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INVESTIGATION OF POTENTIAL CONTAMINATION OF THE ST. LOUIS PLANT SITE ST. LOUIS, MICHIGAN FOR THE VELSICOL CHEMICAL CORPORATION

DAMES & MOORE

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1.0 INTRODUCTION

This report presents the results of the Dames & Moore study for Velsicol Chemical Corporation that consisted of an assessment of the nature and extent of existing on-site contamination and an evaluation of the integrity of the dredge pond.

This study was authorized under Velsicol Chemical Corporation's Purchase Order No. 15895 issued on January 16, 1978 and revised on August 18, 1978 and January 8, 1979.

The work proposed under this purchase order necessitated that subcontractors be retained to provide chemical analysis and drilling services. Environmental Research Group, Inc., of Ann Arbor, Michigan, having had much experience in Michigan, particularly in regard to polybrominated biphenyl analyses, was contracted to perform the chemical analyses of soils, water, and tissue samples. Stearns Drilling Company of Dutton, Michigan was retained to perform drilling services.

The Velsicol Chemical Corporation plant is located on a site of approximately 50 acres adjacent to the Pine River in the city of St. Louis, Gratiot County, Michigan (Figure 1-1). The site is bounded on the north and west sides by the river, which flows to the northeast and drains the entire St. Louis area. In the vicinity of the plant site, the river widens and flows very slowly because of a dam located less than 1,500 feet downstream.

Historically, the plant site has been used as an industrial site since the mid-1800s and was used at various times by a salt plant, a lumber mill, an oil refinery, and a chemical plant (before Michigan Chemical Corporation).

Since 1935, when Michigan Chemical Corporation owned the facility and after the merger with Velsicol Chemical Corporation in 1977, an array of chemical products was manufactured on the plant premises. The chemical parameter list prepared for this study was developed from a compilation of all chemicals produced, packaged, or stored at the St. Louis facility, as indicated from available records (since 1945). This list was edited with regard to general considerations such as quantity present or produced, toxicity, carcinogenicity, and bioaccumulation and is presented in Section 3.0 as Tables 3-1 and 3-2. This final list of chemical parameters and the scope of the investigations were based on guidance and concurrence provided by Mr. Jack Bails and others of the Michigan Department of Natural Resources (DNR) in a meeting on August 8, 1978.

Specifically, the project objectives were the following:

1. To assess the present level and potential environmental implications of the possible contamination of wildlife at the Velsicol plant site;

2. To assess the present levels of possible contamination of the ground water, surface water, and soils at the plant site;

3. To examine the geohydrologic conditions at the site and evaluate the potential for migration of contaminants, if present, from the unsaturated soils to the ground water and via the surface or ground water to the Pine River or nearby shallow wells;

4. To assess the integrity of the dredge pond located on the plant site; and

5. To recommend, if necessary, steps to secure the plant site in an environmentally safe manner.

The results and discussion of the on-site studies of the terrestrial ecology program, the ground water, soils, and runoff investigation, and the dredge pond integrity study are presented in the following sections. A thorough review of literature concerning toxicology and characteristics of all

the organic chemicals studied in this investigation has been made, and the conclusions herein are based, in part, on this review. Those sources reviewed and cited in the following sections are included in the bibliography of this report.

2.0 TERRESTRIAL ECOLOGY

2.1 INTRODUCTION

As part of the investigation to assess the on-site contamination issue, a limited field study was implemented. Originally, the on-site study was planned to include the collection of tissue from small mammals, earthworms, and robins. However, because the study was begun in mid-September, the lateness of the season and the ensuing fall avian migrations precluded using robins. Plants were not considered in this study since recent research has shown that plants bioaccumulate only small amounts of PBB and translocate even less (Jacobs, et al., 1976; Chou, et al., 1978). Therefore, collection efforts were concentrated on small mammals and earthworms.

2.1.1 Habitat

Agricultural land is the dominant land use type in the St. Louis area, including all of Gratiot County. Major crops in the region are corn, dry beans, and sugar beets. Scattered forest land consists of primarily maple, beech, and birch.

The Velsicol Chemical Corporation industrial complex in St. Louis contains little vegetation and generally provides poor habitat for wildlife. The only vegetative cover on the site occurs along the shoreline perimeter. The banks of the Pine River adjacent to the plant site are generally constructed of a clayey, rocky fill material and contain sparse patches of various grasses, milkweed, chicory, goldenrod, asters, and sweet clover. Vegetation cover is greatest on the western and southwestern shoreline areas.

The western shoreline supports two small stands of cattails. A small stand of elm trees is located on the north side of the dredge pond.

Trapping was done solely along the shoreline, but most intensely along the southwestern shore adjacent to the dredge pond where habitat appeared most favorable for small mammal species (Figure 2-1; Appendix A).

2.1.2 Range and Habitats of Mammals Captured

The three species of rodents collected in this study each have relatively limited home ranges. The white-footed mouse (Peromyscus sp.) has a home range of 1/2 to 1-1/2 acres, while that of the meadow vole (Microtus pennsylvanicus) is 1/10 to 1 acre (Burt and Grossenheider, 1964). The home range of the house mouse (Mus musculus) is generally less than 1/5 acre (Jackson, 1961). Although the home range of raccoons (Procyon lotor) is usually less than 1 mile across, the young of the year may travel many miles from their place of birth.

Both the white-footed mouse and the meadow vole feed primarily on seeds, nuts, and insects, and the latter will also eat bark and grasses. Both the house mouse and raccoon are considered omnivorous (Burt and Grossenheider, 1964).

The home ranges indicate that the three rodent species collected were permanent residents of very localized areas of the plant site and obtained all their food within these limited territories. However, the raccoon's presence on the site may have been transient, and it may have obtained food from a variety of sources, both on and off the plant site.

Environmental contaminants, if present on the site and if bioaccumulative, would likely be reflected as a constituent of the tissues of the resident rodent and earthworm populations. This would be true to a lesser extent for the farther ranging raccoons.

2.2 RESULTS

The trapping program yielded a single young raccoon and 12 small rodents -- one white-footed mouse, two meadow voles, and nine house mice (Figure 2-1). In addition, a composite sample of earthworms was collected from an area near the northwestern corner of the dredge pond.

Results of tissue analyses are presented in Table 2-1. Analytical methodologies employed are identified in Appendix C. No trace of allyl chloride, PHT4 (tetrabromophthalic anhydride), tris [tris (2,3-dibromopropyl) phosphate], CCl_4 (carbon tetrachloride), DMAE (dimethyl aminoethanol), or EDTA (ethylene diamine tetracetic acid) was detected in any of the tissue samples. Only a trace (0.70 ppm, wet weight; 1.89 ppm, dry weight) of HBB (hexabromobenzene) was found in one mouse (Peromyscus sp.).

PBB (polybrominated biphenyl) was detected in tissues from every animal. Tissue concentrations ranged from 0.15 to 17.14 ppm, wet weight (0.52 to 61.21 ppm, dry weight) in the rodents and 0.17 ppm, wet weight (0.74 ppm, dry weight) and 1.12 ppm, wet weight (3.39 ppm, dry weight) for the raccoon and earthworms, respectively. The mean concentration [$\pm$ Standard Deviation (S.D.)] of PBB in the nine house mouse specimens was 4.92 $\pm$ 5.14 ppm, wet weight (16.39 $\pm$ 18.85 ppm, dry weight).

Chromium values ranged from less than 0.25 to 1.0 ppm, wet weight (less than 0.55 to 3.45 ppm, dry weight) in mouse tissue and less than

0.22 ppm, wet weight (less than 0.96 ppm, dry weight) and 1.0 ppm, wet weight (3.03 ppm, dry weight) in the raccoon and earthworm tissue, respectively. The nine house mice had a mean concentration (± S.D.) of less than 0.46 ± 0.31 ppm, wet weight (less than 1.48 ± 1.03 ppm, dry weight).

