GROUNDWATER REPORT NO. 2

IBM EAST FISHKILL FACILITY

MAY, 1982

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Outline

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INTRODUCTION

This report regarding the ground-water situation at the IBM Corporation's East Fishkill Facility in Dutchess County, New York, is sequential to an earlier report dated March 1981 and entitled "IBM East Fishkill Ground-Water Report." The earlier report presented a summary of the ground-water situation as of April 1, 1981, and covered the regional hydrogeology, summarized the ground-water quality investigations, and discussed the abatement and protection programs underway at that time. The report also set forth a plan of work identified as "Phase II--Model Verification and Analysis" which began immediately after the completion of the work discussed in the March 1981 report.

The following report summarizes the investigations, results and conclusions derived from the Phase II onsite work. Because of differences in conditions and resulting recommendations for remedial action programs, much of this report is directed toward specific areas within the plant site. These zones are defined as areas A, B, C, and D as shown on Fig. 1.

SUMMARY OF FIELD INVESTIGATIONS

A number of field investigations were conducted from April 1981 through April 1982. These included additional borings and installation of additional piezometers and monitor wells as well as aquifer pumping tests.

Installation of Boundary Piezometers

In order to provide better information on the hydraulic conditions along the east and west boundaries of the plant site, seven additional piezometer sets were installed. Three locations were chosen along the east side of the plant site--one, east of Lime Kiln Road on IBM's recreation area; the second, along the right-of-way of Lime Kiln Road; and the third, on IBM property near gate 4.

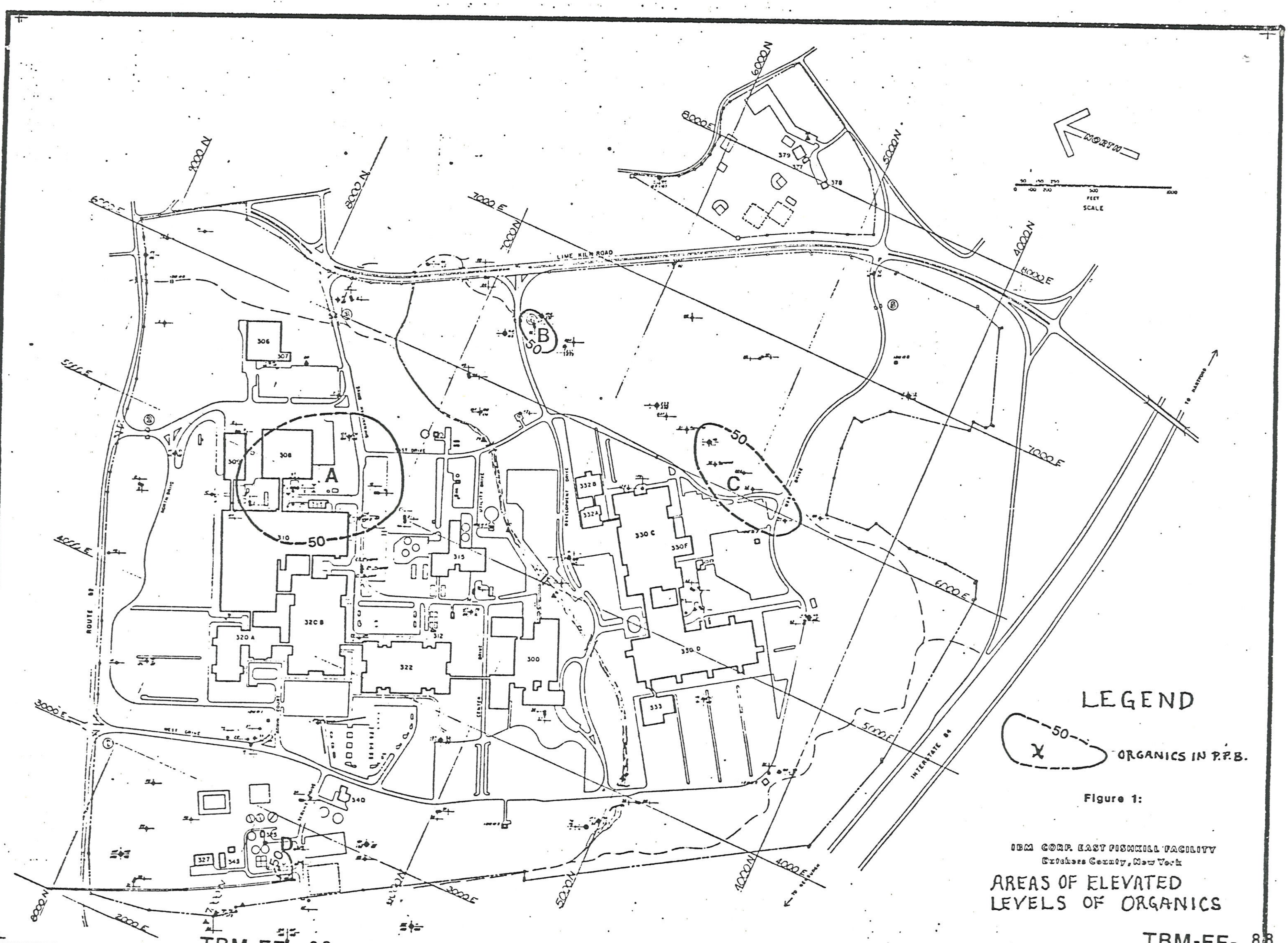

Figure 1:

