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GROUNDWATER STUDY TASK A REPORT
OCTOBER 1985

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DAMES & MOORE/NLO
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REPORT

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Department of Energy G-000-0061
Feed Materials Production Center

GROUNDWATER STUDY
TASK A REPORT

Prepared By:

Dames & Moore

Pearl River, New York

For:

NLO, Inc.

October 1985

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October 29, 1985

Mr. Robert Weidner
Director
Health,
Safety and Environmental Division
NLO, Inc.
7400 Willey Road
Fernald, Ohio 45030

Re: NLO SUBCONTRACTOR S- 1094
Groundwater Study Task A Report

Dear Mr. Weidner:

We are pleased to herewith transmit twenty (20) copies of the Task A Report prepared under the referenced contract. This report incorporates revisions and comments provided to us in your letter of July 1, 1985.

As you know, the purpose of the Task A Report was to evaluate the existing data and to preliminarily identify potential sources of the above background concentrations of uranium in the three offsite wells. Data generated by this task was used in the Task C investigation completed in August of this year.

Sincerely yours,

DAMES & MOORE

Robert P. Blauvelt

Robert P. Blauvelt
Principal Investigator

RPR/dc

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EXECUTIVE SUMMARY

This Task A Report summarizes and evaluates currently available information and data on the quality and flow of groundwater at and near the FMPC. It also identifies (preliminarily) five potential sources for the above background concentrations of uranium in the groundwater of the three offsite wells.

Data summarized and evaluated includes:

- o FMPC Production and Test Well Data - Water quality data collected between 1979-83 from 13 on-site production and test wells were analyzed for concentrations and trends. Three test wells (T4, T5 and T10) near the Waste Pit Storage Area reported elevated levels of uranium and nitrates. This may indicate some potential degree of hydrologic connection between the Pit area and the water table tapped by these wells.

- o FMPC Discharge Data to the Storm Sewer Outfall and Paddy's Run -These discharges were reviewed to evaluate their likelihood as potential uranium sources for the above background levels reported in the offsite groundwater. The total amount of uranium discharged in waste and runoff waters between 1981-83 from the FMPC to these surface drainages, was approximately 90 kg. These areas have been preliminarily identified as potential sources for the elevated offsite uranium levels in the groundwater.

- o FMPC Offsite Water Quality Data - Data from 19 offsite wells were analyzed to assess potential impacts to local users and to gain information on the area wide groundwater system. No concentrations in offsite wells exceeded allowable DOE limits.

- Stream Sediment Sampling Data - Sediment sampling data from the Great Miami River, Paddy's Run and the Storm Sewer Outfall Ditch were evaluated as potential sources for the offsite uranium concentrations. Based on the data, Paddy's Run and the Storm Sewer Outfall ditch may contain up to 9 kg of uranium bearing sediments in the first inch of topsoil and are considered to be potential sources for the reported offsite levels.

- Other data reviewed included published groundwater reports, local regulatory agency files, interviews with selected FMPC personnel, and the results of the soil and air monitoring programs. This data was used to characterize site hydrologic conditions and to preliminarily identify potential sources.

As part of this report, an initial hydrologic characterization was made based on available literature sources. Three groundwater systems are present at the FMPC: a surficial till layer (50 feet thick) containing numerous water bearing pockets and layers of sand and gravel; a shallow sand and gravel aquifer which occurs 60 to 90 feet below the land surface; and a deep sand and gravel aquifer 140 feet below the land surface which is the major regional aquifer. The groundwater system most likely to be affected by FMPC operations is the surficial till layer. This is the system that future monitoring efforts will be focused on.

Five sources for the elevated levels of uranium in the groundwater have been preliminarily identified. They are:

- Water discharged to and stream sediments in Paddy's Run and the Storm Sewer Ditch - The sediments contain uranium concentrations of up to 240 times background, are hydrogeologically upgradient of several affected offsite wells, and can act as either recharge or discharge areas for uraniferous groundwaters. Discharged waters can contain over 40 kg of uranium per year and these discharges serve to recharge the local groundwater table.

- Fly ash piles (covered and active) - These piles rest on uncontrolled earth, may contain up to 1000 kg of uranium-bearing flyash, and are upgradient of affected offsite wells.

- Waste Pit Storage Area - This area contains the largest volume of uranium bearing material and may be hydrogeologically connected to onsite test wells reporting elevated levels of uranium in their groundwater.

- The Plant Production Area-This area contains up to 350 ug/g of uranium in its soils. It is upgradient of affected on-site wells and has available to it pathways to the groundwater.

- The Scrap Metal Pile - This pile rests in places on uncontrolled earth, may contain up to 70 kg of uranium, and is upgradient of some of the affected on-site wells.

1.0 INTRODUCTION

The Feed Material Production Center (FMPC) was designed and built for the production of metallic uranium fuel cores for the Department of Energy's production reactors. Uranium ingots are also produced, and thorium compounds have been produced but on a smaller scale. The feed material for these processes include uranium ore concentrates and various recycled compounds and metals. These materials can be processed through the following steps: refining, hydrofluorination, reduction to metal, casting and machining. The wastes generated from these processes are stored onsite in the waste storage area (Reference A1-2).

The facility is located on a 1050-acre site in a rural area about 20 miles northwest of downtown Cincinnati, Ohio (Figure 1). The Great Miami River is about 0.75 mile east of the site and Paddy's Run flows along the western edge of the site. The production facilities are oriented in a north-south direction and occupy approximately 136 acres in roughly the center of the site. The topography of the site is relatively level, being on an elevated plain at about 580 feet above sea level over most of the production area. The on-site land slopes upward north of the production area, rising to an elevation of 700 feet at the northern edge of the site. Elevations decrease on the western edge of the site towards Paddy's Run to 550 feet.

Underlying the FMPC is about 50 feet of clay-rich till and below this is about 150 feet of sand and gravel, the lower portion of which supplies the FMPC and other local properties with their water supply. A network of test wells, located principally in the waste storage area, along with three production wells, have been sampled and analyzed for various parameters. Regular, routine sampling and analyses of groundwaters from the production wells began after their installation in 1952. Test well sampling and analyses was initiated immediately after installation and development of the wells. Since December of 1981, the sampling program has been expanded to include

offsite private wells. Three of these wells have exhibited above background concentrations of natural uranium (Unat)*. While these concentrations are below the maximum permissable concentration (MPC) allowed for water released to an uncontrolled area (1800 ug/liter, DOE Order 5480.1A), concern as to the potential source of this uranium resulted in a 1982 water quality study initiated by NLO/DOE and performed on a contract basis by the United States Geological Survey. While the release of this study is still pending, initial findings have defined the limits of the offsite area of concern and produced a potentiometric surface map.

The work to be performed as part of this contract (including tasks A, B and C) has as its objectives to:

- Identify the source(s) of the above background concentrations of uranium in the off-site wells, and

- Recommend remedial measures if it is determined that the source(s) originate from the FMPC.

This report, the first in a series of 3 planned reports, reviews the onsite file data, reviews data collected by federal and state agencies, and prepares an evaluation of this data to preliminarily identify the sources of the above background levels of uranium in the offsite groundwater.

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*Natural uranium (Unat) is composed of equal amounts of activity for U-238 and U-234 with a contribution by the U-235. On a weight basis, it is 99.283% U-238, 0.7116% U-235 and 0.0054% U-234.

2.0 SUMMARY AND EVALUATION OF AVAILABLE DATA

This section of the Task A Report summarizes and evaluates the available information on the quality, flow and nature of the groundwaters underlying the FMPC. No statistical analysis of data was conducted as part of this task. Multivariate analyses incorporating variations in well location, depth, concentrations of contaminants, and time will be performed as part of the Task C (final report) efforts. In preparing this section, the following sources of information were utilized:

- o NLO in-house files, permits, memos and consulting reports.
- o Data available from state and federal agency files.
- o Published geologic/hydrogeologic literature.

To facilitate its summation and evaluation, data collected from each of these sources were combined into the sub-categories discussed in this section. A list of utilized data sources is provided in Appendix 1.

2.1 FMPC Production and Test Well Water Quality Data

Onsite production and test well water quality data have been collected and analyzed on a regular basis by the Health and Safety Division since the early 1950's. This report summarizes data collected between 1979 and 1983. Data collected and analyzed during this time period is representative of the quality, flow, and nature of site groundwater conditions for the following reasons:

- o It encompasses over 20 seasonally induced changes in water level and quality.

- o Waste handling and site disposal practices were not drastically changed during this time.

- o The groundwater monitoring system was expanded to include regular sampling of additional wells in new areas of the site.

Summary

Three onsite production and ten onsite test wells are currently being sampled and analyzed for natural uranium on a routine basis at the FMPC. The locations of these wells are shown on Figure 2. Water quality data collected between 1979 and 1983 has been plotted in a series of graphs for each well and is shown in Figure 3.

Wells have been grouped together based upon the water bearing zone they tap and their location relative to each other. All groundwater elevation data has been taken from Water Treatment Plant field notes. Groupings were done to facilitate data reduction, assist in the recognition of water quality trends for a given area of the site, and to help eliminate possible false or inaccurate anomalies. A summary of the well groups and the water zone each well monitors is presented in Table 1.

Evaluation

From a review of the data presented in Figures 3A to 3F and associated well boring data, the following evaluation can be made regarding the groundwater quality at the FMPC wells:

- Wells with the highest levels of above background uranium concentrations* (up to 0.097 mg/l) were test wells T-1S, T-5, T-9 and T-10. The deeper production wells (except for one or two isolated analyses) do not show any consistent above background concentrations. In all cases, the values reported were well below DOE standards for effluents in water discharged to an uncontrolled area (1800 ug/l of natural uranium).

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*Typical uranium concentrations for natural groundwaters range from 0.0001 to 0.01 ppm (Reference A1-8).

- Test wells T-1S, T-4, T-5 and T-10 contain the highest reported levels of nitrates. As these wells are adjacent or close to the waste pit area, this would indicate that these wells may be hydrologically connected to it and that leachate containing uranium and nitrates may be migrating from the waste pit area.

- Reported levels of sulfates show no strong agreement with elevated levels of uranium or nitrates except in well T-10. This is a preliminary indication that there may be a degree of hydrologic connection between the waste pit area and test well T-10. Materials containing concentrations of nitrates and sulfates have been disposed of in the waste pit area (Reference A1-4).

- Plotted water level data tends to support the original grouping of the wells. Plotted water levels show close agreement indicating that wells are monitoring equivalent groundwater zones. Plotted water levels for test well T-9S indicate a difference of 200 feet in approximately 3 months time (Figure 3D) in early 1984. There are no other changes of this magnitude reported for any of the other wells and these levels may be the result of spurious measurements.

2.2 FMPC Discharge Data to Storm Sewer Outfall

The FMPC discharge data to the Storm Sewer Outfall was evaluated to establish the likelihood of it being a potential source for the above background concentrations of uranium which have been detected in the offsite groundwater.

Summary

Storm Sewer Outfall data were compiled from NLO Health & Safety Division Waste Water Quality Reports for the years 1981-1983. Discharge from the Storm Sewer Outfall originates in the plant's Production Area. Rainfall collected from roofs, non-controlled pads, and open ground area drains southward and is collected at the Storm Sewer Lift Station (Figure 2). This lift station intercepts storm sewer flows and pumps collected water through the process effluent line to a combined outfall at the Great Miami River. The initial portion of all rainfall (and the most potentially contaminated from process operations) is handled in this manner (Reference A1-2). Once the capacity of the left station is exceeded, excess water is diverted to the Storm Sewer Outfall.

The flow data shown in Table 2 are for periods of excessive runoff resulting from rainstorms. When such events occur, the pumping capacity of the Storm Sewer Lift Station is exceeded and runoff waters are diverted directly to the Storm Sewer Outfall Pipe. This outfall empties into a natural gully which subsequently drains to Paddy's Run.

Evaluation

As can be seen from the data presented in Table 2, the uranium discharged via the Storm Sewer Outfall Pipe is likely to be a source of the above background concentrations of uranium in the offsite groundwater. Over the past three years approximately 90 kg of uranium have been discharged to this surface drainage. This quantity of uranium would account for the concentrations contained in the Storm Sewer Ditch sediments (see Section 2.6), and are great enough to significantly influence offsite groundwater quality.

In prior years, particularly in the 1950's and early 1960's, significantly greater quantities of uranium were released to the storm sewer (Reference A1-30). Earlier discharges would also be contributing to the uranium concentrations found in ditch sediments (Section 2.6). Given the results of the last three years, the Storm Sewer Outfall appears to be a continuing uranium contributor to ditch sediments and a potential source for the offsite groundwater uranium concentrations.

2.3 Discharge to Paddy's Run

Water quality data from Paddy's Run was also evaluated to assess its potential as a source for the above background uranium concentrations in the offsite groundwater.

Summary

There are no direct discharges from the FMPC to Paddy's Run. The waters of Paddy's Run, however, are regularly sampled by FMPC Health and Safety Division personnel at 3 locations: Route 126; Willey Road; and New Haven Road. These water sampling stations are shown on Figure 4. The analytical results of the water sampling for uranium between 1979 and 1983 are summarized in Table 3. Untreated surface runoff waters are discharged indirectly to Paddy's Run via the Storm Sewer Outfall ditch. This discharge and its influence on Paddy's Run

water quality are discussed in Section 2.2. Stream sediment data collected in Paddy's Run is discussed in Section 2.6.

During periods of high groundwater, Paddy's Run probably does receive local seepage from the waste pit area on the west side of the FMPC.

Evaluation

Table 3 summarizes the results of uranium analytical data from water samples taken from three locations in Paddy's Run. The following evaluation can be made from the data presented in this table:

- Natural upstream concentrations (and quantities) of uranium in Paddy's Run surface waters flowing into the FMPC have remained constant (or slightly decreased) between 1979 and 1983. These concentrations are consistent with natural background levels reported in the literature (Reference A1-8) and indicate that no offsite uranium sources (either naturally occurring or man-made) are present in the upstream drainage area of Paddy's Run.

- Annual average concentrations of uranium reported from the Willey Road Bridge station range from 0.016 ppm to 0.112 ppm with a geometric mean (between 1979 and 1983) of 0.040 ppm. This is a 10 fold increase over natural (background) concentrations. Since this station is downstream of the confluence with the Storm Sewer Outfall ditch, a portion of these concentrations and quantities is attributable to discharges from the Storm Sewer Outfall. Flow rates and concentration data, however, are not available upstream of this point to measure exact amounts. Sediment samples taken upstream of the confluence with the Storm Sewer Outfall contain a geometric mean of 61 ppm uranium (Section 2.6, and Table 6B).

- Average annual concentrations reported at the New Haven Road station indicate that uranium concentrations in Paddy's Run water have been increased approximately 3 to 4 times over natural background, downstream of the FMPC. These concentrations are still below DOE standards.

- Based on the concentrations (and quantities) for uranium at the Willey Road and New Haven Road stations, the surface waters of Paddy's Run (downstream of its confluence with the storm sewer outfall ditch) may be acting as a potential source for the above background concentrations of uranium in the offsite groundwater.

2.4 Offsite Water Quality Data

Offsite water quality data was reviewed as an aid in understanding the movements of groundwater off of and adjacent to the FMPC facility and to evaluate potential impacts to downgradient users of groundwater containing above background concentrations of uranium.

Summary

Offsite water quality data in the vicinity of the FMPC is summarized in Figures 4A and 4B. The location of nineteen offsite industrial and domestic wells currently being monitored by the Health & Safety Division of the FMPC is shown on Figure 4. Table 4 provides a listing of the available information for each well. Groupings of wells are based on their proximity to each other, their estimated or known depth and general location relative to the FMPC production and waste disposal areas.

Regular monthly sampling of wells in Groups 3 through 7 began in 1982 with Groups 1 and 2 being added in August, 1983. Prior to FMPC sampling, and starting in 1973, the Ohio Department of Health periodically sampled seven of these same offsite wells for radiological

and other water quality indicators. The results of this sampling are presented in tabular form in Appendix 2. In general, the Ohio DOH results are consistent with the FMPC analysis.

Evaluation

Offsite water quality data was evaluated to determine if there are concentrations above the allowed limit and to use available well log information as an aid in understanding the movements of groundwaters off of and adjacent to the FMPC.

Figures 4A through 4B present the results of the monitoring program for uranium (u natural) concentrations in offsite wells. The concentrations in Well OS-1 and OS-2, which lie in a line south of Willey Road, were consistently greater (by an order of magnitude and more) than the concentrations found in the other wells. The greatest above background uranium concentration occurred in Well OS-1 and ranged from 410 to 550 ug/liter in 1982, and 363 to 578 ug/liter in 1983.

Based on this analysis of uranium values regularly collected from these wells since 1982, no concentrations exceeded allowable limits. In all cases, the concentrations were below the maximum permissible concentration for Unat in water released to an uncontrolled area. That limit is 6x10 -7 uCi/ml or 1800 ug/l as quoted from DOE Order 5480.1A (Reference A1-29).

Subsurface information from the offsite wells was of limited value. Eleven of the wells had driller's logs available and the very general nature of these logs (e.g., 0-30 feet-sand with clay and gravel) precluded any immediate correlation with onsite wells. In addition, offsite wells were too far away (closest offsite well being 2000 feet from the nearest onsite well) to allow for meaningful correlation in this type of rapidly changing geologic terrain. It should be noted that where information was available, average water levels in the southern offsite wells agree very closely (within three feet) with water levels in the shallow onsite test wells (Table 5).

This indicates that the test wells are probably adequately monitoring the drinking waters of the surrounding homes.

2.5 Other Groundwater Reports

In addition to the NLO file data, other reports describing groundwater conditions at or near the FMPC facility were reviewed. This review was conducted to acquire general background and regional groundwater knowledge about the site and to ensure that other sources of groundwater data were examined in the preparation of the Task A Report.

Summary

Two general types of reports were reviewed as part of this task and are described below.

- Articles describing the geology and groundwater regimes of the Miami River Valley; and

- Site-specific assessments of groundwater conditions at the FMPC. These reports ranged from a pre-construction investigation which estimated water availability and potential contamination impacts through a later onsite evaluation of waste handling practices with recommended short-term remedial actions. Several reports also identified specific areas of the facility as the potential source(s) for the above background concentrations of uranium in the groundwater.

A listing of the groundwater reports reviewed is provided separately in Appendix 3. A general listing of all materials reviewed in the preparation of the Task A Report is provided in Appendix 1.

Evaluation

The reports reviewed were very valuable as sources of general information on geologic/hydrogeologic conditions on a regional and site-specific scale. They provided the background information and framework for the preliminary categorization of aquifer characteristics. They also acted as the starting point in the identification of the sources of above background uranium levels in the groundwater.

2.6 Stream Sediment Sampling Data

Stream sediment sampling data at the FMPC has been evaluated to:

- o Estimate quantities of uranium contained in stream sediments near various FMPC outfalls; and
- o Establish whether stream sediments containing above background levels of uranium are acting as sources for the above background concentrations of uranium detected in the offsite groundwater.

Summary

Stream sediment sampling data at the FMPC facility consists of a semi-annual sampling at various locations of the site's major drainage avenues. These drainage avenues include:

- o Miami River into which all of the facilities treated wastewater is discharged;
- o Paddy's Run which locally drains the site and eventually receives untreated runoff waters from the storm sewer outfall; and

- Storm Sewer Outfall Ditch, a narrow, shallow ravine into which untreated surface water runoff is diverted during and after periods of heavy rainfall.

Figures 5 and 6 give the location of these sampling points. Analytical results are presented in Tables 6A, 6B and 6C. Histograms of this same data are available for review in Appendix 4.

(I) Great Miami River

The Great Miami River is sampled in seven locations - two upstream of the facility (River Mile 27.8 and 25.6); one directly opposite the facility's permitted discharge point (River Mile 24.1); three between the wastewater discharge point and Paddy's Run; and one immediately downstream of the confluence with Paddy's Run. Of the 63 sediment samples taken between June 1979 and October 1983, four have shown slight increases above background* in the concentration of uranium. All four samples were collected immediately downstream of the FMPC outfall (River Mile 24.1) and range from 4.7 to 6.6 ug/g of uranium.

Total quantities of uranium discharged into the Great Miami River since 1981 are provided in Table 7. These data do not show any strong agreement with plotted uranium concentrations in either the onsite or offsite wells for the same time period.

II Paddy's Run

Paddy's Run originates near the plant and flows south on the west side of the waste storage area. Flow in this stream ranges from 0.2 to 4.0 cubic feet per second (cfs) (Reference A1-4). It is generally intermittent and is sustained only from January to May.

*Background concentrations of uranium in the soils of southwestern Ohio range in value from 1-4 ug/g (Reference A1-15).

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(Reference A1-4). During the balance of the year it may be considered a dry stream bed with occasional flash flows of a few hours duration following heavy rains.

Paddy's Run sediments are routinely sampled at four locations as shown in Figure 5: downstream of the FMPC at Willey Road Bridge (PR-1); upstream of the Storm Sewer Outfall Ditch (PR-2), opposite test well T-9 (PR-4); and upstream of all onsite activity (PR-3). Of the 35 stream sediment samples collected at these locations since 1979, 22 have exceeded background levels. These include:

- All samples (10) collected upstream of the Storm Sewer Outfall Ditch. Concentrations of uranium in these samples range from 7.5 ug/g to 523 ug/g with a geometric mean of 61 ug/g.

- Eight of the samples collected at the Willey Road Bridge station. Above background concentrations of uranium in these samples range from 1.7 to 321 ug/g with a geometric mean of 22 ug/g; and

- Four samples collected opposite test well T-9. Above background values ranging from 10-90 ug/g have been reported at this location.

III Storm Sewer Outfall Ditch

The Storm Sewer Outfall Ditch is a narrow and shallow ravine which receives overflow surface water runoff from the FMPC production and waste pit area. Sediments in the Storm Sewer Outfall Ditch are sampled at three locations as shown in Figure 5; immediately downstream of the outfall weir (SS1); at the construction road culvert (SS2); and just prior to its confluence with Paddy's Run (SS3). Of the 33 samples collected at these locations, all but one exceed background levels of uranium. Above background concentrations range from 11.6 ug/g to 380 ug/g with a geometric mean within the outfall ditch of 50 ug/g uranium.

The total amount of uranium discharged to this ditch since 1981 is approximately 90 kg (200 lbs).

Evaluation

(I) Great Miami River

The uranium discharged from the FMPC wastewater treatment plant into the Great Miami River is not acting as a source of the above concentrations of uranium in the offsite groundwaters. The Great Miami River is hydrologically downgradient of both the FMPC and the affected offsite wells and acts as the receiving water for any local groundwater table discharges. Uranium found in the river sediments is effectively isolated from the hydrogeologic regime at the FMPC.

Stream sediment sampling data indicates that there is a slight increase (average of 2-4 ug/g) in uranium levels above background immediately downstream of the discharge pipe, but concentrations return to background levels within 0.8 miles of the discharge.

(II) Paddy's Run

Unlike the Great Miami River and the storm sewer drainage ditch, there are no direct discharges of uranium bearing waters into Paddy's Run. Stream sediment samples, however, downstream of both the waste pit area and Storm Sewer Outfall Ditch, reflect above background levels of uranium. Using the average uranium stream sediment concentrations on Paddy's Run between stations PR4 and PR1, as much as 7 kg (15 lbs) of uranium bearing sediments can be contained in this stream channel (see Appendix 5 for calculations). Since Paddy's Run is intermittant during periods of prolonged dryness and does collect surface runoff from the surrounding area, it serves as a local recharge zone to the shallow groundwater table. Estimated groundwater travel time from the Paddy's Run/Storm Water Outfall confluence to the nearest affected offsite wells, is approximately 200 days (Section 4.2.1). This stream bed, therefore, may be acting as both a source and transport mechanism for some of the above background concentrations seen in the offsite groundwater.

(III) Storm Sewer Outfall Ditch

The Storm Sewer Outfall Ditch contains sediments with reported uranium levels of up to approximately 200 times background (Table 6C). Using the average uranium stream sediment concentrations in the ditch for the reach between the outfall weir and Paddy's Run, as much as 2 kg (4 lbs) of uranium bearing sediments can be contained in the first inch of bottom sediments of this ditch (see Appendix 5 for calculations). As stated previously, this ditch is dry except for periods of precipitation-induced surface runoff. It may, therefore, be concentrating uranium discharged to it and acting as a local recharge area to the shallow groundwater table. Thus, the storm sewer ditch may be a source of the above background concentrations of uranium in the offsite groundwater.

2.7 Other Data

Four other sources of data were reviewed to provide additional information as to the potential sources of above background uranium concentrations in the groundwater. These sources included:

- Interivews with NLO Engineering and Health & Safety personnel;
- Interviews with governmental/regulatory agencies familiar with conditions at the site;
- Review of Air Emmission Stack Monitoring Data; and
- Review of onsite soil sampling and gumpaper data.

2.7.1 FMPC Interviews

Selected employees of the Health & Safety Division, Engineering Division and Water Treatment Department of the FMPC were interviewed

during the weeks of April 28 and May 14, 1984, to provide background information on facility operations and past waste disposal practices. In addition, information for the preparation of the Task B Work Plan (e.g., underground utilities, building dewatering, etc.) was also gathered.

A summary of key points acquired from these interviews is provided below:

- No process wastes were buried in any areas other than the waste pit area.
- Several uranium bearing scrap and flyash piles were described and located.
- There have been no large sudden releases of liquids from the waste pits.
- There have been no large scale, unreclaimed spills or leaks of uranium from the process or production areas of the plant.

2.7.2 Regulatory/Governmental Agency Interviews

Regulatory/Governmental agencies familiar with conditions at the FMPC site were interviewed and their public files reviewed. This was done to ensure the concerns of the appropriate outside agencies were addressed during the course of this study. The agencies interviewed were:

- The United States Geological Survey
- The Ohio Environmental Protection Agency
- The Ohio Department of Health
- The Ohio Department of Natural Resources (Water Division)

Separate debriefing memos have been provided to the Health & Safety Division in each of these interviews. Key points are summarized below:

- o NLO has been very cooperative in providing all requested information to these agencies regarding groundwater conditions at the site and in keeping local area residents informed.

- o Overland flow (surface water runoff and stream flow) are considered to be candidates for the possible distribution of uranium on the site.

- o The shallow subsurface geology and groundwater regime is poorly understood from present data, and the installation of additional monitoring wells, both north and south of the site, is recommended.

- o The Agencies contacted would like to provide input to the Task B Field Work Plan.

- o Notice should be provided so that, if possible, sampling and drilling activities can be observed by agency representatives.

2.7.3 Air Emission Data

A summary of FMPC stack losses of both enriched and depleted uranium between 1981 and 1983 is provided in Table 8.

Annual FMPC air monitoring data (Table 9) indicates that air quality in the primary downwind direction from the facility (Figure 5) is two orders of magnitude below DOE standards. Since large amounts of uranium have not been detected leaving the site, it is reasonable to assume that the airborn releases reported in Table 8, may be contributing to the elevated levels of uranium seen in the plant Production Area soils and eventually the offsite groundwater (Section 2.7.4).

2.7.4 Soil Sampling

Soil samples of the Plant Production Area were taken on an annual basis by the Health and Safety Division between 1964 and 1969. Current soil sampling efforts include boundary station locations and surrounding areas in the nearby communities. Uranium analyses of Plant Production area soil samples have been plotted and contoured. These results are shown in a series of maps on Figure 7. Higher uranium soil concentrations are generally present in the south central portion of the Production Area. Values in this area range from a high of 500 ug/g uranium in 1966 to 200 ug/g uranium in 1969. Sources for these soil concentrations include accidental spillage or dust released during product handling and transfer, and stack air emissions. Table 10 summarizes total quantities of uranium which may reside in Production Area topsoils.

2.7.5 Gumpaper Data

In addition to soil sampling data, gumpaper data from 1959 to 1964 were also evaluated. Table 11 summarizes results of gumpaper analysis for uranium. From the data presented in this table, it can be noted that fallout sampling in this manner does not appear to be quantitative. There is no direct correlation between stack loses and uranium gumpaper values. This is probably due to the large number of variables (e.g., wind speed and direction, nearby processing operations, etc.) which may influence results.

However, the values reported in Table 11 tend to support both soil sampling results (Table 10) and the results of boundary air monitoring stations as discussed in Section 2.7.3. They indicate that quantities of uranium have been released by production area processes and appear to have settled out in adjacent soils.

3.0 PRELIMINARY HYDROGEOLOGIC CHARACTERIZATION

This section of the Task A Report summarizes and evaluates data collected on the ground water system underlying the FMPC. Preliminary evaluations are made as to aquifer characteristics, depth to groundwater, yields, and probable groundwater flow directions. Upon review of the available hydrogeologic data, it is our preliminary evaluation that there are three (3) groundwater units present at the FMPC site. These units are (from deepest to shallowest):

- A deep sand and gravel aquifer which occurs approximately 140 feet below the land surface.
- The shallow sand and gravel aquifer which occurs approximately 60 to 90 feet below the land surface.
- The surficial till layer (approximately 50 to 60 feet thick) which contains water bearing pockets and lenses of sand and gravel.

Table 12 summarizes the available data on specific aquifer parameters for each of these units. For a complete discussion on regional geologic setting and development see the references cited in Appendix 3.