Analytical values reported for copper in the rodent species ranged from 1.6 to 6.7 ppm, wet weight (5.1 to 23.1 ppm, dry weight). Copper concentrations in the raccoon and earthworms were 1.6 ppm, wet weight (7.0 ppm, dry weight) and 3.3 ppm, wet weight (10.0 ppm, dry weight), respectively. The house mouse specimens had a mean concentration (± S.D.) of 3.7 ± 1.3 ppm, wet weight (11.8 ± 5.1 ppm, dry weight).

The mean concentration (± S.D.) of zinc in tissues of the house mice was 32 ± 6 ppm, wet weight (102 ± 29 ppm, dry weight), while the range for all mammals was 23 to 44 ppm, wet weight (51 to 152 ppm, dry weight). In the raccoon tissue concentration was 34 ppm, wet weight (148 ppm, dry weight). However, the value determined for zinc in the composite earthworm sample was much higher: 160 ppm, wet weight (485 ppm, dry weight).

With a tissue concentration of 9.0 ppm, wet weight (27.3 ppm, dry weight), earthworms also exhibited the highest concentration of lead. In raccoon tissue, lead was reported in a concentration of less than 0.5 ppm, wet weight (less than 2.2 ppm, dry weight). The mean lead value (± S.D.) reported from the house mouse specimens was 1.8 ± 1.2 ppm, wet weight (5.5 ± 3.4 ppm, dry weight), while the range for all mice was less than 0.5 to 4.4 ppm, wet weight (less than 1.4 to 14.2 ppm, dry weight).

In rodent tissue, magnesium levels ranged from 290 to 990 ppm, wet weight (607 to 3,536 ppm, dry weight), while the mean value (± S.D.) for house mouse specimens was 427 ± 98 ppm, wet weight (1,364 ± 386 ppm, dry weight).

The raccoon and earthworms had concentrations of 150 ppm, wet weight (652 ppm, dry weight) and 540 ppm, wet weight (1,636 ppm, dry weight), respectively.

2.3 DISCUSSION

2.3.1 Hexabromobenzene (HBB)

Acute oral and dermal lethal doses for 50 percent of the exposed population (LD_{50}) of hexabromobenzene (HBB) determined for experimental mammals were 2.15 to 4.64 gm/kg of body weight and greater than 10.0 gm/kg of body weight, respectively (Root, 1978); therefore, it is not considered highly toxic. HBB was found in trace amounts in the body tissue of only one specimen of white-footed mouse collected from the plant site. It appears that HBB contamination of on-site fauna is relatively insignificant.

2.3.2 Polybrominated Biphenyl (PBB)

The Michigan Department of Natural Resources (DNR) analyzed muscle tissue from five raccoons and one muskrat collected near the Pine River downstream from St. Louis and found polybrominated biphenyl (PBB) in all samples in concentrations ranging from 0.470 to 1.600 ppm, wet weight, in the raccoons and 0.430 ppm, wet weight, in the muskrat (Table 2-2) (Shauver, 1978). These values are higher than the PBB concentration found in the raccoon collected on-site during this investigation, but are very similar to many of the values reported for the mice and voles.

Several groups of rats in a study by Harris, Cecil, and Bitman (1978) that were fed PBB (fireMaster BP-6) mixed with food at 50 to 200 ppm

concentrations for 10 weeks accumulated PBB concentrations in the liver and abdominal fat ranging from 55 to 295 ppm, dry weight, and 864 to 3,574 ppm, dry weight (lipid), respectively. Kimbrough, Burse, and Liddle (1978) fed rats a single dose of PBB (fireMaster FF-1) at 1,000 mg/kg body weight. After 10- to 14-month recovery periods, the ranges of mean PBB concentrations in the liver and adipose tissues of these animals were 22 to 63.2 ppm, wet weight and 713.6 to 1,201.7 ppm, wet weight, respectively. These data must be viewed with caution when compared to those obtained from the animals collected recently on the plant site, since the recent data were determined from whole animal samples while the work presented in the above studies concerns two tissue types, liver and fat, of which the latter has been shown to concentrate PBB (Matthews, et al., 1977).

Also, it is interesting to note that even the control animals in the studies of both Harris, Cecil, and Bitman (1978) and Kimbrough, Burse, and Liddle (1978) often had detectable levels of PBB in their tissue even though they had never been administered the chemical. Highest PBB concentrations in the control animals were 31 ppm, dry weight (lipid) and 0.73 ppm, wet weight, respectively.

All the animals collected on site were found to have PBB concentrations of various levels in their tissues. Highest levels were found in two mice; one (17.14 ppm, wet weight; 61.21 ppm, dry weight) was collected from an area that received surface water runoff from the waste drum storage area where PBB containers were occasionally stored, and the other (7.69 ppm, wet weight; 27.46 ppm, dry weight) was collected adjacent to that section of the plant where PBBs were once manufactured. The above studies indicate that some of the animals collected from the plant site had PBB tissue levels higher than

those reported by the DNR for animals collected off the site, and that the most probable route of contamination is oral through ingestion of soil particles during activities such as feeding, burrowing, and grooming.

2.3.3 Chromium

Studies by Beardsley, et al. (1978) in Great Britain found the median chromium concentration in field vole (Microtus agrestis) carcasses (liver, kidney, brain, and femur removed) collected from a sewage spray field to be 5 ppm, dry weight. Lower median concentrations, 3 and 4 ppm, dry weight, were reported for voles collected from two control areas. Separate analyses of liver, kidney, brain, and femur tissue in both the control and experimental groups found chromium in even lower median concentrations than those reported for carcass analyses.

Laboratory mice fed chromium in their daily diet developed a mean concentration of this metal in major organs (kidney, liver, spleen, heart, and lung) of 1.26 ppm, dry weight (Schroeder, et al., 1964). Mean concentration of the control group was 0.37 ppm, dry weight.

These data suggest that the chromium levels recorded for animals collected from the Velsicol plant site, and the rodents in particular, are levels that might be found in chemically uncontaminated individuals. The results of the current investigation indicate no apparent distributional pattern of chromium in mammals around the plant site.

2.3.4 Copper

Copper in field voles (M. agrestis) in the experimental group examined by Beardsley, et al. (1978) had median dry weight concentrations

of 7 and 11 ppm. In British wheat fields treated with dieldrin and mercury, Jeffries and French (1976) found copper levels in long-tailed field mice (Apodemus sylvaticus) to range from 2.8 to 5.5 ppm, wet weight ($\bar{x} \pm$ S.D. = 4.0 $\pm$ 0.96). A single specimen of a bank vole (Clethrionomys glareolus) from the same fields was found to have a wet weight tissue concentration of copper of 4.3 ppm. Deer mice (Peromyscus maniculatus) and short-tailed shrews (Blarina brevicauda) collected from the Hubbard Brook Experimental Forest in New Hampshire by Schlesinger and Potter (1974) had mean wet weight copper concentrations of 3.2 $\pm$ 0.16 (S.D.) and 2.9 $\pm$ 0.92 (S.D.) ppm, respectively.

The data presented in the above studies compare favorably with the results of recent tissue analyses from the Velsicol plant site and indicate that the copper concentrations in these animal tissues probably reflect typical background levels, particularly for the small mammal species. Also, there is no indication of significant distributional patterns of copper in on-site mammals.

2.3.5 Lead

The composite sample of earthworms had a much higher level of lead than the mammals, a condition that is not unexpected since earthworms have been shown to reflect lead levels in soils (Ireland and Wooton, 1976). Relatively high soil lead concentrations were found on the plant site at various locations (Appendix B).