IBM CORP. EAST FISHKILL FACILITY
Dutchess County, New York

AREAS OF ELEVATED
LEVELS OF ORGANICS

Of the four sets of piezometers installed along the west boundary, only one was installed on IBM property. The other three sets were installed on public utility right-of-way. Because of the time required to obtain permission for installing these piezometers, they were not completed until November 1981. Since that time water levels have been measured on a monthly basis in the new boundary piezometers as well as the previously installed piezometers on the plant site for use in preparing potentiometric surface maps and evaluating ground-water flow directions.

Installation of Additional Shallow Piezometers

Based on an evaluation of existing data, additional drilling was done in five selected locations to determine if different placement of the bottoms of shallow piezometers would indicate perched water tables in the glacial materials. Holes were drilled at these five locations to predetermined depths and slotted PVC pipes were installed in the holes to keep them open. The holes were allowed to remain open for 48 hours to determine if any water zones were indicated. At three of the locations no shallow water zones were indicated. At two locations, shallow water zones were indicated and piezometers were installed.

Neutron Meter Work

A neutron meter was tried in a number of the existing 2-inch diameter piezometer pipes which penetrate the entire glacial overburden. The purpose of this work was to determine if the neutron meter provides a reliable technique for identifying perched water tables in the glacial material. Although quite significant differences in readings with depth were obtained in the piezometers measured, the differences appeared to be caused by something other than saturated versus unsaturated materials. Little or no correlation could be found between the measurements obtained and soil samples taken nearby. Because of this, the neutron meter was discarded as a viable technique for identifying perched saturated zones within the glacial overburden.

Pumping Tests

To develop additional information on the hydraulic characteristics of the aquifers in specific areas, two pumping tests were conducted. IBM production well #8 was pumped for about 2½ days to obtain information on the aquifer in the southeast portion of the plant site. As is discussed in more detail in later sections, this test showed that production well #8 has little, if any, influence on potentiometric levels to the west of the major bedrock ridge which lies between production wells #8 and #7, therefore indicating little hydraulic communication with area C. The location of area C is shown in Fig. 1. The test also showed that pumping of production well #8 can be a method of assuring inward flow of ground water across the eastern boundary in the area of the lowlands between gates 5 and 4 along Lime Kiln Road.

Monitor well #32, near the facility's waste-water treatment plant, was test pumped for several hours to determine the hydraulic characteristics of a thin saturated zone lying above a clay layer in that area. The results of this pumping test and its significance are discussed in a later section concerning the remedial action plan for area D.

Borings, Areas A, B, C and D

Eighteen holes were drilled in area A, which is in the vicinity of buildings 308 and 310 as shown in Fig. 1, to better define hydrolgeologic and water-quality conditions. Monitor wells were installed in 12 of the 18 locations for purposes of measuring water levels and water quality of a saturated zone existing above a well defined clay layer in the area.

Three sets of piezometers and one monitor well were installed in area B to monitor water levels and quality before and after initiation of remedial action planned for that area.

Two shallow monitor wells were installed adjacent to the excavated portion of area C to monitor water quality.

Nine holes were drilled and soil samples were collected for quality analysis in area D. The purposes were to help define the extent of the elevated levels of organics and provide information on the clay layer found in area D. Two shallow monitor wells were installed.

SUMMARY OF GROUNDWATER QUALITY INVESTIGATIONS

On-Site

The East Fishkill Facility groundwater monitoring program continues to operate on a schedule as described[1] previously. No additional quality monitoring wells have been added to the facility during the period March 1981 through May 1982.

Many wells, particularly those with trace levels of organics show a trend towards lower levels. This is due to the removal of materials introduced during the drilling and casing installation process.

Based on 24 months of monitoring data, the size of the areas with elevated levels of organics is significantly smaller than was previously believed. Figure 1 shows the four areas on the East Fishkill Facility in terms of 50 parts per billion contour lines. The contours for areas A, B and C indicate that the organics are moving to and being collected by production wells 2, 4 and 7. There is no evidence of any movement off-site in these areas. Area D has been determined to be almost stagnant with respect to water flow. Stream water quality measurements below area D have consistently been non-detected. This is to be expected in view of the low concentrations in area D and the lack of water flow from this region. No new compounds have been found in any of the areas discussed and the list (page 5[1]) of major organics in the groundwater remains the same.

Groundwater Quality Summary - Organics

The concentration of organic solvents in areas A, B, C and D has not changed significantly in the past year. Analytical data from the wells adjacent to these zones demonstrates that the pumping of production wells #2, 4 and 7 has prevented the migration of materials from areas A, B and C.