3.1 Deep and Shallow Sand and Gravel Aquifers

These units are described as one in this section because of their close similarity in composition. At the site they are separated into two units by a layer of blue clay approximately 10-15 feet thick. This blue clay also acts as a semi-confining layer to the deeper sand and gravel aquifer.

These units were deposited by glacial meltwaters from receding continental ice sheets in an abandoned two-mile wide channel of the ancestral Ohio River known as the New Haven Trough. These aquifers are the major water bearing units within the Great Miami River Basin

and all of the FMPC monitoring and production wells are completed in either the shallow or deep aquifers. The shallow sand and gravel aquifer also supplies water to local domestic users in the FMPC site area. Because these aquifers are major sources of potable water, much information is available on their water bearing characteristics. NLO onsite and offsite monitoring of these aquifers is providing representative information on their water quality.

3.2 Surficial Till Layer

A high terrace composed mostly of till and clay overlies the upper and lower sand and gravel aquifers in the western portions of the valley (New Haven Trough). This surficial till is approximately 30 feet thick and is composed of pockets and lenses of alluvial sands, gravels, and silts in a predominantly clay matrix.

These sediments were deposited in a very irregular manner and contain many localized (perched) groundwater systems. These systems result from the collection of infiltrating precipitation in the porous and permeable sand and gravel units. There is no consistent static water level in this layer and depths to groundwater range from 3 to 20 feet depending upon the unit tapped. Utilizing existing boring and well log data (Figure 8), a series of cross sections were constructed through the Production and Waste Pit Areas within this unit (Figures 9A-9D). These cross sections illustrate the highly variable nature of this layer and its ability to contain numerous, interconnected groundwater units. As reflected in Table 12, very little is known about its water bearing characteristics and no groundwater quality monitoring of this layer is currently in progress.

An initial interpretation of the groundwater units at the FMPC has indicated that the surficial till layer may play a critical role in controlling the migration of groundwater containing above background levels of uranium to the offsite wells. This interpretation is based on the following reasons:

- This layer is the host unit for uranium bearing materials disposed of in the waste pit area. All waste pits are completed within this layer.

- This layer has the potential to allow for the migration of uranium bearing groundwater from the waste pits and other suspected source areas. Two cross sections (A-A' and D-D') compiled from available boring logs show that several gravel and sand lenses are hydrologically connected to the shallow sand and gravel aquifer. It has been in this shallow sand and gravel aquifer that many of the offsite above background concentrations of uranium have been detected.

- This unit can also provide local discharges to Paddy's Run Creek where above background levels of uranium have been detected in bottom sediments.

Because of its prominent role in the possible distribution of uranium bearing offsite groundwater, this layer will be more intensively studied during our Task B effort.

3.3 Pumping Requirements

Well pumping requirements will vary depending upon the reason for pumping. During the field investigation phase of this program (Task B - Implementation), pumping of the new (and existing) test monitoring wells will be performed for three reasons:

- o Well development;
- o Hydrologic testing; and
- o Water quality sampling.

3.3.1 Well Development

Well development is designed to remove the fine sand, silt, and clay materials from the formation surrounding the well screen. This will allow formation waters to flow freely to the well (Reference A1-9). The fundamental objective in any development operation is to induce alternate reversals of flow through the screen openings that will rearrange the formation particles. This process (Reference A1-9):

- o Corrects damage to or clogging of the water bearing zone which occurs as a side affect from the drilling.
- o Increases the porosity and permeability of the sand pack material in the vicinity of the well.
- o Stabilizes the sand pack material around a screened well so that the well will yield water free of sand.

Subsequent to the installation of the monitoring wells to be installed as part of Task B, all wells will be properly developed using overpumping development techniques. Overpumping is pumping the well at a higher rate than the well will be pumped when it is put in service (i.e. sampled). This method has the advantage of being least disruptive to both the natural permeability of the formation and the enclosing sand pack. This method is typically used on small diameter wells and can be done by the driller using standard rig equipment. It is not possible to estimate, at this time, the length of time wells will have to be pumped. We anticipate a minimum pumping time of 2-3 hours per well and all wells will be developed until they yield sand free (clear) water.

3.3.2 Hydrologic Testing

The hydrologic testing of selected new and existing wells will require the pumping of various quantities of water. Short term pumping tests (5-8 hours) will be utilized to estimate a variety of in situ aquifer characteristics. Pumping will be conducted using Dames & Moore's water resources equipment and, where possible, pumps installed in existing NLO wells. Assuming that a total of 32 hours of testing is conducted at a pumping rate of approximately 8-10 gpm, then up to 19,000 gallons of water will be pumped from new and existing FMPC monitoring wells.

3.3.3 Water Quality Sampling

In order to obtain a representative sample of the groundwater, the water within the well casing and in close proximity to the well screen must be removed (Reference A1-27). The recommended amount of water to be removed from the well is dependent upon many factors including well characteristics, types of sampling equipment and the parameters being sampled at the NLO facility. It is anticipated that between 4 and 10 casing volumes of water will be removed prior to sampling the well. Assuming an average water column of 50 feet for all 15 existing and 10 new test wells, a total of up to 640 gallons of water will be removed from these wells and pumped to waste. Pumping and related sampling will be done utilizing Dames & Moore's water resources equipment or, where appropriate, existing NLO well pumps.

3.4 Well Locations and Construction Specifications

As part of this Task A Report, preliminary new well locations and construction specifications are provided in Tables 13 and 14. These locations and specifications will be finalized in our Task B Field Program Work Plan.

3.4.1 Well Locations

After an initial evaluation of the current monitoring network, and in keeping with NLO objectives to keep the number of needed additional wells to a minimum, we are recommending the installation of five additional well clusters. A well cluster is two wells, one shallow, one deep, drilled within a few feet of each other. The location of these well clusters is shown in Figure 10. The rationale for their locations is provided in the Table 13.

Well locations were chosen to provide subsurface and water quality information downgradient of the areas identified as potential sources for the above background concentration of uranium in the offsite ground water.

Based on the recommended locations described in Table 13, Task B drilling efforts will be directed at finding the source of above background offsite concentration of uranium in the groundwater. Six (6) of the 18 wells are specifically dedicated to this objective. The remaining wells will be installed at locations designed to trace offsite above background uranium groundwater concentrations to their potential sources. Additional discussion on how this program will meet project objectives is provided in Section 4.0.

3.4.2 Monitoring Well Construction Specifications

A brief list of construction specifications for the monitoring wells to be installed at the FMPC facility is provided in Table 14. As with well locations, these specifications will be finalized in our Task B Field Program work plan. All appropriate NLO/DOE/Dames & Moore field safety precautions will be taken during the drilling of these wells.

3.5 Recharge/Discharge Areas

Figures 11 and 12 identify the recharge and discharge areas in the FMPC property, respectively. These areas have been delineated to aid in an analysis of the distribution of migration of offsite ground waters containing above background levels of uranium.

For the purpose of this Task A Report, a recharge area is an area on FMPC property in which water is able to enter (infiltrate) into the zone of saturation (water table) and be available for later use. Recharge at this facility will be almost entirely precipitation (rain, snow) induced. A discharge area is an area of FMPC property in which subsurface groundwater is released to the land surface (seeps) or to bodies of surface water (stream base flow).

Note that both Paddy's Run and the Storm Sewer Outfall Ditch have been designated as both recharge and discharge areas. This is because of their intermittent flow nature. During periods of high groundwater, they act as discharge areas, receiving flows from numerous perched water bearing zones and seeps. During periods of low groundwater, they can act to recharge the saturated zone by infiltration through their bottom sediments.

3.5.1 Recharge Area

Figure 11 illustrates the local recharge areas at the FMPC site. The total surface recharge area is approximately 896 acres which is 85% of the entire FMPC property. The Plant Production Area and waste pit area along with access roads and parking lots have not been designated as recharge areas. Uranium contained in runoff from these areas will be collected and discharged via the Storm Sewer Outfall Ditch. These areas have been designed to divert precipitation induced runoff from the natural land surface. It can be seen from this figure that large groundwater recharge areas are available immediately adjacent to all potential uranium sources. This provides the means for surface waters to mobilize uranium into the shallow underlying groundwater.

Because of the nature of the subsurface soils, precipitation induced recharge is serving to replenish only that groundwater in the shallow water table. The recharge area of the deep underlying sand and gravel aquifer is of much larger extent (Reference A1-28).

3.5.2 Discharge Areas

Figure 12 illustrates the local discharge areas at the FMPC site. The total surface discharge area is approximately 4 acres which is 4% of the entire FMPC property. Discharge areas are restricted to the banks of Paddy's Run and the Storm Sewer Outfall Ditch. As previously explained, these drainages serve to act as both recharge and discharge areas. There are also several local discharge areas along the western property boundary near Paddy's Run. These are moist or swampy areas too small to map which occur at the base of some waste pit area berms and small hills.

Discharge areas provide an opportunity to sample shallow ground waters without the installation of monitoring wells. As part of our Task B work plan, representative seeps in the discharge areas will be sampled and their water quality evaluated.

3.6 Boundary Conditions

In this section, a preliminary identification of the aquifer boundaries for the FMPC groundwater regime has been made. An identification of more local and well specific aquifer boundaries, and the extent that they influence pump test and aquifer characteristic analysis will be made during the Task B Field Program.

Figure 13 illustrates the preliminary hydrogeologic boundaries for the FMPC. Preliminary boundary identifications were made to better focus the areal extent of the Task A study as well as to isolate, both laterally and vertically, the groundwater flow regimes operating at the FMPC.

3.6.1 Lateral Boundaries

Lateral boundaries to the hydrogeologic flow regime at the FMPC areas are as follows.

Northern Boundary-The northern hydrogeologic boundary is the 600 foot elevation contour. This elevation generally parallels state Route 126. This elevation is higher than any existing on the site, therefore, the water quality and groundwater flow north of this elevation will not be influenced by FMPC operations. To the northeast, the 600 foot contour line intersects an intermittent stream channel which then becomes part of the northern boundary. This stream channel would serve to intercept and divert shallow groundwater flow to the Great Miami River.

Western Boundary-The western hydrogeologic boundary for the FMPC has been identified as Paddy's Run. This creek receives groundwater discharges from the shallow sand and gravel aquifer and the surficial till layer underlying the FMPC.

Eastern and Southern Boundaries-The eastern and southern hydrogeologic boundary has been chosen to be the great Miami River. This river is the direct recipient of groundwater discharge from the eastern and southeastern portions of the facility.

3.6.2 Vertical Boundary

The preliminary vertical aquifer boundary at the FMPC has been identified as the layer of blue clay 5-10 feet thick which separate the upper and lower sand and gravel aquifers. Although some doubt exists as to its uniformity across the site (Reference A3-4) it is locally present in most borings and has been encountered in all deep test and production wells. This clay layer acts as a local confining layer and may help prevent the downward migration of uranium bearing groundwater. This boundary should be considered as flexible so that, if the results of the Task B field program indicate that it is necessary, other deeper areas in the lower aquifer can be evaluated.

4.0 PRELIMINARY IDENTIFICATION OF POTENTIAL SOURCES FOR THE ABOVE BACKGROUND CONCENTRATIONS OF URANIUM IN THE GROUNDWATER

It is the objective of this study to identify the source or sources of the above background concentrations of uranium in the offsite groundwaters at the FMPC. The objective of this Task A Report is to make a preliminary identification of these source or sources based upon a review and evaluation of currently available data. Subsequent field activities (drilling, sampling, etc.) will be designed to corroborate and quantify this preliminary identification of source(s) in the following manner:

- Initial field activities to be conducted (drilling, seep sampling, water sampling) will be focused on confirming/-refuting the impact each potential source listed in Section 4.2 is having on offsite groundwater quality. Monitoring wells will be constructed both upgradient and downgradient of these potential sources. The geologic and water quality information gathered during their installation and subsequent testing will be utilized to identify offsite migration pathways and evaluate uranium contributions (if any) to the offsite groundwater regieme.

- Monitoring wells are planned for installation around potential major preliminarily identified onsite sources which may be influencing offsite water quality either by releasing uranium directly to the groundwater (e.g., waste pit area), or indirectly by surface water runoff and later recharge (e.g., scrap pile). This phase of the program is designed to characterize and monitor potential offsite pathways by indicating if these sources are contributing uraniferous releases to the groundwater.

4.1 Offsite Sources

As part of the review of available data, an assessment was made of potential offsite sources to evaluate whether they could be contributing to the above background level of uranium in the FMPC groundwater. The potential offsite sources include:

- Other facilities in the area licensed to handle radioactive waste
- Nearby industrial facilities with potentially uranium bearing wastes.
- Naturally occurring uranium deposits.

4.1.1 Licensed Facilities

A review of the list of active/inactive NRC licenses for April 1983 (Reference A1-23) shows no facilities handling radiological materials within a two mile radius of the FMPC. Further to the southwest in the Cincinnati area, several licenses are active but they relate mostly to hospitals and calibration sources for testing equipment.

4.1.2 Industrial Facilities

Two nearby chemical plants (Figure 5; Wells OS-3 and OS-18) were examined as potential offsite sources for uranium in FMPC groundwater. According to Ohio DOH records, one company uses phosphorus in its fertilizer production process and the other is a producer of sulfonated detergents. Wastes relating to both of these materials are disposed of in the ground and could be released to Paddy's Run. This would account for some of the beta activity reported downstream of the FMPC. Beta activity reported from off-site sources is the result of K-40, not uranium (Reference A1-15). Both of these chemical plants, however, are downgradient of the FMPC and could not be contributors to the above background levels of uranium in the groundwater.

4.1.3 Natural Sources

A review of the published geologic literature was made to determine whether the above background levels of uranium in the groundwater of the FMPC are due to natural sources. A listing of materials reviewed is provided in Appendix 6. A more general listing of reports pertinent to this type of study is provided in Appendix 1.

None of these publications show any natural occurrence of uranium, uranium minerals, or radioactive anomalies within a 2 mile radius of the FMPC.

4.2 Onsite Sources

It is the preliminary findings of this Task A Report that there are five potential sources for the above background levels of uranium in the three offsite wells in the vicinity of the FMPC. These sources are located exclusively within FMPC property boundaries (Figure 13) and are, in order of likelihood:

- Sediments and waters discharged to and contained in Paddy's Run and the Storm Sewer Outfall Ditch.
- Covered and Active Flyash Piles.
- Waste Pit Storage Area.
- Plant Production Area.
- Scrap Metal Pile.

The reasons for identifying each of the above areas as potential sources are provided below.

4.2.1 Sediments and Waters Contained in Paddy's Run and the Storm Sewer Outfall Ditch

Evidence pointing to these as the most likely potential source for elevated uranium levels detected in the offsite wells includes:

- The presence in both drainages (Paddy's Run and the Storm Sewer Outfall Ditch) of above background levels of uranium in the sediments (up to a maximum of 240X background - Tables 6A and 6B) and in the water (up to a maximum of approximately 30X background - Table 3). This uranium was derived from seepage of uraniferous groundwater into the drainage and direct discharges of uranium bearing stormwater from FMPC outfalls.

- The uranium bearing sediments in these drainages are hydrologically upgradient from some of the affected offsite wells.

- These areas have the ability to act as a local recharge zone for the uraniferous groundwater into the shallow groundwater regime.

Estimated travel time (calculated using an average water table gradient of 0.006 and hydraulic conductivity of 350 ft/day) for soluable uranium (that portion not taken up by the sediments) entering the groundwater from these sources indicate that first migration of uranium to the offsite wells could have taken place as early as 200 days after release. Travel times will be further analyzed and refined in the computer modeling effort utilizing data gathered during Task B field work.

4.2.2 Covered and Active Flyash Piles

Flyash is produced at the FMPC by the combustion of Kentucky coal. This coal (and resulting ash) contain only natural amounts of uranium. The flyash contains no uranium from process or process waste related operations. Wastes from boiler plant operations are kept completely segregated from process wastes. (Reference A1-30).

Flyash is collected and routinely deposited on FMPC property at the locations shown in Figure 10. Volumes of these piles have been estimated in Table 15. These piles have been preliminarily identified as the second most likely source for the uranium concentrations in the off-site groundwater for the following reasons:

- These piles are hydrologically upgradient of some of the affected off-site wells.

- Flyash piles are deposited directly on uncontrolled ground. There are no runoff or seepage controls. This allows potentially generated uranium bearing leachate access to the local ground and surface waters.

- Although these piles contain low concentration of uranium (estimate of 10 ug/g), they are volumetrically large. This provides a source of potentially leachable uranium to the ground and surface waters. Volume estimate are provided in Table 15.*

- In addition to natural concentrations, small amounts of uranium bearing material were mixed into the old (covered) fly-ash pile as part of a research study. No such mixing has been done in the active flyash storage area. (Reference A1-30)

* A review of available literature and Dames & Moore files was made to assess whether uranium bearing leachates are typically derived from flyash piles. No data was immediately available on this topic and additional research efforts are continuing.

4.2.3 Waste Pit Storage Area

This area was chosen as the third most likely candidate source for the following reasons:

- It contains the largest concentration of uranium bearing waste at the facility. Total quantities of waste buried there have been estimated at 464,000 cubic yards (Reference A1-2).

- It is upgradient of all affected onsite wells and may be hydrologically connected to shallow and deep water bearing zones. Information will be developed during Task B efforts to assess whether the pit area is directly connected (hydrologically) to affected offsite wells .

- Test wells adjacent to and downgradient from it contain groundwater with above background levels of uranium.

4.2.4 Plant Production Area

The reasons for choosing the Plant Product Area as the fourth most likely candidate source are:

- Results of soil sampling and gumpaper analysis which indicate that the Production Area may contain up to 1300 kg (2860 lbs.) of uranium bearing soils derived from process operations and stack emmissions.

- This area is upgradient of some of the affected offsite wells.

- Pathways are available (via overland flow, and downward migration) for the uranium in this area to enter the local groundwater regime.

4.2.5 Scrap Metal Pile

The mixed Scrap Metal Pile is composed of uranium bearing scrap metal from plant production areas. Most of the uranium is removed before placement on the scrap pile but trace amounts remain.

The Scrap Metal Pile (Figure 10) has been designated the fifth most likely candidate source of the above background uranium concentration in the offsite groundwater for the following reasons:

- It is upgradient of some of the affected offsite wells.
- Although it contains low concentrations of uranium, the amount of material is volumetrically large. This provides for a significant source (quantity) of potentially leachable uranium. (Refer to Table 15 for a volume estimate).
- Portions of this pile rest on uncontrolled earth. This allows potentially generated uranium bearing leachate access to the local ground and surface waters.

The next phase of work will be the preparation and implementation of the Task B Work Plan. This plan will be designed and implemented to corroborate these preliminary findings. It will provide the data necessary to quantify the contribution of each potential source to the above background levels of uranium in the groundwater at the FMPC.

TABLES

TABLE 1

SUMMARY OF ONSITE WELL GROUPINGS

Group No.	NLO Well #	Well Depth (Ft)	Water Level Elevation (Ft*)	Grouping Rationale
1	P-1 P-2 P-3	210 210 210	523.66 522.16 519.36	Wells are all production wells screened at same horizon and located within a few hundred feet of each other. All are monitoring deeper aquifer east of pit area.
2	T3 T4	51 40	528.86 525.85	Wells are approximately same depth, water level elevations indicate they are tapping similar horizons. They are located within 300 feet of each other and are monitoring west side of pit area.
3	T1S T5 T9	80 95 99	525.55 520.09 527.23	Wells are approximately same depth, water level elevations indicate they are tapping same horizon and all three are monitoring the south and southeasterly sides of the pit area.
4	T-1D T-8D	187 187	524.31 518.62	Wells are approximately same depth, water level elevations indicate they are tapping the same horizon and they are both monitoring groundwaters east of the pit area. These wells have not been included in group 1 because of their shallower depths.
5	T-8S T-10	116 137	524.60 511.00**	Both wells are monitoring groundwaters east of waste pits. These wells were not included in Groups 1 or 4 because of their intermediate depths.

TABLE 1 (Cont'd)

SUMMARY OF ONSITE WELL GROUPINGS

Group No.	NLO Well #	Well Depth (Ft)	Water Level Elevation (Ft*)	Grouping Rationale
6	T-11	125	516.00**	Not included in Group 2 because of its greater depth and different water level elevation.

P = Production (water supply) well
T = Test well
S = Shallow (upper sand and gravel aquifer) well
D = Deep (lower sand and gravel aquifer) well

*Measured April, 1984
**Elevation estimated

TABLE 2

Summary of FMPC Storm Sewer Outfall Discharge Data

Year*	Total Flow (Mg)	Total Uranium Discharged (kg)
1981	3.08	4
1982	12.43	39
1983	14.14	44
Totals	29.65	87

*No flow records evaluated prior to 1981.

TABLE 3

Summary of Paddy's Run Water Sampling Data (Uranium)

Year	Route 126[a]			Willey Road[b]			New Haven Road[c]		
	Avg Conc. (mg/l)	Estimated Total Flow (10^8 liters)*	Estimated Total U (kg)	Avg Conc (mg/l)	Estimated Total Flow (10^8 liters)	Estimated Total U (kg)	Avg Conc (mg/liters)	Estimated Total Flow (10^8 liters)	Estimated Total U (kg)
1979	0.004	2	0.8	0.016	2	3.2	0.012	2	2.4
1980	0.004	2	0.8	0.028	2	5.6	0.017	2	3.4
1981	0.004	2	0.8	0.031	2	6.2	0.012	2	2.4
1982	0.004	2	0.8	0.017	2	3.4	0.016	2	3.2
1983	0.002	2	0.4	0.112	2	22.4	0.013	2	2.6
Total	--	--	3.6	--	--	40.8	--	--	14

(a)Route 126 = Upstream station
(b)Willey Road = Downstream of the waste pit area and the confluence of Storm Sewer Outfall ditch
(c)New Haven Road = Beyond FMPC property boundaries.

*From Reference: A1-4

TABLE 4

Groupings of Offsite Wells

Well I.D.	Group	Location	Total Depth (ft)	Depth to Water** (ft)	Use
OS-4	1	South-Rt. 126	*	*	Domestic
OS-5	1	North-Rt. 126	*	*	Domestic
OS-6	1	North-Rt. 126	50	30	Domestic
OS-7	1	North-Private Road off Rt. 126	58	12	Domestic
OS-8	2	Northwest-Morgan Ross Road	*	*	Domestic
OS-9	2	Nortwest-Morgan Ross Road	*	*	Domestic
OS-10	2	Northwest-Morgan Ross Road	*	*	Domestic
OS-11	3	Southwest-Paddy's Run Road	90	53	Commercial
OS-12	3	Southwest-Willey Road	*	*	Domestic
OS-13	4	Southeast-River Road	110	55	Public Supply
OS-14	4	Southeast-Rt. 128	85	53	Domestic
OS-15	5	East-Southeast-Rt. 128	*	*	Commercial
OS-16	5	East-Southeast-Rt. 128	*	*	Industrial
OS-2	6	South-Paddy's Run Road	*	*	Commercial
OS-1	6	South-Paddy's Run Road	84	59	Domestic
OS-17	6	South-Willey Road	90	63	Domestic
OS-18	7	South-Paddy's Run Road	83	11.5	Commercial
OS-19	7	South-Paddy's Run Road	*	*	Domestic
OS-3	7	South-Paddy's Run Road	*	*	Domestic

*Information Not Available.
**Below Land Surface.

TABLE 5

Comparison of Water Levels Between Onsite and Offsite Wells

No.	Elevation*(Ft)	Depth to Water (Ft)	Water Level Elevation (Ft)	No.	Elevation (Ft)	Depth to Water (Ft)	Water Level Elevation (Ft)
OS-15	575	59	516	1s	585.6	59.2	526.4
OS-16	580	63	517	3	560.9	32.2	528.7
OS-17	570	55	515	4	556.9	31.3	525.5
OS-2	580	53	527	5	557.1	37.0	520.1
OS-13	575	53	522	8s	576.6	52.0	524.6
OS-3	530	11.5	518.5	9	557.2	30.2	526.0
				10	574*	63.2	510.8
				11	575*	59.0	516.0
Average Water Level Elevation			519.3				522.3

*Elevation Estimated.

TABLE 6A

Uranium Concentration in River Sediment (ug/g)
(I) Great Miami River*

Date	River Mile 27.8	River Mile 25.6	River Mile 24.1	River Mile 23.3	River Mile 20.8	River Mile 19.6	River Mile 19.4
6/79	2.1	3.6	6.1	2.5	2.1	1.6	3.1
11/79	2.0	2.1	2.3	2.2	1.5	2.0	2.1
7/81	2.0	0.6	2.1	1.1	2.0	3.8	1.8
10/81	1.1	1.2	1.1	1.2	1.9	2.5	1.4
8/82	3.2	2.5	6.0	2.2	2.2	2.3	3.9
10/82	2.2	2.5	4.7	3.2	2.9	1.8	2.1
8/83	2.7	2.3	2.3	1.9	2.1	2.2	3.2
10/83	--	2.7	6.6	1.9	2.5	5.7	3.0
Geometric Mean	2.1	2.0	3.3	1.9	2.1	2.5	2.5

*For locations see Figure 6.

TABLE 6B

Uranium Concentrations in Stream Sediment (ug/g)
(II) Paddy's Run

Date	Offsite-Willey Road Bridge (PR1)	Onsite-Upstream of Outfall Ditch (PR2)	Onsite-Upstream of RR Bridge (PR3)	Onsite-West of Test Well #9 (PR4)
6/79	14	523	1.2	--
11/79	1.7	15	1.3	--
6/80	7.2	27	2.1	--
10/80	30	7.5	2.9	--
7/81	3.6	8.1	1.5	--
10/81	28	32	2.7	10.5
8/82	32	362	3.6	11
10/82	117	240	2.6	10
6/83	50	42	2.6	1.8
10/83	321	494	2.7	90
Geometric Mean	22	61	2.2	11

TABLE 6C

Uranium Concentration in Stream Sediment (ug/g)
(III) Storm Sewer Outfall Ditch

Date	Downstream-Outfall Weir (SS1)	Construction Road Culvert (SS2)	Paddy's Run (SS3)
6/79	380	29	14
11/79	109	78	1.2
6/80	84	94	22
10/80	81	20	15
7/81	300	23	11.6
10/81	20	39	21
8/82	147	57	82
10/82	86	40	136
6/83	18	185	22
10/83	25	364	182
Geometric Mean	79	60	24

TABLE 7

Summary of FMPC Discharge Data To Great Miami River

Year	Total Discharge (10^6 gal)	Average Uranium Concentration (mg/l)	Total Uranium Discharged (kg)
1981	153.8	0.99	578
1982	190.0	1.05	757
1983	186.0	0.91	642
Total	529.8	--	1,977

TABLE 8

AIR EMISSIONS OF URANIUM (kg)
(Source: Reference A1-14)

Building	1981	1982	1983
1	1.3	2.1	6.4
2/3	---	2.3	---
4	194.1	19.1	42.9
5	135.6	190.3	41.4
6	---	0.5	---
8	---	81.2	24.7
9	---	5.1	---
Scrubbers	16.0	39.7	48.7
TOTAL	347.0	340.3	164.1

--- Indicates no measurable uranium emission.

TABLE 9

AMOUNT OF U DETECTED DOWNWIND
OF THE FMPC

	(mg/m^3)		Kg	
	Station 1	Station 3	Station 1	Station 3
1981	0.012	0.0014	$6.3X10^{-4}$	$8.4X10^{-6}$
1982	0.023	0.021	$1.2X10^{-5}$	$1.1X1-^{-5}$
1983	0.031	0.074	$1.6X10^{-5}$	$1.9X1-^{-5}$
DOE Std.	3	3	$1.6X10^{-3}$	$1.6X10^{-3}$

TABLE 10

POTENTIAL URANIUM QUANTITIES IN THE SOIL
FMPC PRODUCTION AREA

Year	Average Concentration of U in Soil (ug/g)	Weight of Soil in Production Area (kg)	Kg of U in Soil
1964	142	$8.1X10^6$	1150
1965	163	$8.1X10^6$	1320
1966	79	$8.1X10^6$	640
1967	--	No Samples Taken	--
1968	116	$8.1X10^6$	940
1969	87	$8.1X10^6$	700

* Assumes a volume of 150,000 ft^3 at a density of 120 lbs/ft^3.