Van Hook (1974) found lead in a mean concentration of 4.7 ppm, dry weight, in earthworm tissue collected from uncontaminated soils in Tennessee that contained a mean dry weight concentration of 27 ppm. Investigations by Gish and Christensen (1973) have found that earthworms collected from soils

with a 14.3 ppm mean dry weight lead concentration in the Patuxent Wildlife Research Center in Maryland had a mean lead concentration of 12.0 ppm, dry weight. In the same study, the investigators found mean lead values in soils and earthworms collected near two highways to range from 34.9 to 700.0 ppm, dry weight and 38.5 to 331.4 ppm, dry weight, respectively. Goldsmith and Scanlon (1977) found the lead content of composite earthworm samples from Virginia soils adjacent to roadways to range from 8.51 to 51.01 ppm, dry weight.

Lead concentrations in earthworm tissue at the Velsicol plant site approach the lower values reported by Gish and Christensen (1973) and fall within the range of values presented by Goldsmith and Scanlon (1977) for soils near highways. However, the lead values recorded from the Velsicol plant site may have been influenced, to some degree, by the ingested soil in the gut of the worms which, depending on the lead content of this material, may have magnified these results.

Lead concentrations in small mammals collected from sites of metallic mines in Great Britain have been compared by Roberts, et al. (1978) to uncontaminated control areas. Mean lead concentrations in the body tissues of field mice (A. sylvaticus), field voles (M. agrestis), and bank voles (C. glareolus) collected from two control sites were 0.92 and 1.16, 2.76 and 2.76, and 2.36 and 2.64 ppm, wet weight, respectively, and mean tissue concentrations for all three species collected from contaminated sites ranged from 13.9 to 45.3 ppm, wet weight.

Beardsley, et al. (1978) found median lead levels in body tissues of the field voles (M. agrestis) to be 3 and 6 ppm, dry weight, in two control groups. A third group of voles collected from a population inhabiting a sewage spray field had a median concentration of 12 ppm, dry weight.

Like earthworm studies, many studies regarding lead levels in small mammals have been directed at rodent populations adjacent to highways. Comparing tissue levels of lead between population of the field mouse (A. sylvaticus), field vole (M. agrestis), and bank vole (C. glareolus) living near roads with varying traffic densities, Jefferies and French (1972) found the mean wet weight concentration to range as high as 2.26 ppm, wet weight, in animals closest to the most heavily traveled road. Mean concentrations from populations collected in control areas were only 1.32 ppm, wet weight.

A similar study in Illinois by Getz, et al. (1977) found mean lead levels in the body tissues of deer mouse (P. maniculatus), prairie vole (Microtus ochrogaster), and house mouse (Mus musculus) collected near roads of varying traffic densities to range from 2.4 to 5.5, 2.6 to 8.1, and 3.4 to 6.9 ppm, dry weight, respectively. Lead concentrations for the control specimens collected in this study were 2.8, 3.3, and 4.6 ppm, dry weight, respectively.

In Virginia, Quarles, et al. (1974) found mean lead levels in specimens of meadow voles (Microtus pennsylvanicus), white-footed mice (Peromyscus leucopus), and short-tailed shrews (B. brevicauda) to be highest in tissues from populations nearest a major highway (16.3, 6.8, and 22.7 ppm, dry weight, respectively). Concentrations reported for control groups were 4.9, 2.6, and 5.4 ppm, dry weight, respectively.

The above data suggest that the concentrations of lead in the various mammal species captured at the Velsicol plant site are not abnormally high. No apparent distributional pattern on the plant site is indicated by the study data.

2.3.6 Zinc

Jefferies and French (1976) reported a mean zinc concentration in long-tailed field mice (A. sylvaticus) captured from a dieldrin/mercury treated field of 33.5 ± 8.95 (S.D.) ppm, wet weight. In the same study, a similar concentration (36.9 ppm, wet weight) was detected in a single specimen of bank vole (C. glareolus).

Beardsley, et al. (1978) found the median concentrations of zinc in field vole (M. agrestis) tissue samples collected from two control populations and from a third population resident in a sewage spray field to be 117, 101, and 174 ppm, dry weight, respectively.

The concentration of zinc detected in the tissues of all the mammals collected from the Velsicol plant site are relatively similar, reveal no apparent distributional pattern, and, as suggested by the above data, do not appear to be abnormally high.

The earthworms sampled collected on the Velsicol plant site had a much higher concentration of zinc than any of the mammal samples collected there. Although it is possible for zinc contamination of soils contained in the digestive tracts of the earthworms to contribute to these results, the high concentration reported for the earthworm tissue was enhanced by the phenomenon of bioaccumulation which has been demonstrated by Van Hook (1974). In his work in Tennessee, Van Hook found mean zinc concentrations in earthworm tissues of 317 ppm, dry weight, collected from soils within a naturally occurring mean zinc concentration of 43 ppm, dry weight.

Studies by Gish and Christensen (1973) found zinc levels in earthworm tissues as high as 670 ppm, dry weight collected adjacent to Maryland

highways. The control group collected from isolated fields had a concentration of 223.8 ppm, dry weight.

Ireland and Wooten (1976) investigated zinc contamination in soils and earthworms from a lead/zinc mine in Great Britain. Levels of zinc in earthworms from these contaminated soils ranged from 450 to more than 800 ppm, dry weight. All control groups examined had concentrations of less than 150 ppm, dry weight.

It can be concluded with regard to the above data that the earthworms collected from the Velsicol plant site had higher zinc tissue levels than what would be expected for noncontaminated areas. Zinc levels in earthworms collected from the plant site, although not as high as zinc concentrations in worms from soils near highways, were within the lower range of zinc values reported for worms from soils near metal mines.

2.3.7 Magnesium

Magnesium is an essential element in animal nutrition, a common constituent of mammalian tissues, and found most abundantly in bone (Scott, 1972). Data presented in Bowen (1966) indicate that the average magnesium concentration in mammal tissue is 1,000 ppm, dry weight. In his study, it was found that the concentrations ranged from 150 to 640 ppm, dry weight for various organs, and the level reported for bone was 1,700 ppm, dry weight.

Generally, magnesium concentrations found in the mammals collected on site appear to be somewhat above levels that might be expected from uncontaminated populations. However, two of the three mice having highest magnesium concentrations were collected from habitats adjacent to the kilns and the

hydrotreater pit. Although specimens were washed before processing, dust of magnesium compounds, which is very abundant in these areas, may have adhered to the skin and fur of these animals and influenced analytical results.

The concentration of magnesium in the earthworm tissues does not seem to be particularly high in regard to the much higher levels often found in site soil samples.

3.0 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATION

3.1 SCOPE OF WORK

This investigation was conducted in two overlapping phases. Phase I was basically designed as an environmental assessment of the entire plant site. At the close of the field work involved in Phase I, the data collected were analyzed and it was determined that additional sampling in certain areas of the plant would be helpful. Also at that time, an assessment of the integrity of the dredge pond was added to the scope of work. Phase II included both this additional sampling and the study of the integrity of the dredge pond. Analytical methodologies employed are identified in Appendix C. Both phases are described in detail in the following paragraphs.

3.1.1 *Phase I*

A literature search was conducted by visiting state and federal agencies to obtain geohydrologic data on the region, area, and the site. A brief visit was also made to the site to obtain any additional and pertinent data in Velsicol's files. These data were compiled, tabulated, and assessed for guidance in other data collection activities and inclusion in the final report.

A site reconnaissance was conducted to gain familiarity with the site, to select locations of borings, and to discuss procedures with the drilling contractor. Locations were selected based on the geography of the site and on the proximity to suspected areas of potential ground-water contamination. Ten borings were completed at nine locations that are shown on

Figure 3-1. Stearns Drilling Company of Dutton, Michigan was retained as a subcontractor to Dames & Moore to provide on-site drilling services.