The level of organics in production wells #2, 4 and 7 has not changed in the last 12 months. Organic solvents have not been detected in any other (#1, 5, 6, 9) production wells. This is further evidence of a lack of migration from areas A, B, C and D. Production well #7 was brought on line in 1981 to contain migration from area C. This well is pumped on a continuous basis and all water from the well is treated with granular activated carbon.

The site perimeter wells have shown a marked decrease in the level of organic solvents since 1980. The median values on the geographical boundaries of the site have dropped from 2 - 6 ppb to <2 ppb (limit of detection).

No organic solvents have been detected downstream of area D which is consistent with the hydrogeologic data indicating no appreciable, if any, flow from area "D" toward the swamp. Core borings west of area "D" were also clean.

Off-Site

In cooperation with the Dutchess County Department of Health, IBM has voluntarily funded a water quality monitoring program in homes surrounding the East Fishkill Facility. John Jay High School was also included in this study. Granular activated carbon units were installed in five homes which had organic solvents confirmed in their well water. This program was extended from 12 months to 18 months to allow completion of studies of groundwater conditions in the area.

Solvents have not been confirmed in any homes other than the original five (Feb. 1981). The level of organic solvents has decreased steadily since Feb. 1981 in the homes that originally were found to have solvents in their wellwater. There does not appear to be any seasonal trend to the data; however, a one year period is probably short, in most cases, to determine seasonality. The level of chemicals in the five off-site wells where detectable levels were originally found is now significantly below the New York State Department of Health guidelines of 50 and 100 ppb.

A series of observations/comments are appropriate with respect to the presence of low levels of organics in the off-site wells: (See Figure 2)

a) The finding of chloroform in a groundwater sample which has not been chlorinated is unusual. DCDH investigated the water supply situation at tax map location #45 [1] after chloroform was identified in the sample and the home was reported to have a dry well. Since the time of the original sample, the water table has risen sufficiently for the well at location 45 to be used routinely. Organic solvents have not been detected in any of these samples. IBM concludes that this well was and remains clean.

b) Samples taken at tax map locations #33 and #35 contained 1,1,1-Trichloroethane. Inorganic analysis [2] of the well water at location #35 indicates a connection between the well (in consolidated material) and the unconsolidated shallow zone. This is based on the presence of large amounts of ions such as chloride which is not found in high concentrations in bedrock water in this region. This fact suggests that this well could and may be contaminated as the result of intrusion of surface waters (road

