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PHASE I REPORT
GEOHYDROLOGIC SURVEY OF KPW
EASTMAN KODAK COMPANY
KODAK PARK DIVISION
ROCHESTER, NEW YORK

[redacted]

EO-1
CR-1
SR-2

Dames & Moore
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May 6, 1980

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Attn: Mr. J.R. Brown
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Phase I Report
Geohydrologic Survey of KPW
Eastman Kodak Company
Kodak Park Division
Rochester, New York
11364-DE-L009

Gentlemen:

We are pleased to submit herewith twelve copies of our "Phase I Report, Geohydrologic Survey of KPW, Eastman Kodak Company, Kodak Park Division, Rochester, N.Y.". This study was authorized by Kodak Purchase Order 41-LTO-14484W. The scope of work was outlined in our proposal of January 5, 1979.

This report presents a discussion of geologic and hydrologic conditions in and around the 65-acre KPW site. The study utilized a minimal field program supplemented by the extensive test boring and well data from Kodak Park files to develop a preliminary understanding of site geohydrology.

As a result of this Phase I study, at least two aquifers have been identified at the site: an upper, unconfined aquifer composed of lacustrine soils (primarily silty and clayey sands) and overlying fill; and a slightly lower bedrock, confined aquifer composed of weathered and fractured Medina sandstone. The two aquifers are separated by a discontinuous layer of dense glacial till.

Based on present data, the two aquifers exhibit differing transmissibilities, flow directions, and flow rates. It appears that the upper aquifer transmits a greater quantity of groundwater than the lower aquifer but that water in the lower aquifer may move more rapidly. In order to further refine the present preliminary understanding of site geohydrologic conditions, additional test borings and well installations are recommended.

We are pleased to have served Eastman Kodak on this interesting project. If any questions arise concerning the contents of this report, please contact us.

Very truly yours,

DAMES & MOORE

Dane A. Horna

Dane A. Horna, P.E.
Principal in Charge

DAH/ls

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 GENERAL

This report presents the Phase I portion of our geohydrologic investigation of the KPW area of Kodak Park in Rochester, New York. The KPW sector is an approximately 65-acre area primarily devoted to the manufacture, storage, recovery, and use of synthetic organic and inorganic chemicals. KPW is bordered on the north by commercial and residential properties established to the north of Ridge Road. To the south, Rand Street forms the barrier between KPW and local residential properties. The east and west borders are flanked by other Kodak Park operations, KPE and KPX, respectively.

The bulk chemicals that Kodak utilizes are purchased and/or manufactured in batches and subsequently stored in both surface and subsurface tanks. There are more than one hundred 10,000- to 20,000-gallon holding tanks buried within KPW. Most of the chemicals stored in these tanks exhibit some degree of solubility in water, although a few are considered insoluble. By the nature of the operations within KPW, the area is considered to have a potential for spills. Some discharges are known to have occurred while numerous others are suspected owing to the age and condition of some of the facilities. A tank replacement program is currently underway in which old tanks are being removed and replaced by new structures of improved design providing for secondary containment*.

*"Design Guide, Drainline and Storage Tank Secondary Containment Systems", prepared by Dames & Moore, Nov. 1978.

1.2 OBJECTIVES OF STUDY

In recognition of the potential for spills, Kodak Park representatives expressed concern for: (1) the operational safety of facilities and personnel within KPW; and (2) the potential for contamination beyond the limits of Kodak Park. Since the migration of any spilled material is largely governed by site groundwater hydrologic conditions, effective control of hazardous chemicals strongly depends upon an understanding of the subsurface flow system. Thus, the overall objective of the study was to develop an understanding of the groundwater system within and around KPW which could be used to guide an investigation of any current contaminant spill or "predict" the migration of a potential release.

To satisfy the study objectives, the KPW investigation has been subdivided into three work phases with each phase consisting of a series of discrete tasks. The first phase which is the subject of this report consisted of an investigation of the regional geohydrology in the KPW area.

As currently planned, the second phase of the overall study would be directed towards a more detailed evaluation of the groundwater characteristics within KPW including evaluations of groundwater quality. The third phase of work would include some mathematical modeling designed to evaluate the potential migration of accidental chemical discharges.

2.0 PHASE I INVESTIGATIVE APPROACH

This initial study phase utilized available gèologic and hydrologic data coupled with a minimum field investigation to formulate an understanding of how geohydrologic conditions within KPW might fit the regional framework. The scope of activities performed in each of the principal tasks which make up Phase I is detailed below.

2.1 TASK 1 - REVIEW OF EXISTING DATA

Task 1 involved the accumulation, review and synthesis of available geologic and hydrologic information. These data included information from Dames & Moore files relative to previous investigations within Kodak Park as well as other published and unpublished literature. Information was obtained from such sources as the U.S. Geological Survey, the State of New York, Monroe County, the City of Rochester and the extensive files of Kodak Park. Client confidentiality was maintained in all contacts outside of Kodak Park. We also performed a brief site reconnaissance of KPW and examined selected bedrock core samples collected from borings completed in the area by others.

Through these initial efforts we were able to develop a tentative picture of regional geohydrology including such site characteristics as identification of principal groundwater aquifers and estimation of groundwater flow direction. The results of Task 1 were presented verbally to Kodak Park representatives along with recommendations regarding the scope of activities for Task 2.

2.2 TASK 2 - FIELD INVESTIGATIONS

Having developed a general picture of the regional geohydrologic regime from the literature and existing data base, it was deemed necessary to seek additional site specific information in order to fit the KPW area into the regional picture. Accordingly, three pairs of borings/wells (wells 201, 202 and 204*) were drilled. General target areas for these boring clusters were selected within KPW based on the results of the Task 1 study. Final boring locations were chosen in conjunction with Kodak personnel in order to limit disruptions of Kodak Park operations. The final locations for each of these boring sites are shown on the Site Plot Plan, Figure 2.

During the drilling of the borings, representative undisturbed and disturbed samples were obtained from each principal soil layer. Where bedrock was encountered, core samples of the bedrock were obtained to evaluate the rock types and degree of fracturing.

At each boring site two wells were installed in separate aquifers to provide an opportunity to evaluate the piezometric head and hydraulic characteristics of each aquifer. The deep well at each drill site simply consisted of four-inch ID

*A single boring was completed at drill site 203 but not developed into a test well.

stainless steel casing grouted into the surface of relatively sound bedrock. In a nearby (within 10 feet) separate drill hole, another well utilizing four-inch ID stainless steel screen was installed to encounter any shallower groundwater aquifers. Installation procedures and development techniques are described in the appendix. Schematic illustrations of each completed well are presented on Figures 3, 4, and 6. In addition, one boring (203) was begun approximately 200 feet from well 204 but was abandoned when an oily substance was encountered during drilling. The log of this boring is shown as Figure 5.

After each of the wells was developed, in situ permeability tests were performed. Rising head and falling head permeability tests were run to evaluate the average coefficient of permeability for each of the two principal aquifers. The results of these permeability tests are discussed in Section 3.2.3.2.

2.3 TASK 3 - ANALYSIS OF DATA

The results of the field testing conducted during Task 2 were evaluated during this task. The groundwater level measurements made during our field investigation, as well as some additional readings taken subsequently by Kodak Park personnel, are presented in Table 1. These measurements in conjunction with selected data from borings drilled previously by others were then utilized to prepare groundwater level contour maps. One map was drawn for each of the two aquifers.

These maps were, in turn, utilized to examine the directions of groundwater flow.

Estimates of transmissibilities, permeabilities and flow velocities were calculated, based on the results of the in situ permeability tests performed during Task 2. Recommendations regarding additional investigative efforts and areas of study were formulated based on the results of these Task 3 analyses.

3.0 GEOHYDROLOGIC CHARACTERISTICS

3.1 REGIONAL HYDROLOGY

The bedrock of the Kodak Park area is composed of relatively flat lying sedimentary rocks deposited during the Paleozoic Era. These rocks strike roughly east-west and dip towards the south at a rate of 40 to 60 feet per mile. This southerly dip of the bedrock combined with a northerly dip in the ground surface topography, results in a sequence of younger rocks being exposed as one travels southward. These bedrock characteristics produce an overlapping shingle-like appearance in cross section. Thus, any one bedrock unit exists at an increasing depth below the surface towards the south.

The Genesee River, located to the east of Kodak Park, has carved a postglacial gorge near Maplewood Park in Rochester. Within this gorge, an excellent section of rocks from upper Ordovician (Queenston Shales) to Middle Silurian (Rochester Shales) are exposed. Overlying the bedrock throughout the area are unconsolidated deposits of glacial age. These deposits commonly referred to as "glacial drift", consist of debris or rock rubbish brought down by the ice sheet from the north and scattered over the area (Leggette et al, 1935).

Ridge Road, which runs east-west across Monroe County and also forms the northern boundary for the KPW area, is constructed along a heavy wave-built gravel "ridge" which nearly encircles the Lake Ontario Basin. This gravel ridge was formed by wave work of rising water during the life of glacial Lake Iroquois, a predecessor to the present Lake Ontario. To the north of the ridge, finer sediments (lacustrine deposits) were deposited in deeper water further offshore in Lake Iroquois. This blanket of finer material combined with the erosional effect of the glacial waters results in a relatively smooth surface dipping gently to the north.

The surface area to the south of Ridge Road was also inundated by a glacial lake (Lake Dawson). This glacial lake, which was developed before Lake Iroquois, existed for a relatively short period of time when compared to the life of Lake Iroquois. Consequently, the topography south of the Lake Iroquois shoreline more nearly reflects the original glacial topography with only minor alterations by wave action. Relatively thin lacustrine deposits are also characteristic. Localized pockets of sands and gravels from Lake Dawson beach ridges form a parallel line at an elevation approximately 50 feet above the Lake Iroquois shoreline. The bedrock surface underlying this area is generally separated from these beach deposits by a veneer of glacial till. In some areas, however, this dense till was eroded before the buildup of any lacustrine deposits from either Lake Iroquois or Lake Dawson.

Surface drainage throughout the region is generally from south to north directly via small creeks that drain the glacial lake plain or indirectly via the Genesee River. Most surface streams which drain the glacial lake plain are quite small with many originating from or draining into small swampy areas.

The Niagara Escarpment, which is formed by the resistant rocks of the Lockport Dolomite, bisects the region south of KPW from east to west. This feature results in both a groundwater divide and a bedrock surface divide. To the north of the Lockport Group of rocks, the groundwater surface and bedrock surface dip gently to the north (Figure 7). To the south of this divide however, a more southerly and easterly component of dip is characteristic of both the bedrock and groundwater surface. As a result, groundwater movement south of the Niagara Escarpment is generally towards the east or south flowing into the Genesee River.

3.2 <u>SITE GEOHYDROLOGIC CHARACTERISTICS</u>

3.2.1 GENERAL

The KPW area has undergone extensive development in the form of surface grading, placement of fill material and construction of numerous buildings, roads and parking lots. Consequently, the original surface topography has been altered to the extent that it is no longer recognizable. This extensive surface development has had the effect of reducing rainfall infiltration into the soils and therein limiting the recharge of underlying aquifers. Runoff is collected and transported offsite via industrial sewers (combined) and several separate storm water drains. The present ground surface across the site slopes gently (1.8%) towards the southeast.

Much of the fill material that was added to the KPW area consists of relatively coarse sands and gravels mixed with loose organic material (vegetation), cinders and building rubble. Early topographic maps indicate a small stream flowing from east to west within the southern portion of the site (Figure 8). This old stream channel may still serve as a water flow route for at least some surface infiltrate. Additionally, construction of storm water drainlines and industrial sewers have, no doubt, altered the near surface flow characteristics considerably. Many of these sewer lines have been installed below the bedrock surface utilizing relatively deep open cuts backfilled with relatively loose permeable material.