The first-phase borings were drilled and sampled using the methods described in Appendix D. Selected samples were subjected to physical identification and testing for grain-size distribution. Selected soil samples were also used for chemical testing to determine the presence and concentration of contaminants (Table 3-1).

Piezometers (small-diameter wells), constructed of 5.08-centimeter (2-inch), galvanized iron pipe and steel well points, were installed in the borings and packed with gravel around the well points. The remainder of the annulus between the well pipe and the boring wall above the well points was grouted with concrete. Figure 3-2 shows a typical piezometer installation. Appendix E lists pertinent information concerning piezometer construction. The piezometers were developed and falling head tests conducted to determine the aquifer or aquiclude permeability. Ground-water samples were collected from the piezometers for laboratory analyses to determine the presence and concentrations of certain constituents (Table 3-1). The piezometers were also used to measure ground-water levels.

Shallow soil samples were collected from land surface to a depth of 0.3 to 0.6 meter (1 to 2 feet) at 15 locations on the plant site (Figure 3-3). The soil samples were visually described, and selected samples were subjected to chemical testing.

Office analyses, using the field data generated and existing records, included the assessment of the direction of ground-water movement and calculations of rate of ground-water movement based on the potentiometric gradient, porosity, and permeability. A map showing the elevation of the

underlying clay till confining unit was constructed (Figure 3-4). Calculations were made to assess the transport of contaminants, if any, to nearby wells and the Pine River.

Analysis of the data gathered during Phase I and concern expressed to Velsicol by the Michigan DNR about the integrity of the dredge pond on the south end of the plant site led to the formulation and completion of Phase II.

3.1.2 Phase II

In order to augment the data collected in Phase I, 20 additional soil samples were collected from 16 locations on the plant site (Figure 3-1). Also, additional ground-water samples were collected from six of the ten Phase I piezometers. These soil and water samples were analyzed for selected chemical parameters (Table 3-2). Many of the parameters included in Phase I were eliminated on the basis of concentrations found in the first phase.

In order to determine the integrity of the dredge pond, seven additional borings were drilled at six locations in and around the pond (Figure 3-1). Piezometers were installed, developed, and falling head tests run in each of these borings. Water samples taken from the piezometers and two soil samples taken from the boring located in the center of the pond (DP-6) were analyzed for selected chemical parameters (Table 3-2). These piezometers were also used to monitor water levels in the pond and embankments. Shallow backhoe pits were dug at the interface between the pond surface and the embankment; however, the instability of these observation pits prevented close examination or sampling of the dike materials.

3.2 SITE GEOLOGICAL CONDITIONS

The topography and drainage patterns of the St. Louis area are the result of geologic processes associated with the retreat of the last continental ice sheet that at one time covered the entire state of Michigan. The plant site is located in a topographic low cut by the Pine River through a north-south trending belt of morainal hills.

The bedrock formations underlying the St. Louis area consist of sediments deposited in extensive inland seas that covered Michigan during the Paleozoic era between 500 and 200 million years ago. Deformation, subsidence, and compaction that occurred contemporaneously with the sedimentation produced a bowl-shaped structure known as the Michigan Basin. When these sediments were lithified, limestones, dolomites, shales, and sandstones were formed, which are commonly interbedded with evaporite deposits such as rock salt and gypsum.

The time interval following the Paleozoic era was characterized principally by erosion. During this time, an extensive drainage pattern was cut in the bedrock surface.

During the Pleistocene glacial epoch, a thick mantle of glacial drift was deposited on this eroded bedrock surface. This drift is approximately 91.4 meters (300 feet) thick in the St. Louis area and consists of lacustrine deposits, outwash, and till. The generalized columnar section in Table 3-3 illustrates the lithology and water-bearing properties of the glacial drift material as well as that of the bedrock units present beneath the site.

For the purposes of this study, the deposits present within approximately 9.1 meters (30 feet) of the surface are of particular interest. These deposits are described in detail in the following section.

3.2.1 Near-Surface Stratigraphy of the Velsicol Plant Site

The near-surface stratigraphy of the plant site is quite complex. This is primarily due to the many different industrial and construction activities that have taken place on the site over the past 100 years. The materials present in the upper 9.1 meters (30 feet) of the plant site include miscellaneous fill, alluvial sands, marsh deposits, lacustrine silts and clays, and clayey glacial till. The general area and vertical distribution of these materials are illustrated on the cross sections on Figures 3-5, 3-6, and 3-7. Appendix F contains the boring logs for the 17 borings completed for this study (Figure 3-1).

Miscellaneous Fill - The upper 0.61 to 6.1 meters (2 to 20 feet) of material at the plant site generally consists of fill that is highly variable in composition, both vertically and areally. The fill material includes relatively clean sands, cinders, bricks, mixtures of sawdust and small pieces of lumber, and other miscellaneous refuse.

Alluvial Sands - Sands of probable alluvial origin were penetrated in 12 of the 17 borings drilled for this study. These sands vary from 0.61 to 5.5 meters (2 to 18 feet) in thickness and are generally well sorted.

Marsh Deposits - Deposits indicative of a marsh environment were penetrated in one boring completed for this study and were reported in three

of the borings completed during soils exploration completed earlier by the Michigan Drilling Company. All these borings were located in the northwest portion of the site within 76.2 meters (250 feet) of the Pine River. These deposits consist primarily of a layer of peat from 0.91 to 1.5 meters (3 to 5 feet) thick.

Lacustrine Silts and Clays - A 0.91 to 1.2 meter (3 to 4 foot) thick layer of silty clay over- and underlain by sands was penetrated in five borings in the southern half of the plant site. This deposit contains little, if any, coarse material and is indicative of deposition in a low-energy environment such as a lake or pond.

Clayey Glacial Till - A hard, gray, clayey silt with a trace of fine gravel was penetrated at depths ranging from 1.5 to 6.4 meters (5 to 21 feet) in each of the borings completed for this study. Each of the borings was completed in this unit. Occasional thin [0.3 meter (1 foot) or less] lenses of fine to medium sand were found at various depths within this clayey till.

3.3 SITE GEOHYDROLOGY

The bedrock formations which underlie the Velsicol plant site generally yield only moderate supplies of water that are typically highly mineralized. Some of the deeper formations are used as sources of brine for the chemical industry in central lower Michigan. As illustrated in Table 3-3, the outwash portion of the glacial drift is the best source of fresh ground water in the vicinity of the plant site. Examination of drillers' well logs (Appendix G) from an area within approximately 1.6 kilometers (1 mile) of the

site reveals the existence of relatively thin [3 to 9 meter (10 to 30 foot)] lenses of sand or sand and gravel capable of yielding reliable supplies of fresh water to small-diameter, domestic wells. These lenses occur within or between thick layers of till which consist of relatively impermeable clayey silt with a trace of sand and gravel. The presence of these thick clayey till deposits beneath the entire site makes the downward migration of any contaminants extremely unlikely. Therefore, only the geohydrology of the near-surface materials will be described in detail.

As mentioned in the preceding section, the surficial deposits in the immediate vicinity of the Velsicol plant site consist of variable thicknesses of fill material and alluvial sands. These deposits are underlain by a clayey glacial till that appears to constitute the lower boundary of an unconfined, perched, ground-water flow system. Due to the impervious nature of the till, any contamination of the ground water is expected to be contained in this thin, perched aquifer system.