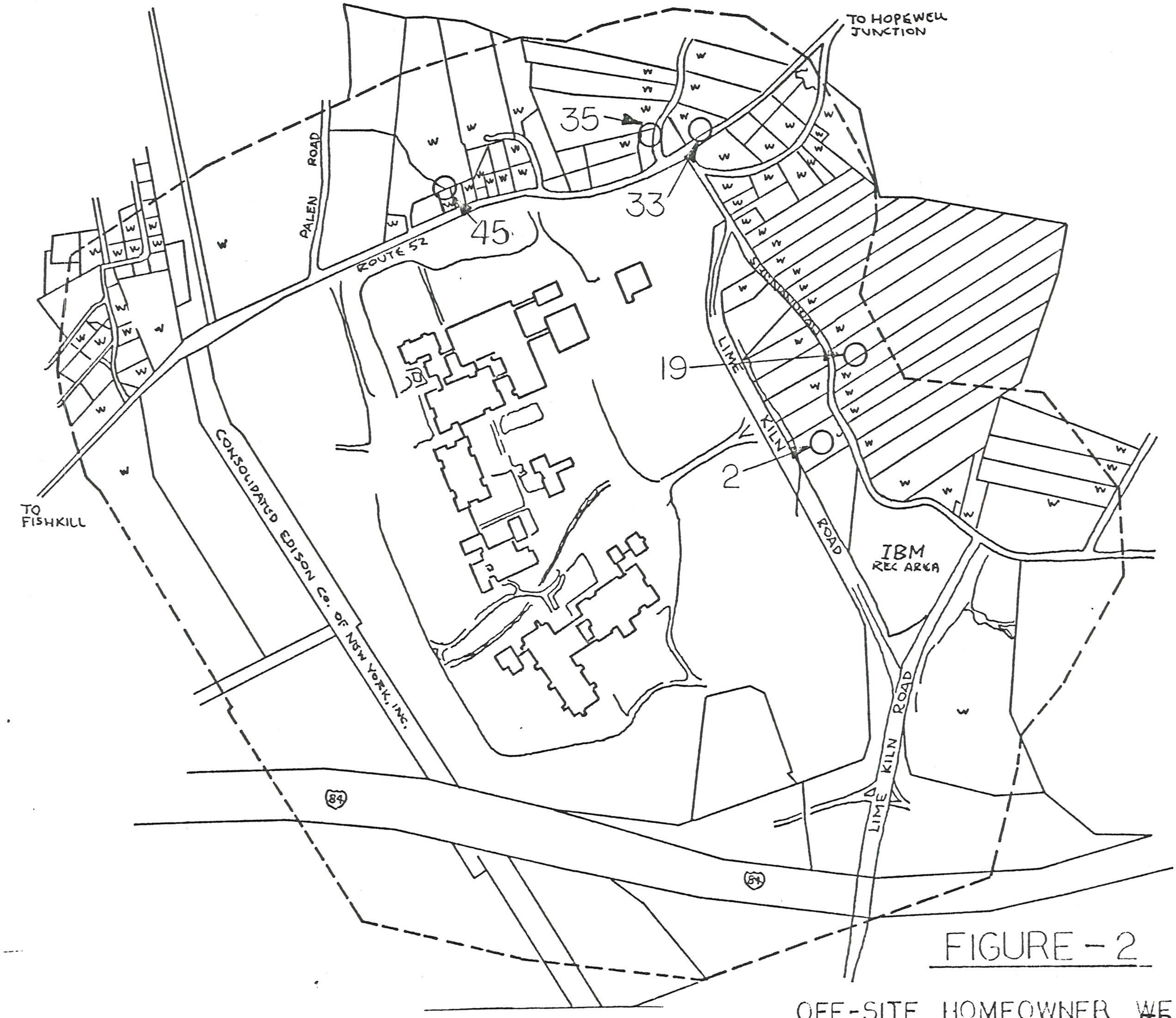

FIGURE - 2

OFF-SITE HOMEOWNER WELL LOCATIONS

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salts) and/or subsurface discharges from area septic systems. Groundwater flow directions in this area are towards the South (towards IBM).

c) Studies carried out as part of IBM's voluntary effort to aid off-site identification [2] at location #19 demonstrated a very rapid response between the homeowner's well and the homeowner's septic disposal system. Bacterial contamination of the well quickly followed pumping of the well and disposal of the water in the septic system. The well did not have a proper sanitary seal and was down gradient from a barnyard. Surface runoff from this area easily entered the well. Any chemicals used in the household or used for maintaining the septic system could easily have entered the well.

d) The DCDH found that the remaining well (location #2) in which chemicals were found was associated with a homeowner who had an autobody refinishing work area in his house [2]. Numerous solvents were stored and used in this house and it was difficult to sample water in the basement of the house due to the high concentrations of solvents in the air which contaminated the water samples. Analysis of water samples taken directly from the well revealed the presence of both gasoline and oil in the well water. Based on the usage of chemicals in the house and the need to dispose of them, it is fair to assume that the chemicals in the well most likely originated in the house.

e) Dispersive forces in the groundwater system result in horizontal and vertical spreading of chemicals as they move away from a point source. Since only four widely separated home wells have had chemicals confirmed in them and the wells in adjacent properties have remained clean, the source of chemicals appears to be localized to the immediate vicinity of each of the individual homes involved. Home subsurface disposal systems are the most likely source of chemicals in the groundwater in these areas.

f) The predominant type of chemical found off-site (1,1,1-Trichloroethane) is not the chemical which predominates in groundwater on the East Fishkill Facility (1,1,2,2-Tetrachloroethylene).

Site Specific Groundwater Hydraulic Characteristics

As part of IBM's groundwater investigations, additional piezometers have been added to the existing (as of March 1981) network. These piezometers provide water elevation data for use in assessing flow direction in the unconsolidated and consolidated zones. In addition, this data was and is used as input to the site groundwater mathematical models. Piezometers were installed off-site on Lime Kiln Road (east of the facility) and on the property of Consolidated Edison Corporation which is west of the facility (between IBM and John Jay High School). A summary of flow information follows:

1) North side (Route 52) water is flowing towards IBM from North to South.
2) South side (Route 84) water is flowing towards IBM.
3) East side (Lime Kiln Road) flow direction is seasonal. It approximately follows Lime Kiln Road swinging East and West depending on the water table. The bedrock hydraulic gradient in this area is very low and is probably strongly influenced in the vicinity of IBM Gate #4 by IBM's on-site pumping.
4) West side (John Jay High School) bedrock flow direction is strongly influenced by IBM production wells (from West to East). Large hydraulic gradients exist in this region, towards the IBM site. Water in the unconsolidated zone flows to the swampy area on the facility's western side. Water moves from the East and West to the swamp which is drained by a small stream flowing North from the site and eventually emptying into the Fishkill Creek. The water in the unconsolidated zone shows no appreciable movement.

5) Evaluation of existing data, geology and modeling of the aquifers in the region indicates that flow patterns prior to IBM pumping (1963) were very much as they are today. The primary difference is the large gradient which now exists due to IBM's on-site pumping. The vertical gradients which now exist also have increased the drainage from the upper aquifer to the lower aquifer and have resulted in less movement in the upper aquifer system.

After careful review of all existing data (on and off-site), surface/subsurface hydrogeology and aquifer model runs, IBM concludes the following:

1) Chemicals in the groundwater in areas A, B and C are being contained, collected and treated by production wells #2, 4, 7 and their GAC units.
2) There is no evidence that chemicals may have migrated from area D to the swampy area West of area D.
3) Based on monitoring data (on and off-site), there does not appear to be any migration of chlorinated hydrocarbons off the IBM East Fishkill Facility.
4) IBM is not the source of the chlorinated hydrocarbons found off-site in private wells.
5) The most likely source of chlorinated hydrocarbons (such as 1,1,1-Trichloroethane) in off-site wells is subsurface disposal via home septic systems, through the use of any of numerous household products containing chlorinated hydrocarbons.