3.2.2 STRATIGRAPHY

General subsurface data indicate a sequence of deposits consisting of miscellaneous fill, lacustrine deposits (sands, silts and clays) and glacial till over sandstone bedrock. Test boring results available for many locations within KPW indicate the following stratigraphic sequence from top to bottom:

FORMATION	AGE	THICKNESS
Fill	Recent	8 - 10 feet
Lacustrine deposits	Recent	0 - 4 feet
Glacial till	Pleistocene	1 - 12 feet
Grimsby Formation	Silurian	55 feet

The overlying fill material shows considerable variation in composition with depth and in lateral extent across the site. This fill generally consists of yellowish-brown to black organic silt with fine to medium sand and occasional fine gravel. Cinders and fly ash are prevalent throughout the fill sequence along with building rubble. Wood fragments are occasionally encountered near the base of the fill close to the original ground surface.

Underlying the fill in most borings is a dark gray to brown fine to medium sand with occasional pockets of brown fine sand. These sands were apparently deposited in a shallow water environment, and generally grade coarser with depth. Boring 202, drilled as part of the Task 2 investigation, does not conform to the idealized profile in that the sand unit is absent with fill directly overlying a thin veneer of glacial till.

The glacial till underlying KPW consists of dense gray to reddish-brown silty fine sand with a trace of clay. Occasional cobble- and boulder-size fragments of the underlying bedrock are encountered in the lower portions of this unit. This till is relatively thin (1 1/2 to 2 ft) in boring 202 but as thick as 12 feet elsewhere. Field and laboratory permeability tests performed for a previous Dames & Moore investigation* in Kodak Park yielded measured and estimated

*"Design Guide for Drainline and Storage Tank Secondary Containment Systems", Dames & Moore, November, 1978.

permeabilty values of 1×10^{-5} to 1×10^{-6} cm/sec (3×10^{-2} to 3×10^{-3} ft/day) for the glacial till.

The bedrock which directly underlies the glacial till consists of horizontally bedded reddish-brown and gray mottled fine- to medium-grained sandstone. Occasional shale and silt partings have been noted throughout. These rocks, deposited in late Silurian times, are a part of the Grimsby Formation of the Medina Group. The sandstone is very well cemented and consequently exhibits a very low primary porosity. The upper portions of the bedrock are weathered and contain numerous fractures. One boring (204B) encountered a small void space about a half-foot thick near the rock surface. Fracture frequencies were noted to decrease and rock quality designation (RQD) values to increase with depth in all borings.

3.2.3 AQUIFER DESCRIPTION

3.2.3.1 General

The results from the Task 2 boring program tend to confirm the early hypothesis that at least two groundwater aquifers exist at the site. An upper aquifer, composed of the lacustrine soils and overlying fill material, is apparently separated from a lower bedrock aquifer by a dense glacial till layer. The upper aquifer is phreatic (unconfined) whereas the lower aquifer is artesian (confined).

The bedrock aquifer is formed in a well-cemented sandstone which has a very low primary permeability. Groundwater movement is largely controlled by the secondary or fracture permeability of the rock. The uppermost layers of the bedrock are most highly fractured with fracture frequency and fracture size decreasing with depth, as shown on the boring logs (Figures 3, 4, and 6).

3.2.3.2 Transmissibility and Permeability

The physical characteristics of each aquifer were estimated by means of variable head permeability tests conducted at each drill location. Water was evacuated from the bedrock wells by means of air lifting. The rates of recovery of the water levels in the casings were then monitored. For the shallow overburden aquifers (except in well 201C), the method was reversed. These wells were first filled with clean water and the rates of water level decline were observed. Semi-logarithmic plots of water head ratios vs time were utilized for both types of tests to estimate the basic time lag factor for each aquifer. These plots are shown as Figures 10, 11, and 12, for well pairs 201, 202, and 204, respectively.

These data provide a means for estimating the average horizontal permeability of subsurface materials which exist along the intake (or outflow) segment of each well. The horizontal permeability (K_h) can be calculated from the following equations:

(soil aquifer)

$$K_h = \frac{d^2 \ln \left(\frac{2mL}{D}\right)}{8x \; L \; X \; T} \qquad \text{for } \frac{mL}{D} > 4 \text{ ; and}$$

(bedrock aquifer)

$$K_h = \frac{d^2 \ln\left(\frac{4mL}{D}\right)}{8 \times L \times T} \qquad \text{for } \frac{2mL}{D} > 4$$

where

d = inside diameter of riser pipe.

m = transformation ratio. (assumed to be unity)

L = length of intake section.

D = inside diameter of intake.

T = basic time lag.

(Cedergren, H.R., 1977)

These computations yielded permeability values of 1.3×10^{-5} to 1.8×10^{-4} cm/sec for the rock and 7.3×10^{-5} to 3.1×10^{-4} cm/sec for the shallow aquifer (see Table 2).

In wells 202C and 204B, falling head permeability tests were performed in the soil aquifer whereas in well 201C a rising head permeability test was run. A comparison of these test results (Table 2) indicates that the permeabilities calculated for wells 202C and 204B are very similar while the value for well 201C is lower by approximately a factor of three. The apparent disparity between the two test methods may be attributable to the segment of well screen which extends above the current groundwater level. In the falling head tests, water flows from the well screen through a small upper unsaturated soil zone above the water table as well as through the larger saturated zone below. Conversely, in the rising head test, water flows into the well only through the saturated zone. Thus, the unsaturated flow in the falling head test represents "leakage error". Since this leakage is not taken into account in the equations, the effect is to produce higher than actual permeabilities from falling head tests (i.e., well 202C and 204B). In addition, rising head tests occasionally underestimate permeability because soil fines migrate from the soil mass into the well filter and thereby act to inhibit groundwater flow into the well.

A comparison of these test results with data in the literature for similar soils (i.e. fine sand and silt mixtures) indicates that the results are generally consistent with published permeability values for lacustrine silty sands (Terzaghi & Peck, 1967, pg. 381).

Permeability computations calculated for the bedrock in wells 201A and 202A differ by a factor of two (2.6×10^{-5} and 1.3×10^{-5} cm/sec, respectively). The results, however, from well 204A yielded a permeability value (1.8×10^{-4} cm/sec) nearly one order of magnitude higher. This range in local permeability values for the rock is believed to reflect the degree of fracturing observed in each boring. Also, the drilling of boring 204A encountered a 1/2 foot void. The variation in bedrock permeabilities shown by these three tests is at least that which can be expected across the KPW site. Consequently, based on present data, a "probable average value" for the permeability of the bedrock aquifer is estimated to be on the order of 4.0×10^{-5} cm/sec (0.11 ft/day). Local variations in bedrock fracturing could provide for bedrock permeabilities significantly higher or lower than this "average" value.

The transmissibility factor (T) of an aquifer represents the capability of that aquifer to transmit water. It is numerically represented as the product of the coefficient of permeability and the saturated thickness of the aquifer. The transmissibility calculations for the bedrock included in this report utilize aquifer thicknesses equal to the total length of rock cored in each boring. Thus, it has been presumed that any rock fracturing present below the cored depth is insignificant. If present, these deep fractures would contribute to the total aquifer transmissibility, and cause the reported estimates of transmissibility to be low.

Transmissibilities have been calculated for each of the tests conducted in both the soil and rock aquifers. The results of these calculations, as summarized on Table 2, indicate that the transmissibilities calculated for shallow aquifer wells 201C, 202C, and 204B are very similar (1.36, 1.76 and 1.50 ft^2/day, respectively). At drill sites 201 and 202, the transmissibiliites calculated for the soil aquifer are higher than those calculated for the bedrock aquifer. This relationship is reversed, however, at drill site 204 where the transmissibility of the rock is five times that of the soil. This high transmissibility value calculated for well 204A within the bedrock aquifer may again reflect the local fracture conditions of the bedrock. However, the estimated transmissibilities for both the bedrock and soil aquifers would suggest that overall, the soil aquifer is capable of transmitting more water than the bedrock aquifer.

3.2.3.3 Groundwater Flow Regime

The groundwater flow system which would most directly affect the migration of spilled chemicals is characterized by two aquifers, a shallow soil aquifer and a deeper bedrock aquifer. The dense till of relatively low permeability which stratigraphically separates these two aquifers is fairly thin over most of this site. Kodak Park construction records indicate that in places the till has been excavated for the placement of buildings, sewers, etc. In other areas, natural erosion may have produced discontinuitites in this layer. Consequently, the hydraulic separation of the two aquifers is probably incomplete.

At each drill site one well was screened only across the soil aquifer while a second well tapped the underlying bedrock. By constructing pairs of wells in this manner, it was possible to obtain piezometric levels and thereby estimate hydraulic gradients in both the vertical and horizontal directions. A summary of the water level data is presented in Table 1.

At the three observation points, the potentiometric surface is higher in the soil aquifer by 1.2 to 4.2 feet than in the underlying bedrock. This characteristic indicates that a downward hydraulic gradient exists. Because of this downward hydraulic gradient, water in the upper aquifer has a downward flow component into the underlying bedrock aquifer as well as a horizontal component.

Groundwater level contour maps were drawn for both the shallow and the bedrock aquifers (Figures 8 and 9). The data utilized to prepare these contour maps include groundwater levels collected from a variety of borings drilled for other investigations in the vicinity. These borings were drilled over a period of years by several contractors employing different drilling techniques. Most borings were not drilled for the purpose of investigating groundwater conditions. Thus, in order to utilize these data for developing groundwater level contour maps, considerable judgement was required in assessing the applicability of individual measurements. The distribution of data points across KPW was also non-uniform.

In that groundwater flow is generally normal to potentiometric contour lines, examination of the contour map for the shallow soil aquifer (Figure 8) indicates that the general pattern of groundwater flow is not unidirectional. The groundwater flow direction north of the old streambed underlying KPW appears to be generally to the northeast, while the groundwater south of the old stream channel flows primarily to the south. Localized construction activity combined with the placement of the main trunk sewer system along the southern border of KPW may have resulted in local perturbations in the regional groundwater flow direction.

Groundwater flow directions for the bedrock aquifer are depicted on Figure 9. From this contour map it can be seen that the general flow direction is from the northwest to the southeast. Because few borings in the KPW have penetrated bedrock, this contour map was drawn with considerably less data than were utilized for construction of the soil aquifer contour map.

An approximate velocity component for the groundwater flow (V_A) can be estimated from Darcy's Law by the expression:

$$V_A = \frac{KI}{a}$$

where

K = coefficient of permeability

I = hydraulic gradient

a = porosity

Based on the types of soils encountered in the shallow aquifer, a porosity value of 30 percent was estimated. A hydraulic gradient for the groundwater flow can be estimated from the contour maps. Figure 6 would suggest that an average hydraulic gradient of 0.05 exists for flows south of the old streambed and a gradient of 0.025 can be applied to flows north of the old streambed. From the limited data available, the flow velocity to the south towards Rand Street from the area south of the old streambed is estimated to be approximately 0.1 ft/day whereas flow to the northeast would be about one-half this value.

A similar exercise can be performed to estimate horizontal flow velocities in the bedrock. However, because of the expected small percentage of void spaces in the rock as represented by the fractures, the effective groundwater velocity in the rock fractures is probably higher than the velocity in the pore spaces of the overlying soil aquifer. For the purpose of this exercise, an effective fracture porosity of 1 percent was assumed together with the "probable average permeability" of 0.11 feet/day and a hydraulic gradient of 0.025. This combination of values results in an estimated effective groundwater velocity in the bedrock of approximately 0.3 feet/day.

Although this effective flow velocity appears relatively fast (compared to the groundwater velocity in the overlying alluvial aquifer), it is the quantity of water flowing through the bedrock which may be of more significance. To compute this quantity, the following expresssion was utilized:

$$Q = IT \times w$$

where

Q = flow rate

I = hydraulic gradient

T = transmissibility

w = width of flow section (example: w = 2000 ft = length of south and southeast boundaries of KPW)

This calculation yields a groundwater flow of approximately 300 gal/day through the bedrock away from KPW. For the soil aquifer, the comparable groundwater flow rate toward the south is on the order of 1100 gal/day.

