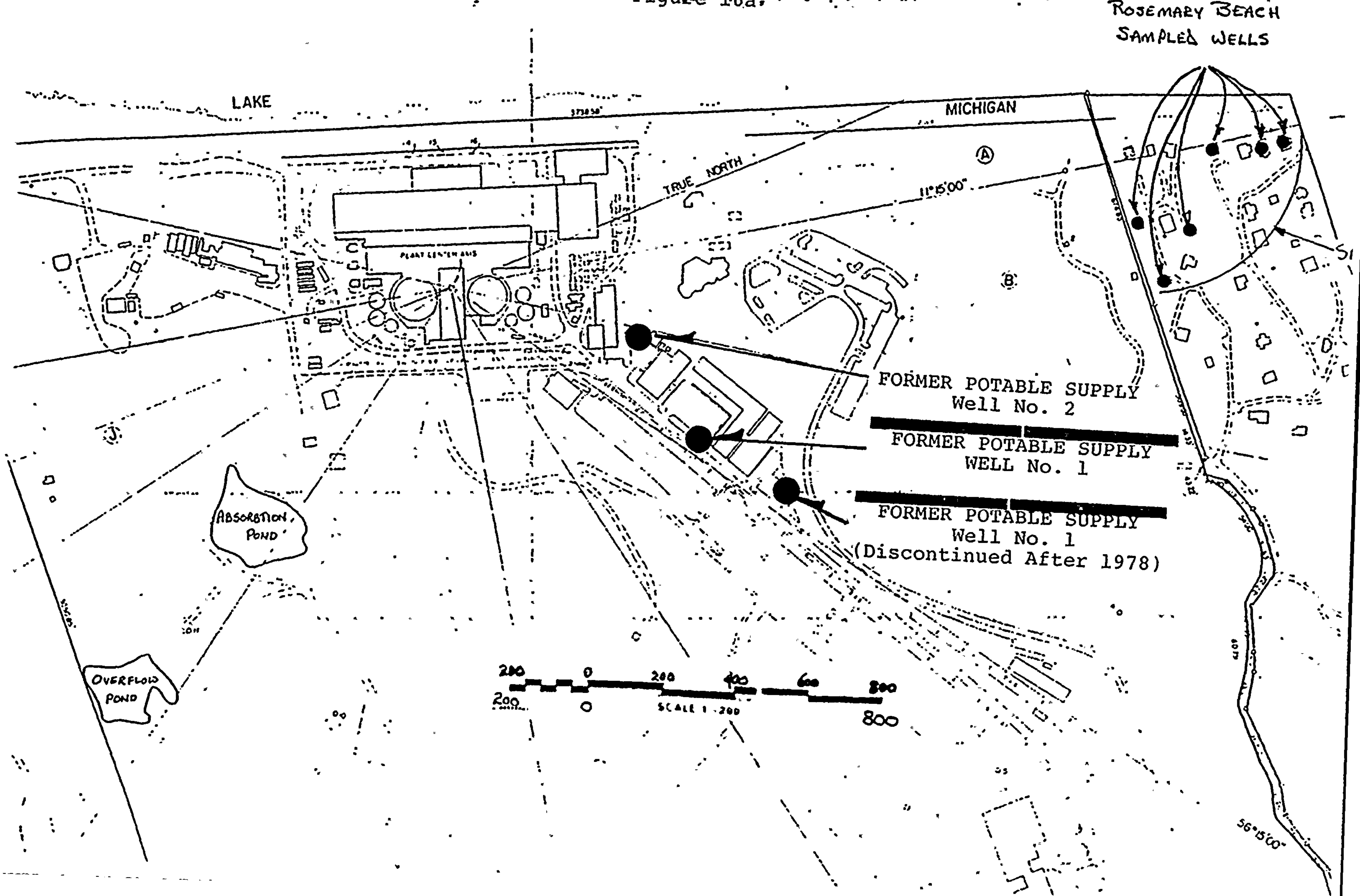

ROSEMARY BEACH
SAMPLED WELLS
LAKE
MICHIGAN
TRUE NORTH
ABSORBTION POND
OVERFLOW POND
FORMER POTABLE SUPPLY
Well No. 2
[redacted]
FORMER POTABLE SUPPLY
WELL No. 1
[redacted]
FORMER POTABLE SUPPLY
Well No. 1
(Discontinued After 1978)
200 0 200 400 600 800
200 0 800
SCALE 1 : 200