TABLE 11

Summary of Gumpaper Data

Year	Uranium (mg/ft^2)	Stack Loss (kg)
1959	112,024	6,416
1960	252,812	4,748
1961	119,782	2,273
1962	249,402	4,647
1963	407,743	8,129
1964	321,350	4,805

TABLE 12

SUMMARY OF HYDROGEOLOGIC CHARACTERISTICS

Aquifer	Characteristics	Source
Surficial Till Layer	Type: Perched (local)	Ref. A3-2, 4, 7
	Transmissivity: No data	
	Specific Yields: No data	
	Hydraulic Conductivity: Low	
	Depth to Water: Varies -3 to -20 feet below land surface	Ref. A1-1
	Flow Direction: Follows local topography	Ref. A3-2, 4, 7
	Porosity: No data	
	Flow Velocity: No data	
	Storage Coefficient: No data	
Shallow Sand and Gravel Aquifer	Type: Water table	Ref. A3-2, 4, 7
	Transmissivity: No data	
	Well Yield: 100-500 gpm (max. of 1000 gpm)	
	Hydraulic Conductivity: No data	
	Depth to Water: 30-50 below land surface	Ref. A3-3, 13
	Flow Direction: On west side of plant toward Paddy's Run, east of 600-foot contour flow is toward Great Miami River. Possibly some local diversion toward FMPC production wells. Corresponds generally to surface topography	Ref. A3-2
	Porosity: 35%	Ref. A3-2
	Flow Velocity: No data	
	Storage Coefficient: No data	
Deeper Sand and Gravel Aquifer	Type: Artesian	Ref. A3-3,4,5,7
	Transmissivity: 140,000 gpd/ft^2	Ref. A3-11
	Well Yield: 100-500 gpm (max. of 1000 gpm)	Ref. A3-10
	Hydraulic Conductivities: 349 ft/day (range 267-668 ft/day)	Ref. A1-25, 26
	Depth to Water: 60 feet below land surface	Ref. A3-1, 3, 7
	Flow Direction: Southeast toward Great Miami River	Ref. A3-2, 13
	Porosity: 35%	Ref. A3-2
	Flow Velocity:0.2 - 2 ft/day	Ref. A1-25,26
	Storage Coefficient: No data	

TABLE 13

PROPOSED MONITORING WELL LOCATIONS-RATIONALE

Well No.	Location	Reason
D-M 1s 1d	Waste Pit Area Waste Pit Area	Gather subsurface info and water quality data downgradient of waste pit area.
D-M 2s 2d	Waste Pit Area Waste Pit Area	Gather subsurface info and water quality data downgradient of waste pit area.
D-M 3s 3d	Waste Pit Area Waste Pit Area	Gather subsurface info and water quality data downgradient of waste pit area.
D-M 4s 4d	Plant Production Area Plant Production Area	Monitor water quality in immediate vicinity of plant Production Area.
D-M 5s 5d	Fly Ash Pile Fly Ash Pile	Monitor water quality downgradient of pile.
NLO 12s 12d	North Access Road North Access Road	Gather subsurface info and water quality data upgradient of FMPC
NLO 13s 13d	East Production Area East Production Area	Gather subsurface info and water quality in this area of facility. Possible correlation use with NLO well T-10.
NLO 14s 14d	West Storm Sewer Outfall West Storm Sewer Outfall	Gather subsurface info and water quality data downgradient of Flyash Pile and adjacent to Storm Sewer Outfall.

TABLE 13 (Cont'd)

PROPOSED MONITORING WELL LOCATIONS-RATIONALE

Well No.	Location	Reason
NLO 15s 15d	Willey Road Willey Road	Gather subsurface info and water quality data down-gradient of Storm Sewer Outfall and Paddy's Run. Will also provide data on offsite wells OS-1 and OS-2.

s: well screened in surficial till layer
d: well screened in upper part of upper sand and gravel aquifer

TABLE 14

Well Construction Specifications
FMPC, Fernald, Ohio

1. Well diameter = 4" i.d.

2. Well casing and screen will be flush joint threaded and coupled schedule 40 PVC with bell end bottom cap. No glue to be used-teflon tape only.

3. Five feet of well screen with slot sized according to sediment size of formation to be monitored.

4. All wells to be gravel packed to one foot above top of screen intervals.

5. A 3 foot thick bentonite pellet seal to be installed around annular space from top of gravel pack. Annular space to be backfilled with clean backfill material.

6. 6" i.d. steel protective pipe with locking vented cap to be cemented into place over PVC riser pipe.

7. Cement collar to be installed around protective pipe in such a manner to encourage surface drainage away from well.

8. During drilling, split spoon or undisturbed sediment samples to be collected at every five foot interval or change in lithology. These samples to be later analyzed at a qualified soils laboratory for a variety of sediment characteristics. Selected soils will also be analyzed for uranium concentration.

9. During drilling, the boring will be logged describing soils encountered, types, colors, textures, etc.

TABLE 15

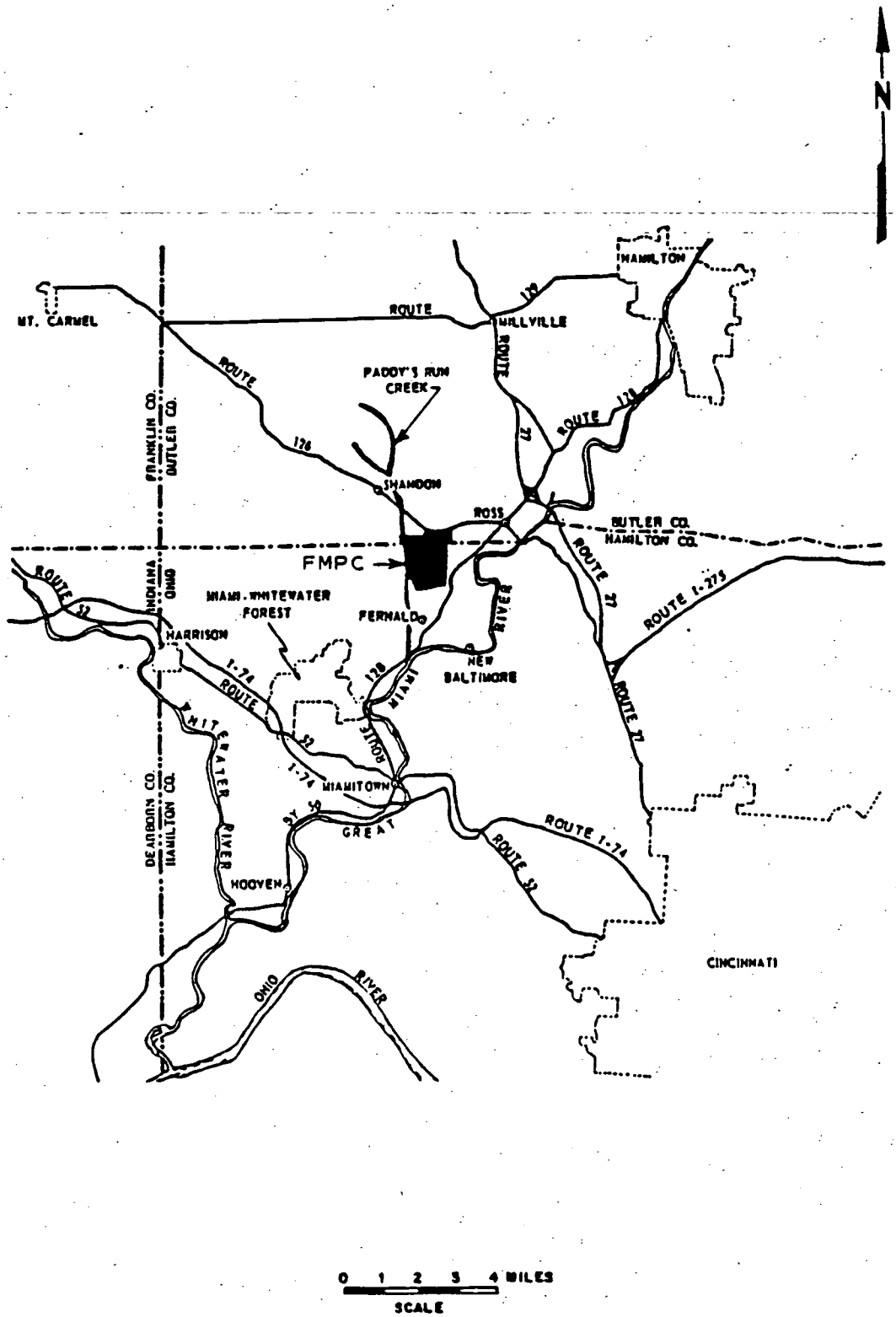
Volume Estimate of Scrap Metal and Fly Ash Piles

Pile	Volume (ft^3)	Average Concentration of U (ug/g)	Estimated Quantity (kg) **
Mixed Scrap Metal Pile	450,000	2.2	70
Covered Fly Ash Pile	1,350,000	10*	600
Active Fly Ash Pile	900,000	10*	400
Total Uranium Potentially Present		=	1070

* From Reference A1-31.

** Assumes a density of 100 lbs/ft^3 for flyash and a density of 150 lbs/ft^3 for scrap metal pile.

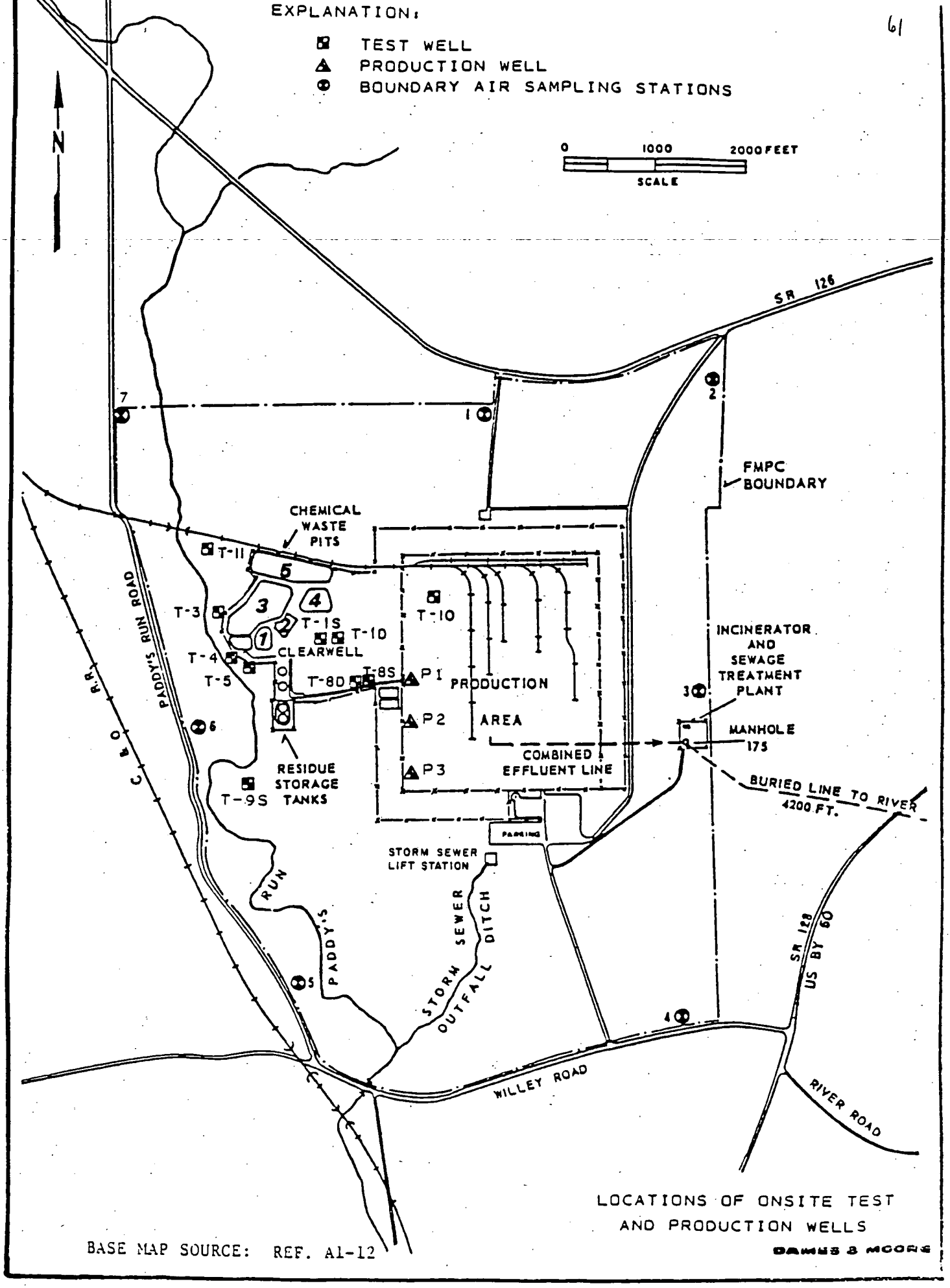
FIGURES



SITE LOCATION MAP

DAMES & MOORE

FIGURE 1

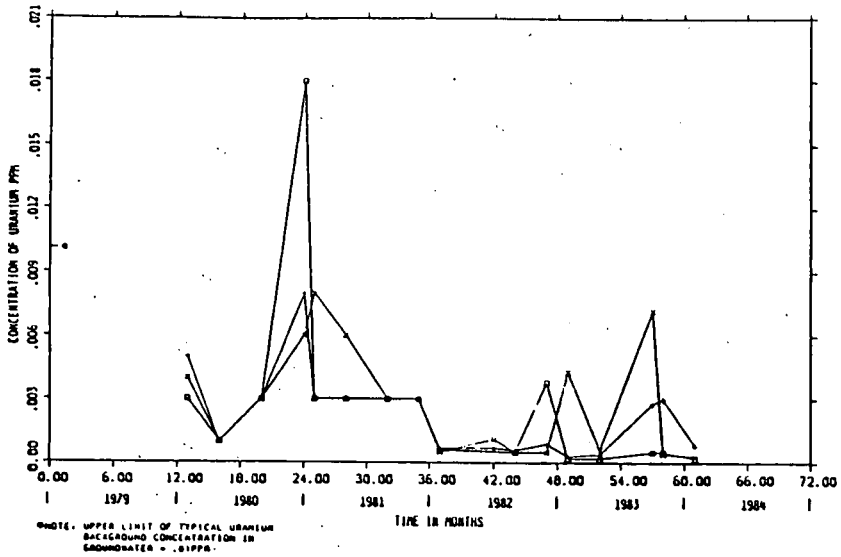


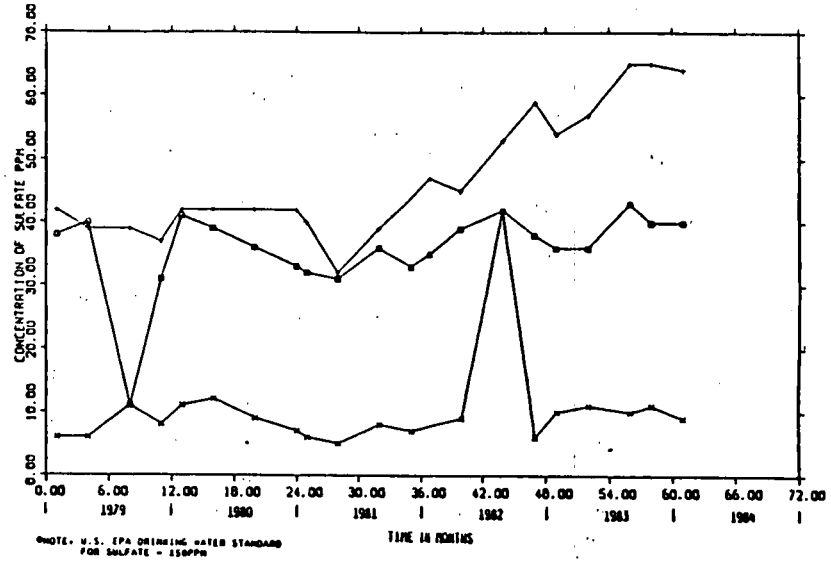
LOCATIONS OF ONSITE TEST AND PRODUCTION WELLS

BASE MAP SOURCE: REF. A1-12

DAMES & MOORE

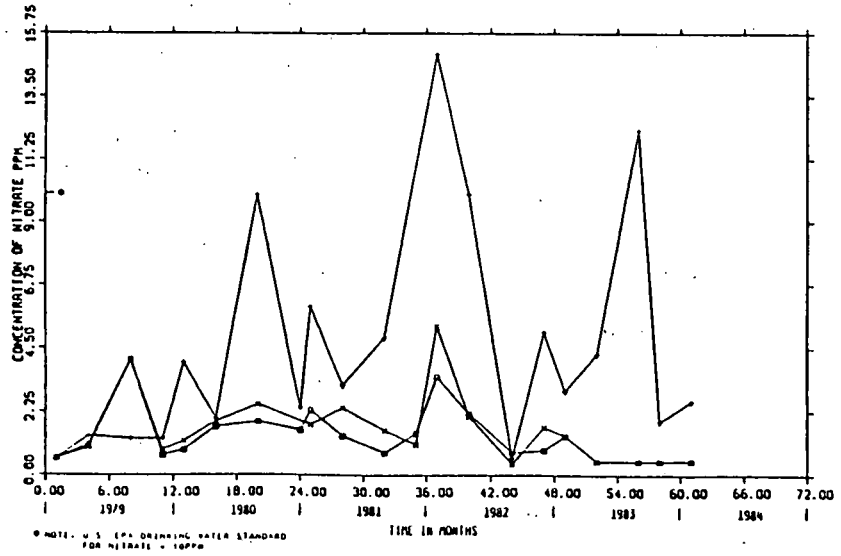
FIGURE 2

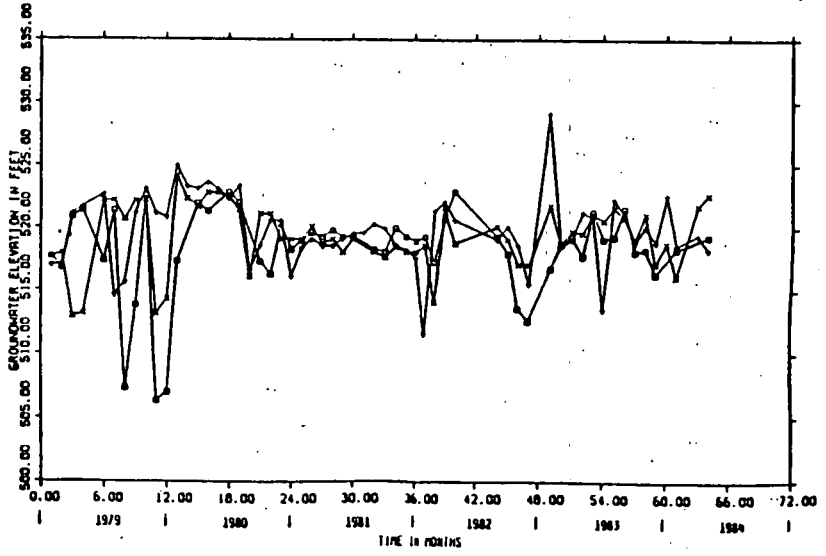




EXPLANATION:

+ WELL P1
X WELL P2
□ WELL P3

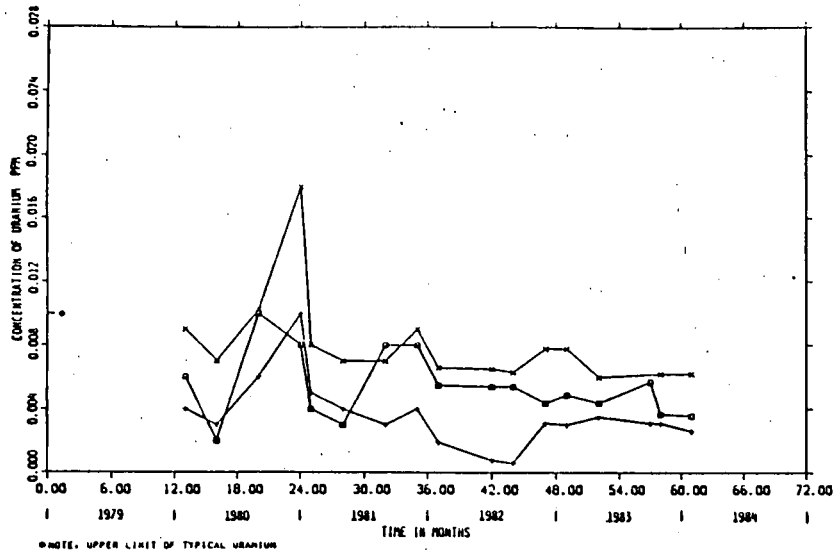




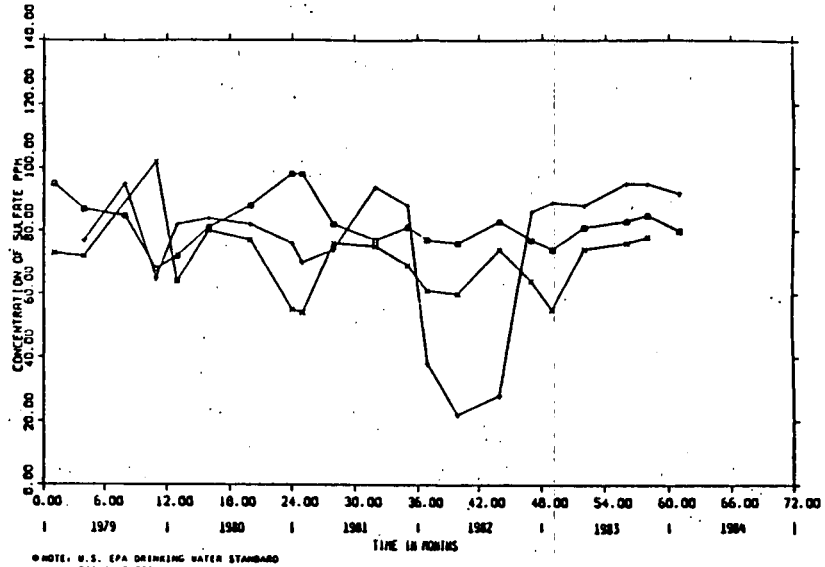
ONSITE WATER QUALITY WELLS
P-1, P-2, P-3

DAMES & MOORE

FIGURE 3A

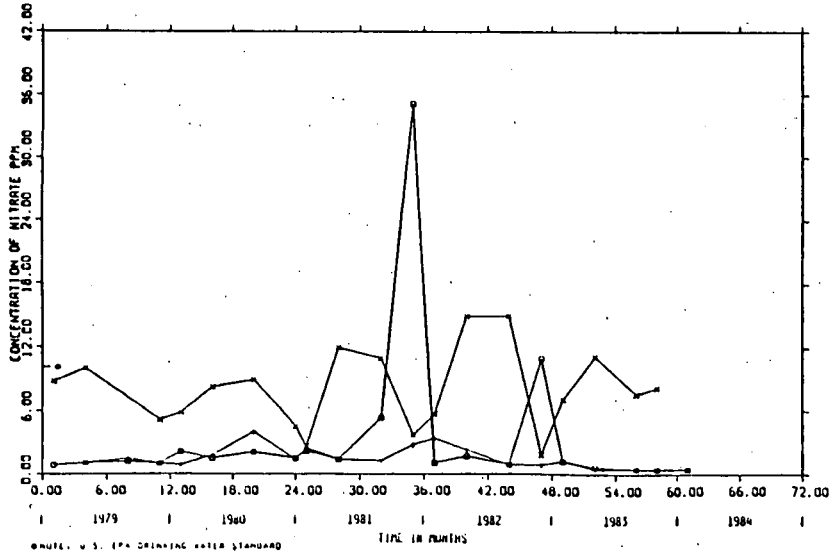


*NOTE: UPPER LIMIT OF TYPICAL URANIUM BACKGROUND CONCENTRATION IN GROUNDWATER = .01 PPM

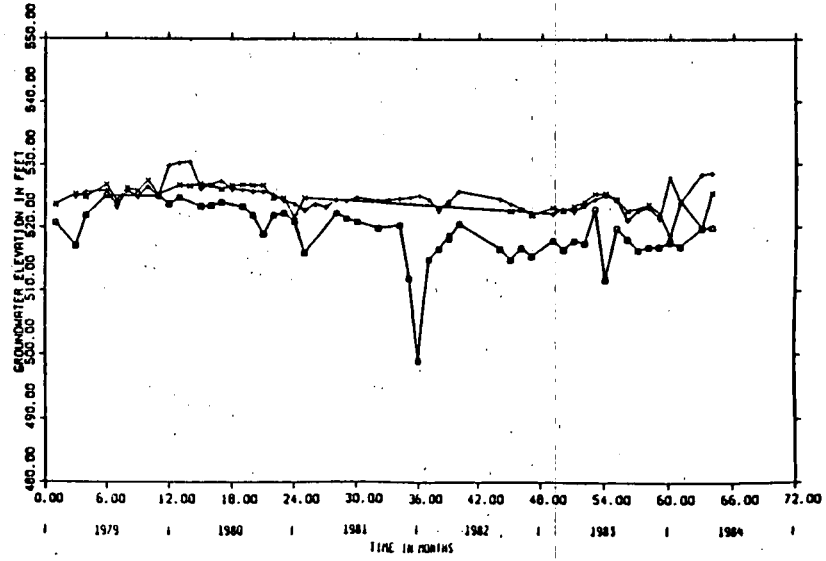


*NOTE: U.S. EPA DRINKING WATER STANDARD FOR SULFATES = 250 PPM

EXPLANATION:
+ WELL T-3
X WELL T-4
□ WELL T-5



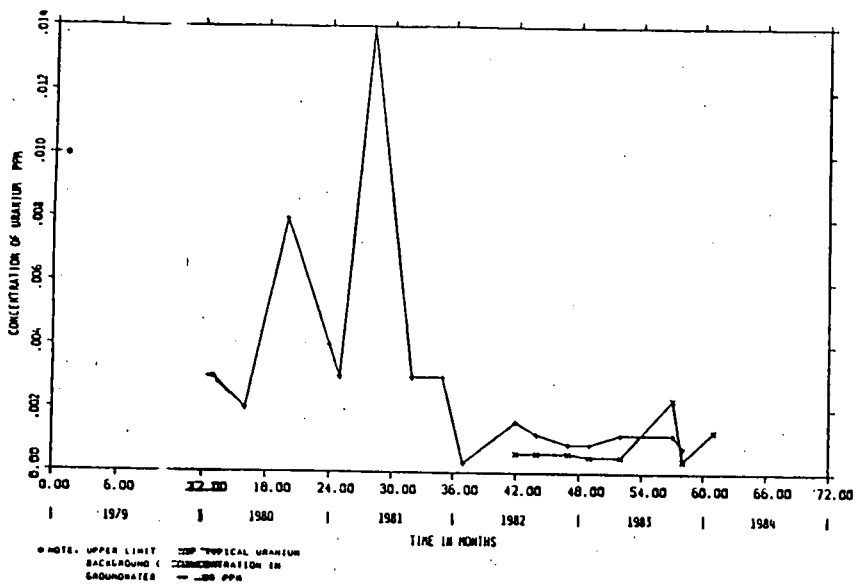
*NOTE: U.S. EPA DRINKING WATER STANDARD FOR NITRATES = 10 PPM

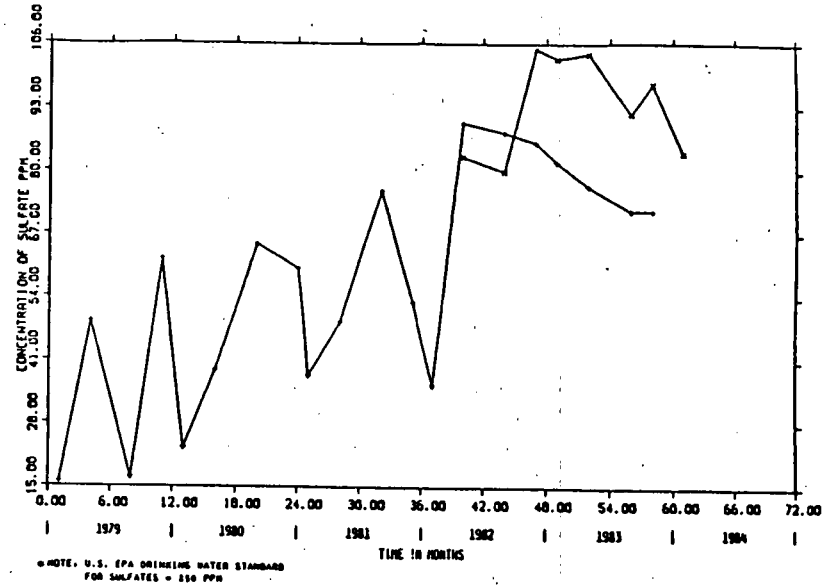


ONSITE WATER QUALITY WELLS
T-3, T-4, T-5

DAMES & MOORE

FIGURE 38

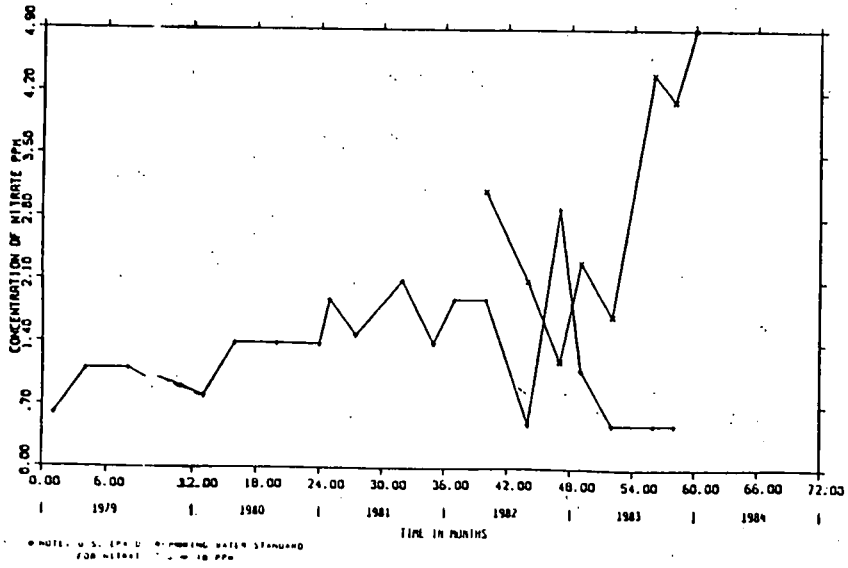


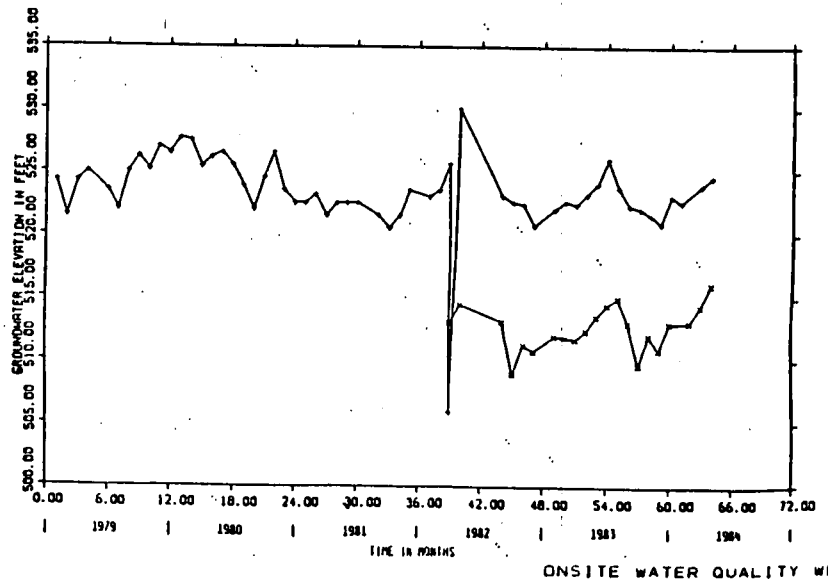


EXPLANATION:

+ WELL T-8S

X WELL T-11

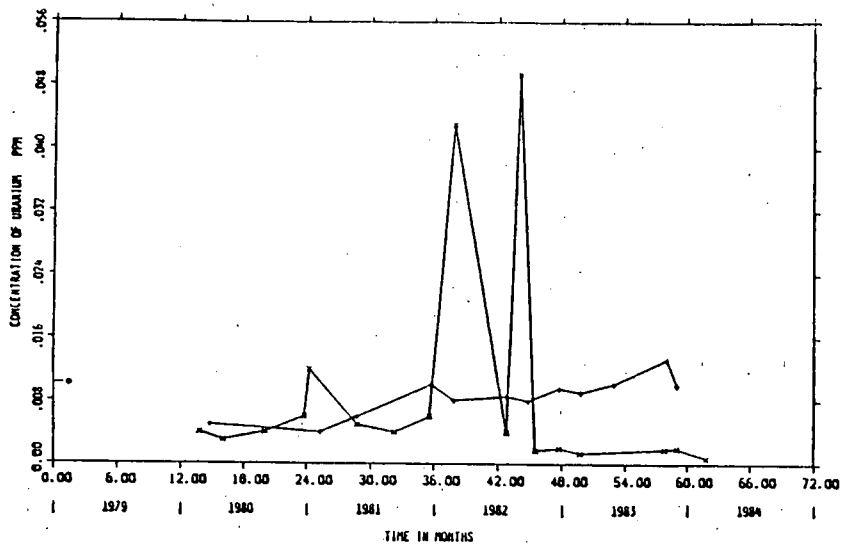




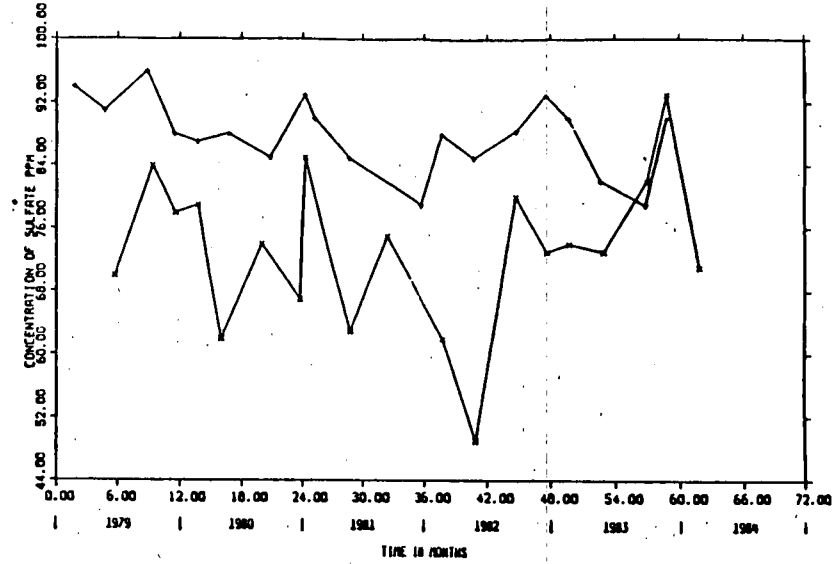
ONSITE WATER QUALITY WELLS
T-8S, T-11

DAMES & MOORE

FIGURE 3C



* NOTE: UPPER LIMIT OF TYPICAL URANIUM BACKGROUND CONCENTRATION IN IN GROUNDWATER = .01 PPM

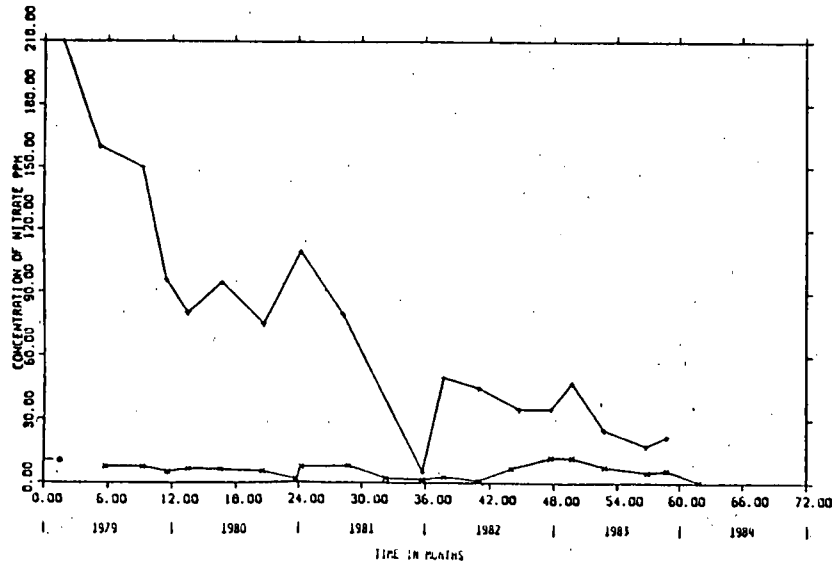


* NOTE: U.S. EPA DRINKING WATER STANDARD FOR SULFATES = 250 PPM

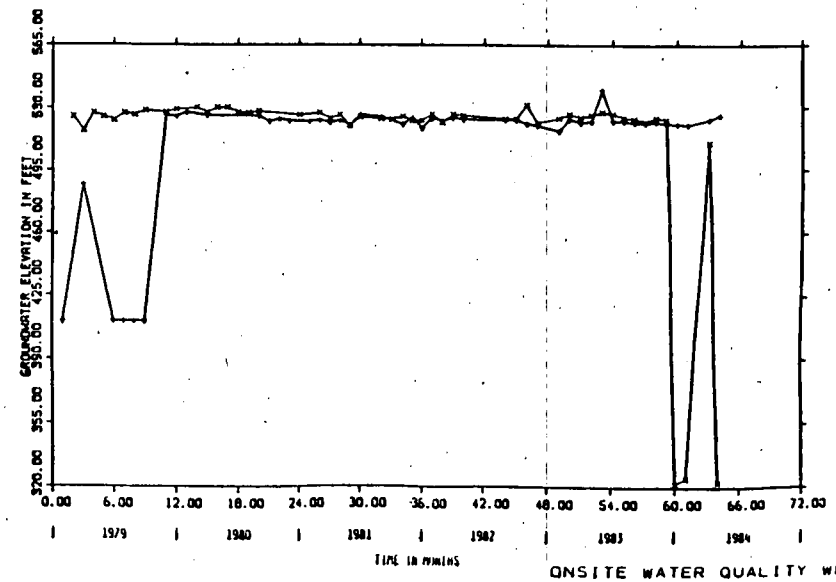
EXPLANATION:

+ WELL T-1S

X WELL T-9S



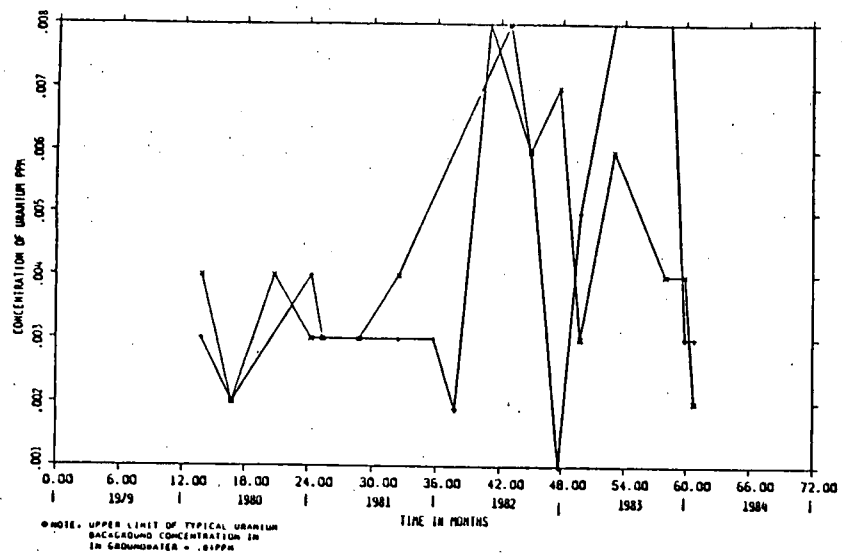
* NOTE: U.S. EPA DRINKING WATER STANDARD FOR NITRATES = 10 PPM

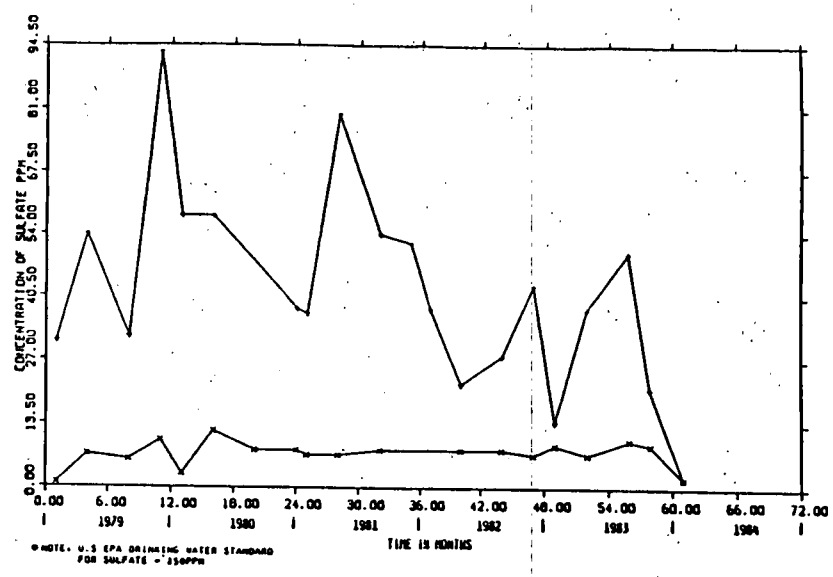


ONSITE WATER QUALITY WELLS
T-1S, T-9S

DAMES & MOORE

FIGURE 30

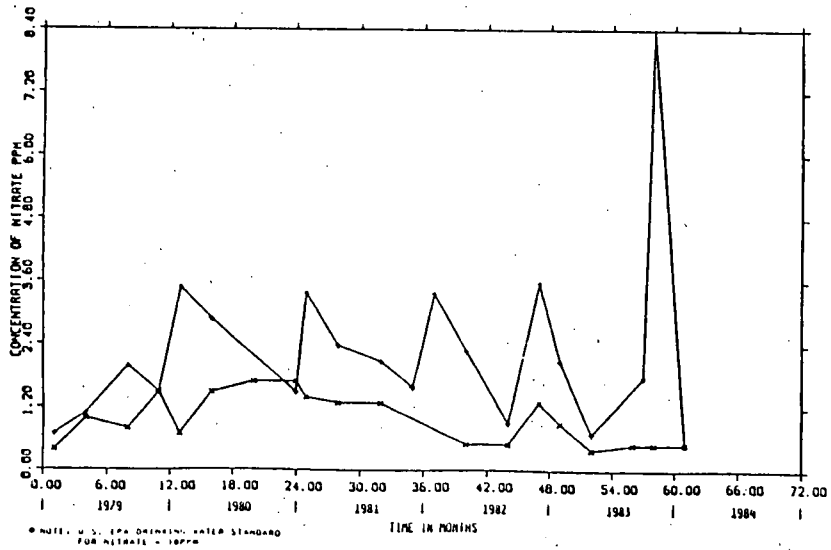


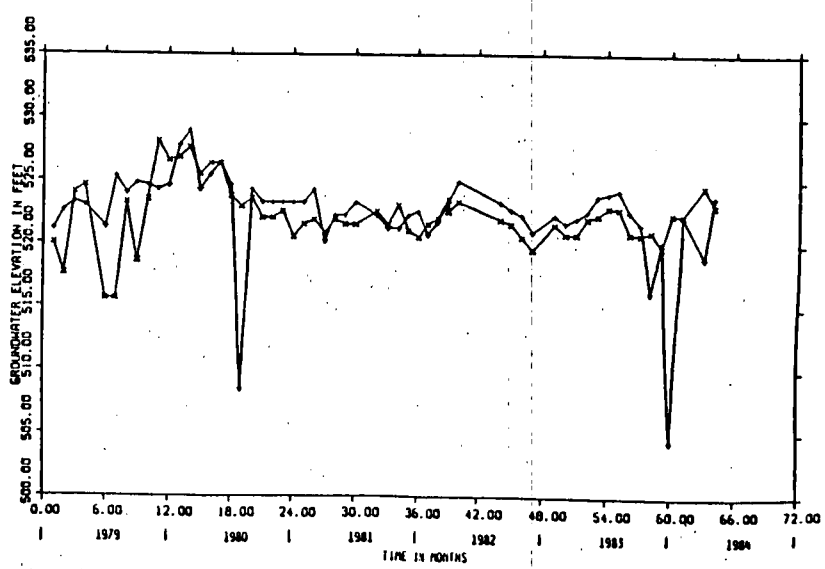


EXPLANATION:

† WELL T-1D

× WELL T-8D

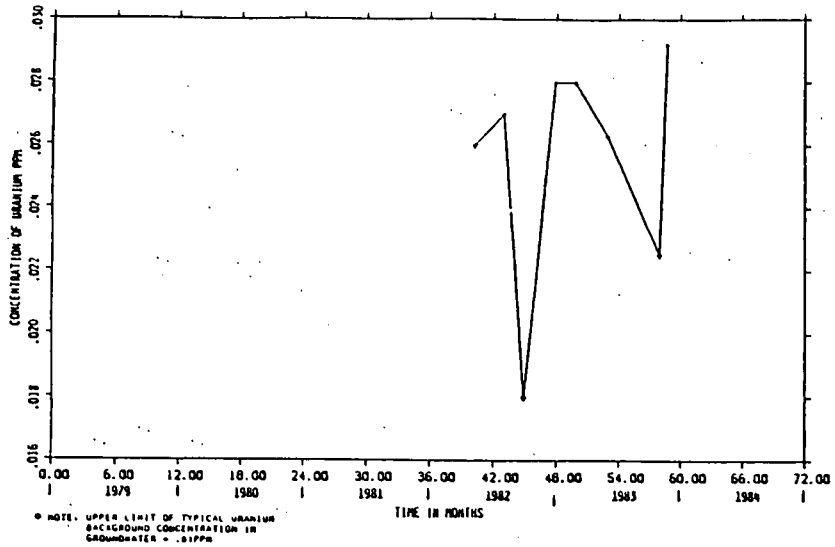


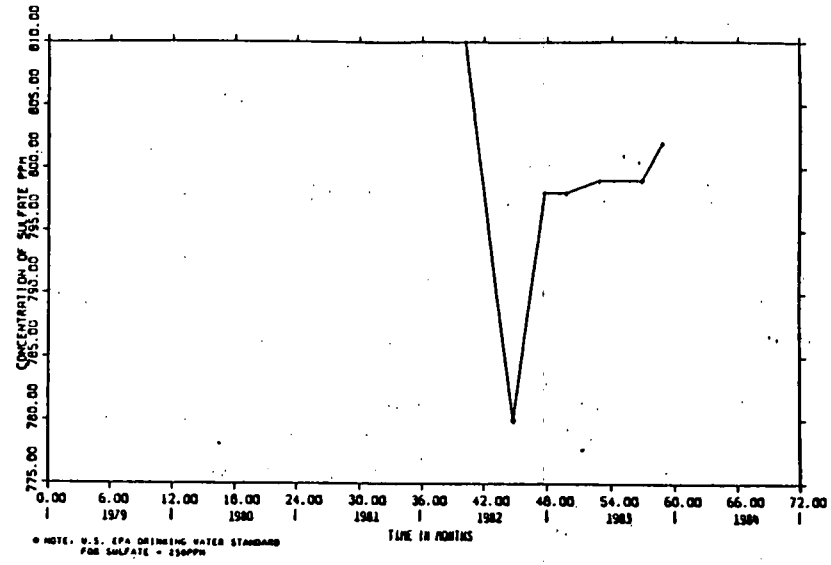


ONSITE WATER QUALITY WELLS
T-1D, T-8D

DAMES & MOORE

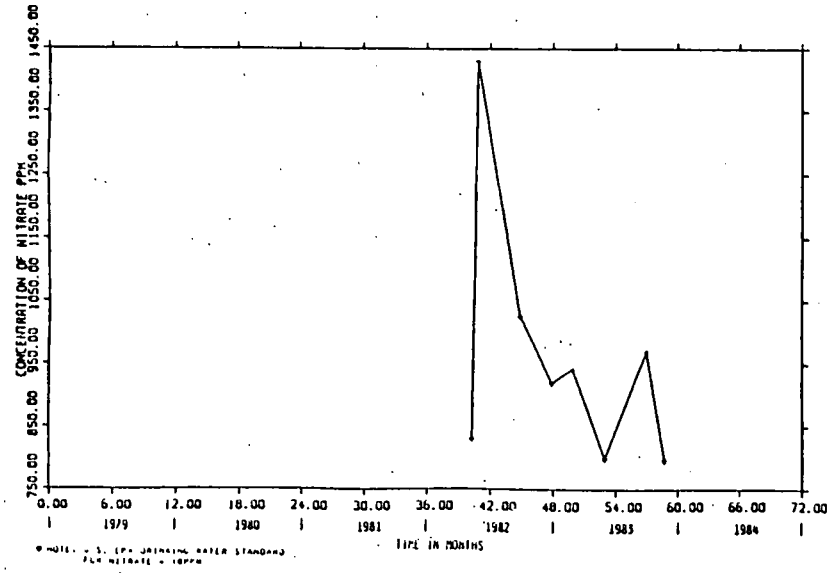
FIGURE 25

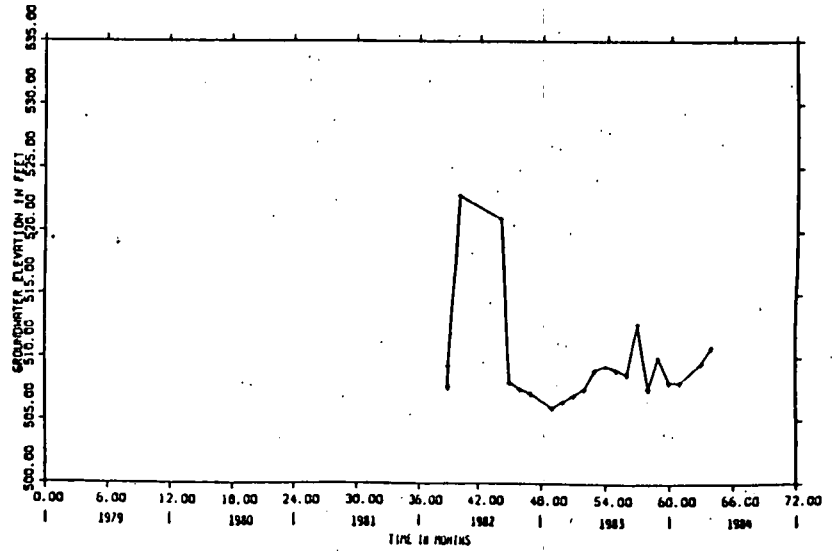




EXPLANATION:

+ WELL T-10





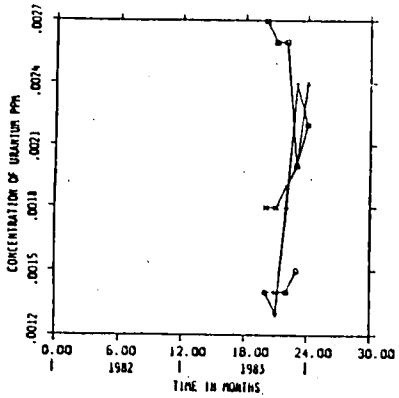
ONSITE WATER QUALITY WELL
T-10

DAMES & MOORE

FIGURE 3F

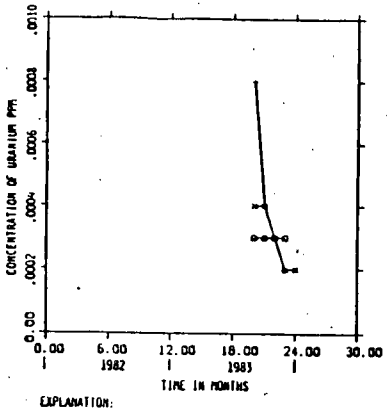
74

61



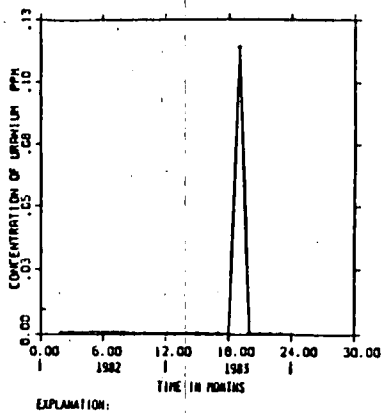
EXPLANATION:
+ WELL OS-4
X WELL OS-5
O WELL OS-6
O WELL OS-7

GROUP 1



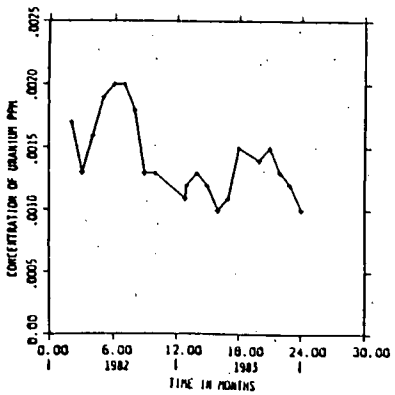
EXPLANATION:
+ WELL OS-8
X WELL OS-9
O WELL OS-10