The flow velocity and quantity calculations presented above are based on rather limited data. These calculations are only presented to indicate the comparative relationships* between the flow characteristics of the soil aquifer and the bedrock aquifer. Although relatively small quantities of groundwater may be moving through the bedrock aquifer as compared to the soil aquifer, the water in the bedrock may move more quickly. In light of the fact that the shallow aquifer has a downward groundwater flow component toward the bedrock in addition to a horizontal flow component, this difference in aquifer flow rate will become important in tracing the movement of any spilled contaminant. Hypothetically, a water soluble pollutant may enter the soil aquifer and travel laterally and downward at one velocity, then flow at a faster pace and in a different direction if and when it enters the bedrock aquifer.

*For example, inspection of Figure 8 indicates that southward flow gradients within the soil aquifer vary locally by more than an order of magnitude. Thus, the flow rates presented here do not represent estimates of actual flow conditions but are valid for comparison.

4.0 RECOMMENDATIONS

The estimates of groundwater flow directions and flow rates that were presented above are based heavily on the observations and testing at only three drill sites. Before a final assessment of the groundwater flow system is made, we recommend that a refinement of the available information be made through additional exploration. Presently, we have identified several areas from which additional information would greatly enhance the current understanding of groundwater flow within KPW.

Based on the available data, it appears that the hydraulic gradients for both the soil and bedrock aquifers increase for flows south of the old streambed. Also, the flow direction for both of these aquifers is to the south and east within the area south of this streambed while a flow component to the northeast is indicated for the soil aquifer north of the old streambed. Consequently, it is recommended that additional exploration be conducted in the south central part of the site and in the northeastern sector to refine these estimates of apparent groundwater flow directions and gradients.

Very limited information currently exists for the bedrock aquifer north of the old streambed. Therefore, it is recommended that wells be established into the bedrock aquifer northwest of boring 201 and in the northwestern portion of the site.

Based on records available for borings drilled in the central portions of the site, there is an apparent groundwater mound in the soil aquifer in this area. This condition suggests that the area is a zone of local groundwater recharge. To investigate this groundwater feature, we recommend installing a pair of wells in the vicinity of Building 145 and/or the silver recovery settling basin. These wells should be designed to obtain information from both the soil and the bedrock aquifers as there is little information with respect to the bedrock aquifer in this vicinity.

As discussed earlier the groundwater flow path, and thus, the pathway of any spilled contaminant is not necessarily limited to the lateral direction. Thus, the possibility of interaquifer contamination exists because the two aquifers appear to exhibit some hydraulic intercommunication. It is therefore possible that a contaminant could move laterally and downward through the shallow aquifer and subsequently into the bedrock aquifer where it could begin to flow laterally in a different direction and at a faster rate. By comparing water levels in new well pairs, local vertical groundwater gradients can be evaluated. Areas within KPW where a high potential for interaquifer contamination exists may then be identified.

The quantity of groundwater flowing through the soil aquifer may be considerably greater than that through the bedrock aquifer. Consequently, the flow direction in the soil aquifer is of great importance in tracing the movement of any contaminant that may be introduced into the subsurface. Therefore, it is necessary to refine the current understanding of the site geohydrologic characteristics especially in the soil aquifer before any permanent monitor wells are installed.

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The following figures, tables and appendix are attached and complete this report:

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Bibliography

Appendix Field Exploration and Installation of Test Wells

Respectfully submitted,

DAMES & MOORE

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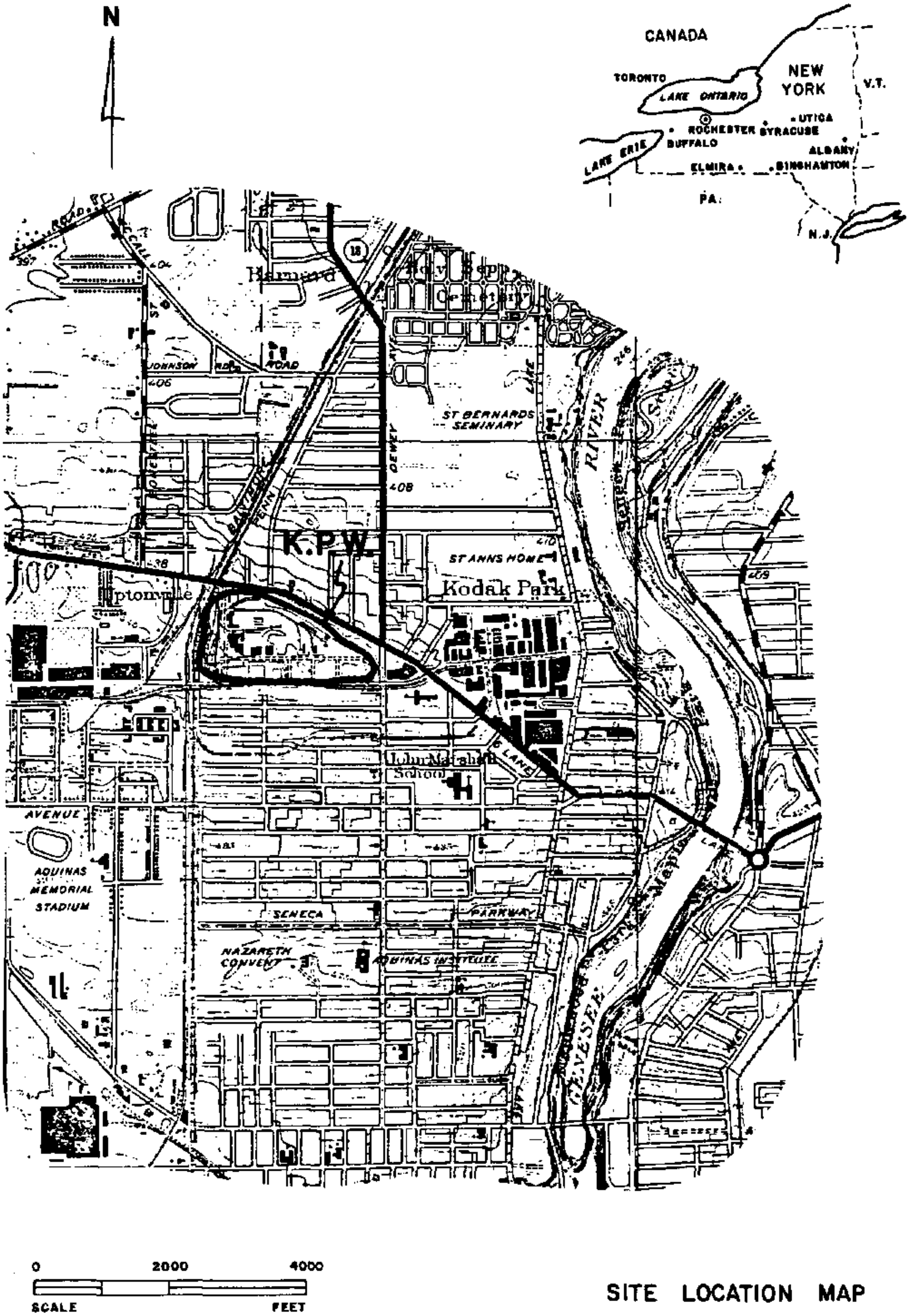

SITE LOCATION MAP

DAMES & MOORE

Reference: U.S.G.S., Rochester West, N.Y., 1969

FIGURE 1

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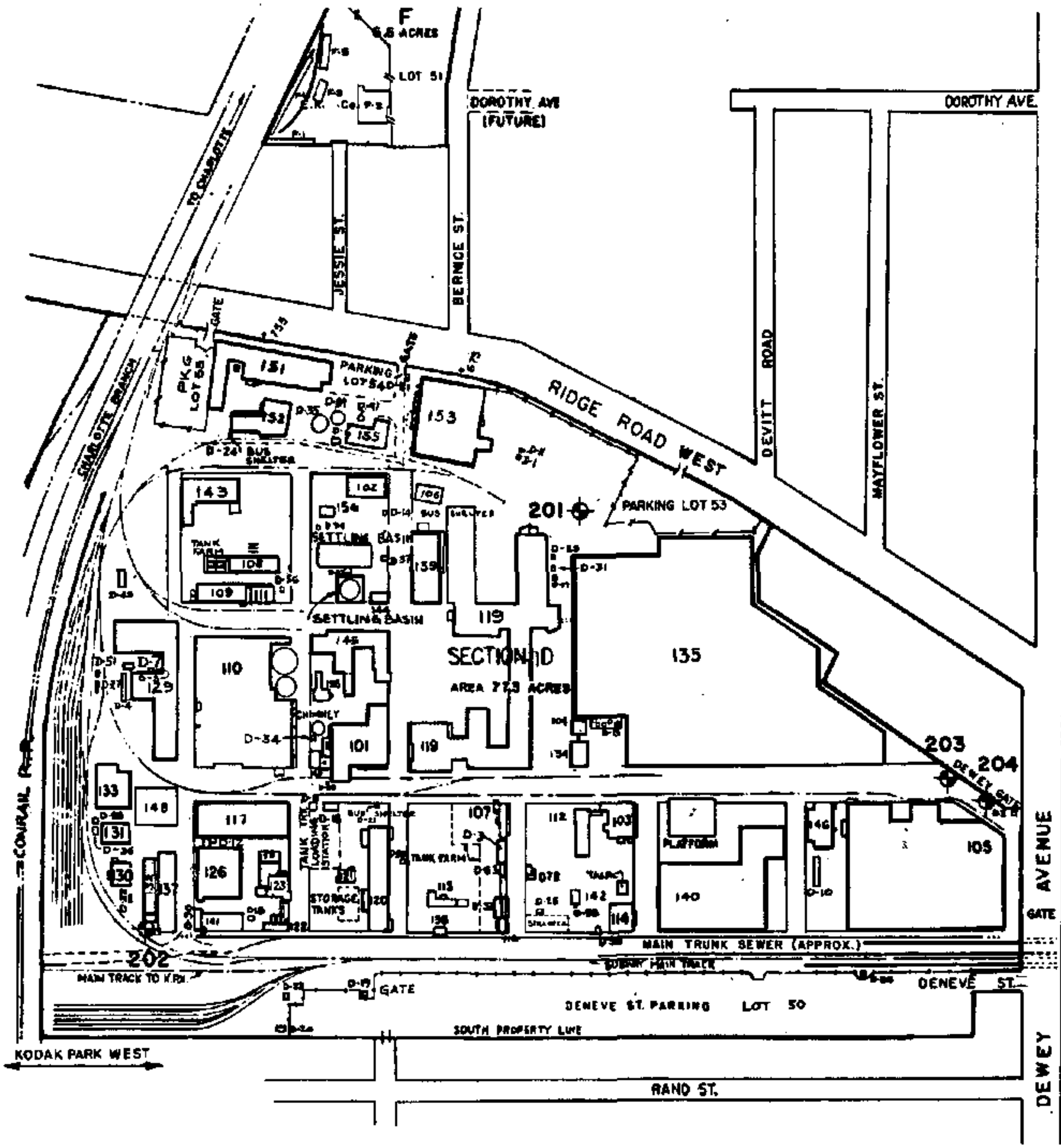


KEY:

201 Location of wells installed under the supervision of Dames & Moore for this investigation

0 200 400 600
APPROX. SCALE FEET

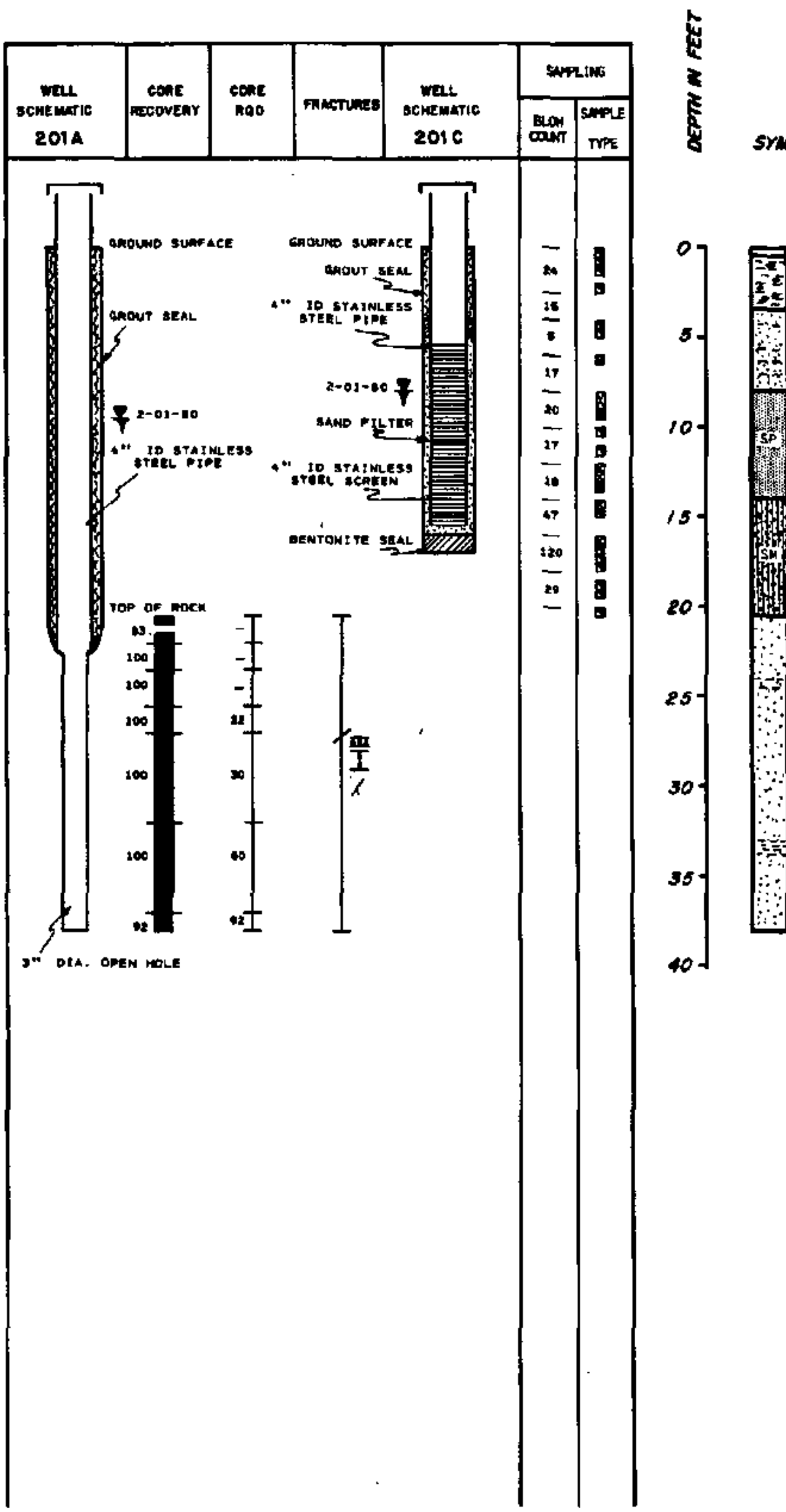
SITE PLOT PLAN

DAMES & MOORE

FIGURE 2

BORING CLUSTER 201

SURFACE ELEVATION 230.8'



SYMBOLS ***DESCRIPTIONS***

TOPSOIL
BLACK ORGANIC SILT WITH INTERMIXED ASH CINDERS FINE TO MEDIUM SAND AND TRACE COARSE GRAVEL (FILL)

YELLOWISH BROWN SILTY VERY FINE TO FINE SAND WITH A TRACE FINE GRAVEL OCCASIONAL POCKET OF BROWN SAND (FILL)

DARK GRAY FINE TO MEDIUM SAND TRACE SILT WITH OCCASIONAL SMALL POCKETS OF BROWN FINE SAND
- SLIGHT CHEMICAL SMELL NOTED IN SAMPLE
- GRADING WITH TRACE FINE GRAVEL
- GRADING WITH TRACE COARSE SAND

GRAY TO YELLOWISH GRAY SILTY FINE SAND WITH TRACE COARSE SAND OCCASIONAL RED SANDSTONE FRAGMENT (TILL)
- GRADING REDDISH BROWN WITH SOME SILT
- GRADING WITH POCKETS OF GREENISH GRAY VERY FINE SAND

REDDISH BROWN AND GRAY MOTTLED FINE TO MEDIUM GRAINED SANDSTONE WITH OCCASIONAL SHALE PARTINGS HORIZONTAL BEDDING (MEDINA SANDSTONE)
- REDDISH BROWN SHALE
- SLIGHT CHEMICAL SMELL NOTED IN CORE
- SOFT CLAY BRECCIA
- NUMEROUS FRACTURES
- GRADING LESS SILTY

REDDISH BROWN SHALE

BORING TERMINATED AT A DEPTH OF 38.0 FT. ON OCT. 16, 1979
NO WATER LOSS RECORDED DURING DRILLING
STAINLESS STEEL 4" ID SCREEN INSTALLED IN BORING 201C (ZONE OF INFLUENCE FROM 5 TO 16 FEET)
4" STAINLESS STEEL CASING GROUTED TO A DEPTH OF 22.5 FT. IN BORING 201A. OPEN 3" DIA. HOLE TO A DEPTH OF 38.0 FT.

SOIL SAMPLING INFORMATION

- STANDARD PENETRATION TEST
- UNDISTURBED SAMPLE
- DISTURBED SAMPLE
- NO SAMPLE RECOVERED

ROCK CORE INFORMATION

80 — CORE LOSS ZONE — PERCENT CORE RECOVERY

82 CORE RQD

2-01-80 PIEZOMETRIC SURFACE & DATE TESTED

FRACTURES

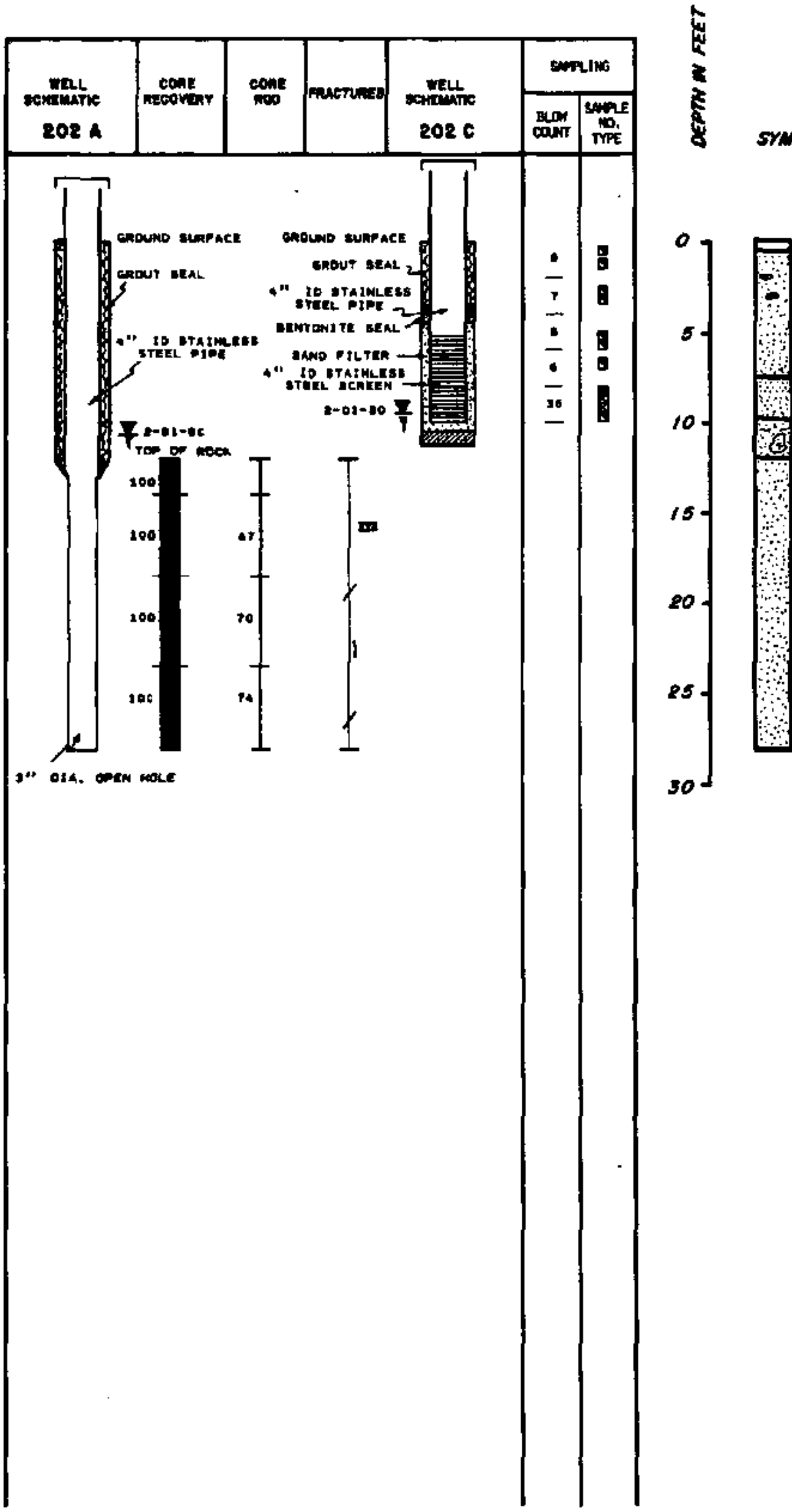
- Zone of core loss
- Breccia zone
- Dip-slip slickensides
- Fractures-shown at approximate angle to core axis
- Mineralized fracture c - calcite s - sulfide
- Fractured zone
- Void

DAMES & MOORE

FIGURE 3

BORING CLUSTER 202

SURFACE ELEVATION 233.0'



SYMBOLS *DESCRIPTIONS*

ASPHALT

FINE TO MEDIUM SAND WITH TRACE GRAVEL LOOSE (FILL)

- GRADING WITH CINDERS, ASH AND WOOD

- GRADING WITH POCKETS OF FINE SAND

REDDISH BROWN FINE SAND (FILL)

- SLIGHT CHEMICAL SMELL NOTED IN SAMPLE

SILTY SAND WITH OCCASIONAL COBBLES AND BOULDERS (TILL)

REDDISH BROWN AND GRAY MOTTLED FINE TO MEDIUM GRAINED SANDSTONE WITH OCCASIONAL SHALE PARTINGS HORIZONTALLY BEDDED (MEDINA SANDSTONE)

- THIN CLAY BRECCIA

- NOTED SLIGHT CHEMICAL SMELL

BORING TERMINATED AT A DEPTH OF 28.15 FT. ON OCT. 17, 1979

STAINLESS STEEL 4" ID SCREEN INSTALLED IN BORING 202C WITH ZONE OF INFLUENCE FROM 4.5 TO 10.5 FEET

4" STAINLESS STEEL CASING GROUTED IN BORING 202A TO DEPTH OF 13.0 FEET. 3" OPEN HOLE DRILLED TO TOTAL DEPTH OF 28.15 FT.