Water levels in this perched system were obtained from the 17 piezometers installed on the plant site for this study (Table 3-4). This information was used to construct a general potentiometric map of the site (Figure 3-8). The ground-water gradient represented on this map indicates that the direction of flow is toward the Pine River. The gradient is generally quite gentle, ranging from 0.005 to 0.02 over most of the plant site. On the interior surfaces of the embankments which surround the dredge pond, a thin layer of clayey silt applied in construction and the fines contained in the dredged material have combined to establish interior surfaces having relatively low permeability. This condition has created a ground-water mound in the pond itself as well as in the area in and around the calcium chloride tank farm. Gradients of 0.10 to 0.50 may exist in this area.

The permeability of the various soil and fill materials at the plant site were evaluated using falling head permeability tests in the piezometers. Also, permeability calculations were made using the Hazen approximation that relates the grain size of granular material to its permeability (Hazen, 1911). The results of the tests and calculations are presented in Tables 3-5 and 3-6.

The median of the permeability values calculated using the falling head test is 5.2×10^{-5} cm/sec [1.1 gallons per day per foot squared (gpd/ft^2)]. This result should be indicative of the permeability of the sand and fill material on the site. However, it is believed that the values obtained from the falling head tests are misleadingly low due to the partial plugging of the screened intervals with silt. The permeabilities calculated using the Hazen approximation are believed to represent a more realistic value for the sand and fill material. This method results in a range of permeabilities from 4×10^{-5} to 6×10^{-2} cm/sec (0.8 to 1,270 gpd/ft^2) with a median value of 2×10^{-3} cm/sec (42 gpd/ft^2).

For the clayey till material, the Hazen permeability approximation results in a range of 4×10^{-6} to 3×10^{-4} cm/sec (0.08 to 6.4 gpd/ft^2) with a median of 4×10^{-5} cm/sec (0.8 gpd/ft^2). Norris (1961) tabulated permeability values for 37 samples of clay-rich till deposited by continental glaciers. The permeabilities ranged from 1.6×10^{-8} to 4.8×10^{-5} cm/sec (0.0003 to 1.0 gpd/ft^2) with an average of 2.1×10^{-6} cm/sec (0.04 gpd/ft^2).

The quantity of ground water being discharged to the Pine River adjacent to the plant site can be calculated using the following equation:

$$Q = KIA \qquad \text{(EX 3-1)}$$

where Q = total ground water discharge;
K = permeability of the aquifer;
I = hydraulic gradient; and
A = area of discharge to the river.

Using the median permeability for the sand and fill of 2×10^{-3} cm/sec (42 gpd/ft^2), an average gradient for the entire site of 0.02, and a cross-sectional area of 2,284 square meters (24,590 square feet), the total discharge equals 0.91 liter per second (21,000 gallons per day).

3.4 DREDGE POND INTEGRITY

The dredge pond was constructed in the early 1970s to contain material dredged from the Pine River in the vicinity of the plant site. The pond was constructed using material present on the site. The sand and fill present at the surface was pushed up into berms forming the outer portion of the embankment. Excavation of material continued through the sand and fill and into the clayey till which was lapped up on the interior of the embankment in an effort to minimize the movement of water from the pond. Fines contained in the dredged material were expected to further seal the pond, and this material was then emplaced as a slurry from a single pipe at the north end of the pond.

This brief summary of the pond construction history was compiled primarily from personal communication with Velsicol employees and the local contractor who built the pond. Details such as the continuity and thickness of the till liner were impossible to verify. Borings on the embankments did show that the outer portion was composed of sand and sandy fill material. An attempt to visually verify the existence of the till liner using backhoe trenches at two locations failed due to the instability of the material forming the observation pit walls and limited depth that could be reached. A layer of fine-grained clayey silt was observed to a depth of 3.0 to 3.7 meters (10 to 12 feet) below the top of the embankment, but this is still at least

3.0 meters (10 feet) above the pond bottom. Figures 3-9 and 3-10 show generalized cross sections of the dredge pond.

The water-level measurements from piezometers in and around the pond provide indirect evidence of the continuity of the till liner. As indicated on the general potentiometric map, a substantial drop in head occurs from the material in the pond to the sandy outer portion of the north, west, and south embankments. This suggests the existence of a less permeable layer in the embankments.

The total quantity of ground water discharged from the vicinity of the dredge pond can be calculated using the same equation mentioned earlier, $Q = KIA$. This dredge pond area includes the dredge pond, the calcium chloride tank farm containment area, the truck staging and washing area, and the southwestern portion of the waste drum storage area. If the high gradient from the interior of the pond and the calcium chloride tank farm containment area to the river is used in this equation, some assumptions about the existence, thickness, and permeability of the till layer on the inside of the embankments of the pond must be made. To circumvent the error inherent in these assumptions, the total discharge can be calculated using the gradient from the sandy exterior of the north, west, and south embankments to the river. The permeability of 2×10^{-3} cm/sec (42 gpd/ft^2) for the sand and fill material can be used with an average gradient of 0.04 and a cross-sectional area of 819 square meters (8,820 ft^2). This yields a total discharge from the pond area of 0.66 liter/sec (15,000 gal/day), which equals approximately 70 percent of the total flow from the plant site to the river.

The general integrity of the pond appears to be good, as shown by the large drop in the water levels from the interior of the pond to the sandy

portion of the embankments. Impeded movement of water from the pond due to a seal of low permeability created by the thin, clayey till layer and the fine-grained dredged materials could account for this drop. Even with this large difference in water level from the pond to the embankments, the gradient from the embankments to the Pine River is considerably higher than that for the remainder of the plant site. This can be explained by the probable flow of ground water mounded in the area of the calcium chloride storage tanks through the sandy portions of the embankments to the river. This flow around the pond through the pond embankments is further supported by the high chloride content of the water samples collected from the calcium chloride tank farm and embankment piezometers. These results suggest a hydraulic connection between these piezometers.

4.0 GROUND-WATER AND SOIL CHEMISTRY

4.1 GROUND-WATER CHEMISTRY

Ground-water samples were taken from 15 of the 17 piezometers. Two of the piezometers, DM8 (deep) and DP2 (shallow), did not yield enough water to make up a sample. Piezometer DM3 did not yield enough water to make up a sample during Phase I but was sampled during Phase II and analyzed for an abbreviated list of parameters based on the results of the Phase I analyses. Table 3-1 lists the parameters for which analyses were made during Phase I, and Table 3-2 lists the parameters for Phase II. In addition to the above samples, the ground water used as the plant water supply was also analyzed. This water was used to make up the drilling fluid and the results of the analysis were included in the statistics of the ground-water chemical analyses.

Table 4-1 summarizes the ground-water chemical analyses. The parameters listed reflect plant site activities which have occurred over the years. Allyl chloride, EDTA, hexabromobenzene, PHT4, and tris, raw materials which were used in product formulation or chemical products which were formulated over the years, were "not detectable" in the ground water. However, ammonia is present in the brines used, as are chlorides and magnesium.

It was found that, in general, a log-normal distribution more accurately defined the variability of parameter concentrations than did the traditional normal distribution. As a result, the geometric mean and geometric standard deviations were calculated for each parameter and are listed in Table 4-1.

Ammonia concentrations in the ground water ranged from 0.14 to 53 mg/l and had a geometric mean of 4.7 mg/l. Concentrations of chlorides ranged from 82 to 82,000 mg/l with a geometric mean of 5,800 mg/l, while the ground-water concentrations of magnesium ranged from 26 to 570 mg/l with a geometric mean of 220 mg/l. The highest concentrations of ammonia and chloride were found in the water samples taken from piezometer DM8, while the highest concentration of magnesium was found in the water from DM6. Both DM8 and DM6 are located in the waste drum storage area.

Nitrate is an oxidation product of ammonia, and sulfates are probably due to the use of sulfuric acid in product formulation and due to the high quantity of sulfate in the plant water. The concentrations of nitrate ranged from less than 0.01 to 0.11 mg/l with a geometric mean of 0.021 mg/l. The sulfates had a geometric mean of 150 mg/l and a range of 3 to 2,400 mg/l. All the nitrate concentrations were well below the drinking water standard of 10 mg/l. The highest sulfate concentration was found in the plant water, with the highest concentration found in a piezometer water sample being 650 mg/l from DM6.