GROUP 2



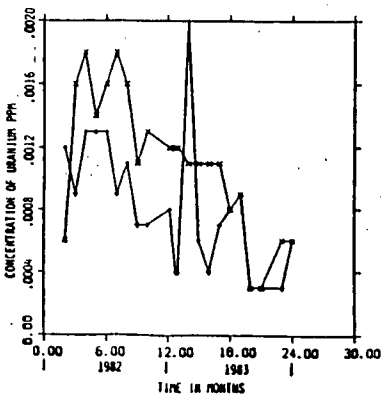
EXPLANATION:
+ WELL OS-11

GROUP 3



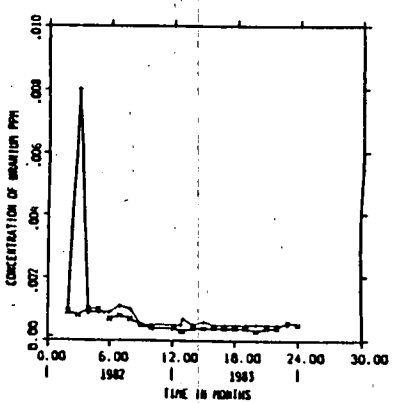
EXPLANATION:
+ WELL OS-12

GROUP 3



EXPLANATION:
+ WELL OS-13
X WELL OS-14

GROUP 4



EXPLANATION:
+ WELL OS-15
X WELL OS-16

GROUP 5

* NOTE: UPPER LIMIT OF TYPICAL URANIUM BACKGROUND CONCENTRATION IN GROUNDWATER = .01PPM

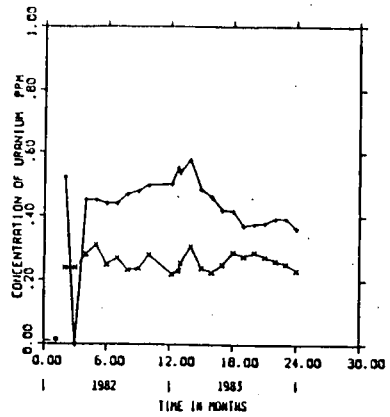
OFFSITE WATER QUALITY GROUPS 1-5

DAMES & MOORE

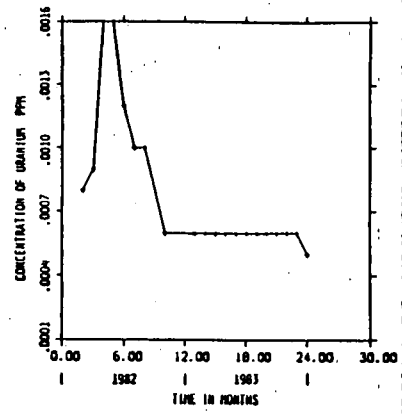
FIGURE 4A

75

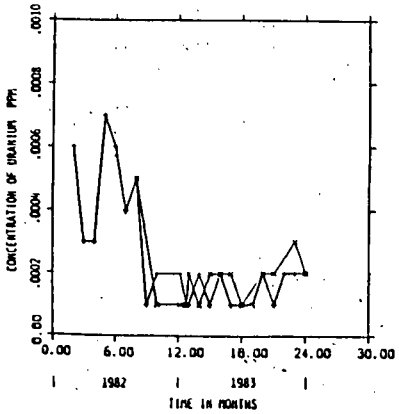
76



EXPLANATION:
+ WELL OS-2
x WELL OS-1
GROUP 6

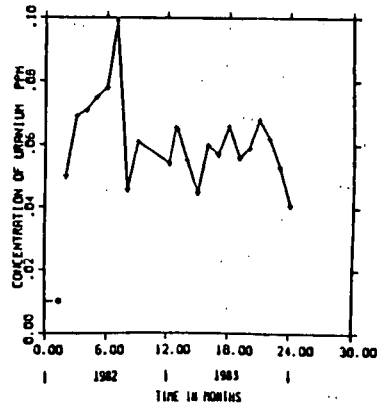


EXPLANATION:
+ WELL OS-17
GROUP 6



EXPLANATION:
+ WELL OS-18
x WELL OS-19
GROUP 7

* NOTE: UPPER LIMIT OF TYPICAL URANIUM BACKGROUND CONCENTRATION IN GROUNDWATER = .01 PPM

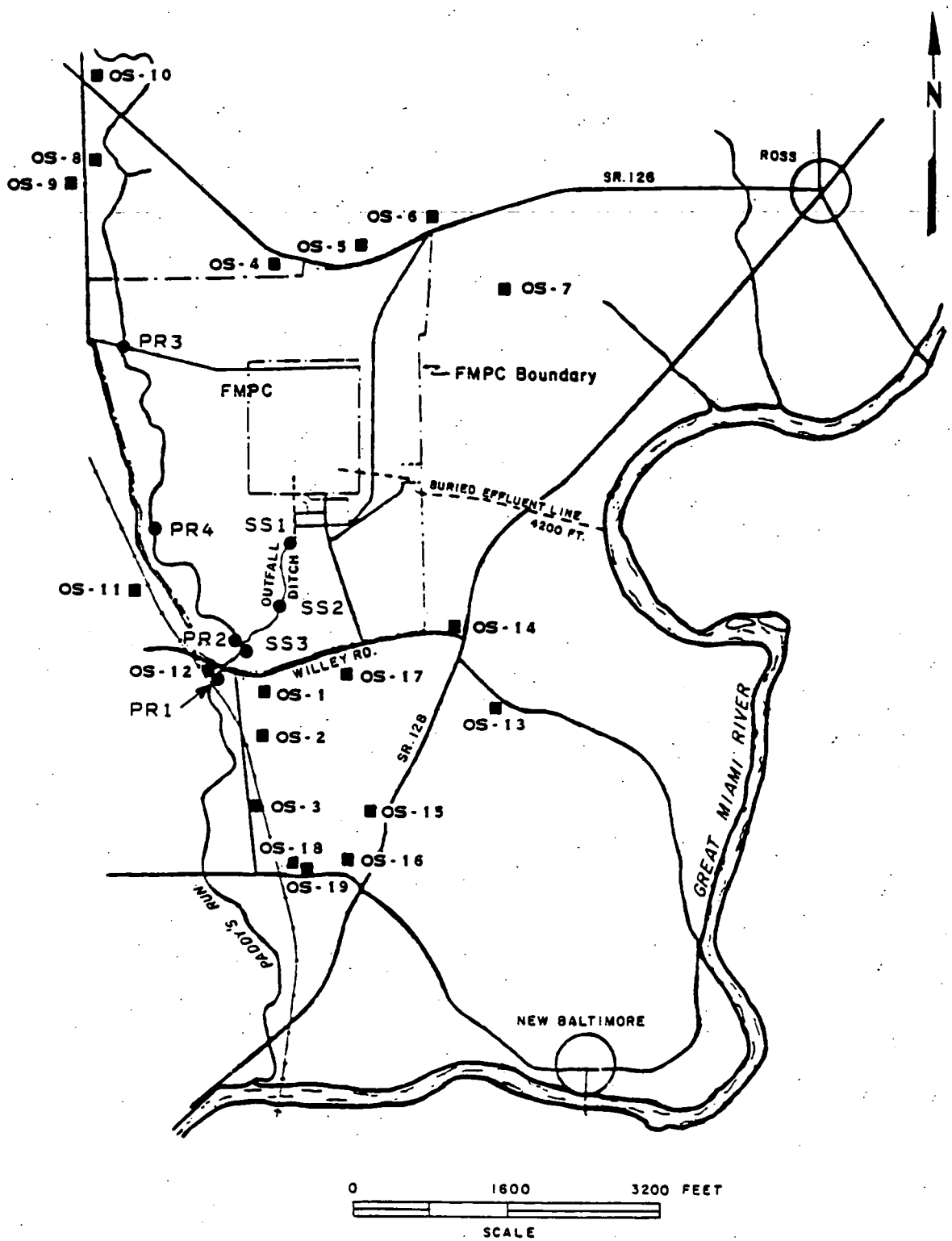


EXPLANATION:
+ WELL OS-3.
GROUP 7

OFFSITE WATER QUALITY GROUPS 6-7

DAMES & MOORE

FIGURE 48



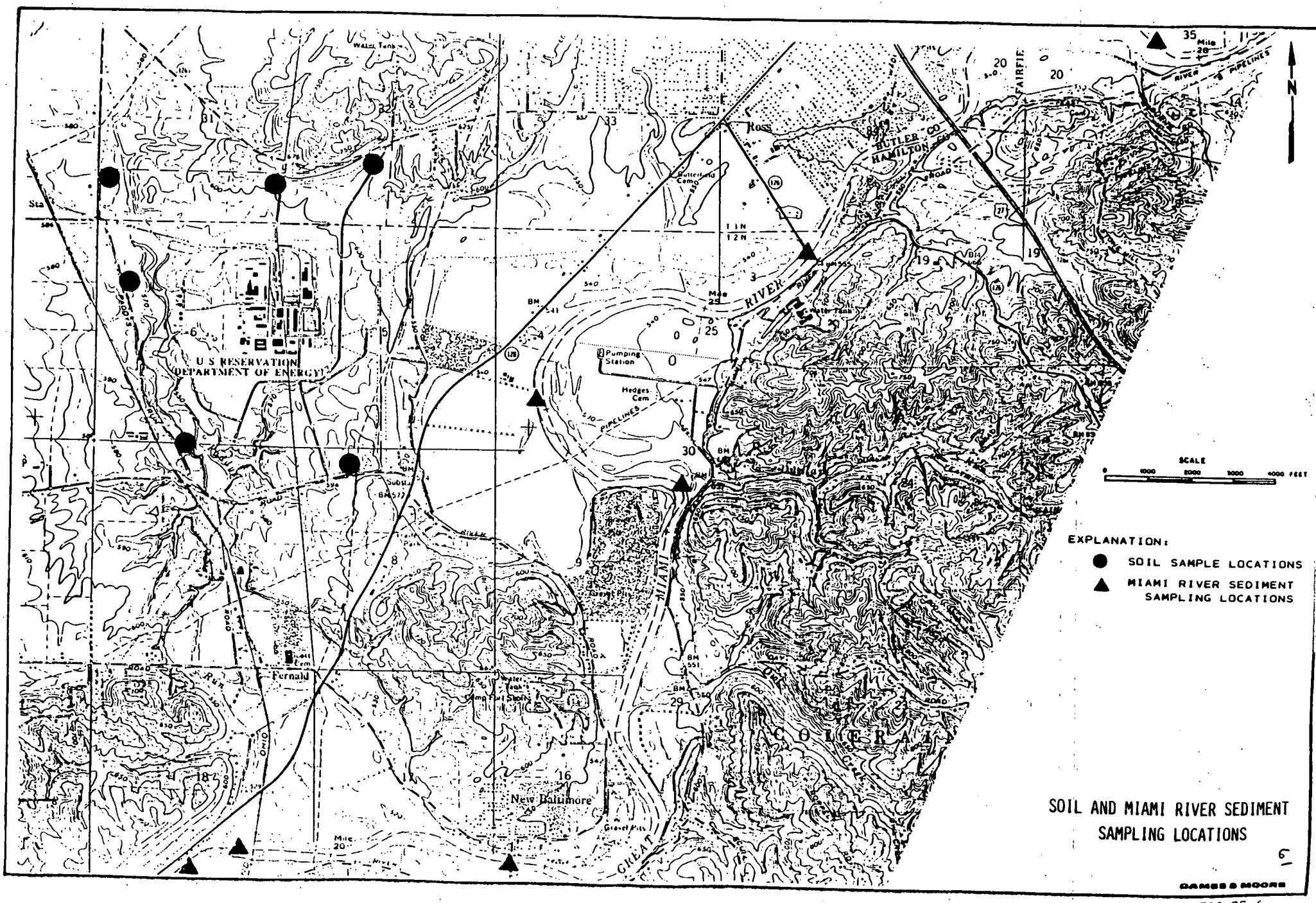
EXPLANATION:

- ■ LOCATION OF SAMPLED WELL
- ● SAMPLING LOCATION STREAM SEDIMENT

OFFSITE GROUNDWATER SAMPLING LOCATIONS

DAMES & MOORE

FIGURE 5


U S RESERVATION
DEPARTMENT OF ENERGY
Fernald
New Baltimore
Ross
BUTLER CO
HAMILTON CO
MIAMI
RIVER
GREAT
PIPELINES
Pumping Station
Hedges Cem
Water Tank
Gravel Pits
T 1 N
T 2 N
N
SCALE
0 1000 2000 3000 4000 FEET
EXPLANATION:
SOIL SAMPLE LOCATIONS
MIAMI RIVER SEDIMENT SAMPLING LOCATIONS
SOIL AND MIAMI RIVER SEDIMENT SAMPLING LOCATIONS
6
DAMES & MOORE

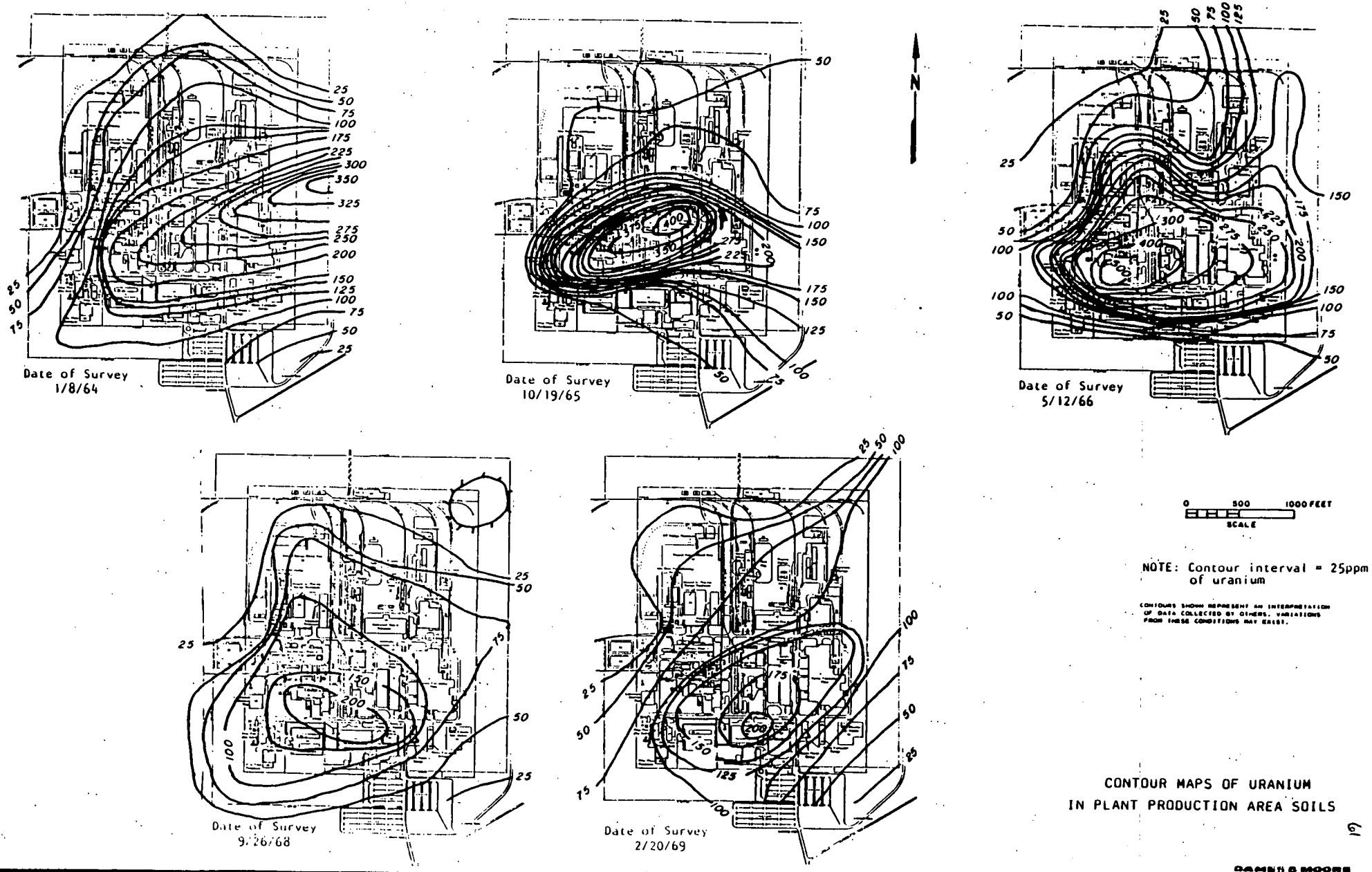
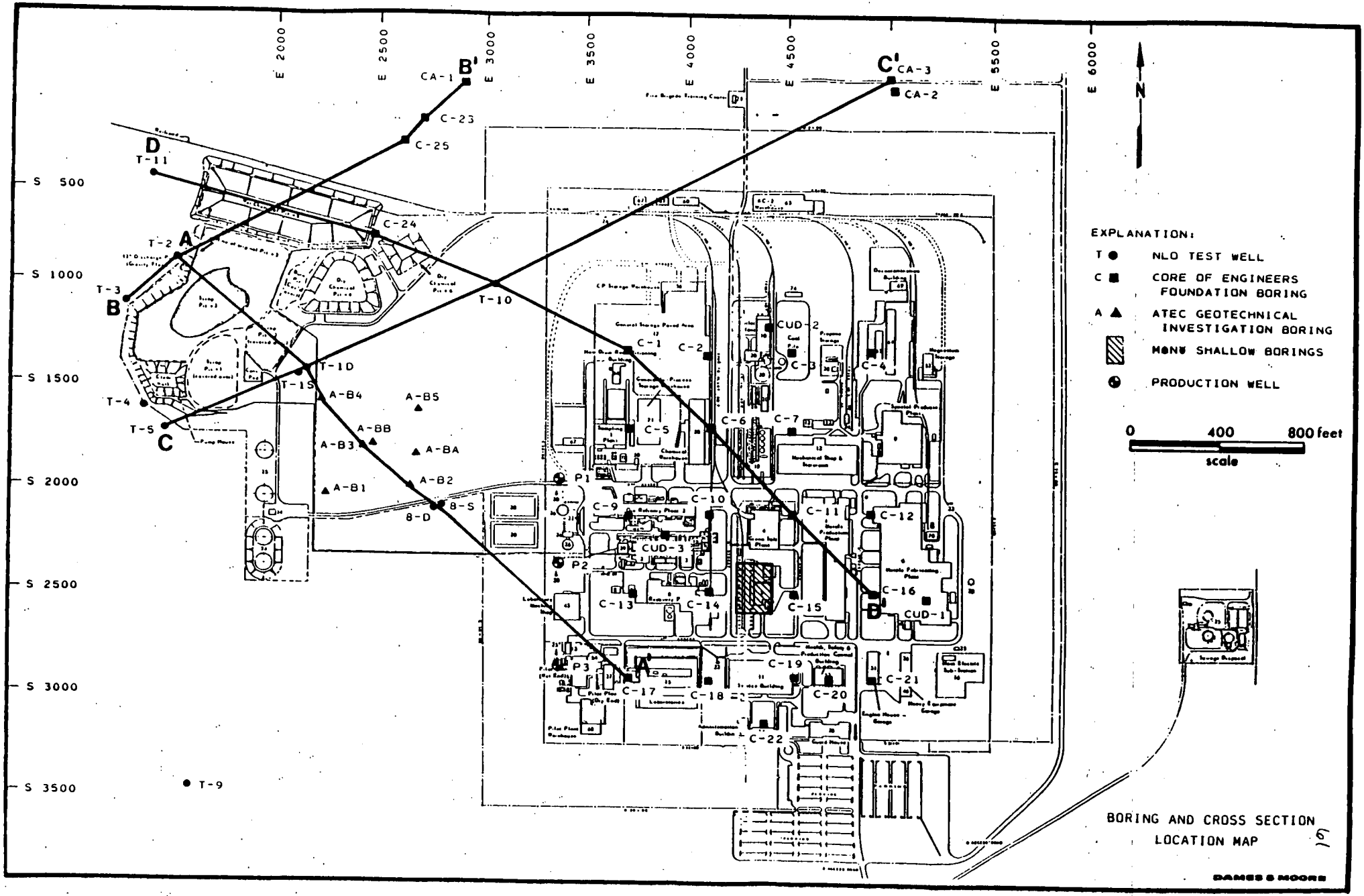
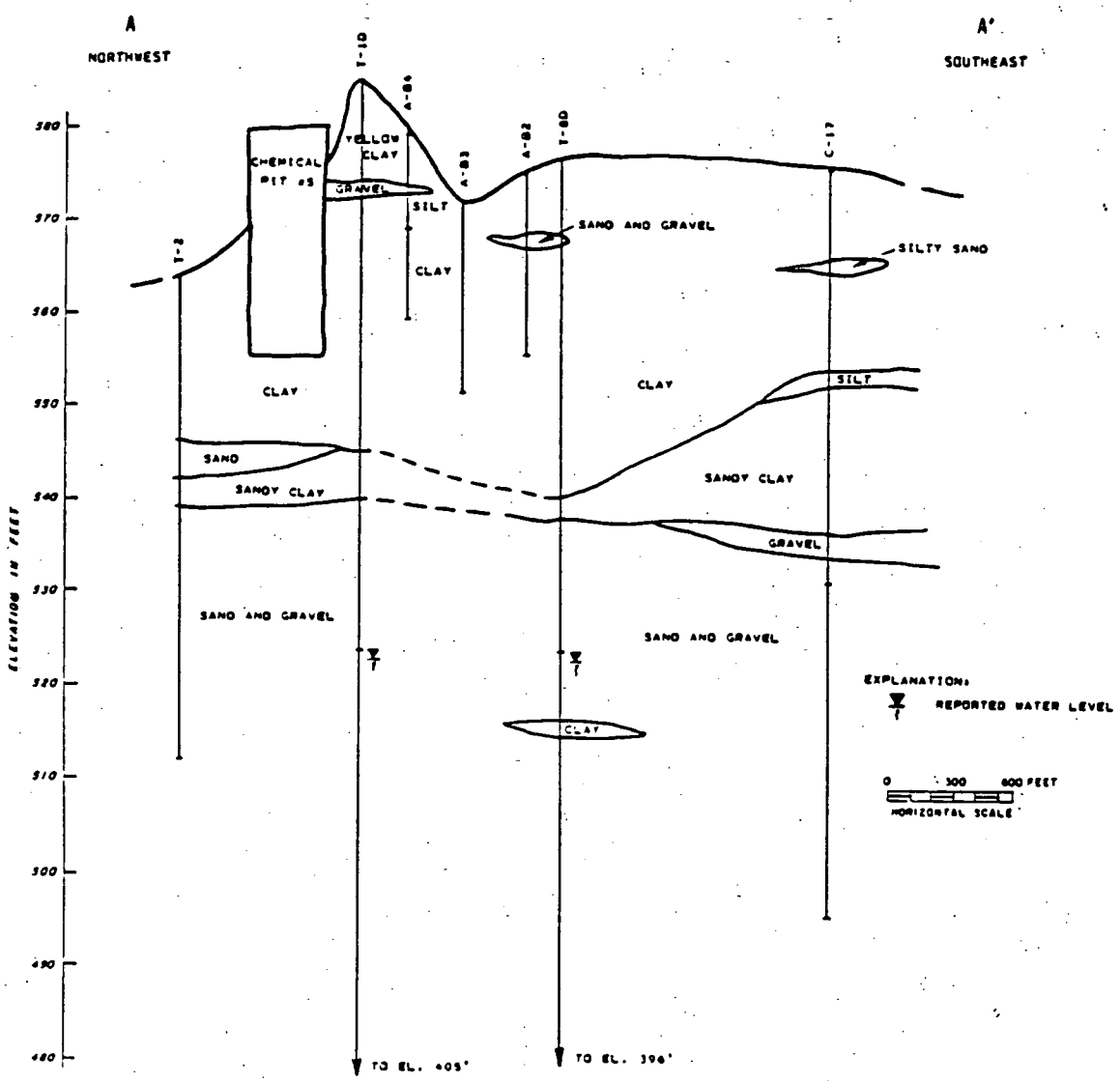

Date of Survey
1/8/64
Date of Survey
10/19/65
Date of Survey
5/12/66
Date of Survey
9/26/68
Date of Survey
2/20/69
N
0 500 1000 FEET
SCALE
NOTE: Contour interval = 25ppm of uranium
CONTOURS SHOWN REPRESENT AN INTERPRETATION OF DATA COLLECTED BY OTHERS. VARIATIONS FROM THESE CONDITIONS MAY EXIST.
CONTOUR MAPS OF URANIUM
IN PLANT PRODUCTION AREA SOILS
DAMES & MOORE

FIGURE 7



BORING AND CROSS SECTION LOCATION MAP

FIGURE 8



CROSS SECTION A-A'

THE SUBSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF DATA COLLECTED BY OTHERS. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

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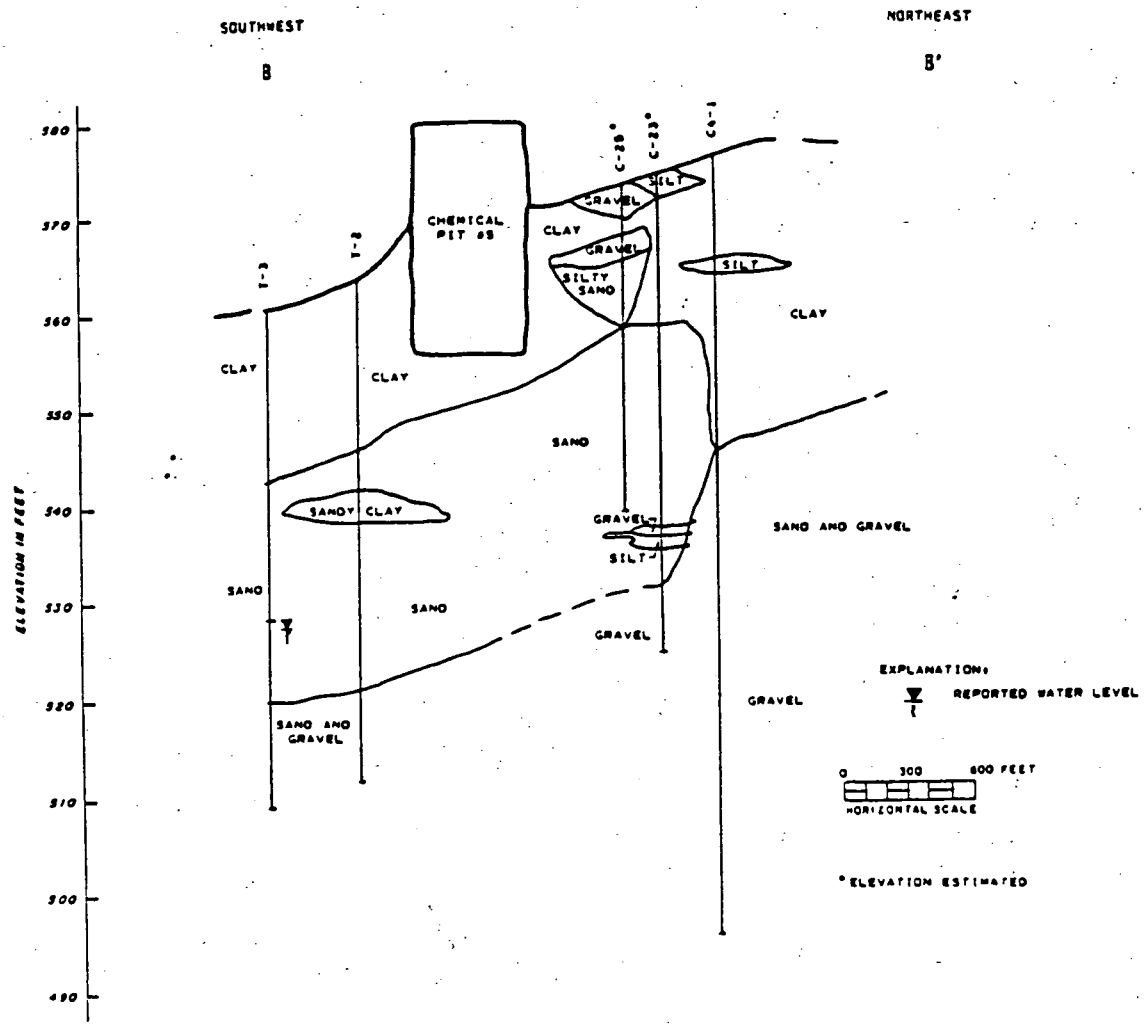
FIGURE 9A 81

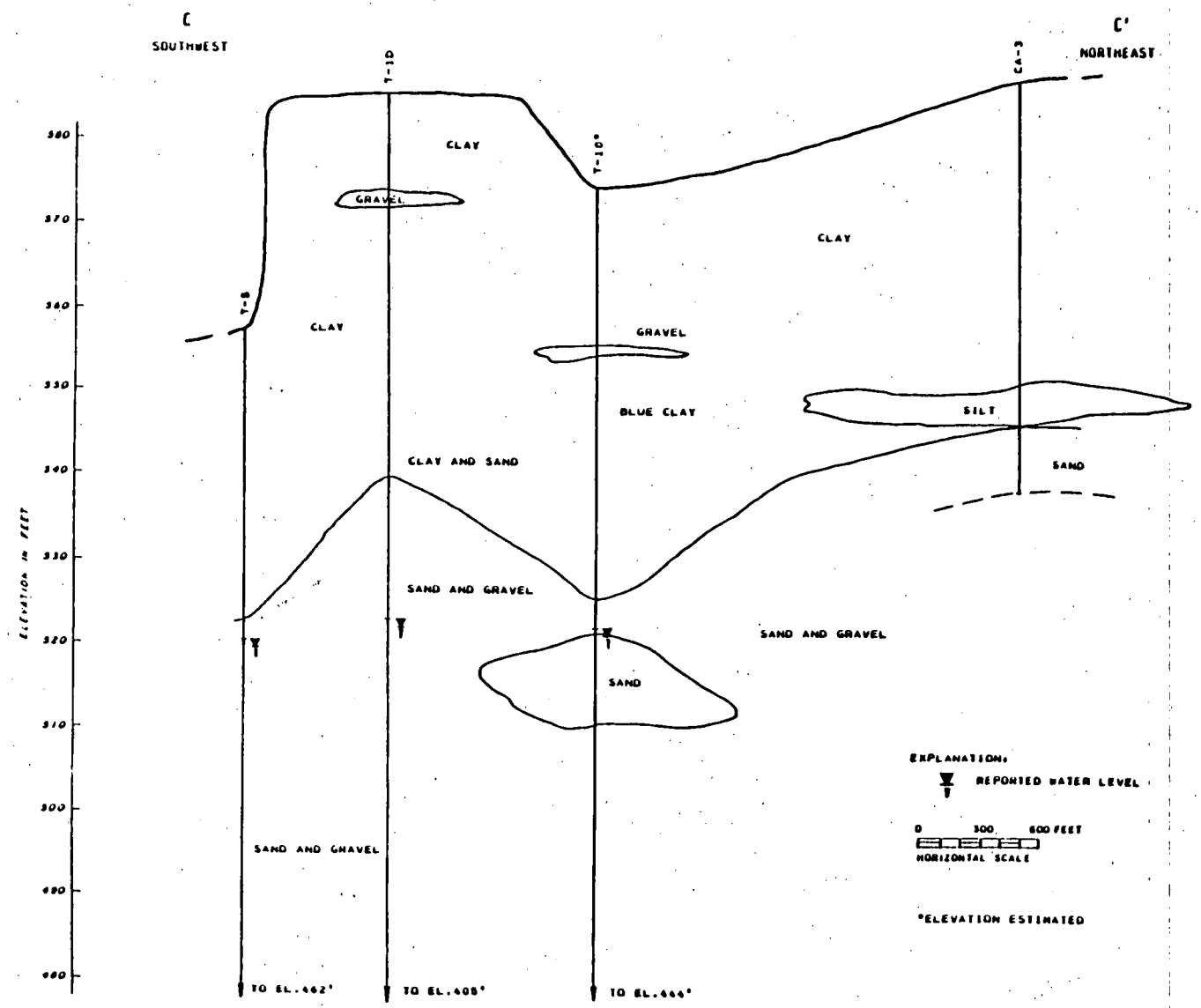


CROSS SECTION B-B'

THE SUBSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF DATA COLLECTED BY OTHERS. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

DAMES & MOORE

FIGURE 9B

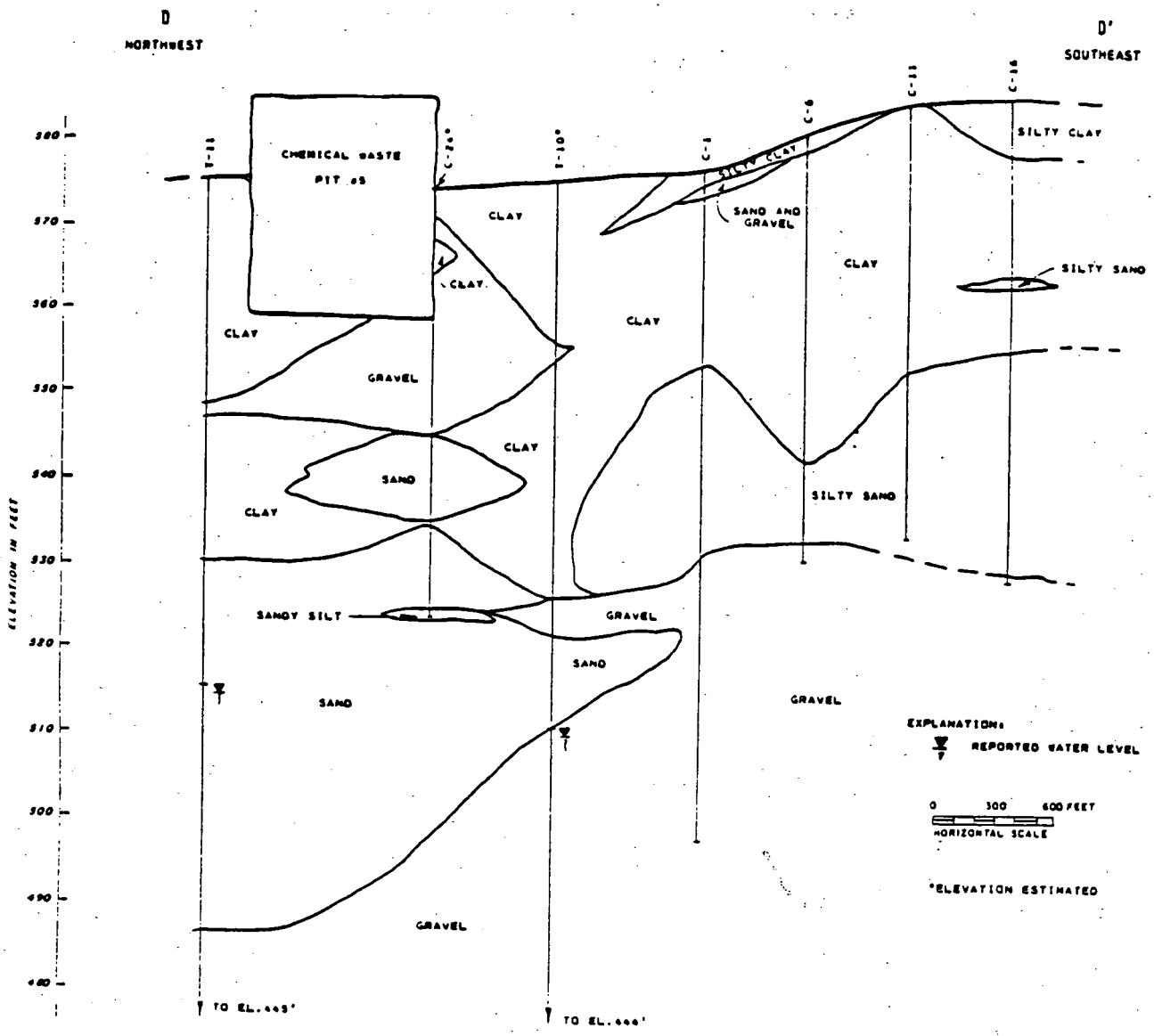


THE CORSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF DATA COLLECTED BY OTHERS. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