Figure 16b

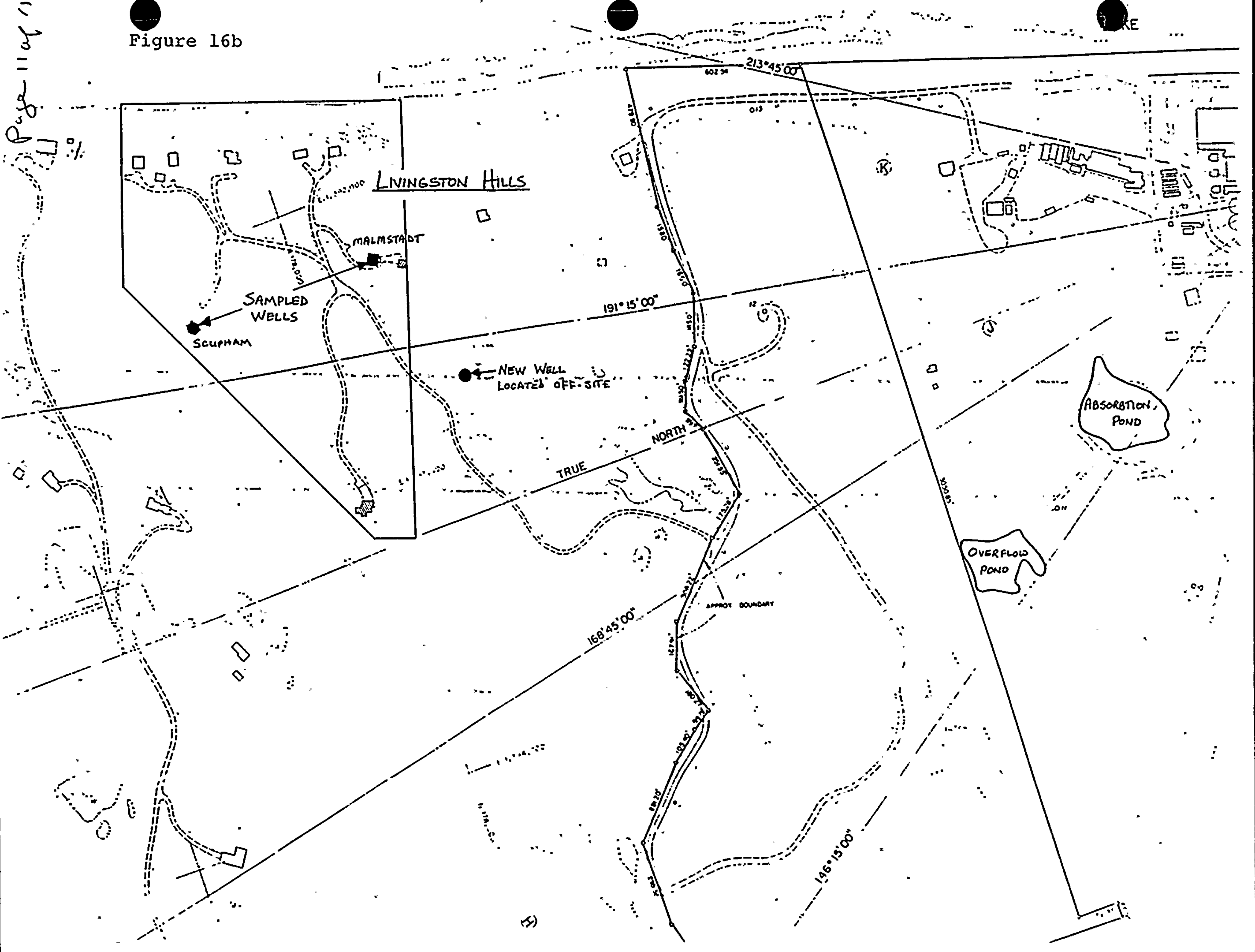

LIVINGSTON HILLS
MALMSTADT
SAMPLED WELLS
SCUPHAM
NEW WELL LOCATED OFF-SITE
ABSORBTION POND
OVERFLOW POND
TRUE NORTH
191° 15' 00"
168° 45' 00"
146° 15' 00"
213° 45' 00"
APPROX BOUNDARY