Chromium and lead concentrations probably reflect the use of stainless steel fixtures and lead pipe plumbing, respectively. The geometric mean of chromium was 0.087 mg/l and chromium concentrations ranged from 0.060 to 0.14 mg/l. The highest chromium concentrations were found at DM7 and DM9. The water sample from DM9 also contained the highest concentrations of lead, zinc, and copper. Ranges of concentrations for lead, zinc, and copper are 0.015 to 8.1 mg/l, 0.040 to 1,000 mg/l, and 0.035 to 9.0 mg/l, respectively. The geometric means were 0.26 mg/l, 26 mg/l, and 0.25 mg/l, respectively. Zinc levels result from the use of zinc bromide and zinc oxide, and copper reflects the earlier use of ion exchange facilities.

The remaining parameters listed are also used in product formulation as shown below:

PARAMETER	PRODUCT
Carbon Tetrachloride	Bromotrichloralmethane
DMAE	Dimethylaminoethylchloride Hydrochloride
PBB	fireMaster BP-6
Phenol	Tribromophenol

Carbon tetrachloride, DMAE, and PBB occurred only occasionally in the samples analyzed, and then only in trace amounts. Carbon tetrachloride concentrations ranged from less than 0.01 to 0.08 mg/l with the highest concentration being found at DM6. DMAE was found only in the water from piezometer DM5. The highest concentration recorded was for the Phase II sample taken at this station. This value was less than 500 mg/l and reflects interference in the analytical procedure. The Phase II sampling was done to verify the 20 mg/l concentration recorded for the Phase I sample. PBB concentrations were found at DM5 and DM8 during the Phase I sampling. Their presence there was verified during the Phase II sampling. In addition, trace PBB values were found in all the DP-series water samples. The PBB concentration ranged from less than 10^{-5} to 0.0013 mg/l. For both phases, the highest PBB values were recorded at DM8 (1.3×10^{-4} and 0.0013 mg/l) while the second highest values were recorded at DM5 (2×10^{-5} and 3.5×10^{-4} mg/l). Phenols were found in all ground-water samples and ranged from 0.004 to 1.2 mg/l with a geometric mean of 0.029 mg/l. The highest phenol concentration was found at DM9.

While the ground-water quality of the site would not meet drinking water standards (U.S. Public Health Service, 1962; U.S. EPA, 1976a), the

effect of ground-water seepage from the plant site would result in little, if any, change in concentrations of water constituents, the criteria for which, if not exceeded, are expected to result in an aquatic ecosystem suitable for the higher uses of water as outlined by the U.S. EPA (1976b).

This small amount of change can be shown by predicting the downstream concentrations for each parameter using the geometric mean of the recorded concentrations, the approximate ground water contribution to the river, the 30-day low flow of the Pine River, and the assumption that the concentration of each parameter in the river water is zero. Complete mixing is also assumed.

The approximate ground-water flow to the river is 0.0009 m^3/sec (0.03 cfs). The flow of the Pine River was chosen to be the 30-day low flow of 1.2 m^3/sec (42 cfs). This was chosen because it was the flow used by the Michigan DNR to develop the discharge standards for the plant permit (1971).

Table 4-1 lists the predicted concentrations for the parameters listed. These predictions provide an estimate of the effect of the constituents on the water quality of the receiving stream. As can be seen, this effect would be minimal. This effect is minimized even more when one considers that approximately 70 percent of the total ground-water seepage originates in the dredge pond area. The general ground-water quality in this area is, in most cases, better than that of the rest of the plant site. Therefore, the general water quality of the ground-water seepage into the Pine River would probably be better than assumed above.

The water quality at each piezometer was ranked in order to determine the order of the general water quality. Water samples from each piezometer used in Phase I and the plant water source were ranked for each parameter by giving the highest concentration a ranking of one and the lowest

concentration a ranking of nine. If two concentrations were equal they were given the same ranking. Once the concentrations were ranked, the number of times a particular ranking occurred for each water sample was recorded. Each ranking was given a value where the ranking of one would have a value of nine, the ranking of two would have a value of eight, etc. The number of times a particular ranking occurred for each water sample was then multiplied by its appropriate value. The results were totaled to yield a number which was used as an indicator of the general water quality. These general water quality indicators are listed in Table 4-2. As can be seen, the water sample having the best overall water quality is the plant water. The indicators for DM1 and DM2 seem to show that these samples are representative of the background water quality levels on the plant site. The two samples having the highest ranking numbers (DM6 and DM8) are located in the waste drum storage area, and the others are located in the main body of the plant. Upon reviewing the groundwater ranking numbers in conjunction with individual parameter values, several piezometers were found to have questionable concentrations of certain parameters, and these piezometers were resampled during Phase II. A summary of these samples is presented below:

SAMPLE	PARAMETER	PHASE I CONCENTRATION (mg/l)	PHASE II CONCENTRATION (mg/l)
DM1	CCl_4	0.03	0.0026
DM5	PBB	0.00002	0.00035
	DMAE	20	<500
DM6	CCl_4	0.08	0.027
DM7	CCl_4	0.02	0.0016
DM8	PBB	0.00013	0.0013

Values for carbon tetrachloride were significantly lower for the Phase II samples. The existence of PBB in DM5 and DM8 samples was verified and no evaluation could be made of DMAE values because of interference in the analytical methodology.

There is little correlation between ground-water samples based on chemistry, probably reflecting the processes of dilution, dispersion, and sorption. This condition is reflected in the water quality data of DM8 and DM6. DM8 is upgradient from DM6; thus, the ground water flows from DM8 to DM6. A definite decrease in the concentrations of all parameters occurs at DM6 with the exception of sulfate, magnesium, carbon tetrachloride, and phenols.

The PBB concentrations in the ground-water samples reflect the insolubility of this chemical (Jacobs, et al., 1976; Filonow, et al., 1976; Jacobs, et al., 1978). Ground-water PBB concentrations are listed in Table 4-3. Concentrations range from less than 0.01 to 1.3 µg/l and the geometric mean is 0.12 µg/l. The highest concentrations were recorded at DM8, which is located in the center of the waste drum storage area. No PBB was found in the water from DM9, which is located next to the area in which PBB was handled in product formulation. PBB was found in water from DM5, which is southwest of the above area. Small amounts of PBB were also found in the ground water sampled during Phase II. The Phase II piezometers are located near the truck washing area. In this area, truck exteriors were washed and this exterior road dust accumulated, in part, on site and may be a source of PBB in this area.

4.2 SOIL CHEMISTRY

Surface and subsurface soil samples were taken for chemical analysis. In addition to samples taken for this study, samples were previously taken by personnel of both the Velsicol Chemical Corporation and the Michigan DNR. A summary of the analytical results can be found in Table 4-4.

Soil samples taken for Phase I of this study were analyzed for the parameters listed in Table 3-1 while the soil samples taken during Phase II were analyzed for the parameters listed in Table 3-2. A summary of the results of chemical analyses for both surface soil and subsurface soil samples are listed in Tables 4-5 and 4-6, respectively. Allyl chloride, EDTA, and PHT4 were not found in any of the soil samples. Carbon tetrachloride was not found in any of the surface soil samples, but was found in trace amounts in some subsurface soil samples. The subsurface carbon tetrachloride concentrations ranged from less than 0.03 to 0.06 mg/kg with a geometric mean of 0.02 mg/kg.