SOIL SAMPLING INFORMATION

- STANDARD PENETRATION TEST
- UNDISTURBED SAMPLE
- DISTURBED SAMPLE
- NO SAMPLE RECOVERED

ROCK CORE INFORMATION

80 CORE LOSS ZONE

PERCENT CORE RECOVERY

82 CORE RQD

2-01-80 PIEZOMETRIC SURFACE & DATE TESTED

FRACTURES

- Zone of core loss
- Breccia zone
- Dip-slip slickensides
- Fractures-shown at approximate angle to core axis
- Mineralized fracture c - calcite s - sulfide
- Fractured zone
- Void

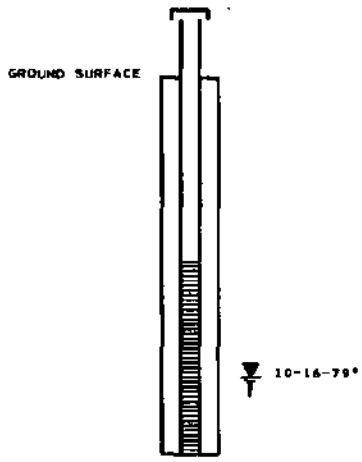
DAMES & MOORE

FIGURE 4

BORING 203

SURFACE ELEVATION 233.1'

WELL SCHEMATIC 203A	SAMPLING: BLOW COUNT	SAMPLING: SAMPLE TYPE	DEPTH IN FEET
	2		0
	4		
	11		5
	15		
	19		10
	19		
	17		15
	25		
	15		
	60		20



* WELL PIPE LATER REMOVED BY KODAK

SYMBOLS *DESCRIPTIONS*

TOPSOIL

YELLOWISH BROWN TO BLACK ORGANIC SILT AND FINE TO MEDIUM SAND VERY LOOSE (FILL)

-GRADING MAINLY CINDERS AND ASH AND FINE TO COARSE GRAVEL

-GRADING MAINLY CINDERS AND ASH FROM 6.5 TO 10.5 FEET

YELLOWISH BROWN TO BROWN FINE SAND TRACE VERY FINE SAND MEDIUM DENSE

DARK GRAY SILT WITH TRACE OF CLAY

-GRADES TO GRAY SILTY FINE SAND WITH TRACE FINE GRAVEL 15 TO 16 FEET

-GRAY AND BROWN INTERLAYERED CLAYEY SILT AND SILT

REDDISH BROWN FINE SAND WITH SILT AND TRACE GRAVEL OCCASIONAL SMALL COBBLE (TILL)

RESISTANCE ENCOUNTERED AT 19.5 FEET PRESUMED BEDROCK

BORING TERMINATED AT A DEPTH OF 19.5 FEET ON 9/22/79

BORING ABANDONED WHEN CONSIDERABLE QUANTITY OF OILY MATERIAL NOTED IN BORING

2" PVC PIPE WITH LOWER 10 FEET SLOTTED INSTALLED IN BORING

NO DEVELOPMENT ATTEMPTED

SOIL SAMPLING INFORMATION

- STANDARD PENETRATION TEST
- UNDISTURBED SAMPLE
- DISTURBED SAMPLE
- *NO SAMPLE RECOVERED*

ROCK CORE INFORMATION

80 — CORE LOSS ZONE — PERCENT CORE RECOVERY

82 CORE RQD

2-01-80 PIEZOMETRIC SURFACE & DATE TESTED

FRACTURES

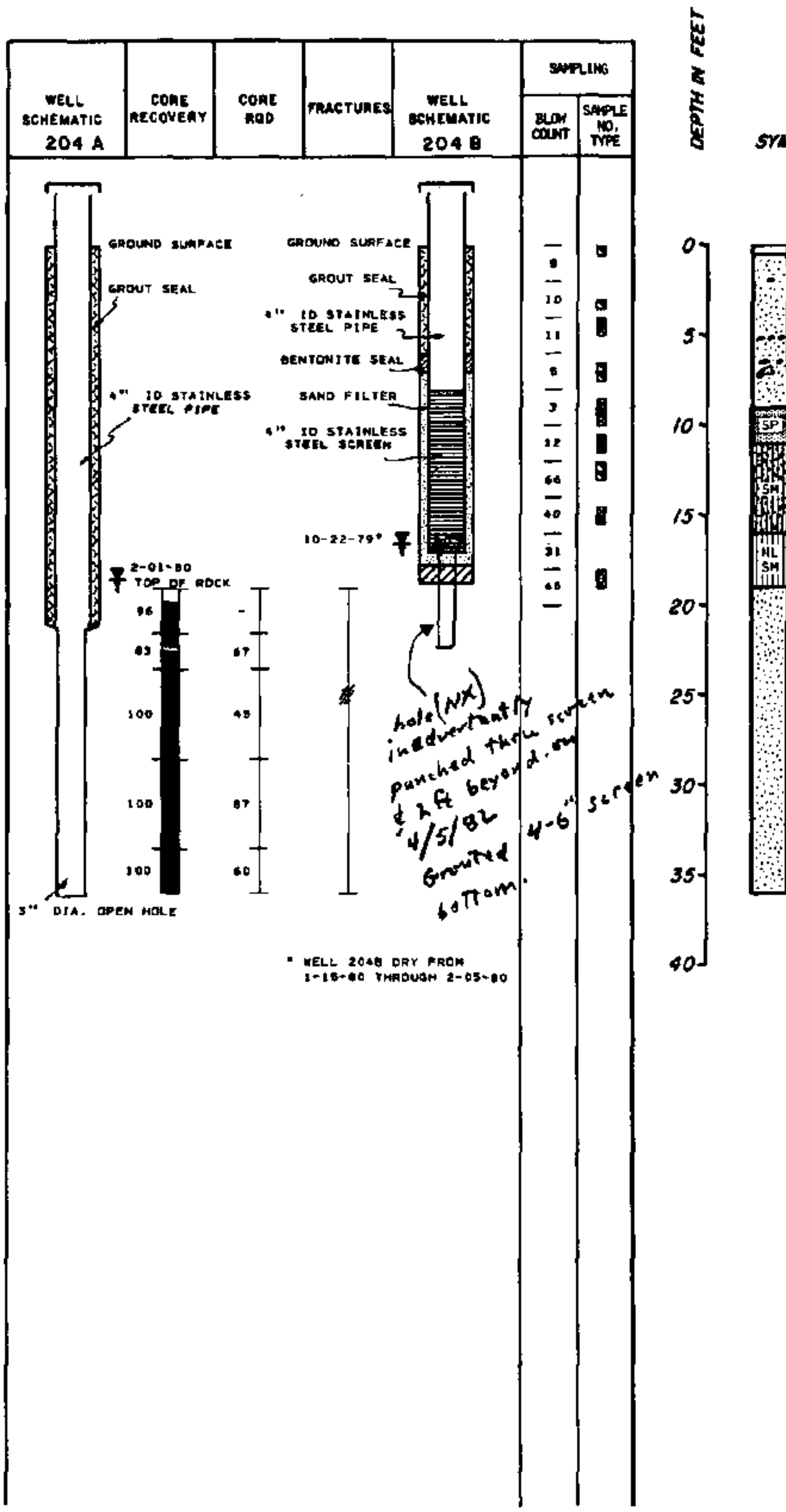
- *Zone of core loss*
- Breccia zone
- Dip-slip slickensides
- Fractures-shown at approximate angle to core axis
- Mineralized fracture c = calcite s = sulfide
- Fractured zone
- Void

DAMES & MOORE

FIGURE 5

BORING CLUSTER 204

SURFACE ELEVATION 232.6'



SYMBOLS *DESCRIPTIONS*

BLACK ORGANIC SILT WITH SOME FINE SAND AND GRASS ROOTS

YELLOWISH BROWN AND BLACK FINE SAND WITH OCCASIONAL COARSE GRAVEL LOOSE (FILL)
- -DRIVING GRAVEL
- -GRADING BROWN
- -GRADING WITH CRUSHED STONE
- -GRADING MEDIUM TO COARSE SAND WITH ASHES/CINDERS AND WOOD PIECES

GRAY AND YELLOWISH BROWN FINE SAND WITH OCCASIONAL VERY SMALL POCKETS OF BLACK SAND AND SILT (LOOSE)
- -GRADING WITH COBBLES

REDDISH BROWN SILTY FINE SAND TRACE COARSE SAND AND COARSE GRAVEL, VERY DENSE (TILL)
- -GRADING WITH ROCK FRAGMENTS

REDDISH BROWN FINE SAND AND SILT TRACE MEDIUM SAND AND OCCASIONAL GRAVEL

REDDISH BROWN AND GRAY MOTTLED FINE TO MEDIUM GRAINED SANDSTONE WITH OCCASIONAL SHALE PARTINGS HORIZONATALLY BEDDED (MEDINA SANDSTONE)
- -LOSS OF DRILLING FLUID FROM 19.5 TO 20.6 FEET
- -22.2 TO 22.6 FEET- VOID

BORING TERMINATED AT A DEPTH OF 36.0 FEET ON 10/18/79

STAINLESS STEEL 4" ID SCREEN INSTALLED IN BORING 204B, ZONE OF INFLUENCE BEING 4.5 TO 17.6 FEET

6" STAINLESS STEEL CASING GROUTED TO DEPTH OF 21 FEET IN BORING 204A. 3" DIA. OPEN HOLE TO TOTAL DEPTH OF 36 FEET

SOIL SAMPLING INFORMATION

- STANDARD PENETRATION TEST
- UNDISTURBED SAMPLE
- DISTURBED SAMPLE
- NO SAMPLE RECOVERED

ROCK CORE INFORMATION

80 — CORE LOSS ZONE — PERCENT CORE RECOVERY

82 CORE RQD

2-01-80 — PIEZOMETRIC SURFACE & DATE TESTED

FRACTURES

- Zone of core loss
- Breccia zone
- Dip-slip slickensides
- Fractures-shown at approximate angle to core axis
- Mineralized fracture c - calcite s - sulfide
- Fractured zone
- Void

DAMES & MOORE

FIGURE 6

BY ____ DATE ____ CHECKED BY ____ DATE ____ PLATE ____ OF ____

FILE 11364-001-17

BY D. T[illegible] DATE 3/3/8[illegible]