CROSS SECTION C-C'

DAMES & MOORE

FIGURE 9C



CROSS SECTION D-D'

THE SUBSECTIONS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS, BASED UPON INTERPRETATION OF DATA COLLECTED BY OTHERS. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

DAMES & MOORE

FIGURE 9D

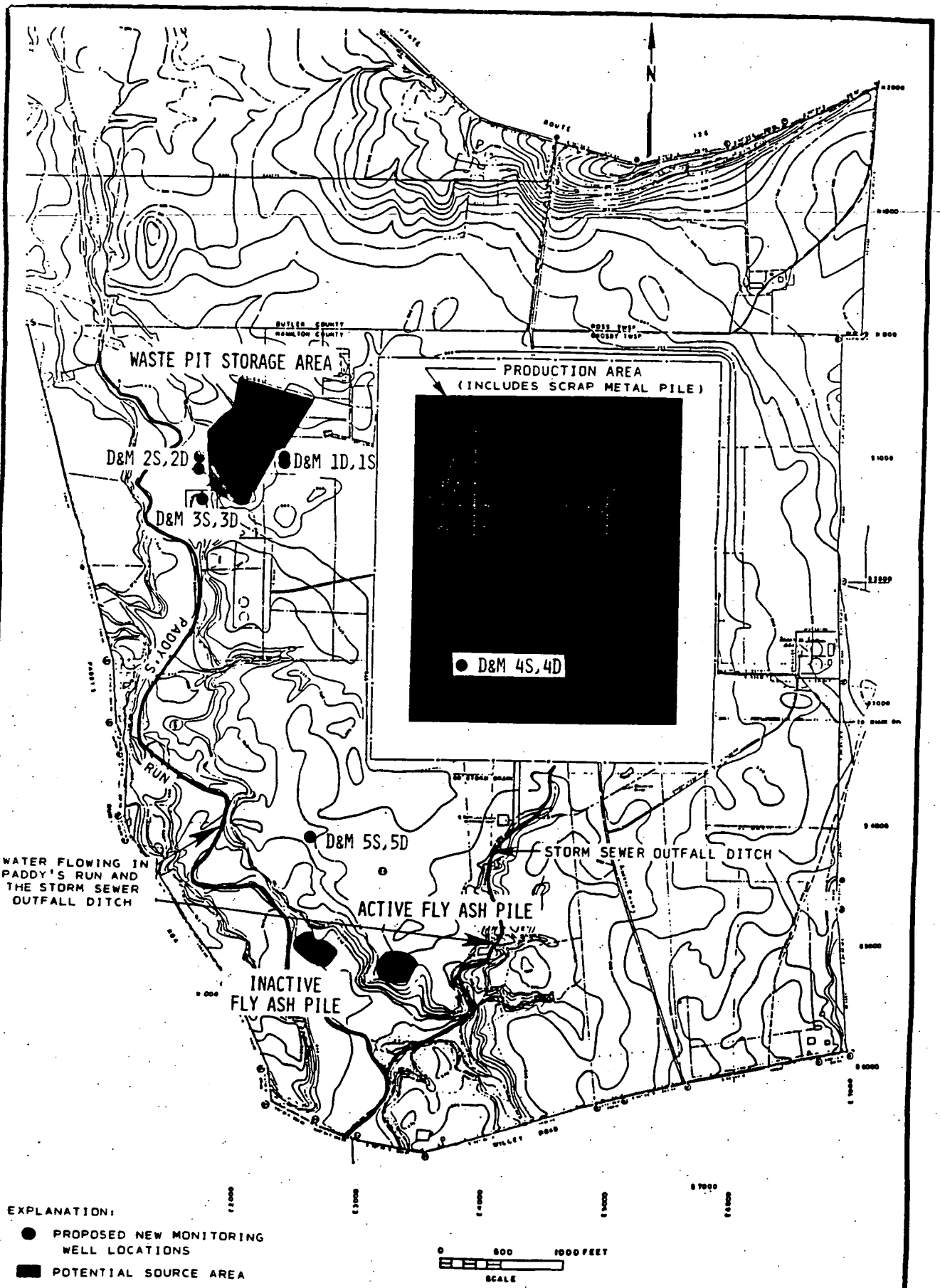
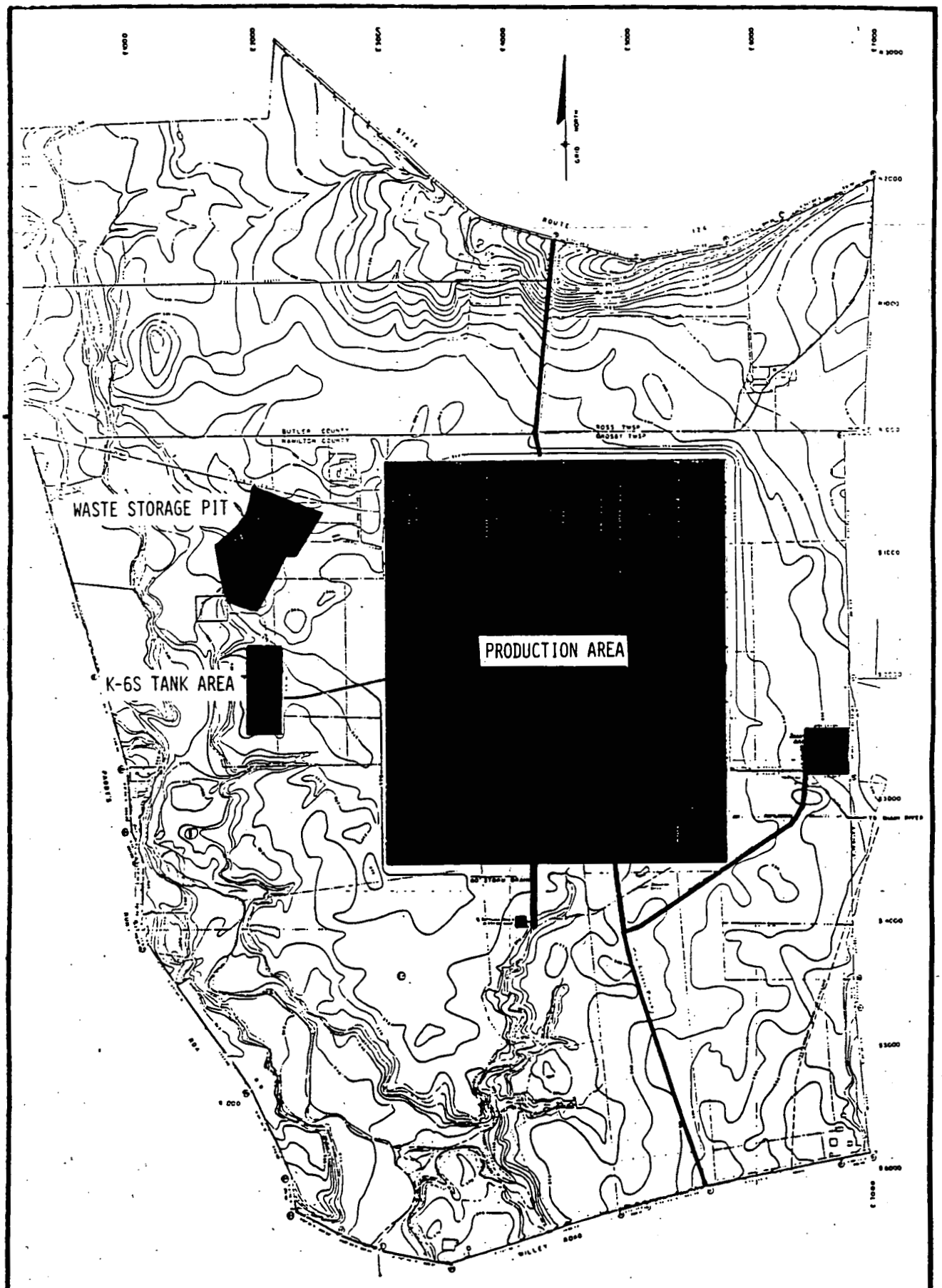


FIGURE 10

PROPOSED NEW WELL LOCATIONS AND PRELIMINARY IDENTIFICATION OF POTENTIAL SOURCES

FOR THE ABOVE-BACKGROUND CONCENTRATIONS IN THE THREE OFFSITE WELLS

DAMES & MOORE



EXPLANATION:

NON-RECHARGE AREAS

NOTE: ALL AREAS NOT SHADED ARE RECHARGE AREAS

THE POTENTIAL RECHARGE AREAS SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

RECHARGE AREAS

DAMES & MOORE

FIGURE 11

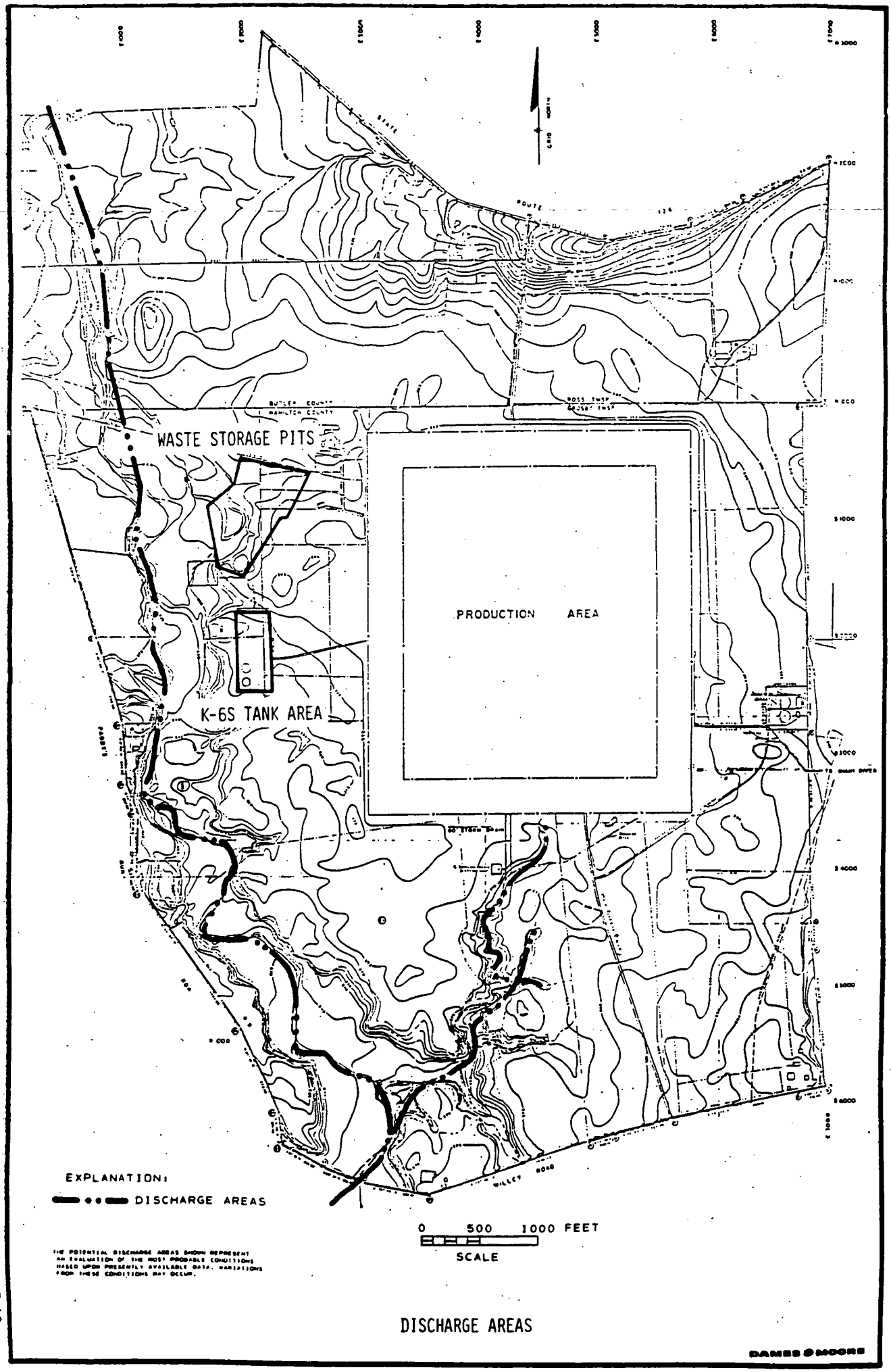
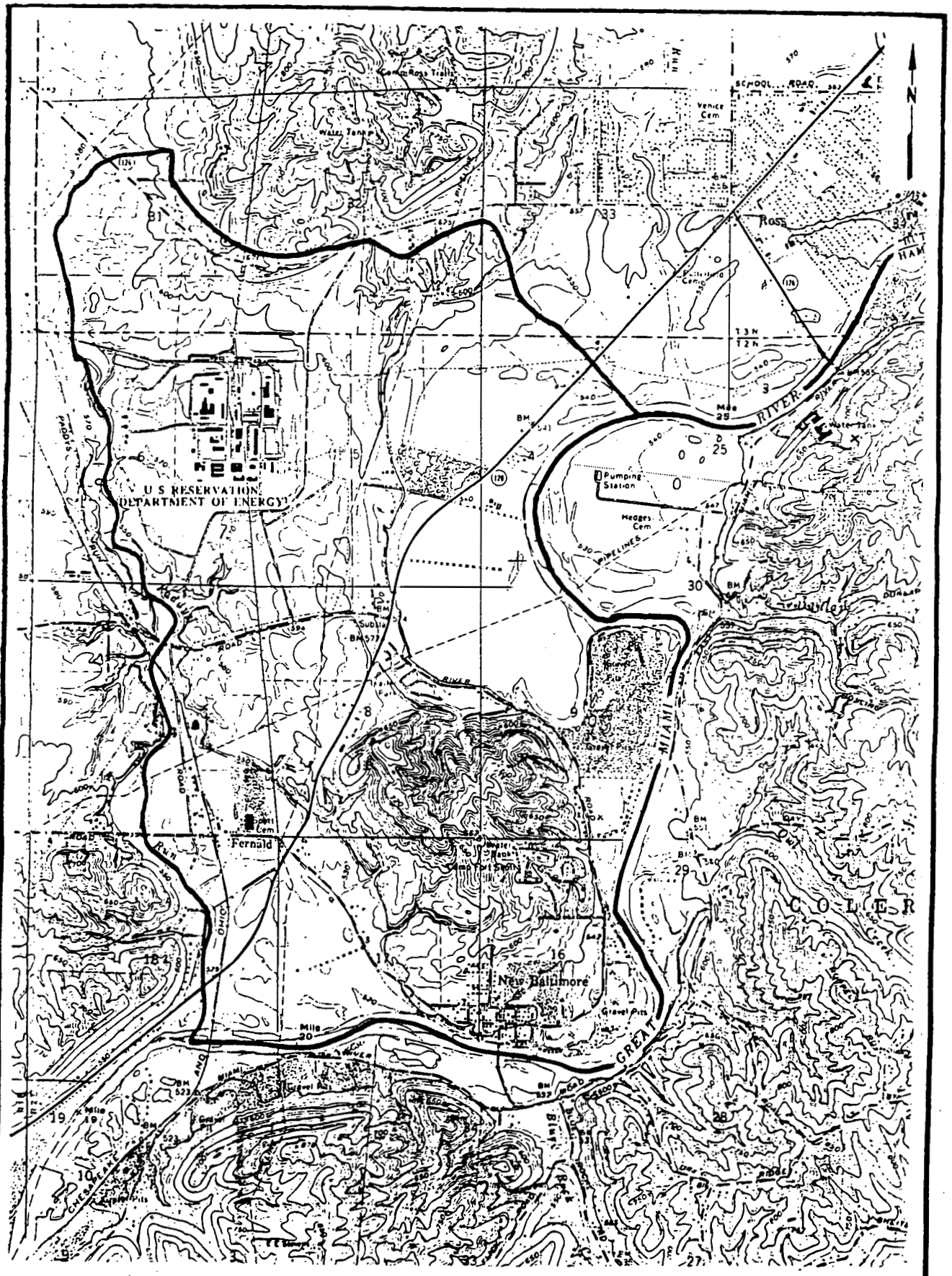


FIGURE 12

DISCHARGE AREAS



BOUNDARY CONDITIONS

THE BOUNDARIES SHOWN REPRESENT AN EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON THE INTERPRETATION OF PRESENTLY AVAILABLE DATA. VARIATIONS FROM THESE CONDITIONS MAY OCCUR.

DAMES & MOORE

FIGURE 13

APPENDIX 1

LIST OF DATA SOURCES

APPENDIX 1

LIST OF DATA SOURCES

1 ATEC Associates, Inc., 1982. Topographic Survey and Geotechnical Investigation. FMPC Water Pollution Control, Report dated October 5, 1982.

2 Battelle, 1981. Environmental Report of the Feed Materials Production Center, Final Report to NLO. Battelle, Columbus Laboratories.

3 Corps of Engineers, 1952. Report of Foundation Investigation, Feed Materials Production Center, Fernald, Ohio. Prepared by Ohio River Division Laboratories, Mariemont, Ohio.

4 Dames & Moore, 1983. Final Safety Analysis Report, FMPC Waste Storage Area, Prepared for the Health and Safety Division, NLO, Inc., FMPC, Fernald, Ohio.

5 Department of Energy, 1981. Site Map. Feed Materials Production Center, Fernald, Ohio.

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9 Johnson, 1980. Ground Water and Wells. Published by the Johnson Div., UOP, St. Paul, Minnesota.

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11 NLO, Inc., 1984. FMPC Soil and Grass Sampling Data, 1964 to 1969. Letter from R.M. Spenceley, Plant Manager to Mr. W.H. Travis, Director. Safety and Environmental Control Division, DOE, Oak Ridge Operations, dated February 19, 1984.

12 NLO, Inc., 1980-1984. Report to the Manager, Aquifer Contamination Control, Present Status. Reports prepared by R.B. Weidner.

13 NLO, Inc., 1983a. Bulletin No. 1 to Subcontract NO. S-1094, Background Information about the FMPC. Letter dated November 23, 1983 from Peter I. Campisi.

14 NLO, Inc., 1983b. FMPC Stack Losses, 1981-1983. Internal memo.

15 NLO, Inc., 1983c. Non-FMPC sources of radioactivity in Environmental samples, Item 2 in a letter from R.M. Spenceley, Plant Manager, to M.R. Theisen, Director, Weapons Division, Weapons Division, DOE, Oak Ridge Operations. Dated July 26, 1983.

16 NLO, Inc., 1983d. Request for Proposals No. S-1094, Groundwater Study at the FMPC and Vicinity, Health & Safety Division. Dated October 24, 1983.

17 NLO, Inc. 1979-1983. Waste Water Quality Report. NPDES Permit Parameters. Data Summary.

18 NLO, Inc., 1982, FMPC Emergency Plan, NLCO-1129. Special, Revision 2.

19 NLO, Inc., 1980. Authorization to Discharge Under the National Pollutant Discharge Elimination System. NPDES Permit, valid to February 1, 1985.

20 NLO, Inc., 1977a. FMPC Radioactive Waste Management Plan.

21 NLO, Inc., 1977b. Study of Radioactive Waste Storage Areas at the Feed Materials Production Center, National Lead of Ohio. Contract No. EY-76-C-05-1156.

22 NLO, Inc., 1959. Topographic Map Immediate Area, FMPC. Engineering Division Drawing #G-2014.

23 Nuclear Regulatory Commission, 1983. List of all Active/Inactive NRC Licenses, Office of Freedom of Information.

24 Ohio Environmental Protection Agency, 1977-1983, Water Quality Data Sheets. Samples Collected from private wells in the vicinity of the FMPC.

25 Plummer, Paul M., 1982. Ground Water Quality in the Hamilton-New Baltimore area. Ohio, an assessment through 1981, Published by the Water Conservation Subdistrict of the Miami Conservancy District.

26 Plummer, Paul M., 1982. Hydrologic Data for the Hamilton-New Baltimore Area. 1978-1981. Published by the Water Conservation subdistrict of the Miami Conservancy District.

27 Scalf, Marion R., McNabb, James F. Dunlap, Cosby, Roger L., Fryborgen, John, 1982. Manual of Ground Water Sampling Procedures, USEPA, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

28 Spieker, Andrew M., 1968. Ground Water Hydrology and Geology of the Lower Great Miami River Valley, Ohio, U.S. Geological Survey Professional Paper 605-A.

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30 NLO, Inc. 1984, Comments on Draft Task A Report, letter to Mr. R.E. Berlin (Dames & Moore) from M.W. Boback, Director, Health & Safety, NLO

31 Dames & Moore, 1968, Airborne Radioactive Emission Control Technology, Volume I, Prepared for the USEPA, Office of Radiation Programs, Washington, D.C., under Contract No. 68-01-4992.

APPENDIX 2

OHIO DEPARTMENT OF HEALTH OFF-SITE WATER QUALITY RESULTS

APPENDIX 2

OHIO DOH OFFSITE WATER QUALITY RESULTS

Well	Date	pH	Cl	NO_2	SO_4	Alpha	Beta
OS-20	9/80	--	313	0.91	181	--	--
	12/80	--	202	--	166	--	--
	4/82	--	--	--	--	<3	409.5
	5/82	7.0	70	<0.05	104	--	--
	9/82	6.5	48	--	96	<3	<4
OS-21	4/77	--	25	0	90	--	--
Paddy's Run	1/80	--	--	--	--	<1	<2
OS-22	4/77	--	--	0.05	--	--	--
S.W.O.W.C.**	10/56	7.3	7.5	1.04	52	--	--
Col. #2	11/56	7.4	11	0.44	50	--	--
	3/57	7.7	9.2	1.27	44	--	--
	6/58	7.4	9.0	1.71	59	--	--
	10/58	7.3	7.5	1.04	52	--	--
	2/59	7.2	8.0	1.17	51	--	--
	6/83	7.4	12	1.93	56	--	--
	1/65	7.4	16	1.17	64	--	--
OS-10	4/77	--	27	0.0	71	--	--
OS-14	4/73	7.7	16	0.01	98	--	--
OS-15	7/81	--	41	1.79	93	<1	<2
	11/81	--	--	--	--	86±7	31±5
OS-19	4/73	--	80	0.0	204	--	--
	3/81	--	224	0.06	94	--	--
	10/80	--	111	<0.05	110	--	--
	11/81	--	--	--	--	0±6	274±9
	4/82	7.0	147	0.05	98	6.7	170.6
OS-17	6/83	7.4	21	1.0	75	--	--
OS-18	5/78	--	41	0.05	115	--	--
	4/79	--	--	--	182	--	--
	4/80	--	29	0.17	98	--	--
	4/81	--	22	0.18	81	--	--
	10/81	--	98	<0.05	85	<5	99
	11/81	--	--	--	--	<3	99±6
	4/82	7.0	86	0.05	85	<3	61.3
OS-16	7/81	--	46	4.99	71	<1	39
	8/81	--	41	4.77	--	--	--
	9/81	--	--	4.84	--	<3	28
	10/81	--	--	--	--	<3	33
	11/81	--	--	4.67	--	<3	37

* See Figure 5 for locations. OS-20 through 22 not regularly sampled as part of FMPC monitoring program. Locations not shown on Figure 5.

** Southwest Ohio Water Company, Collector #2. - Figure 6.

APPENDIX 3

OTHER GROUNDWATER REPORTS REVIEWED

APPENDIX 3

OTHER GROUNDWATER REPORTS REVIEWED

1. Bernhagen, R.J.; Schaefer, E.J., 1947. Groundwater Conditions in Butler and Hamilton Counties, Ohio. Ohio Division of Water, Bul. 8.

2. Dove, George D.; Norris, Stanley E., 1951. Conditions Governing the Occurrence of Groundwater in the Fernald Area, Ohio, with Reference to the Possibilities of Contamination by Disposal of Chemical Wastes. U.S. Geological Survey - Ground Water Branch.

3. Evans, Kenneth F., 1977. Water Quality of the Glacial-Outwash Aquifer inteh Great Miami River Basin, Ohio. U.S. Geological Survey Open File Report, Water Resources Investigations 77-76, Columbus, Ohio.

4. Eye, J.D., 1961. A Report on the Groundwater Pollution Potential in the FMPC Operated By the National Lead Company of Ohio. Report to Dr. J.A. Quigley, M.D., from the University of Cincinnati, dated January 23, 1961.

5. _____, 1961. (b) Special Report on the Occurrences and Movement of Groundwater in the FMPC Area. Report to Dr. J.A. Quigley, M.D., from the University of Cincinnati, College of Engineering, dated June 28, 1961.

6. Fenneman, N.M., 1916. Geology of Cincinnati and Vicinity, Bulletin 19. Geological Survey of Ohio.

7. Hartsock, John K., 1960. Geologic Considerations of Waste Control at the Feed Materials Production Center, Fernald, Ohio. U.S. Atomic Energy Commission Report, dated February 15, 1960.

8. Klaer, F.J. Jr.; Thompson, D.G. 1948. Groundwater Resources of the Cincinnati Area, Butler and Hamilton Counties, Ohio. U.S. Geological Survey, WSP 999.

9. Spieker, Andrew M., 1968. Future Development of the Groundwater Resource in the Lower Great Miami River Valley, Ohio -- Problems and Alternative Solutions. U.S. Geological Survey Professional Paper 605-D.

10. Spieker, A.M., 1968. Groundwater Hydrology and Geology of the Lower Great Miami River Valley, Ohio. U.S. Geological Survey, Professional Paper 605-A.

11. _____, Norris, Stanley E., 1962. Groundwater Movement and Contamination at the AEC Feed Materials Production Center Located Near Fernald, Ohio. A Report Prepared by the U.S. Geological Survey for the U.S. Atomic Energy Commission dated September, 1962.

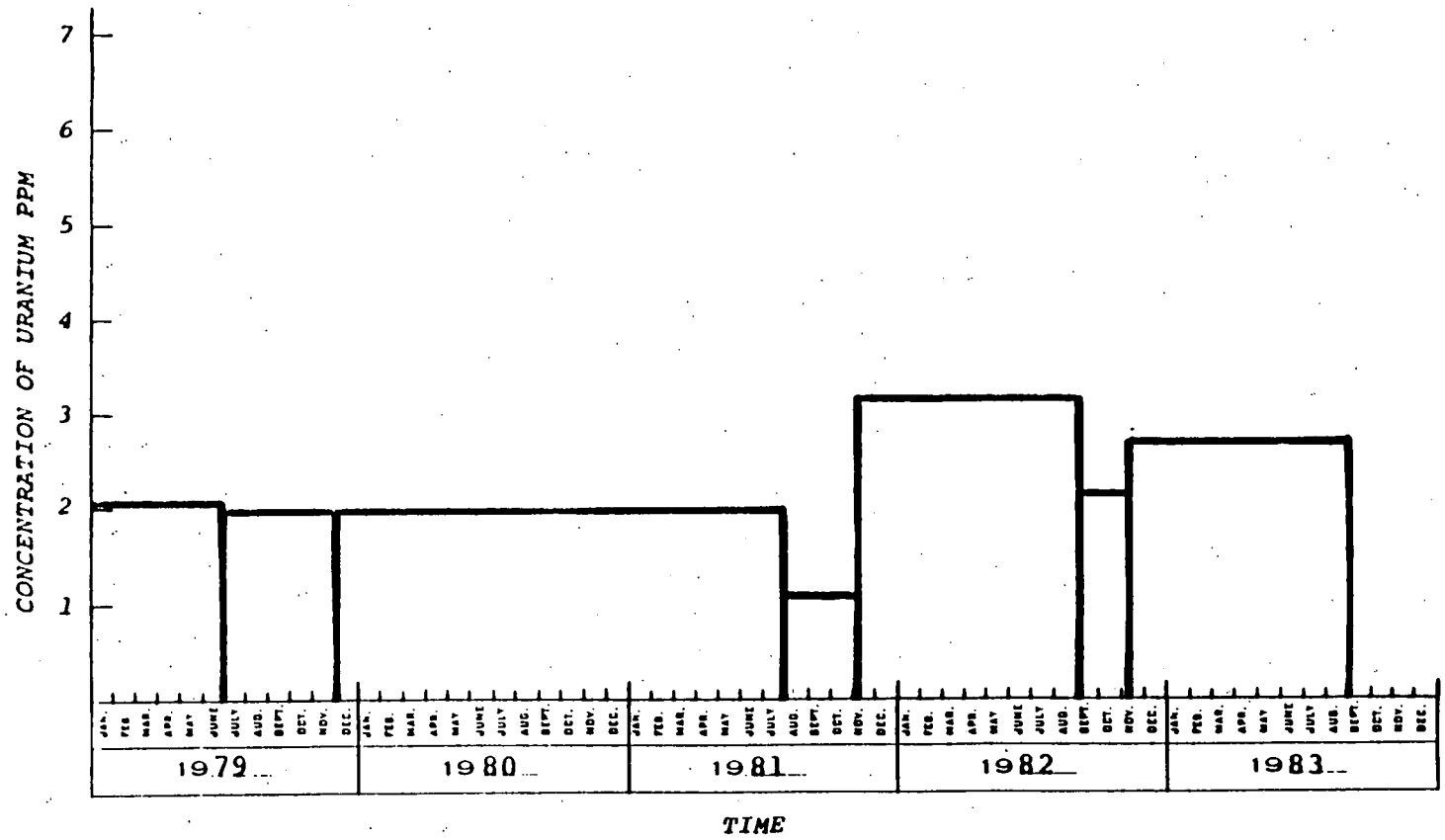
12. Starkey, R.H., Watson, C., Coates, R.C., Riestenberg, E.B., Robinson, J.W., 1962. Report of FMPC Ground Contamination Study Committee. A Report to the National Lead of Ohio Company, Cincinnati Ohio, dated September 30, 1962.