Figure No. 17
Former Potable Supply Well No. 2
Concentration of
Na, Ca, Mg, HCO_3, SO_4 & Cl

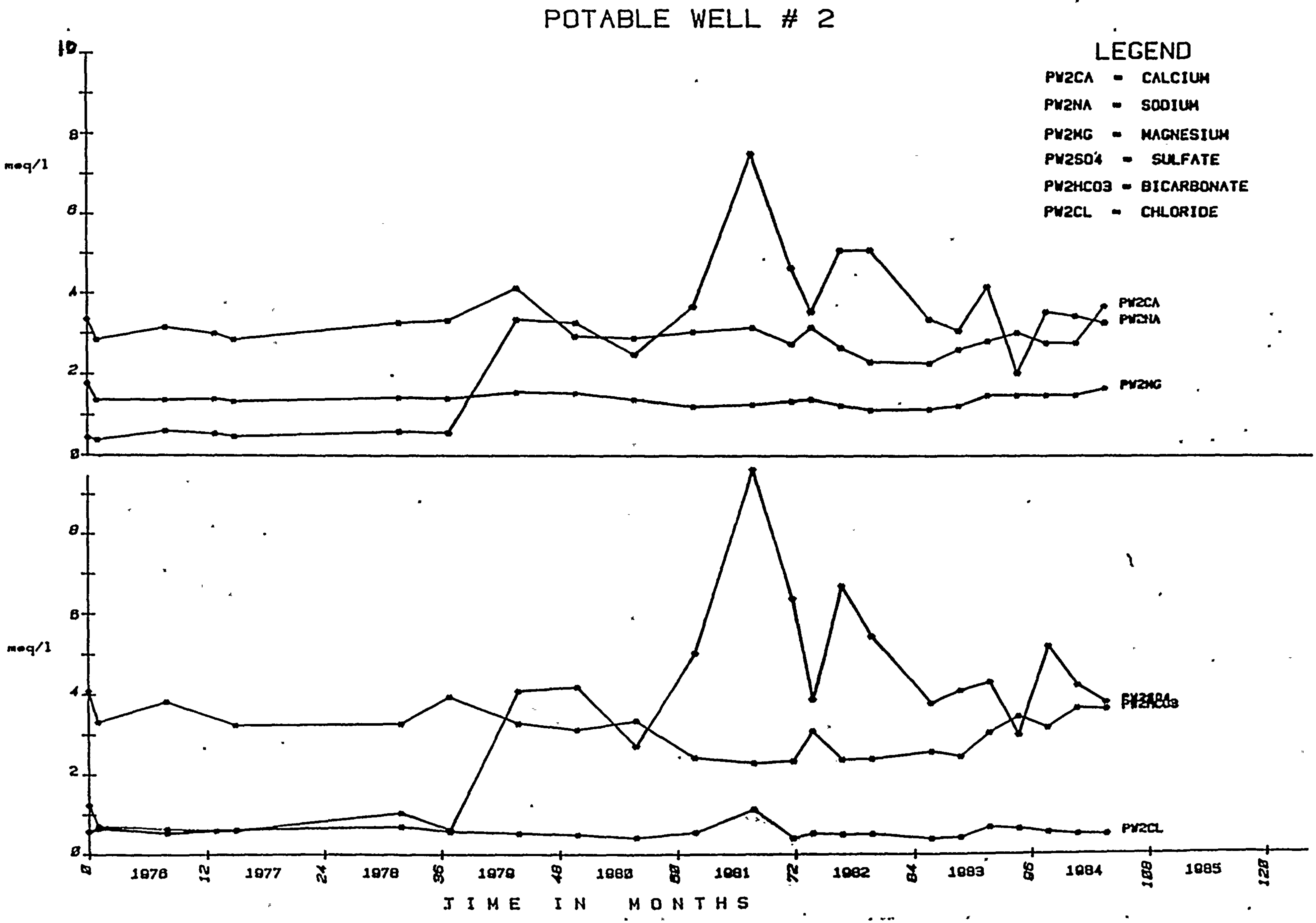
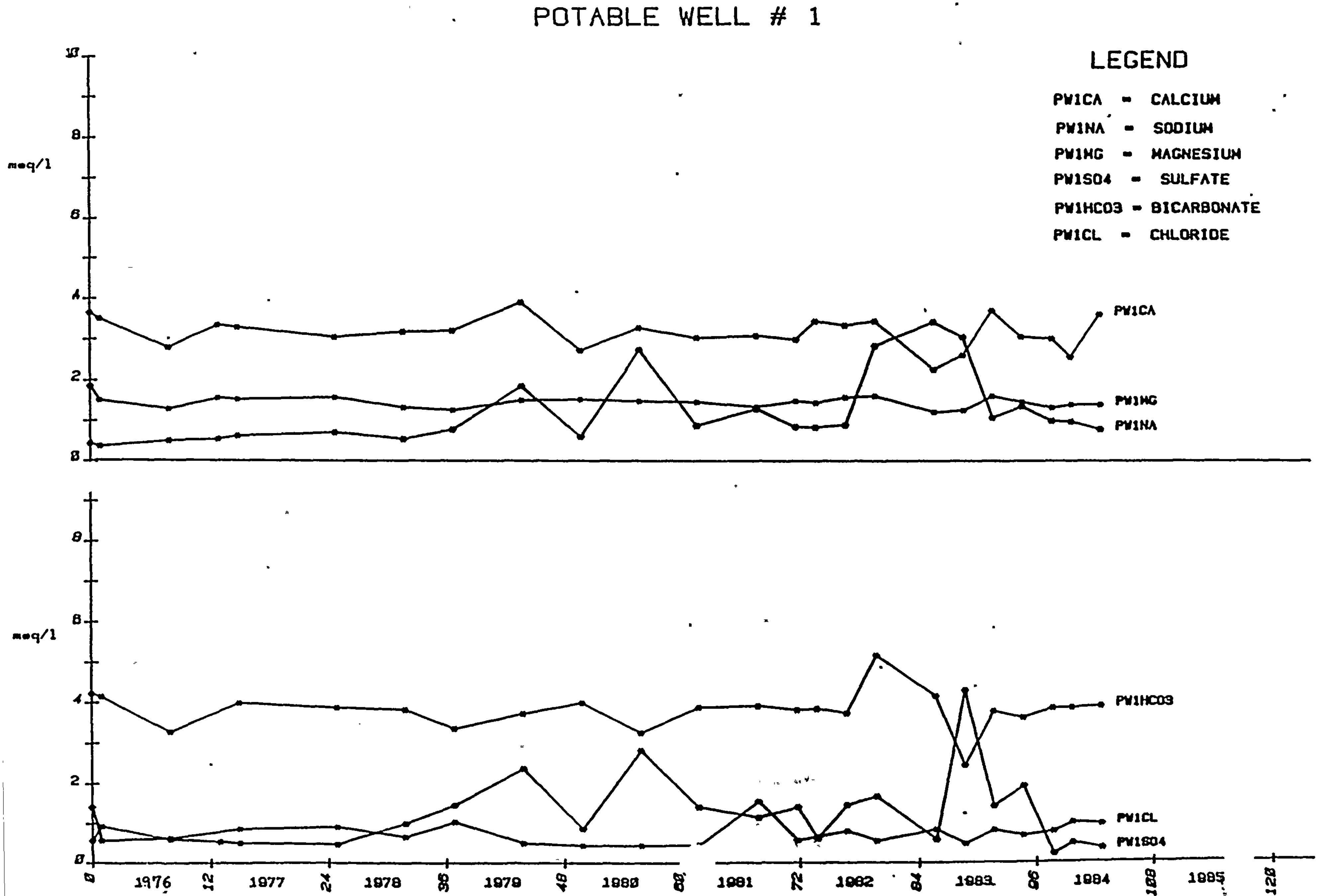