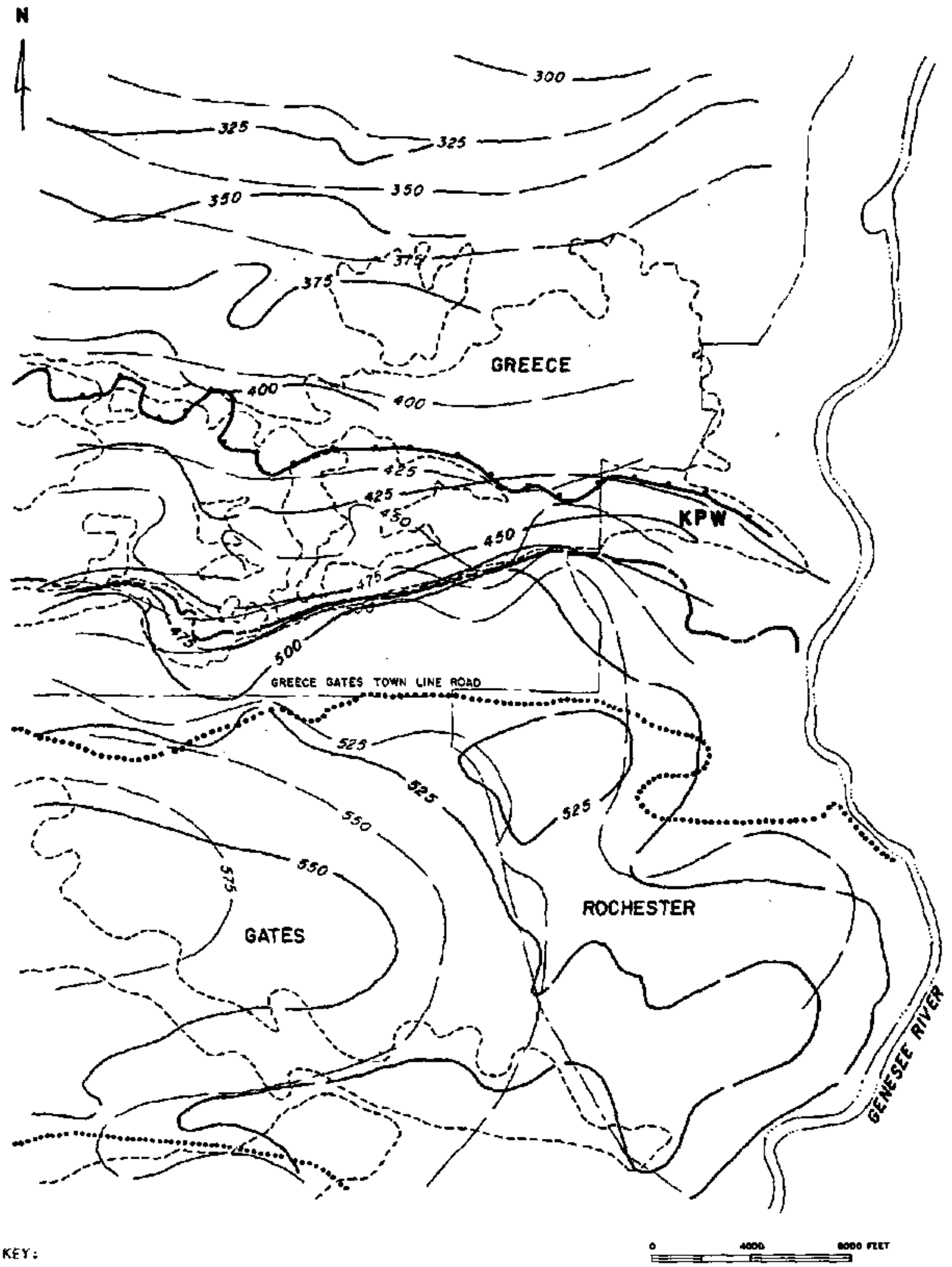
CHECKED BY ______ DATE ______

REVISIONS

BY ______ DATE ______

BY ______ DATE ______

PLATE ______ OF ______



KEY:

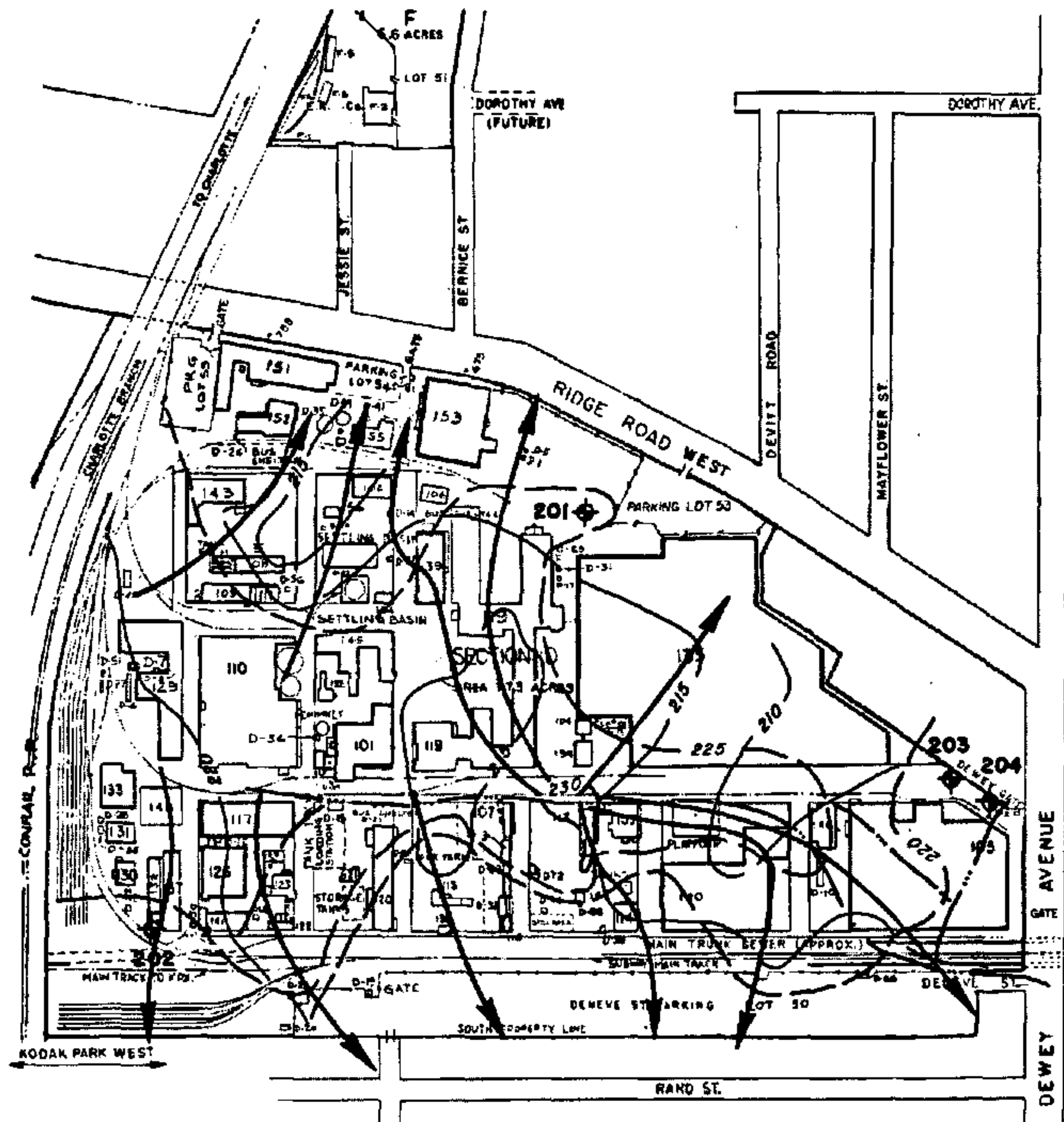
- 525 — Groundwater Contours
- 550 — Bedrock Contours
- Sands Associated with Shorelines
- Iroquois Shoreline
- Dawson Shoreline
- Lockport Dolomite

NOTE: The elevations presented here are based on the USC&GS datum, mean sea level. This datum is 201.75 ft. higher than the [illegible] datum.

Reference: R.A. Young, 1975

REGIONAL GROUNDWATER CONTOUR MAP

FIGURE 7



KEY:

201 — Location of wells installed under the supervision of Dames & Moore for this investigation

Approximate location of old stream

—215— Top of rock

—220— Surface water level

0 200 400 600
APPROX. SCALE FEET

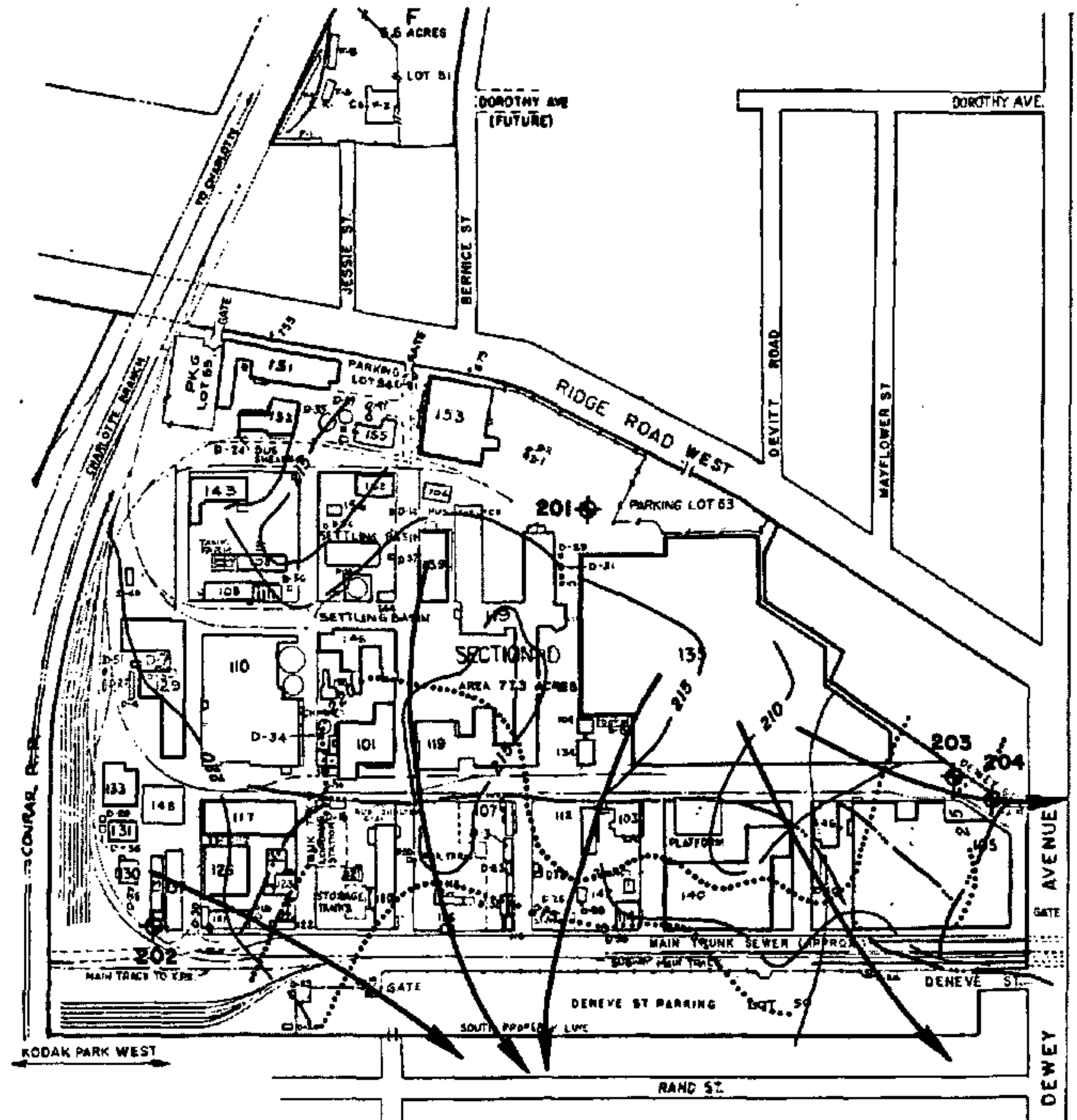
Notes:

1. The water level contours shown hereon reflect Kodak test boring data (not plotted) as well as measurements made in wells 201 through 204.
2. Arrows indicate the direction of groundwater flow.

GROUNDWATER CONTOUR MAP
SURFACE AQUIFER

DAMES & MOORE

FIGURE 8



KEY:

201 Location of wells installed under the supervision of Dames & Moore for this investigation

Approximate location of old stream

— 215 — Top of rock

···· 220 ···· Rock water level

Notes:

1. The water level contours shown hereon reflect Kodak test boring data (not plotted) as well as measurements made in wells 201 through 204.
2. Arrows indicate the direction of groundwater flow.