DESCRIPTION OF MODELING WORK

As set forth in the original work plan, modeling of the ground-water system had three principal objectives: (1) evaluation of potential abatement or remedial action plans, (2) evaluation of water-supply needs in conjunction with ground-water quality remedial action programs and (3) evaluation of any possible offsite migration of ground water containing organics. As these objectives were investigated more closely, it became apparent that separate modeling endeavors were required for the solute transport simulation versus water-supply studies. Therefore, transport models were developed for the plant site (both glacial and bedrock aquifers), and a water-supply model was developed for a larger area (bedrock aquifer only). These are described below.

Solute Transport Model

Resource Consultants, Inc., conducted the modeling of the solute transport of the dissolved materials in the ground water using ISOQUAD, a two-dimensional areal finite-element dispersion model written by Dr. George Pinder of Princeton University. Because of the complex hydrogeology, the model was used to simulate two different aquifers--a relatively shallow glacial aquifer overlying a much thicker bedrock aquifer. The glacial aquifer consists of saturated silts, sands, and gravels in the glacial till that are above one or more clay layers. The clay layers restrict deep percolation to the bedrock aquifer below. The bedrock aquifer consists primarily of fractured limestone and dolomite. In some areas, IBM pumping from the bedrock aquifer has lowered the potentiometric surface in the bedrock aquifer below the bottom elevation of the clay layers. These clay layers have such low hydraulic conductivity that, in some cases, the material below them is unsaturated, thus creating a hydraulically separate glacial aquifer over a large area of the site.

The model was calibrated for both ground-water flow and solute transport for each aquifer. This process was a tedious trial-and-error procedure requiring a great deal of time and effort. One input parameter which was required during both calibration and predictive runs was the flow across the boundary of the model: This quantity came from results derived from the water-supply model, described below, which modeled a much larger area than the plant site alone.

The solute transport model focused principally on the situation in area A. Although the other areas were considered for modeling, this action was not pursued because the areal spread of organics in the other areas was too small relative to the model's nodal point spacing to accurately simulate the transport of solutes.

Water-Supply Model

One of the primary purposes for the water-supply model was to provide flux (ground-water flow) boundary conditions for the bedrock portion of the solute transport model. Ground-water models are quite sensitive to the boundary conditions used. Since the boundaries of the solute model correspond to property lines rather than well defined hydrogeologic boundaries, it was necessary to utilize a flux boundary condition for the most part. The water-supply model covered a much larger area than the solute model and, as such, could utilize constant head or impermeable boundaries where appropriate for its boundary conditions. The study area for the water-supply modeling extended approximately 1 mile to the south, west, and north of the plant site and about ½ mile to the east.

The model used was a relatively simple two-dimensional finite-difference flow model known as GRWATER developed by the staff at Colorado State University. Most of the effort in the modeling study was directed towards calibrating the model such that head contours generated by the model matched estimated contours from actual field data. The calibration process required a major work effort due to the large areal variation in transmissivity in the fractured limestone aquifer. Also, outside of the plant area little field information was available to assist in the calibration process.

The water-supply model appears to give reasonable results and utilizes hydrogeologic parameters that are reasonable when compared to known information from pumping tests, recharge rates from base stream-flow studies, etc. The model also simulates with reasonably good accuracy head contours both during wetter and drier periods, at least in those areas where the head contours can be estimated from known field data. As with most models, the calibration could be improved and the model revised as more field information becomes available. Also a finer grid network could be employed to yield more detailed results (a 21-by-30 grid which is considered large for finite-difference models was used for most of the water-supply model runs).

In addition to simulating historic and present conditions, the model was used to simulate future possible conditions with various changes of pumping rates of IBM production wells. From the model's output, the ground-water flow along various reaches of the plant perimeter was calculated and used as input for the solute transport model. From the model simulations, the major area of influence due to pumping from the IBM production wells was also determined. Inside the area of influence, recharge from precipitation entering the bedrock aquifer is directed towards the production wells and removed by pumping. Outside of the area of influence, the recharge from precipitation that enters the aquifer is eventually discharged into various surface-water streams.

OFFSITE MIGRATION EVALUATION

Using potentiometric level data as well as model analyses, it can be conclusively shown that ground-water flow in both the unconsolidated overburden materials and the bedrock is inward to the plant site at all boundaries, with the possible exception of two small areas. These areas are near the northwest corner of the plant site in the unconsolidated overburden materials and in the low-lying area along Lime Kiln Road on the eastern boundary near gate 5.

Additional drilling and water-level measurements made in the vicinity of area D indicates that a saturated zone exists above a clay layer in this region with a gentle slope to the water table of about 0.5 percent towards the west and away from the plant property. Below the glacial aquifer, in the bedrock aquifer, the elevation of the potentiometric surface is much less than the elevation of the water table, and the slope of the bedrock's potentiometric surface is not towards the west but rather towards the southeast. Borings made between area D and the westerly boundary indicate that glacial materials with a much lower hydraulic conductivity exist in this area and are probably the reason for the formation of a swamp along this boundary. The westerly movement of ground water in the glacial aquifer is therefore very slow, and any ground water that could percolate through the clay layer and reach the bedrock aquifer would be directed towards the southeast and towards plant property. Since all borings and monitor wells between area D and the western boundary are free of organic solvents, it is believed that no migration has occurred offsite.