DMAE was not found in any of the borehole soil samples and was found only occasionally in the standard surface and subsurface soil samples. Concentrations ranged from less than 7.0 to 53 mg/kg with a geometric mean of 3.9 mg/kg for surface soil samples and 4.5 mg/kg for subsurface soil samples. The highest DMAE concentration was found in the subsurface sample taken at SS6 which is located in the waste drum storage area.

Hexabromobenzene is generally distributed in the samples collected. The highest value of 56 mg/kg was measured at SS10. The geometric mean of the hexabromobenzene concentrations was 2.4 mg/kg for surface soil samples and 0.10 mg/kg for subsurface samples. The concentrations ranged from less than 0.02 to 58 mg/kg.

PBB was also generally distributed in most of the soil samples collected. PBB concentrations ranged from less than 0.02 to 53,000 mg/kg and had geometric means of 7.9 and 0.13 mg/kg for surface and subsurface soil samples, respectively. Highest PBB values were recorded for the soil samples taken at the waste drum storage area.

Concentrations of phenols were found in all soil samples analyzed. The surface and subsurface geometric means for soil samples were respectively 0.26 and 0.23 mg/kg. Phenol values in the soil ranged from less than 0.15 to 4.2 mg/kg. Borehole soil sample data indicates that phenol concentrations were highest in the waste drum storage area; however, the highest phenol concentration was recorded at SS10.

Tris concentrations were recorded from only one borehole soil sample (DM6). Tris was recorded in less than 50 percent of the standard surface soil samples, and only occasionally in the subsurface soil samples. Concentrations ranged from less than 0.60 to 4,700 mg/kg and the geometric mean was 4.7 mg/kg for the surface and 1.5 mg/kg for the subsurface samples. Highest tris values were reported for those samples collected from the waste drum storage area.

Ammonia concentrations occurred in most soil samples. Concentrations ranged from 2.5 to 390 mg/kg and the geometric means were 36 and 24 mg/kg for surface and subsurface soils, respectively. Highest concentration was reported for DM4 in the waste drum storage area.

Chlorides were found in all soil samples analyzed. Concentrations ranged from 2.8 to 4,700 mg/kg. The highest chloride concentrations were recorded from the area of the kilns and hydrotreater pit located in the northwest portion of the plant site. The geometric means were 42 mg/kg for surface soils and 100 mg/kg for subsurface soils.

Similarly, highest magnesium concentrations occurred in the northwest portion of the site in addition to high concentrations in the waste drum storage area. Magnesium values ranged from 33 to 130,000 mg/kg and had geometric means of 6,900 mg/kg in surface soils and 3,100 mg/kg in subsurface soils.

Nitrate values were often below detection limits. Values for nitrates ranged from less than 0.01 to 17 mg/kg and highest recorded were from DM1. However, other high values were also recorded from the soils from the northwestern portion of the site. The geometric means were 0.16 and 0.10 mg/kg for surface and subsurface soils, respectively.

Highest sulfate concentrations were found in soils from the waste drum storage area. Sulfate values ranged from less than 10 to 5,900 mg/kg and the geometric means were 38 mg/kg for surface and 58 mg/kg for subsurface soils.

Chromium values ranged from 4.4 to 51 mg/kg. The highest concentration occurred in the waste drum storage area. The geometric means were 16 and 13 mg/kg for surface and subsurface soils, respectively.

Copper values ranged from 5.2 to 410 mg/kg and the geometric means were determined to be 47 mg/kg for surface soils and 26 mg/kg for subsurface soils. The highest concentration was found in sample SS12.

Lead occurred in various concentrations in the samples collected. These concentrations ranged from 3.3 to 11,000 mg/kg. The highest concentration was recorded from SS13. The geometric mean for this metal was 92 mg/kg for the surface samples and 32 mg/kg for the subsurface samples.

The highest zinc values occurred in samples taken from the waste drum storage area. Zinc values ranged from 1.2 to 2,700 mg/kg. The geometric means for surface and subsurface soils were 86 and 32 mg/kg, respectively.

Two samples were collected for analysis of DDT and its analogs from the dredge pond (DP6). Results of the analyses of surface and subsurface samples were 0.55 and 13 mg/kg, respectively.

As was the case with the ground-water samples, it was found that, in general, the results of the chemical analyses conformed to a log-normal distribution more readily than to the traditional normal distribution. A review of the parameter geometric means of both the surface and subsurface soil samples shows significant decreases in the concentrations of most of the parameters between surface and subsurface concentrations. This indicates limited downward movement of contaminants due to percolating water and is further substantiated by the relatively low concentrations of most of the parameters in the ground water (Table 4-1).

General soil quality indicators were determined for all the soil samples using the same technique outlined previously for the ground-water samples. A summary of the indicators can be found for borehole soil samples and for standard soil samples in Tables 4-7 and 4-8, respectively.

As with the ground-water samples, soil samples taken at DM6 and DM8 had the highest ranking numbers. These two boreholes are located down-gradient from and directly in the waste drum storage area, respectively. The variation of ranking numbers between surface and subsurface samples at DM6 and DM8 suggest the surficial nature of the contamination. This is further supported by the generally lower ranking numbers for the subsurface samples indicating that no measurable concentrations of certain parameters, which were found in the surface samples, were found in the subsurface samples.

The standard soil samples taken in the waste drum storage area also exhibit the highest ranking numbers. The standard subsurface samples do not

reflect a general decrease in the ranking numbers as do the borehole subsurface samples. This occurs because the standard subsurface samples were taken at 0.3 m (1.0 ft) as opposed to 1.1 m (3.5 ft) for the borehole subsurface samples.

Upon reviewing the standard soil sample ranking numbers in conjunction with individual parameter values, several areas were found to have questionable concentrations of certain parameters, and these areas were resampled during Phase II. A summary of these samples is presented below.

SAMPLE	PARAMETER	PHASE I CONCENTRATION (mg/kg)	PHASE II CONCENTRATION (mg/kg)
SS3	DMAE	14	<8.0
SS10	PBB	31	2.0
	HBB	52	1.1
SS11	Tris	930	790
SS12	Tris	8.9	2.5

In all cases, except for the tris, the Phase II sampling resulted in significantly lower values, indicating that these chemicals are not uniformly distributed in the soils and are probably in their original state, randomly mixed in with the soil.

In addition to the soil sample taken at SS10, the only area found to have significant concentrations of PBB in the soil was the waste drum storage area. In order to assess the extent of the PBB contamination in this area, 12 more surface soil samples and one composite soil sample were taken in this area as part of Phase II. A summary of PBB soil concentrations is presented in Table 4-9. As can be seen by analyzing the data in the table, there is a significant decrease in the PBB concentrations of the subsurface samples

when compared to the surface samples. In addition, the Phase II soil sampling of the waste drum storage area (DS1 through DS12) exhibited the same degree of variability in PBB concentrations as was found throughout the site during Phase I with the exception that the high PBB concentrations were several orders of magnitude higher than previously recorded.

All available PBB information was analyzed in order to establish an overall perspective of the PBB situation on the plant site. This data is summarized in Table 4-10. This summary shows that the PBB is, in general, retained by the surface soils. PBB concentrations as high as some of those found in surface soil samples (Table 4-9) and the variability in the concentrations found suggests that in addition to sorption and leaching much of the PBB is probably in its original undegraded state and randomly mixed in with the soil (Jacobs, et al., 1978). PBB will be physically transported downward by percolating water, but this is a minor migration as can be verified by the approximately 2-1/2 orders of magnitude difference between the surface and subsurface soil samples (Table 4-10). Very slight amounts of PBB are solubilized by the percolating water as can be seen by the geometric mean of the ground water PBB concentrations.