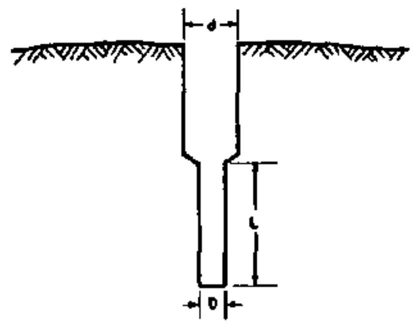
0 200 400 600
APPROX. SCALE FEET

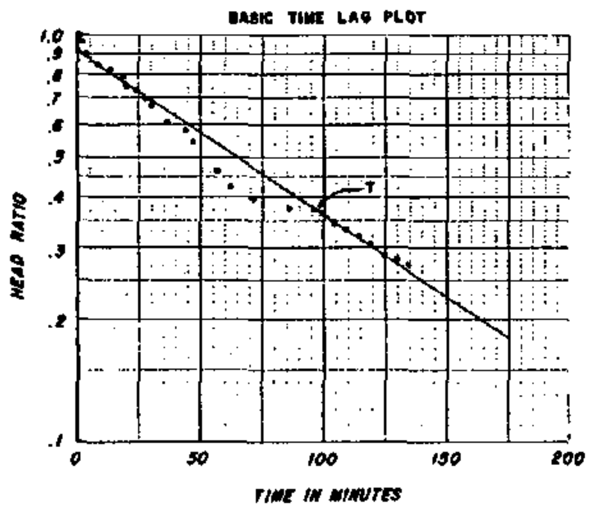
GROUNDWATER CONTOUR MAP
ROCK AQUIFER

DAMES & MOORE

FIGURE 9

119NE





T = Time at Head Ratio of 0.37

T from Plot = 5820 seconds (Time Lag)

$$K_h = \frac{(d^2)\ \ln\left(\frac{4mL}{D}\right)}{(8)(L)(T)}$$

$= 7.5 \times 10^{-2}$ ft/day

$= 2.6 \times 10^{-5}$ cm/sec

$d = 4''$

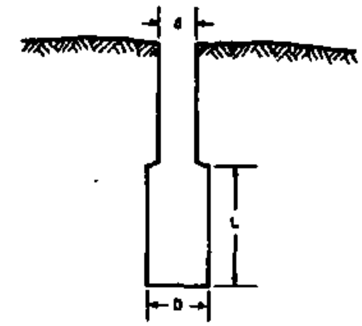
$D = 3''$

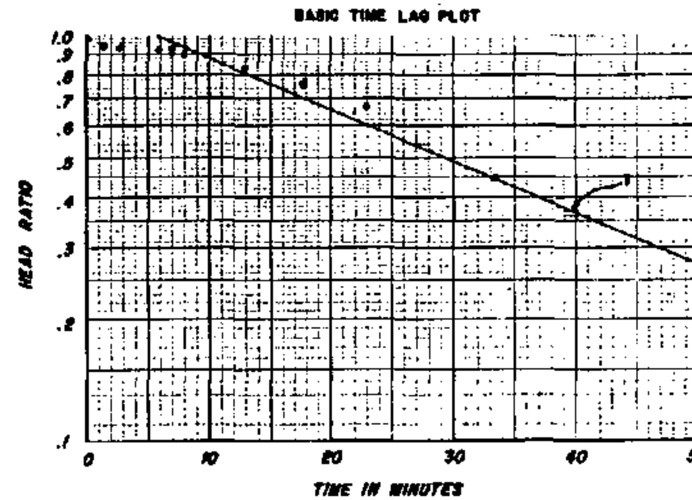
$L = 15.2'$

$m = 1$ (Assumed)

VARIABLE HEAD FIELD PERMEABILITY TEST

BORING 201 A





T = Time at Head Ratio of 0.37

T from Plot = 2370 seconds (Time Lag)

$$K_h = \frac{(d^2)\ \ln\left(\frac{2mL}{D}\right)}{(8)(L)(T)}$$

$= 2.1 \times 10^{-1}$ ft/day

$= 7.3 \times 10^{-5}$ cm/sec

$d = 4''$

$D = 6''$

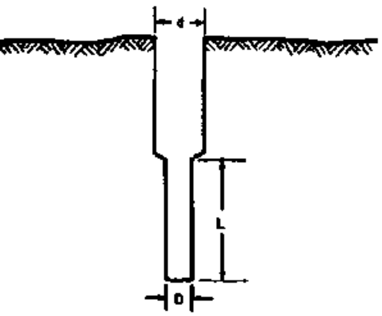
$L = 8.5'$

$m = 1$ (Assumed)

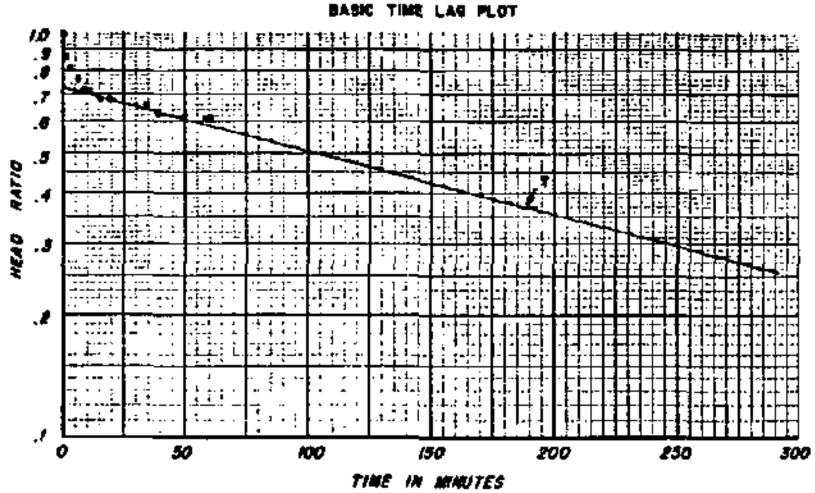
VARIABLE HEAD FIELD PERMEABILITY TEST

BORING 201 B

1373W



BASIC TIME LAG PLOT



T = Time at Head Ratio of 0.37

T from Plot = 11400 seconds (Time Lag)

$$K_h = \frac{(d^2)\ \ln\left(\frac{4mL}{D}\right)}{(8)(L)(T)}$$

$= 3.0 \times 10^{-2}$ ft/day

$= 1.3 \times 10^{-5}$ cm/sec

d = 4"

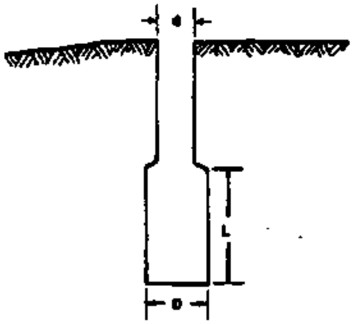
D = 3"

L = 15.3'

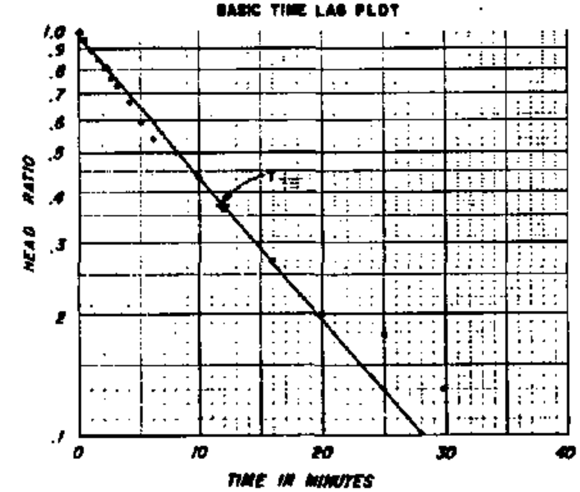
m = 1 (Assumed)

VARIABLE HEAD FIELD PERMEABILITY TEST

BORING 202 A



BASIC TIME LAG PLOT



T = Time at Head Ratio of 0.37

T from Plot = 720 seconds (Time Lag)

$$K_h = \frac{(d^2)\ \ln\left(\frac{2mL}{D}\right)}{(8)(L)(T)}$$

$= 8.8 \times 10^{-1}$ ft/day

$= 3.1 \times 10^{-4}$ cm/sec

d = 4"

D = 6"

L = 6'

m = 1 (Assumed)

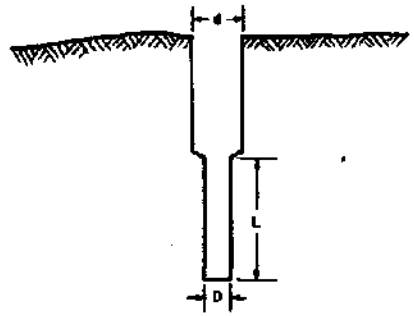
VARIABLE HEAD FIELD PERMEABILITY TEST

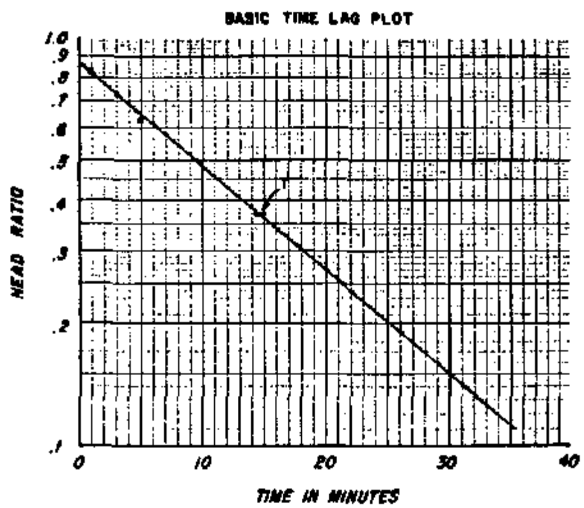
BORING 202 C

FIGURE 11

REVISIONS BY DATE
BY DATE
PLATE OF

BY S. Stephens DATE 2/8
CHECKED BY DATE





T = Time at Head Ratio of 0.37

T from Plot = 870 seconds (Time Lag)

$$K_h = \frac{(d^2)\ \ln\left(\frac{4mL}{D}\right)}{(8)(L)(T)}$$

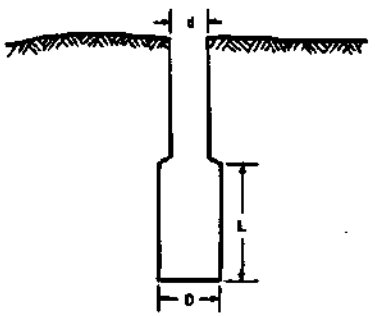
$= 5.0 \times 10^{-1}$ ft/day

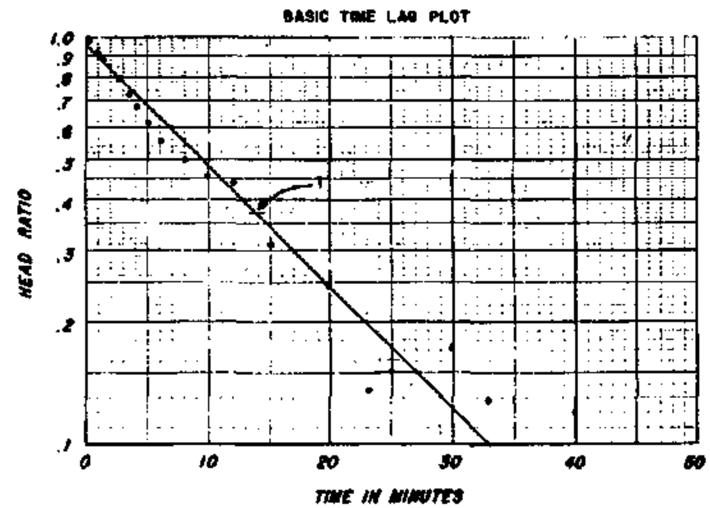
$= 1.8 \times 10^{-4}$ cm/sec

d = 4"
D = 3"
L = 15'
m = 1 (Assumed)