Ground-water flow directions in the bedrock aquifer are strongly influenced by pumping from the IBM production wells. Potentiometric contour maps, prepared using water-level data from the bedrock piezometers and production wells, indicate that the flow of ground water is inward across plant boundaries. Further, the results of the water-supply modeling analysis indicate that the area of influence due to pumping from the production wells covers a larger area than just that area within the plant boundaries. A portion of the recharge to the bedrock aquifer outside of the plant boundaries is also being intercepted and directed towards the production wells with a resulting inward ground-water flow direction along the plant boundaries.

On a local scale there is minor exception to the inward flow pattern and that is for an area along the eastern boundary. The southeastern corner of the plant site, including the low-lying area along Lime Kiln Road between gates 4 and 5, is somewhat isolated hydraulically from the rest of the plant site because of the less permeable zone manifested by the bedrock outcropping and topographic ridge extending southward from gate 4. For an area approximately 1,000 feet southeast of gate 4, ground water may be flowing in a generally northerly direction and offsite for a short distance before flowing in a westerly direction back towards the plant property. The extent of this offsite flow is apparently small, but plans are to install additional piezometers in this area to better determine actual flow directions.

Results of the pumping test on IBM production well #8 indicate that this well could be used to effectively assure inward flow of ground water across Lime Kiln Road in the questionable area. Production well #8 has heretofore not been used as a water-supply well because of its relatively low yield.

REMEDIAL ACTION CONCEPTS AND ANALYSES--AREA A

Hydrogeology and Water Quality

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Earlier water-quality analyses indicated organic solvents existing as a separate phase near the west side of building 308. The additional borings made during the past year indicate that the separate phase exists within a silt zone overlying a clay layer at a depth of approximately 20 feet below the ground surface, generally between buildings 308 and 310. This corresponds to the location of five underground tanks which have been used for storage of solvents in the past. These tanks have been cleaned and taken out of service.

A perched water table also exists on the clay layer mentioned above and the slope of the water table indicates flow easterly under building 308. Materials under the clay layer appear to be drained, for the most part, by the influence of pumping the bedrock production wells, particularly production well #2. The gradient of the potentiometric surface in the bedrock is relatively steep under this area with a southwesterly flow direction towards production well #2. Since borings to bedrock east of building 308 did not encounter the clay layer found between buildings 308 and 310, it appears that the perched water is flowing easterly to the discontinuous clay layer and then downward to the bedrock system and then back southwesterly to production well #2. The ground water in the glacial aquifer flowing over the separate phase solvent and taking some of the solvent into solution and then flowing into the bedrock aquifer is probably the principal source of organics being measured in water pumped from production well #2. This concentration level has stayed quite constant at 10 parts per million while the well is pumped at a constant rate of 150 gallons per minute.

Solute Transport Modeling

Assumptions

As stated earlier, it was assumed that the hydrogeologic system could be divided into two different aquifers. The leakage out of the glacial aquifer was used as deep percolation input into the bedrock aquifer. Part of this assumption is that the glacial aquifer is continuous over the site. Actually, the glacial material is quite heterogeneous, and the water-bearing zones are not completely continuous. However, this assumption was conservative in that the spread of ground water containing organics in the numerical model will be more extensive than that observed in the field.

A second assumption was in the use of a constant source of organic solvents during both calibration runs and predictive runs. This assumption, though somewhat conservative, was necessary even if all leaks in pipelines and tanks have presumably been stopped. That is because the materials already underground as a separate phase will slowly dissolve as recharge water contacts it and acts as a source of organics for a long period of time, unless, of course, all of the separate phase could somehow be removed.

Glacial aquifer

The results of the calibration procedure for the glacial aquifer indicated the leak or leaks of organic solvents began approximately 10 years ago. The leak or leaks may have begun earlier, though, because the glacial aquifer model showed that the system had nearly reached the point where the compounds entering at the source was offset by the dilution from precipitation recharge and leakage down to the bedrock. This means no further spread was occurring. Once that point has been reached, one can only set the minimum length of time required for the system to reach its present state.

Once both hydraulic heads and concentrations had been calibrated, a run was made of the glacial aquifer model with no change in present operating conditions. This run confirmed the fact that the solute is not spreading beyond its present limits. The results after 20 years were not noticeably different from the initial conditions.

Another run incorporated a change in the hydraulic conditions near the source. The heads in the source area were set at a lower level and held constant in the model to induce flow back toward the source. This would be similar to installing some type of drainage system in the source area. This run showed that a reduction in the affected area occurs for about 5 years, after which there is little change in the size of the area.