13. Theis, C.V., 1955. Visit to AEC's Fernald, Ohio Area, September 26, 1955. Memo from U.S. Geological Survey's Albuquerque, New Mexico office to Mr. Arthur E. Gorman, Sanitary Engineer, Division of Reactor Development, AEC, Washington, D.C. dated October 31, 1955.

14. Watkins, Joel S., Spieker, Andrew, M., 1964. Seismic Refraction Survey in the Great Miami River Valley and Vicinity, Montgomery, Warren, and Butler Counties, Ohio. U.S. Geological Survey Open-File Report, Prepared in Cooperation with the Ohio Division of Water and the Miami Conservancy District.

APPENDIX 4

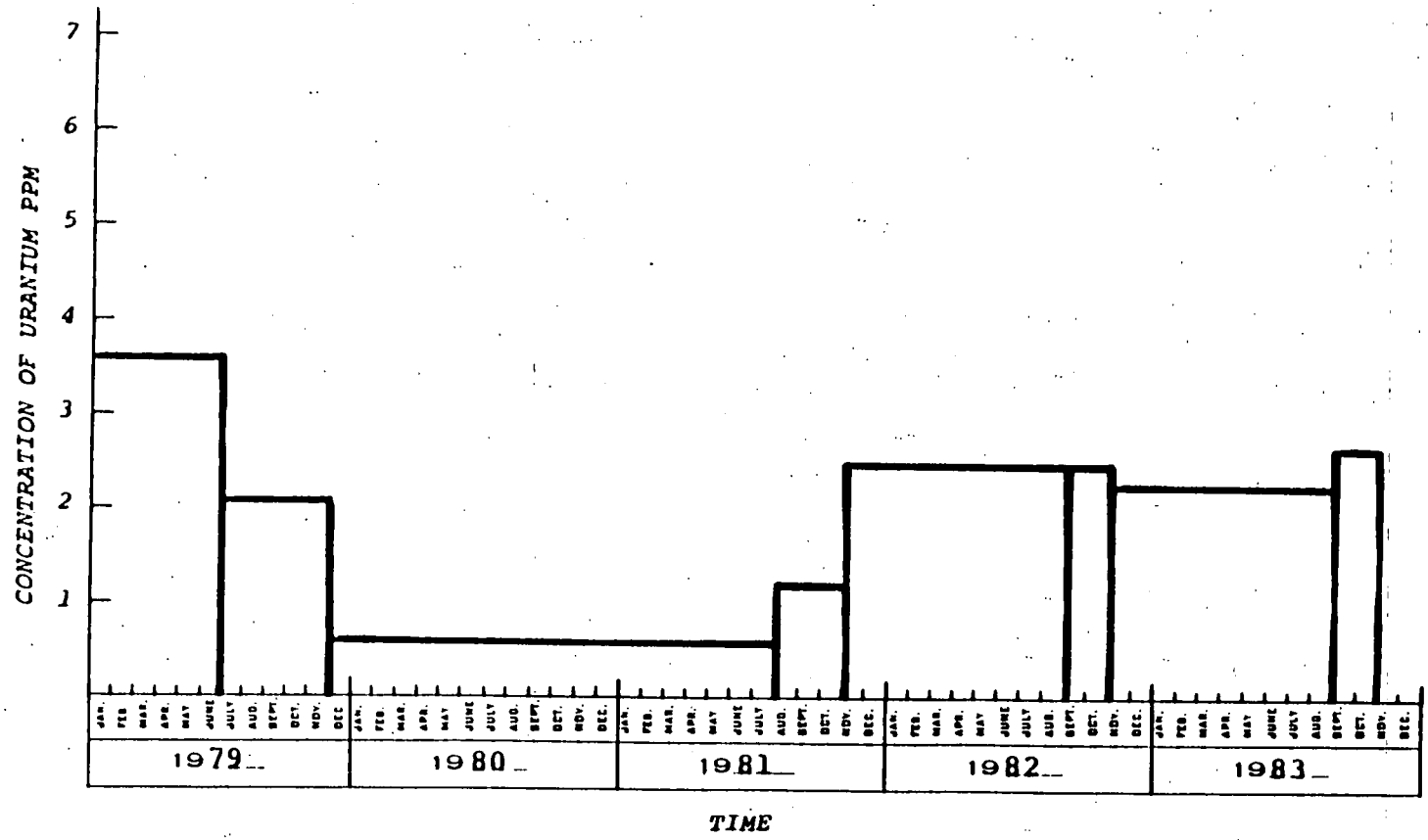
HISTOGRAPHS OF URANIUM CONCENTRATIONS IN STREAM SEDIMENT



RIVER MILE 27.8

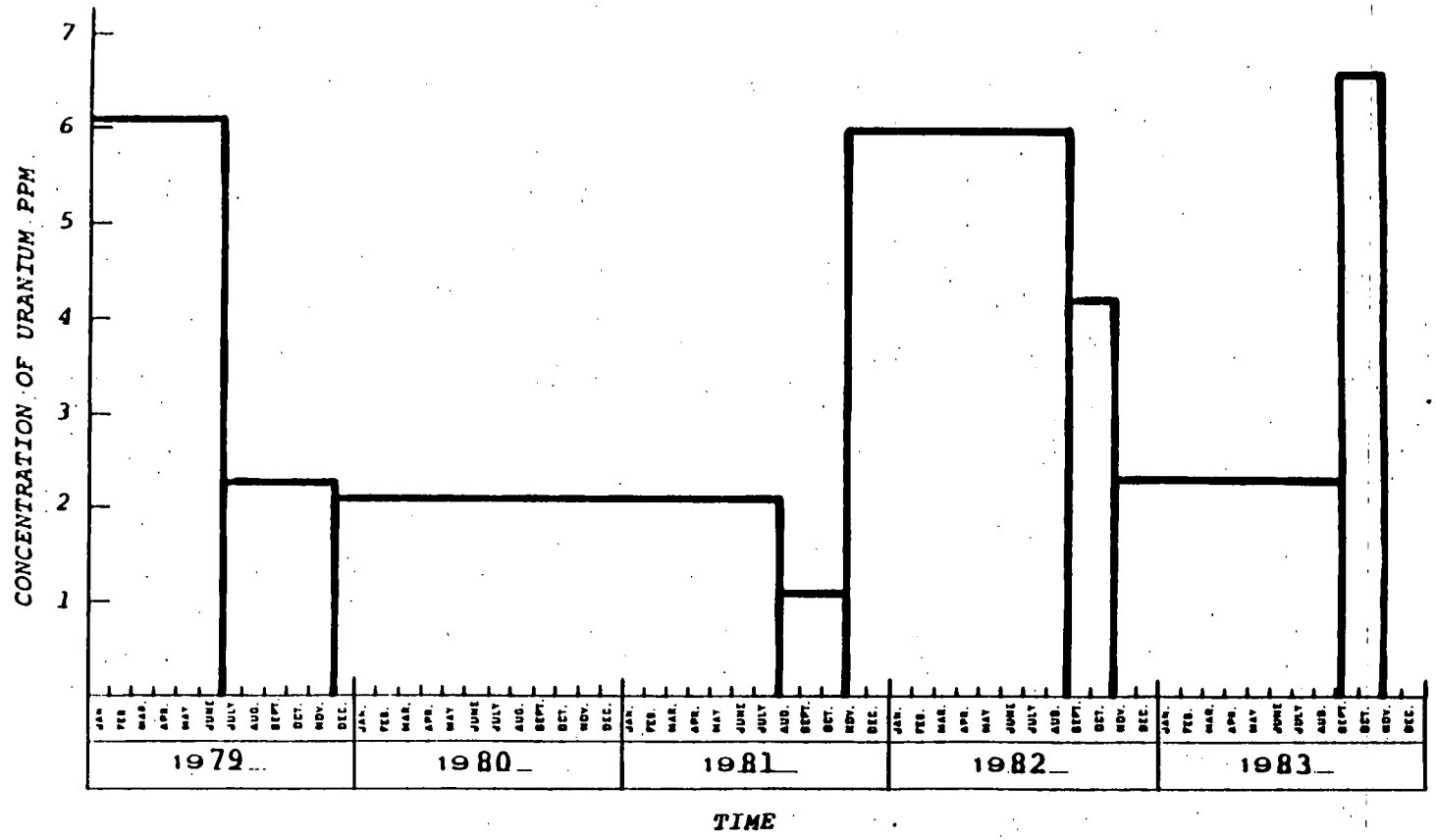
URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

DAMES & MOORE



RIVER MILE 25.6

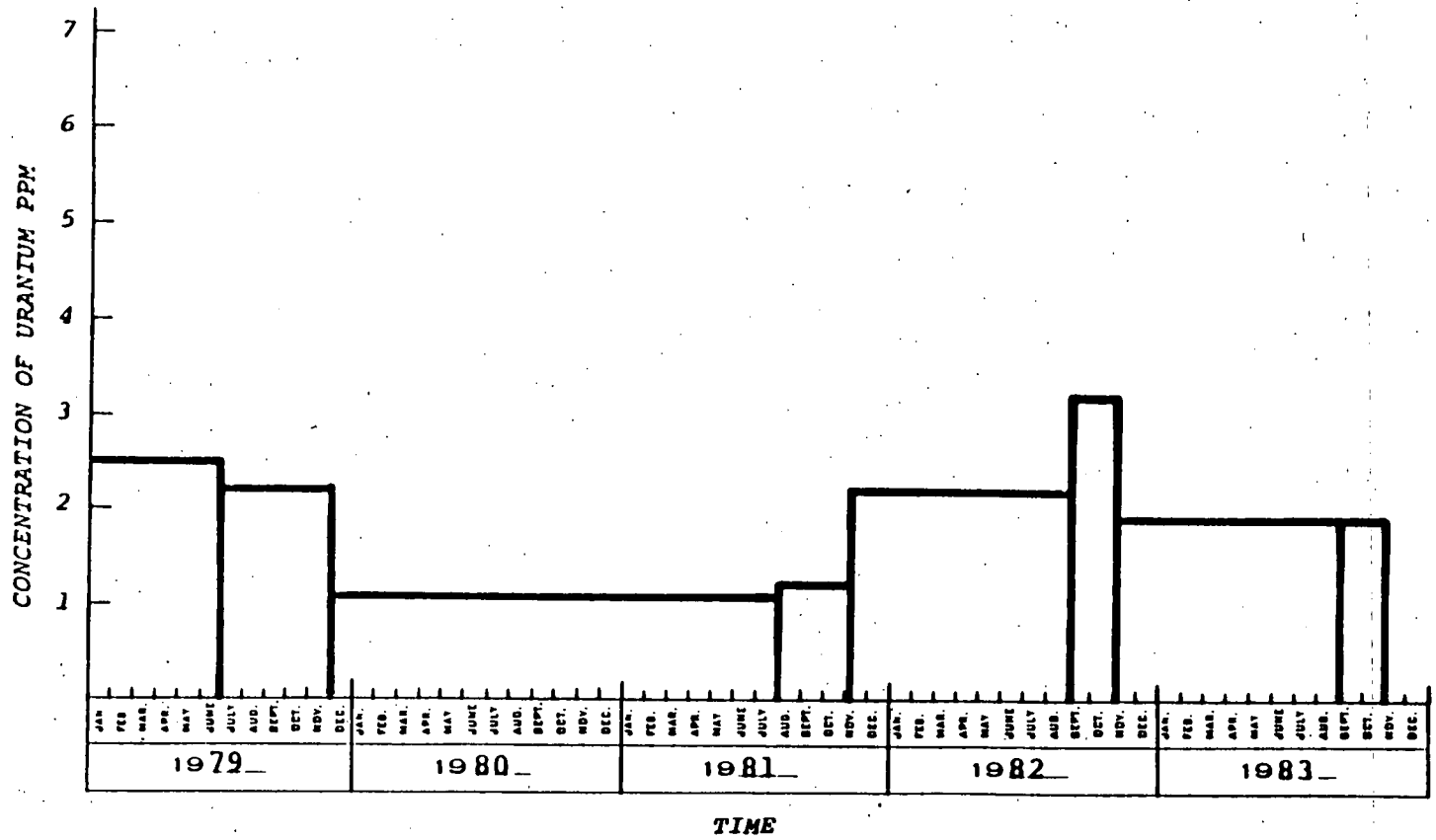
URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT



RIVER MILE 24.1

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

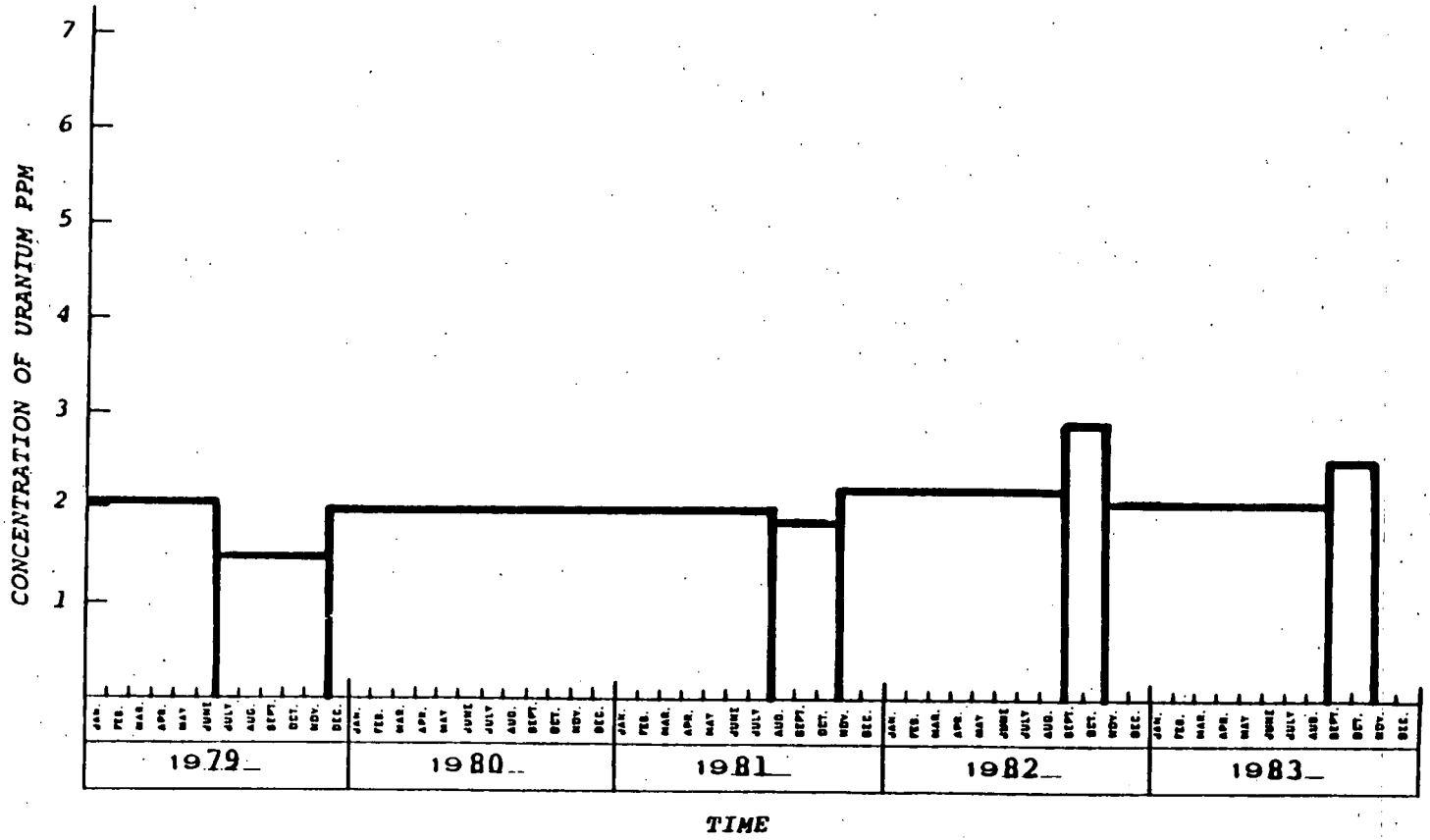
DAMES & MOORE



RIVER MILE 23.3

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

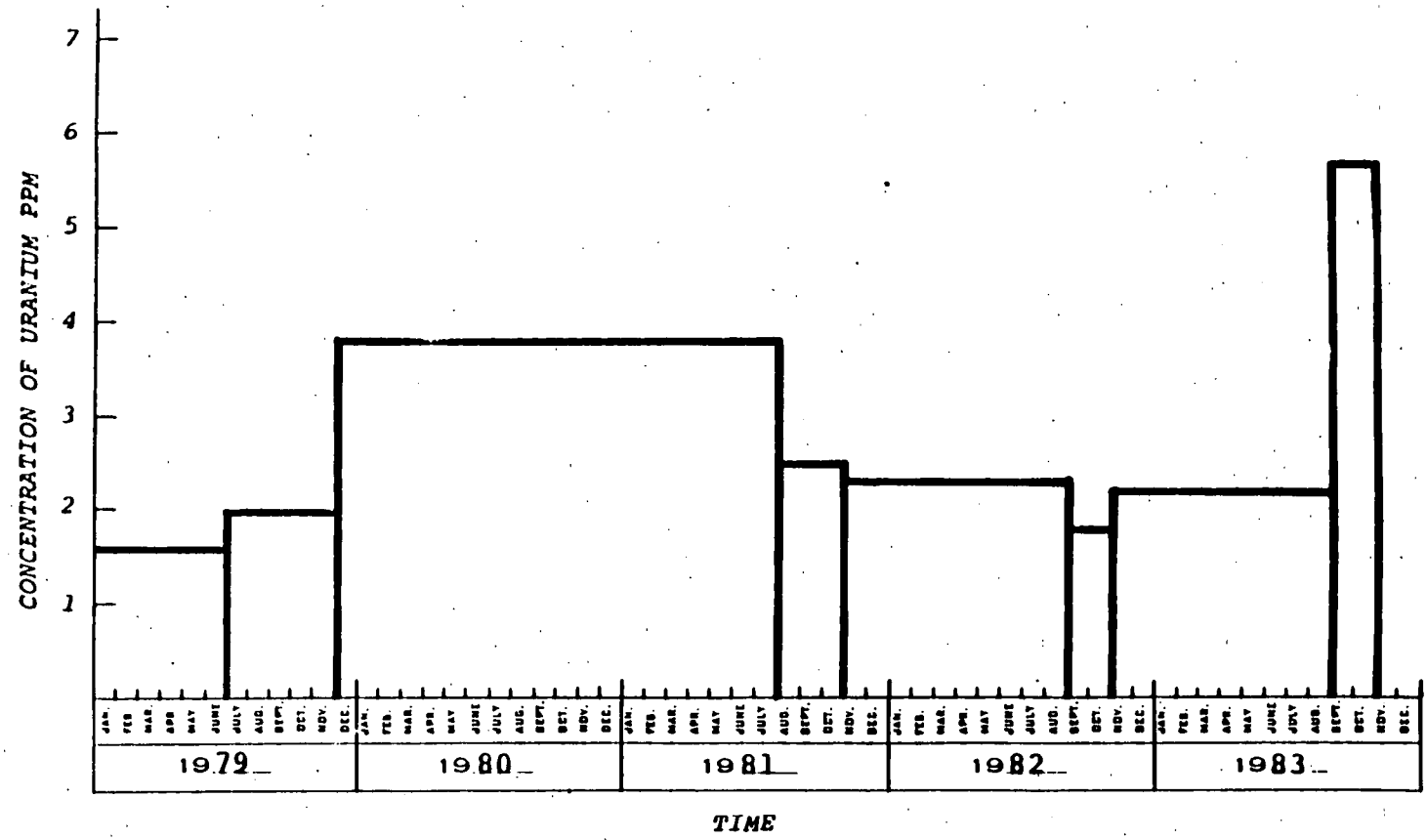
DAMES & MOORE



RIVER MILE 20.8

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

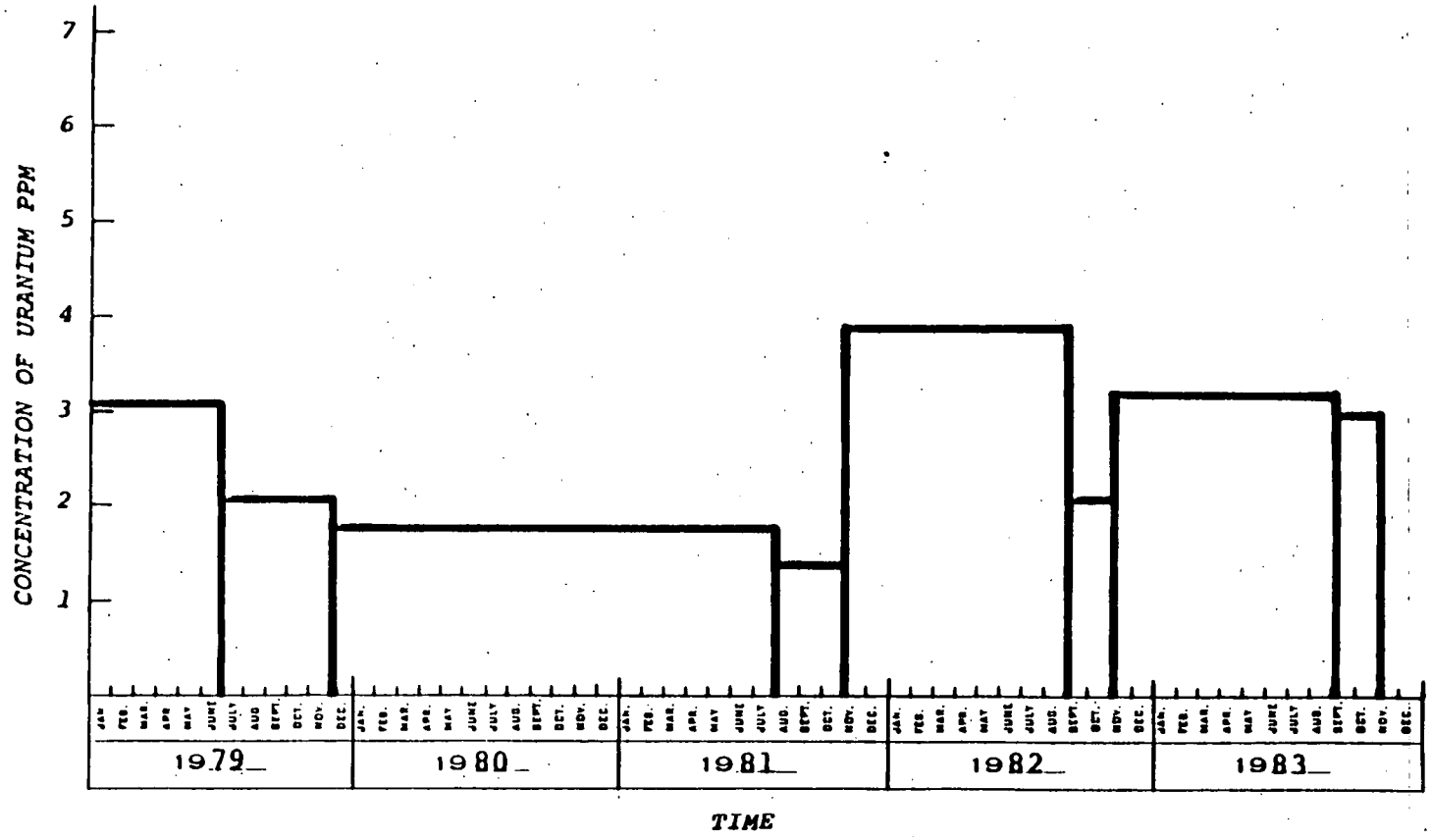
DAMES & MOORE



RIVER MILE 19.6

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

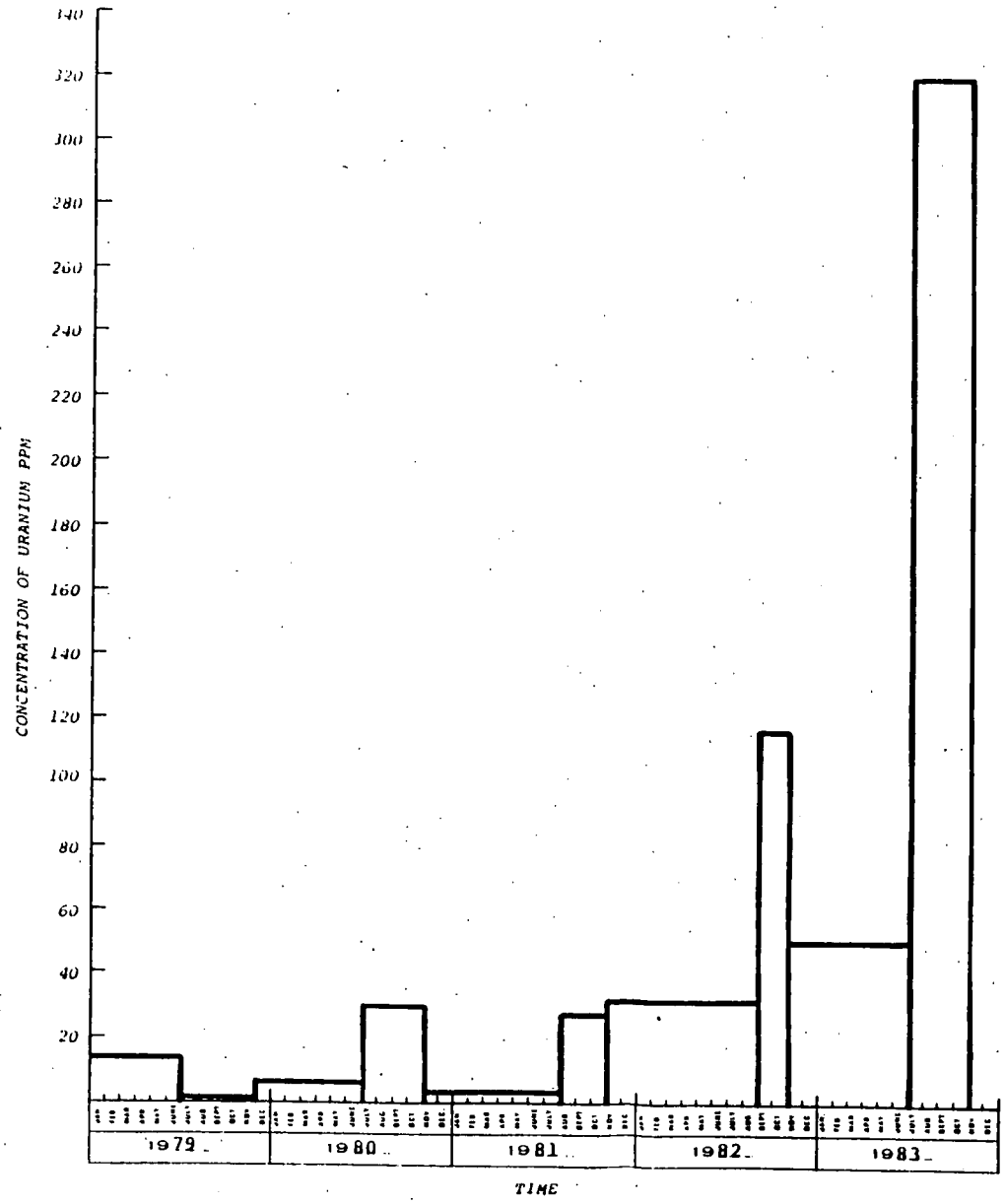
DAMES & MOORE



RIVER MILE 19.4

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
GREAT MIAMI RIVER SEDIMENT

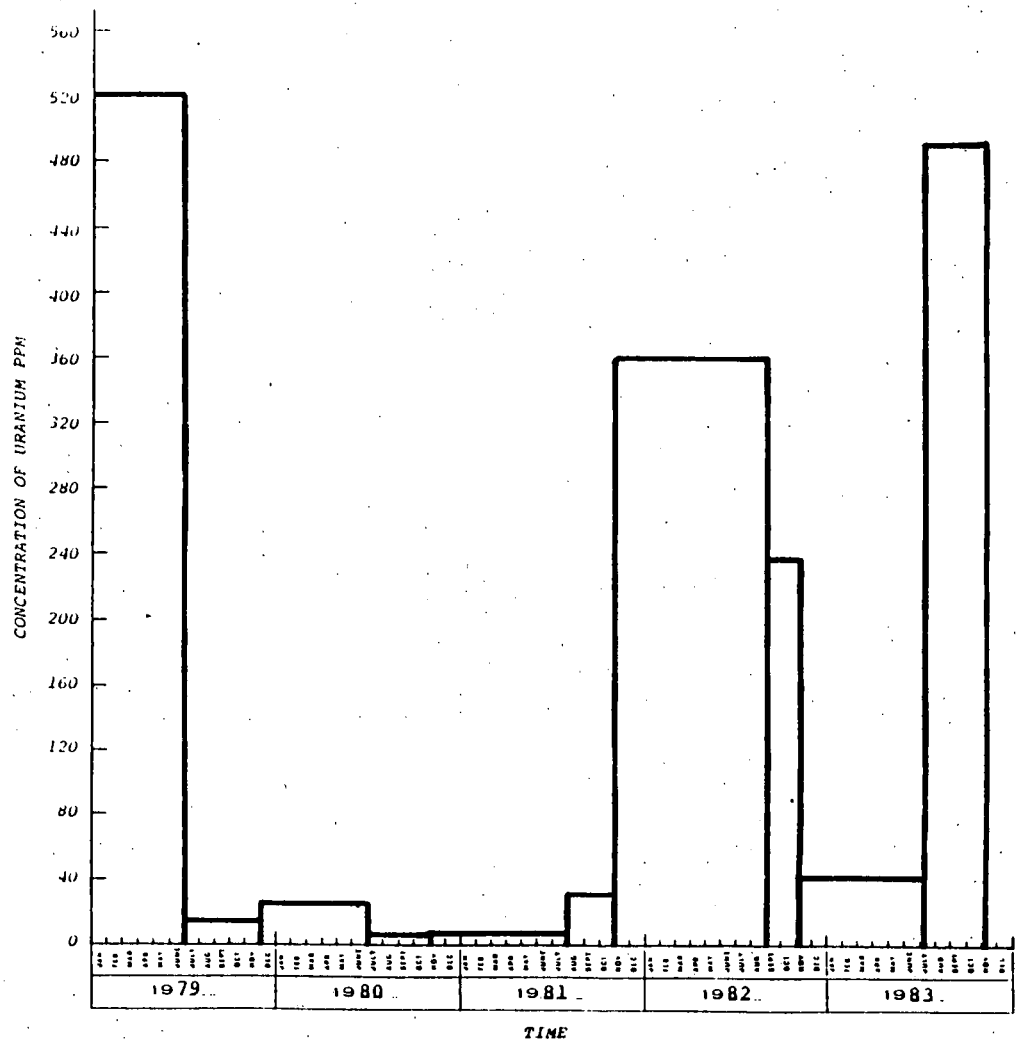
DAMES & MOORE



OFFSITE - WILLEY ROAD BRIDGE

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
PADDY'S RUN STREAM SEDIMENT