VARIABLE HEAD FIELD PERMEABILITY TEST

BORING 204 A





T = Time at Head Ratio of 0.37

T from Plot = 840 seconds (Time Lag)

$$k_h = \frac{(d^2)\ \ln\left(\frac{2mL}{D}\right)}{(8)(L)(T)}$$

$= 5.05 \times 10^{-1}$ ft/day

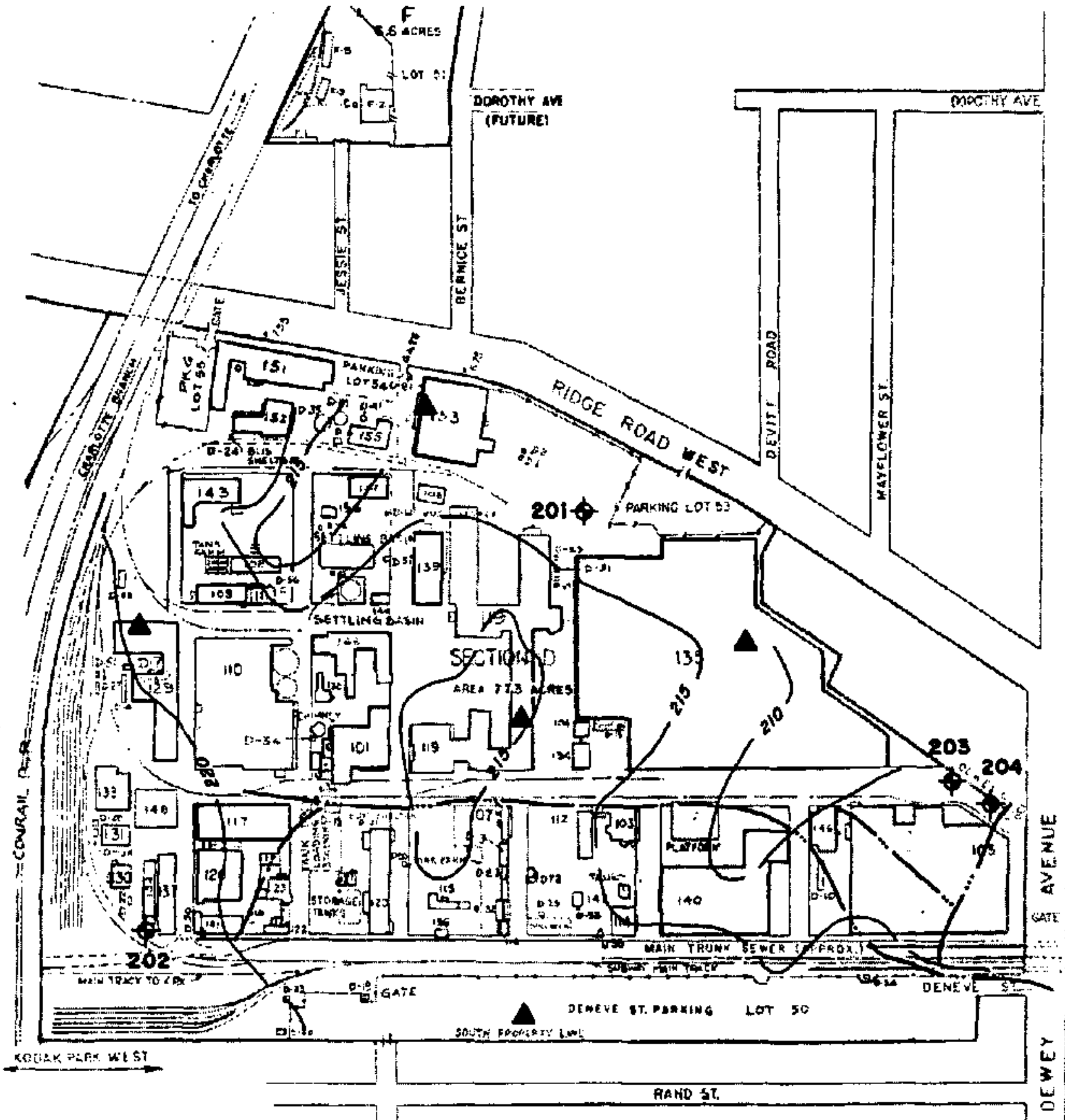
$= 1.8 \times 10^{-4}$ cm/sec

d = 4"
D = 6"
L = 10.6'
m = 1 (Assumed)

VARIABLE HEAD FIELD PERMEABILITY TEST

BORING 204 C

FIGURE 12



KEY:

201 Location of wells installed under the supervision of Dames & Moore for this investigation

Approximate location of old stream

215 Top of rock

▲ Recommended target areas for additional investigative efforts

0 200 400 600
APPROX. SCALE FEET

RECOMMENDED LOCATIONS FOR ADDITIONAL STUDY

DAMES & MOORE

FIGURE 13

TABLE 1
POTENTIOMETRIC SURFACE ELEVATION

Well No.	Ground Elev.	10/18/79	10/23/79	11/08/79	01/11/80	01/15/80	01/18/80	01/22/80	01/25/80	01/29/80	02/01/80	02/5/80
201A	230.9	221.8	221.8	221.9	221.7	221.9	221.7	221.8	221.2	221.4	221.4	221.6
201C	230.8		223.1		223.5	223.4	223.0	223.4	222.8	223.1	223.0	222.8
202A	233.0	221.8	222.1	221.8	221.9	221.9	221.8	221.9	221.6	221.1	221.3	222.0
202C	233.3		225.6	225.6	225.6	225.5	225.4	225.6	225.2	225.3	224.8	224.8
204A	232.6	214.4	213.9	213.8	213.3	213.7	213.1	213.6	213.4	213.2	212.9	212.9
204B	232.3	216.6	215.6	215.6	214.9	dry	dry	dry	dry	dry	dry	dry

Note: The temporary standpipe in boring 203 was removed by Kodak Park personnel.

TABLE 2
AQUIFER PARAMETERS

Aquifer	Observation Well	Permeability ft/day (cm/sec)	Aquifer Thickness (ft)	Transmissibility ft^2/day
Bedrock	201A	7.5×10^{-2} (2.6×10^{-5})	15.2[b]	1.14
Bedrock	202A	3.8×10^{-2} (1.3×10^{-5})	15.3[b]	0.58
Bedrock	204A	5.0×10^{-1} (1.8×10^{-4})	15.0[b]	7.5
Soil	201C	2.1×10^{-1} (7.3×10^{-5})	6.5[c]	1.36
Soil	202C	8.8×10^{-1} (3.1×10^{-4})[a]	2.0[c]	1.76
Soil	204B	5.0×10^{-1} (1.8×10^{-4})[a]	6.0[c]	1.50

[a]Falling head permeability tests, all others were rising head tests.

[b]The bedrock aquifer thicknesses are based on bedrock conditions as revealed in test borings 201, 202, and 204. It has been assumed that relatively few bedrock fractures exist below the cored depths and therefore have relatively little effect on total transmissibility. Thus, the values indicated here represent estimates of "effective aquifer thickness".

[c]Average thickness of saturated zone.

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Terzaghi, Karl and Peck, Ralph B., Soil Mechanics in Engineering Practice, second ed., John Wiley & Sons, Inc., New York, 1968.

Young, Richard A., "Analysis of General Geologic and Geohydrologic Factors Relating to Landfill Locations in the Rochester East, Rochester West, West Henrietta, and Pittsford Quadrangles", prepared for the Monroe County Environmental Management Council, April 27, 1979.

APPENDIX

FIELD EXPLORATION AND INSTALLATION OF TEST WELLS

Field Explorations

Drilling and Sampling

The subsurface conditions of the study area were investigated by drilling and sampling nine exploratory borings varying in depth from 11 feet to 38 feet below the ground surface. Four-inch diameter permanent stainless steel observation wells were installed in six of the borings. Two-inch slotted PVC standpipes were installed in auger holes at each of three drill locations. The observation wells were installed to monitor the groundwater levels and to provide a means for obtaining groundwater samples.

The field program was completed under the direct supervision of a Dames & Moore geotechnical engineer who maintained a log of the borings and obtained representative samples for identification and laboratory testing. The boring locations are shown on the Site Plot Plan (Figure 2). The "as drilled" coordinate locations and elevations were supplied by Kodak Park surveyors. The wells were installed during the time period from September 19 to October 18, 1979.

All borings were advanced through the soil material using a tractor-mounted drill rig. Two methods of advancing the bore-holes were utilized: (1) hollow-stem augers, and (2) rotary wash with casing. Additionally, rock cores of the bedrock were obtained with an NX-size core barrel. Representative samples of principal soil layers and fill were obtained utilizing the Dames & Moore soil sampler type-U and the standard split spoon sampler. The split spoon sampling was performed in general accordance with ASTM test procedure D-1586, "Standard Method for Penetration Tests & Split-Barrel Sampling of Soils". The Dames & Moore sampler (2.5 in. ID, 3.25 in. OD) was advanced by blows from a 300-pound drop hammer, free falling a distance of 30 inches. The number of blows required to drive each type of sampler as well as the type and condition of the sample obtained are presented on the Log of Borings under the appropriate heading. The soil samples were packaged in either plastic tubes or jars and transported to our Syracuse office. The field classifications were reviewed for consistency during further inspection by the office engineering staff. All soils have been classified in accordance with the Unified Soil Classification System.

All rock cores were obtained and stored in wooden core boxes. The cores were described for lithology, fracture frequency, as well as core recovery.

Observation Well Installation

Groundwater Observation Wells

To ensure that the stainless steel screening was located at the optimum depth in the soil materials, temporary PVC standpipes were installed to investigate the groundwater levels. Three locations were chosen to investigate the groundwater levels, one at each of the well cluster locations. These borings were advanced using a hollow-stem auger. No soil or rock samples were obtained from any of these borings.

The borings were utilized as groundwater observation wells by installing 2-inch ID PVC standpipe to the bottom of the hole through the hollow-stem augers. The lower portion (approximately 8 to 10 feet) of the PVC pipe was slotted using a common hacksaw. The augers were removed from the boring allowing the standpipe to remain in the hole. No attempt to install filter sand nor to develop the well was made as the standpipes were intended to be temporary.

Rock Wells

To evaluate the bedrock aquifer characteristics, three wells were installed into bedrock. Following the soil sampling in borings 201A, 202A and 204A, a working steel casing of 6.0 inches ID was installed through the overburden and driven approximately 6 inches into bedrock. The boring was then reamed to 5 5/8 inches to the described depth. After a thorough cleaning and flushing with clear water, a 4 inch OD stainless steel riser pipe was carefully installed and centered in the hole. A grout mixture consisting of 9 parts cement, 1 part bentonite and 7.5 parts of water was then placed through a 1/2 inch ID plastic tube between the 6-inch working casing and the stainless steel pipe.

The working casing was then withdrawn slowly while the level of the grout was maintained inside the casing (i.e. tremie method). The grout seal was placed completely to the ground surface and allowed to set for at least 24 hours. When the grout was set, the boring was extended to a depth of 15 feet below the base of the stainless steel casing. This lower 15 foot section was cored using a standard NX (3-inch OD) size core barrel. The riser pipe was then capped to limit rain water infiltration. Water level records were recorded shortly after completion of the well and periodically to February 5, 1980 by Kodak Park personnel (Table 1).

A well schematic for each of these rock wells is included with the boring logs (Figures 3, 4, and 6).

Shallow Screen Wells

To evaluate the aquifer characteristics of the shallow soil aquifer, 4-inch stainless steel screens were installed in borings 201C, 202C, and 204B. The length of each of these screens was established based on the depth to the groundwater level in the surface aquifer and an estimated high water level. Consequently, screening was installed in all wells above the present groundwater level.

To install these wells, borings were advanced with a tractor-mounted rotary drilling rig using 6-inch hollow stem augers. No additional soil samples were extracted from these borings because of the available soils information from the adjacent rock wells. The wells were drilled to the required depth in the overburden (i.e. generally just penetrating into the glacial till) and the 6-inch augers were removed. A 6-inch working casing was then installed to the total depth drilled and the boring flushed clean. An 8- to 12-inch bentonite seal was then placed in the bottom of the boring to limit direct communication between the two aquifers. A thin (6") sand blanket was then placed over the bentonite seal.

0.040 inch

A 4-inch stainless steel #40 slot well screen was then lowered into the hole, 4-inch stainless steel riser pipe then extended to the surface. The screen and riser pipe were centered in the hole and a filter was formed by pouring sand around the screen to a level of about 3 to 4 feet off the bottom of the hole. The 6-inch steel working casing was subsequently withdrawn slowly and additional filter material added. The sand filter was placed to a height of one foot above the top of the screen. A one-foot bentonite seal was then placed over the sand and the remainder of the boring was grouted to the surface.