Bedrock aquifer

The calibration of the organic levels in the bedrock aquifer indicated that the problem in the bedrock aquifer is more recent than in the glacial aquifer. The model showed that the materials had to have begun entering the bedrock aquifer in significant quantities approximately 4 years ago for the levels of organics in the monitor wells and production well #2 to reach their presently measured concentrations. Apparently, there was a time lag between solvents affecting the glacial aquifer and solvents affecting the bedrock aquifer.

The predictive runs of the bedrock aquifer model consisted of four different operating schemes. The first run was a continuation of present operating conditions. Under these conditions the affected area spread somewhat to the south for the next 10 years whereupon the plume stabilized and no further spread was observed. Most of the spread occurred in the fringe of the plume--between 1 and 5 percent of the maximum concentration. The higher concentrations remained fairly stable from the start between the source under building 308 and production well #2.

The second run investigated the changes associated with increasing the pumping rate for production well #2 by 100 gpm. The pumping rates for the other production wells remained at their present levels. The results of this run showed a decrease in the affected area over the first 5 years after which the size stabilized. There was also a slight decrease in the levels of organics within the plume.

The next model run showed very similar results to the previous one. It depicted the effects of installing a new production well near the source area and pumping this well at 100 gallons per minute while all the other wells were maintained at their present rates. Again, the area decreased over the first 5 years, then stabilized. Also, this run showed a more significant drop in the levels of organics within the plume than the previous run.

A fourth run of the bedrock aquifer model was made to examine the consequences of pumping IBM production well #9 at 250 gallons per minute (gpm) while the rest of the production wells were held constant at their present rates. While the affected area southwest of the source decreased, the area northeast of the source, toward production well #9, increased slightly before stabilizing within 5 years. Also, this pumping caused the piezometric head gradient between the source area and production well #2 to decline. Hence, the solutes were not carried away as rapidly as in the other runs, so the concentration levels within the plume increased.

Conclusions

From the modeling results, it is apparent that under present conditions and with continued pumping by IBM, there is no danger of offsite migration of dissolved organics solvents from area A either in the glacial or bedrock aquifers. The pumping in the bedrock aquifer near the center of the plant site has induced enough flow towards the wells to insure containment of the organics, even if the source of is considered continuous. In the glacial aquifer, the dilution due to recharge from precipitation and the losses due to deep percolation prevent any contaminant from migrating offsite.

Either pumping production well #2 at a higher rate or installing a new production well near the source is an effective means of limiting the spread of organics. Although pumping a new well shows greater reduction in the levels of organics than pumping production well #2 more heavily, the reduced area is about the same for either scheme. Because the capability to pump and treat water already exists at production well #2, that is the action deemed most appropriate.

Separate Phase Remedial Action Concepts

As mentioned above, borings made between buildings 308 and 310 indicate that separate phase solvents exist in this area. The separate phase appears to exist in a silt layer which is found immediately above a dense, gray clay layer in this vicinity. The gray clay layer dips to the east under building 308 and apparently terminates under that building. The separate phase solvent probably tends to flow along the clay layer but quite slowly because of the low permeability of the silt and the low gradient.

The solute transport modeling efforts described above pertain only to the movement of ground water and any dissolved solvents they may contain. All indications are that the separate phase area will remain essentially stable but will continuously provide a source of dissolved organics to the ground-water system. Although the separate phase solvents can be wholly contained and controlled so that there is no risk to others, the Corporation wishes to do what it can to remove as much of the separate phase as is feasible. The most obvious first step in this endeavor is to remove all the old storage tanks which had previously been taken out of service and are suspected to have contributed to this situation, along with any separate phase solvents found in the soil adjacent to or under those tanks. By extending these excavations into the clay layer, installing drainage sumps and backfilling with clean permeable material, an additional amount of organics could be collected in the sumps over time.

Additional excavation (over and above that required for the removal of the storage tanks and installation of the sumps) has been considered, but because of a large number of underground utilities and above-ground structures that would have to be removed and relocated, other methods of capturing the separate phase solvents appear to be more practical and equally effective.

A network of drainage sumps could be installed throughout the separate phase area, but in order to be effective in capturing a significant portion of the separate phase, the drainage sumps would have to be spaced very closely together. Under any closely spaced configuration, the same obstructions that would interfere with total excavation would also present problems in constructing the drainage sumps at the most ideal locations.

Interception of the separate phase organics with a horizontal drainage line running approximately under the west face of building 308 is a method which deserves consideration. Installation of the drainage line would have to be accomplished by horizontal boring or tunneling, and to be most effective it would need to lie on the clay layer. Because the clay layer surface is uneven, the diameter of the drainage line should be fairly large in order to assure interception of the maximum amount of organics. However, before such a line is designed and installed, it would be wise to learn more about the hydraulics of this 2-phase flow system--probably with laboratory experiments in which the hydraulic conductivity and gradient are duplicated.

REMEDIAL ACTION--AREA B

The proposed remedial action for area B was presented to the New York State Department of Environmental Conservation (NYSDEC) on January 8, 1982, and approval was received by letter dated Feb. 1, 1982. The basic plan is to pump ground water from monitor well #47, treat the water with activated carbon filters and return the clean water to the ground-water system through a recharge facility. The system is currently under design and construction is expected this summer.