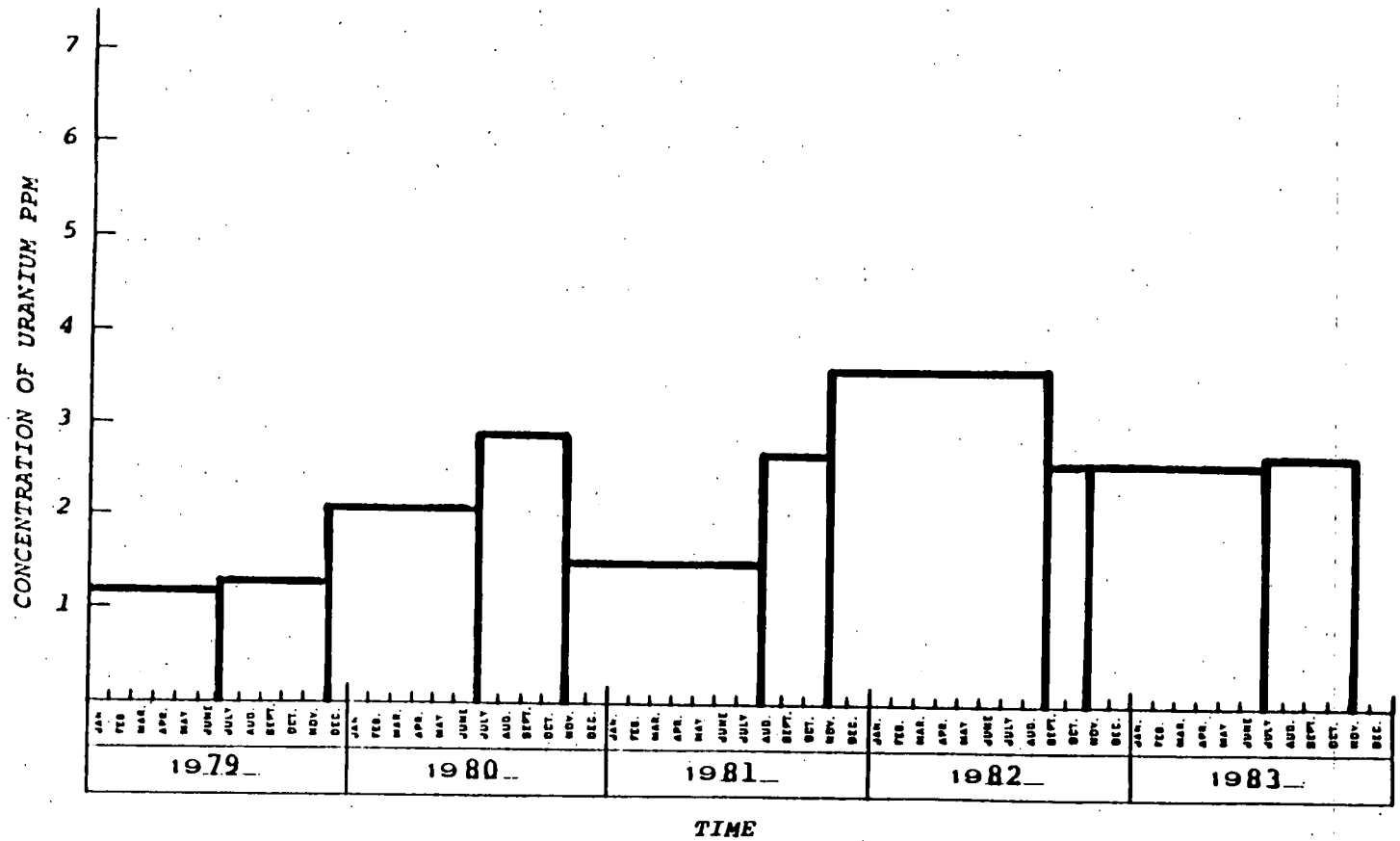
DAMES & MOORE



ONSITE - UPSTREAM OF OUTFALL DITCH

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
PADDY'S RUN STREAM SEDIMENT

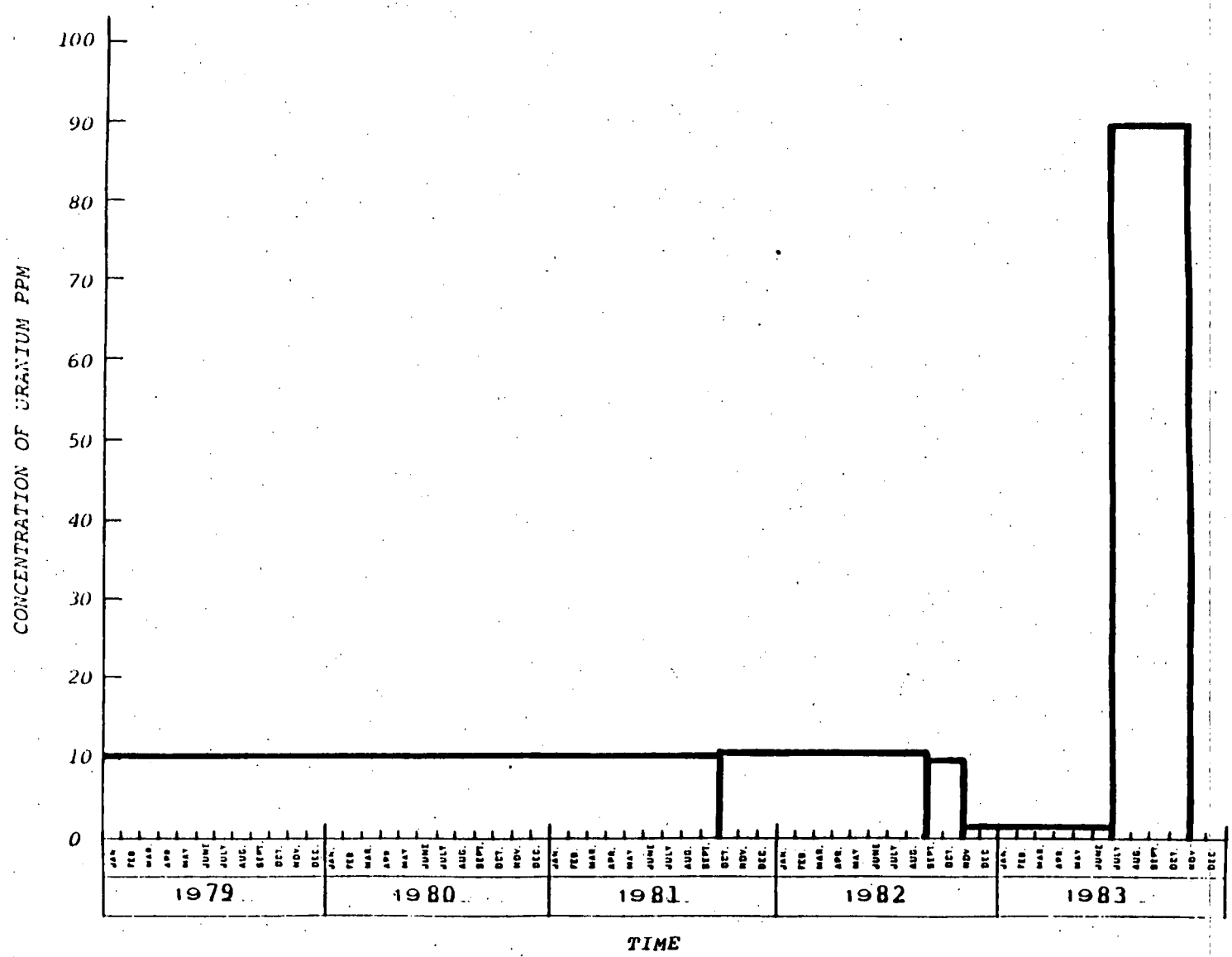
DAMES & MOORE



ONSITE - UPSTREAM OF RAILROAD BRIDGE

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
PADDY'S RUN STREAM SEDIMENT

DAMES & MOORE

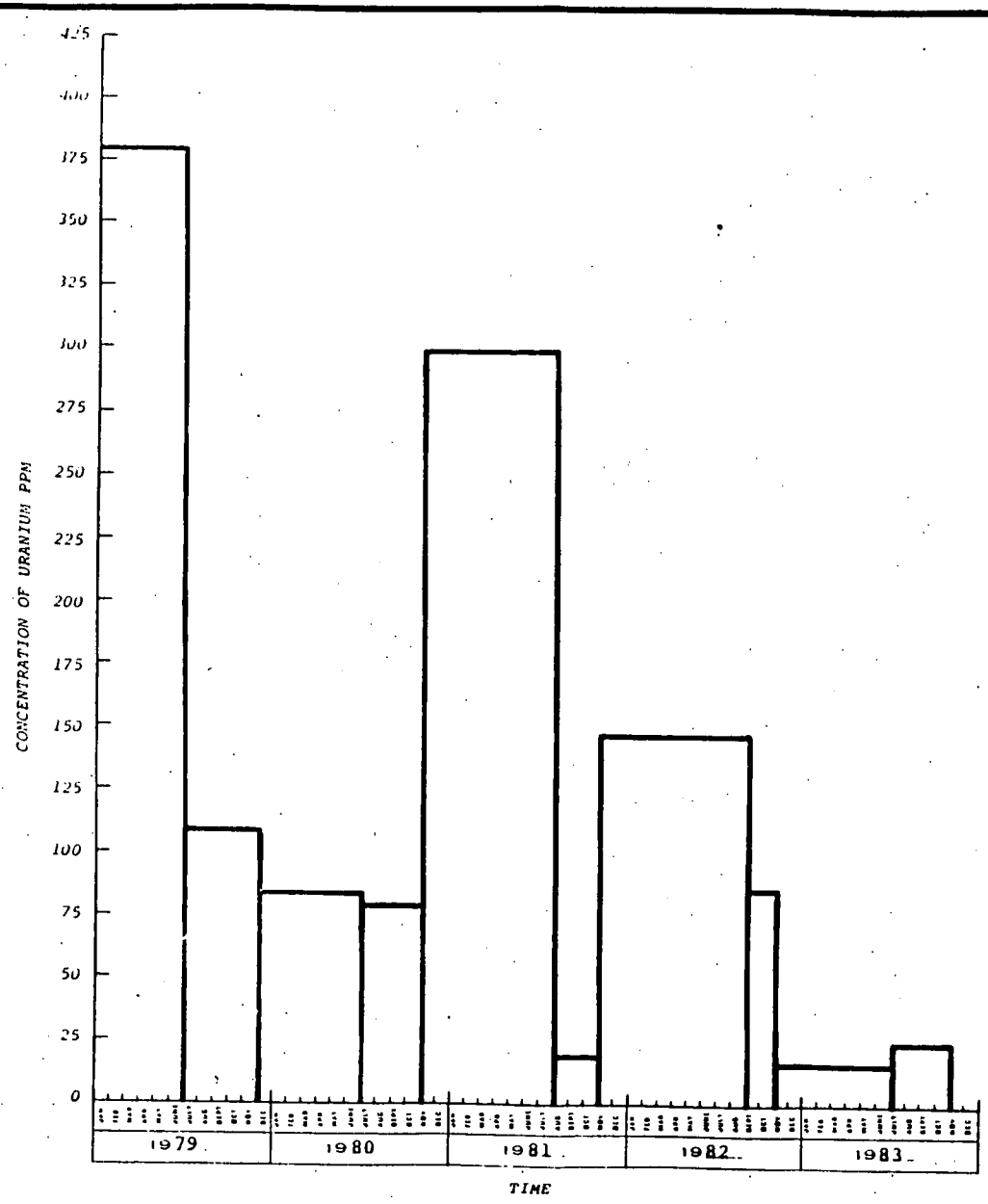


ONSITE - WEST OF TESTWELL #9

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM

PADDY'S RUN STREAM SEDIMENT

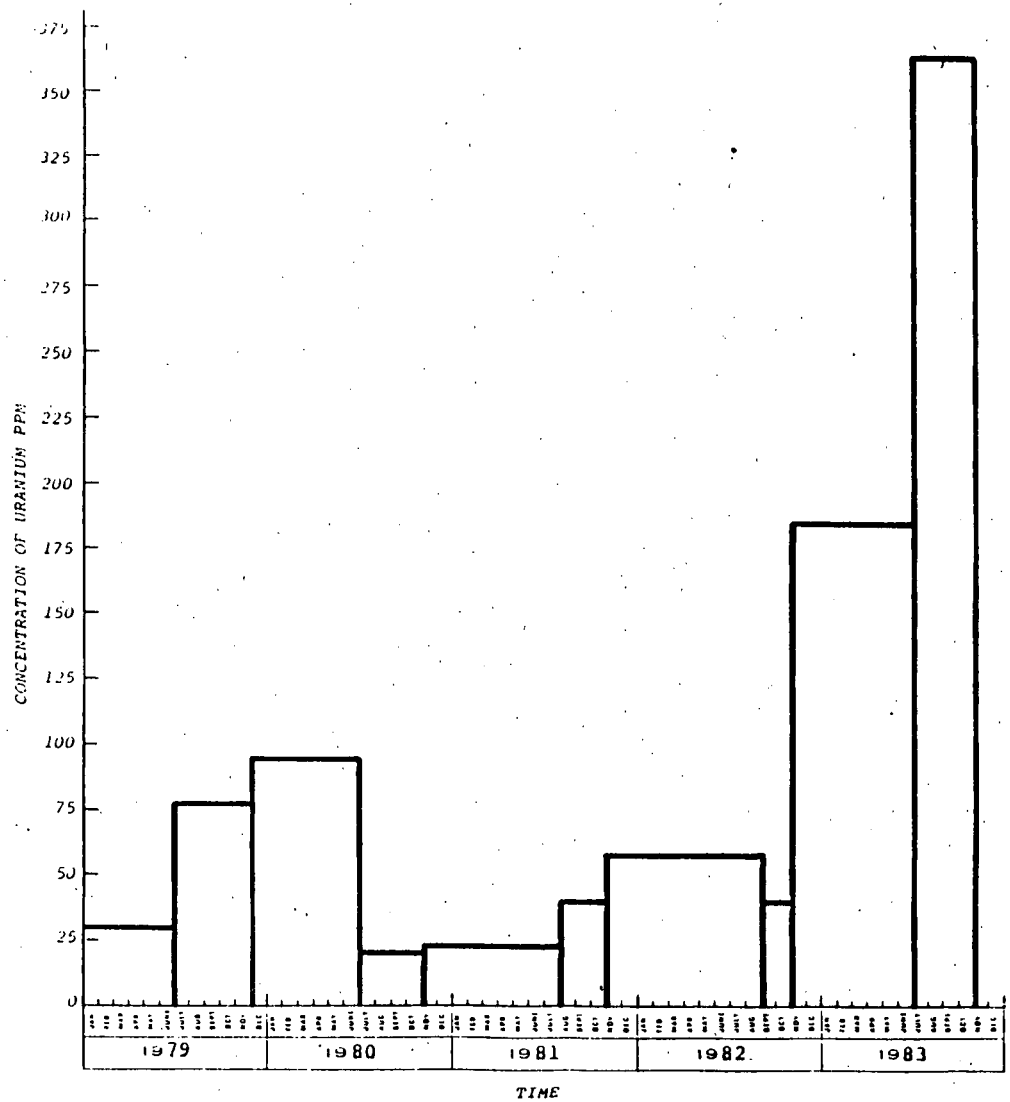
DAMES & MOORE



DOWNSTREAM - OUTFALL WELL

URANIUM CONCENTRATION
IN SEDIMENT SAMPLES PPM
STORM SEWER OUTFALL DITCH

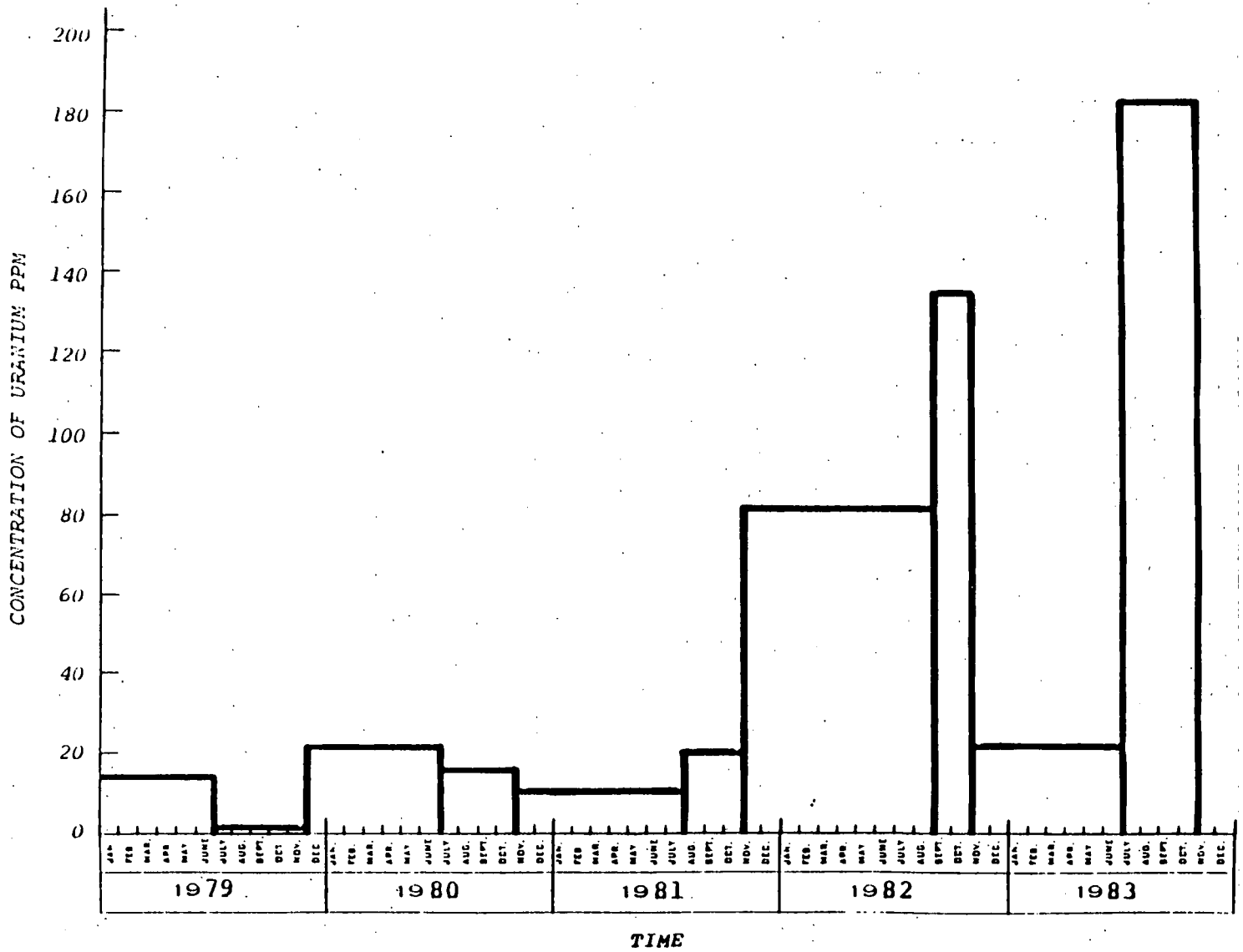
DAMES & MOORE



CONSTRUCTION ROAD CULVERT

URANIUM CONCENTRATION
IN SEDIMENT SAMPLES PPM
STORM SEWER OUTFALL DITCH

DAMES & MOORE



AT PADDY'S RUN

URANIUM CONCENTRATION IN SEDIMENT SAMPLES PPM
STORM SEWER OUTFALL DITCH

DAMES & MOORE

APPENDIX 5

ESTIMATE OF URANIUM QUANTITIES IN STREAM SEDIMENTS

APPENDIX 5

ESTIMATE OF URANIUM QUANTITIES IN STEAM SEDIMENTS

A5-1 Paddy Run Creek

o Between PR3 and PR4

Length of Reach	=	4,600 ft.
Average Width	=	4 ft.
Sampling Depth	=	0.08 ft.

Volume of sediment	=	1470 ft^3
Average concentration of Uranium in sediment*	=	11 ug/g
Average density of sediment	=	120 lbs/ft^3**

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of uranium potentially present

(1470 ft^3) (120 lbs/ft^3) (11 ug/g) (0.000001 g/ug) (0.45 kg/lb) = 0.9 kg (2.lbs)

o Between PR4 and PR2

Length of Reach	=	3,300 ft.
Average Width	=	6 ft.
Sampling Depth	=	0.08 ft.

Volume of sediment	=	1580 $ft.^3$
Average concentration of uranium in sediment*	=	61 ug/g
Average density of sediment	=	120 lbs/ft^3*

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of Uranium Potentially Present

(1580 ft^3) (120 lbs/ft^3) (61 ug/g) (0.000001 g/ug) (0.45 kg/lb) = 5.2 kg (11 lbs)

o Between PR2 and PR1

Length of Reach	=	550 ft.
Average Width	=	8 ft.
Sampling Depth	=	0.08 ft.

Weight of sediment	= 350 ft^3
Average concentration of uranium in sediment*	= 22 ug/g
Average density of sediment	= 120 lbs/ft^3*

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of uranium potentially present

(350 ft^3) (120 lbs/ft^3) (22 ug/g) (0.000001 g/ug) (0.45 kg/lb) = 0.4 kg (1 lbs)

Total uranium potentially present in the first inch of sediment in Paddy's Run = 6.5 kg (14 lbs).

* From Tables 6B and 6C.

** Soils Manual, 1961, The Asphalt Institute, Manual Series No. 10 (MS-10, pp. 55.

A5-2 Storm Sewer Outfall Ditch

o Between Outfall Weir and SS1

Length of Reach	= 10 ft.
Average Width	= 2 ft.
Sampling Depth	= 0.08 ft.

Volume of sediment	= 2 ft^3
Average concentration of uranium in sediment*	= 79 ug/g
Average density of sediment	= 120 lbs/ft^3**

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of uranium potentialy present

(2 ft^3) (12 lbs/ft^3) (79 ug/g) (0.000001 g/ug) (0.45 kg/lbs) = <0.001 kg (<0.002 lbs)

o Between SS1 and SS2

Length of Reach	= 1,700 ft.
Average Width	= 4 ft.
Sampling Depth	= 0.08 ft.

Volume of sediment	= 540 ft^3
Average concentration of uranium in sediment*	= 60 ug/g
Average density of sediment	= 120 lbs/ft^3*

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of uranium potentially present

(540 ft^3) (120 lbs/ft^3) (60 ug/g) (0.000001 g/ug) (0.45 kg/lbs) = 1.7 kg (3.7 lbs)

o Between SS2 and SS3 (Paddy's Run)

Length of Reach	= 960 ft.
Average Width	= 4 ft.
Sampling Depth	= 0.08 ft.

Volume of Sediment	= 310 ft^3
Average concentration of uranium in sediment*	= 24 ug/g
Average density of sediment	= 120 lbs/ft^3**

(Weight of sediment) (Average concentration of uranium in sediment) = Quantity of uranium potentially present

(310 ft^3) (120 lbs/ft^3) (24 ug/g) (0.000001 g/ug) (0.45 kg/lbs) = 0.4 kg (0.1 lbs).

Total uranium potentially present in the first inch of soil in the Storm Sewer Outfall Ditch = 2.1 kg (5 lbs)

APPENDIX 6

LITERATURE REVIEW FOR NATURAL SOURCES OF URANIUM

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LITERATURE REVIEW FOR NATURAL SOURCES OF URANIUM

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APPENDIX 7

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APPENDIX 8

VOLUME ESTIMATE OF SCRAP METAL

AND FLYASH PILES-CALCULATIONS

APPENDIX 8

CALCULATIONS

Mixed Scrap Metal Pile

A. Volume

(30')(150')(30')
450,000 ft^3

B. Concentration

- o No analysis available.
- o Health and Safety Division estimates that there are less than several hundred pounds of uranium present in the pile.

  Based on volume present, the estimated total weight of uranium in the pile (150 lbs.) and an assumed density of 150 lbs/ft^3. The average concentration =

$$\frac{150 \text{lbs.}}{(450{,}000\ ft^3)\ (150\ lbs/ft^3)} \times \frac{X}{1{,}000{,}000\ ppm}$$

= 2.2 ppm

C. Estimated Quantity

- o Health and Safety personnel assume that pile contains less than several hundred pounds of uranium.

Active Fly Ash Pile

A. Volume =

(300 ft)(300 ft)(10 ft)

900,000 ft^3

B. Concentration

- o Core sample taken and analyzed from pile yielded a uranium concentration of 10 ppm.

C. Estimated Quantity

- o Based on an average density of 100 lbs/ft^3, total uranium content =

$$\frac{X\ lbs}{(900{,}000\ ft^3)\ (100\ lbs/ft^3)} = \frac{10ppm}{1{,}000{,}000\ ppm}$$

= 900 lbs. (408 kg)

Covered Fly Ash Pile

A. Volume

(300 ft)(150 ft)(30 ft)

1,350,000 ft^3

B. Concentration

- o Assumed to be the same as that of Active Pile (10 ppm). No other information available.

C. Estimated Quantity

- o Based on an average density of 100lbs/ft^3. Total uranium content =

$$\frac{X \text{ lbs}}{(1{,}350{,}000 \text{ ft}^3)\ (100 \text{ lbs/ft}^2)} = \frac{10 \text{ ppm}}{1{,}000{,}000 \text{ ppm}}$$

= 1350 lbs (612 kg)