Figure No. 18
Former Potable Supply Well No. 1
Concentration of Na, Ca, Mg, HCO_3, SO_4 & Cl

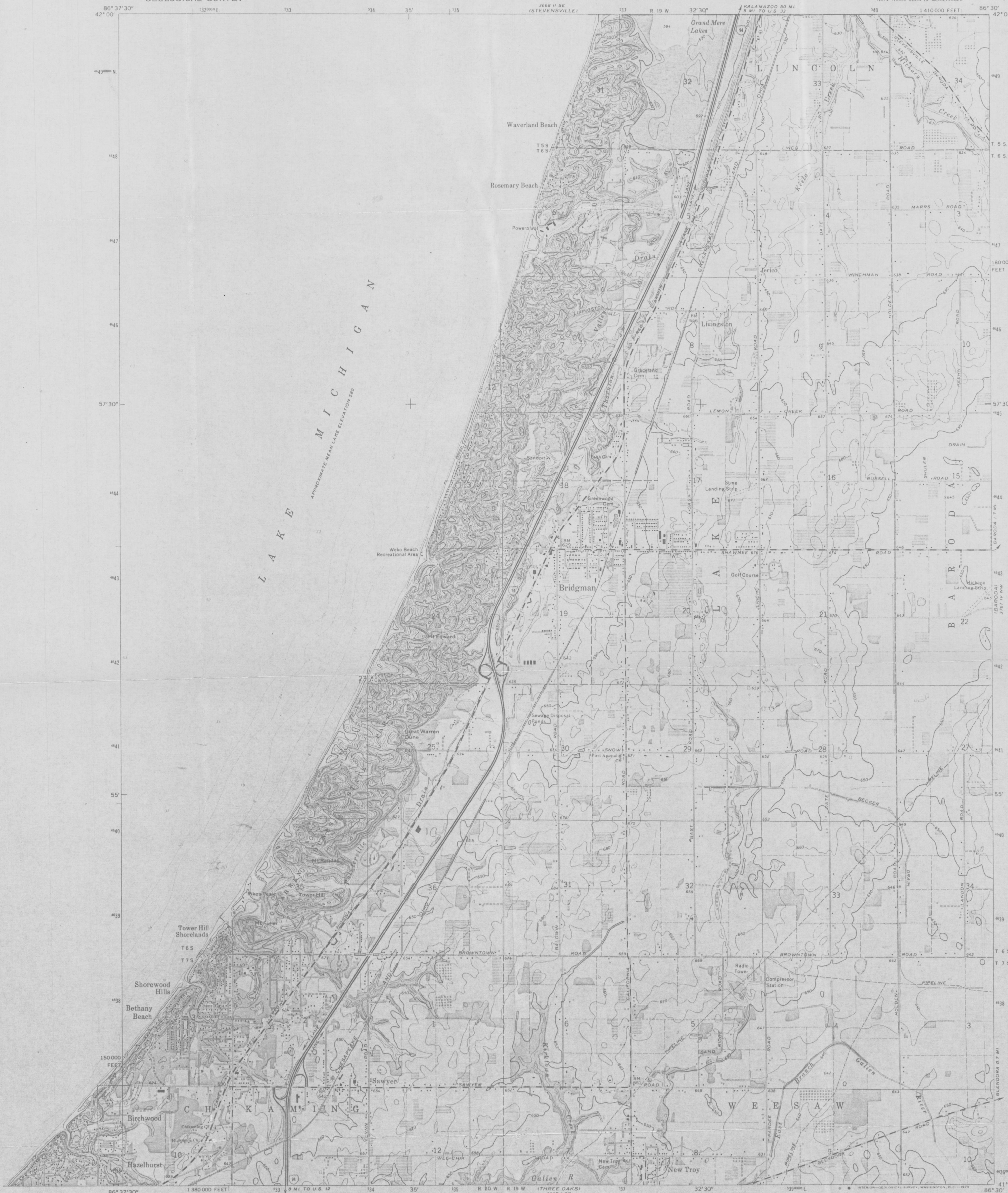


32. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I
NRC, October 1977
Regulatory Guide 1.109

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF MICHIGAN

BRIDGMAN QUADRANGLE
MICHIGAN–BERRIEN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 THREE OAKS 15' QUADRANGLE



Mapped, edited, and published by the Geological Survey
in cooperation with State of Michigan agencies

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1969. Field checked 1970

Selected hydrographic data compiled from U. S. Lake Survey Chart 75 (1969). This information is not intended for navigational purposes

Polyconic projection. 1927 North American datum
10,000-foot grid based on Michigan coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 16, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1970 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDING IN FEET—DATUM IS LOW WATER 576.8 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

MICHIGAN
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route

BRIDGMAN, MICH
NE/4 THREE OAKS 15' QUADRANGLE
N4152.5—W8630/7.5

1970

AMS 3667 I NE—SERIES V862

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