Analytical studies were made to predict the amount of mounding that would be caused by the recharge of this water and the flow directions of the water after it enters the ground-water system. To help monitor the effects of the remedial action on water levels and water quality, three sets of piezometers and one monitor well have been installed during recent months.

REMEDIAL ACTION--AREA C

The proposed remedial action for area C was also presented to NYSDEC personnel on January 8, 1982, and was subsequently approved by letter from NYSDEC dated Feb. 5, 1982. The plan consisted of excavation of an old construction debris landfill suspected of being the cause of degraded ground-water quality in that area. After the plan was approved, the excavation was accomplished with the removal of about 20,000 cubic yards of material. The excavation was backfilled with clean soil, and a clay cap to minimize infiltration was placed over the top. It is believed that this action has effectively removed the source and that any remaining organics in the ground water surrounding the excavated area will be effectively contained and removed by continued pumping of IBM production well #7.

REMEDIAL ACTION CONCEPTS AND ANALYSES--AREA D

Hydrogeology and Water Quality

Additional borings in the area D vicinity during March and April 1982 revealed that the extent of the degraded ground water is very limited and apparently centered around monitor well #32. Further, the ground water is within a perched saturated zone above a clay layer with no direct evidence that the material has migrated below the clay layer. The potentiometric surface in the bedrock is considerably below the clay layer, thus providing a strong vertical gradient for such migration, but no organics have been measured in monitor wells, piezometers, or pumped wells tapping the bedrock in the area D vicinity.

Approximately 10 feet of saturation exists above the clay layer in the monitor well #32 vicinity. The water table slopes westerly at about 0.5 percent, but no organics were found to the west of monitor well #32.

Monitor Well #32 Pumping Test

An 8-hour pumping test of monitor well #32 was conducted utilizing a pumping rate of 7 gpm. Water levels were routinely measured in the pumping well and at two other monitor well locations. Analysis of the data indicated a reasonable hydraulic conductivity that would be expected for the silty sands and gravels overlying the clay layer. Water levels responded quickly to the imposed pumping which was more representative of a confined aquifer situation rather than an unconfined situation that would have otherwise been expected. A drawdown contour map for conditions existing after 8 hours of pumping was also prepared. The estimated area of influence extended approximately 200 feet to the west, north, and east of the pumped well and approximately 400 feet to the south of the well. Within this area, ground water was being directed towards monitor well #32 where eventually it would be removed by pumping.

From the pumping test of monitor well #32, it is estimated that the safe continuous yield of the well is around 5 gpm. A relatively large cone of depression surrounded the well and any degraded ground water within this area would flow towards and be discharged by pumping. The area of influence covers all suspected sources of organics within area D.

Conclusions

The logical remedial action scheme for area D is to pump monitor well #32 and maintain a cone of depression that will assure the containment and removal of the organics. Disposal of the pumped water can be accomplished through the aeration process in the nearby waste-water treatment plant.

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CONCLUSIONS AND RECOMMENDATIONS

The following summarizes the conclusions and recommendations (or already approved actions) for remedial action in areas A, B, C and D.

Area A

Dissolved organics in the ground water in area A can be effectively controlled through pumping of production well #2. In that production well #2 has a capability of producing at least 250 gallons per minute, it is recommended that the production rate be increased to that level to further assure containment.

The IBM Corporation further intends to take steps to remove as much of the separate phase organics as feasible in the building 308-310 area. The first action to be taken will be the removal of all old unused buried storage tanks in that area, along with any separate phase existing, adjacent to or under those tanks. Where possible, the excavation will proceed to the clay layer which has been identified approximately 20 feet below the land surface. All soil from this excavation will be disposed of at a permitted hazardous waste disposal facility. A drainage sump will be installed which has a perforated zone through the silt layer containing the separate phase organics. The remaining portion of each excavation will be backfilled with permeable materials.

In addition, studies will be initiated to help evaluate the possible effectiveness of a horizontal drain for collecting separate phase solvents. If such a drain is determined to be reasonably effective and can be constructed with proven techniques without endangering buildings and utilities, the plans for same will be presented to NYSDEC for review.

Area B

Design work on remedial action for area B is underway as set forth in a meeting with NYSDEC held on January 8, 1982, and described further in an attachment to a letter to Mr. G. Burns dated January 20, 1982. Completed construction and implementation of the plan is expected by August, 1982.

Area C

Completion of the excavation and backfill of the old landfill has been completed as presented previously to NYSDEC. The clay cap will be finished in June 1982. New monitor wells have also been installed. IBM production well #7 will be pumped as necessary to remove the remaining organic solvents ground water in area C.

Area D

Pumping of monitor well #32 will provide an effective containment and removal of materials found in a saturated zone above the clay layer in area D. It is recommended that monitor well #32 be pumped at a constant rate of about 5 gallons per minute and that the pumped water be piped to the existing waste-water treatment plant for disposal.

REFERENCES

1. IBM Corporation, *IBM East Fishkill Groundwater Report*, March, 1981

2. M. Chazen Associates, *Source Identification of Trace Organics in Groundwater - Shenandoah Road & Route 52 East Fishkill, NY,* January, 1982