The major route of migration for PBB appears to be from the surface soils to the river by storm runoff erosion where PBB remains in the river sediments and possibly is transported downstream as part of the sediment load of the river. This is reflected in the geometric mean of the PBB concentration in the sediments as compared to the subsurface soil data. In addition, the insolubility of PBB is again emphasized by the 1975 data which show relatively high PBB concentration in the river sediments when compared to the nondetectable PBB concentration in recent river water samples.

Although high values of contaminants occurred at various points on the site, these points are generally scattered, localized, and difficult to quantify. Of the chemical contaminants investigated in this study, only PBB, phenols, tris, zinc, chromium, lead, copper, and magnesium appear to be present in relatively high and widespread concentrations in the ground water and soils to be considered an environmental concern.

Tris was not found in any ground-water sample due to its low solubility, and it is of no concern in ground water. Concentrations of phenols, zinc, lead, and copper were highest in water samples collected from piezometer DM9 located in the northeastern corner of the site. However, analyses indicate that the dilution capacity of the Pine River negates the effects of loading of these contaminants into the river system. The remaining two contaminants, PBB and magnesium, occurred in highest concentrations in the ground-water samples collected from the waste drum disposal area.

PBB, phenols, tris, zinc, chromium, and copper occurred most consistently in high concentrations in the soils of the waste drum storage area. Although magnesium also occurred in high concentrations in the waste drum storage area, high values were found most widespread in the soils from the northwestern corner of the site in the vicinity of the magnesium and dolomite kilns and the hydrotreater pit. However, the magnesium compounds which occur on the site are, for the most part, magnesium oxide and magnesium hydroxide, both dietary food supplement additives, and are of no significant environmental concern. Highest concentrations of lead in soils were found near the tank farm and truck washing area in the southern portion of the site and in the northeastern corner of the site.

Generally, as indicated by the results of soil and ground-water analyses, it appears that the majority of the chemical parameters deemed environmentally significant occurred most consistently and in highest concentrations in the waste drum storage area.

5.0 EROSION LOSS AND PBB LOADING TO THE PINE RIVER

The annual soil loss from the plant site due to storm runoff erosion was calculated using the Universal Soil Loss Equation. This information was used along with the PBB concentrations in the soil to estimate the PBB loading to the Pine River due to storm runoff erosion.

The Universal Soil Loss Equation, as shown below, estimates the rate of erosion from an exposed area and depends on the erosive power of the rainfall, the erodibility of the soil, the slope and slope length, the degree of soil cover, and conservation practices (Haan and Barfield, 1978).

$$A = RKLSCP \qquad \text{(EX 5-1)}$$

where A = Computed soil loss (tons/acre);
R = Rainfall factor;
K = Soil erodibility (tons/acre-R unit);
LS = Length-slope factor;
C = Cover factor; and
P = Conservation practice factor.

The rainfall factor (R) is based on rainfall energy and intensity (Wischmeier and Smith, 1965). The average annual value for R was taken from an isoerodent map developed by Stewart, et al. (1975) and is equal to 100. The range of R values of 35 to 161 was the 22-year range observed by Beasley (1975) at East Lansing, Michigan.

The soil erodibility factor (K) based on the physical characteristics of the soil such as the grain-size distribution, general structure, general permeability, and the amount of organic matter. This information is used in a nomograph developed by Wischmeier (1971). Typical surface soil on the plant site had the following characteristics which were used to determine K:

% Sand	77.1
% Very fine sand	5.4
% Silt	12.6
% Clay	2.0
Structure	medium or coarse
Permeability	slow to moderate
% Organic matter	2.2

The resultant erodibility factor was equal to 0.16.

The length-slope factor (LS) was determined using the following relationship (Haan and Barfield, 1978):

$$LS = \left(\frac{\lambda}{72.6}\right)^{m} \left(\frac{430x^2 + 30x + 0.43}{6.613}\right) \qquad \text{(EX 5-2)}$$

where λ = Slope length

x = Sin θ

θ = Slope angle

m = 0.3 for slope $\leq$ 3%
0.4 for slope $>$ 3% and $<$ 5%
0.5 for slope $\geq$ 5%

Where the slope was greater than 10 percent (Haan and Barfield, 1978):

$$LS = \left(\frac{\lambda}{72.6}\right)^{m} \left(\frac{430x^2 + 30x + 0.43}{6.613}\right) \left(\frac{10000}{10000 + (100x)^2}\right) \qquad \text{(EX 5-3)}$$

and $m = 0.6$

Slope length was determined from the site drainage map (Figure 5-1) and was, therefore, the horizontal distance between points. The slope length was used in conjunction with the change in elevation between the same two points to calculate the average gradient or slope.

The control practice factor (CP) was calculated using the relationship:

$$CP = C_s \cdot C_r \cdot C_o \qquad \text{(EX 5-4)}$$

where C_s = Factor due to surface stabilization or protection treatments
C_r = Factor due to runoff reduction practices
C_o = Factor due to other practices.

Since C_r and C_o were not applicable to the site area, $CP = C_s$. Most of the site has no appreciable ground cover and therefore a value of 0.45 for C_s was used based on Soil Conservation Service tables (1977). Areas of the plant site having a grass or weed cover also were the areas having the steeper slopes. The C_s value for these areas was determined to be 0.011. A summary of the soil loss conditions is presented in Table 5-1.

The drainage of the site is shown on Figure 5-1. The site was divided into drainage basins based on the ground cover and the average gradients determined from the drainage flow patterns and the average change in elevation. The drainage basins are shown on Figure 5-2 and the areas are listed in Table 5-1. Only erodible surfaces were used in determining the areas of the drainage basins. Approximately 42 percent of the site had erodible surfaces.

Annual soil losses were calculated for each drainage basin and for each of the rainfall factors. The results are tabulated in Table 5-2 and are summarized below:

RAINFALL FACTOR (R)	ANNUAL SOIL LOSS (metric tons/year)
35	9.6
100	27
161	45

In order to determine the PBB loading to the Pine River as a result of soil loss, all existing site soil data were analyzed. Many of the higher PBB values recorded prior to this study were not used in this analysis because the areas generating these values have been paved over and therefore are not erodible surfaces. The geometric mean was calculated for the set of samples contained in each drainage basin, and this value was taken to be the average concentration of PBB in the soil for that drainage basin. If only one sample existed within a drainage basin the PBB value of that soil sample was used for the basin average. Several of the smaller basins had no available PBB data and the soil for these basins were considered void of PBB. A summary of the surface soil PBB concentration data is listed in Table 5-3.

Annual PBB loadings were determined using the information from Tables 5-2 and 5-3, and the results are tabulated in Table 5-4. The PBB loading from the entire plant site as a result of average rainfall factor conditions is 260 grams/year (0.57 pound/year), and the loading as a result of high rainfall factor conditions is 440 grams/year (0.97 pound/year). Because PBB is relatively insoluble, very little of the PBB will be dissolved in the river water. Most of the PBB will remain in the river sediments and could be transported as part of the sediment load.

Data from the chemical analyses of river sediment samples were analyzed (Michigan Chemical Corporation, 1975). Although all outfalls originating from the plant site are now sealed, in 1975, PBB concentrations seemed to have been highest near the outfalls located in the area where PBB was used in product formulation (outfalls 002, 003, 006, and 008). The PBB values in the sediment at these locations were significantly higher than at any other location where sediment was sampled. Other high PBB concentrations were

recorded in portions of the river receiving surface runoff from the truck washing area and from the waste drum storage area. The data suggest that PBB in the sediment, in general, remains in place. In most cases, sediment samples taken downstream from these locations and those samples taken outboard from the plant site had lower PBB concentrations by several orders of magnitude. Sediment transport is responsible for sediment PBB concentrations in sediment samples taken downstream from the plant site, but the low PBB concentrations of these samples suggest that sediment containing PBB is transported in periods of high flow and little is transported under normal or low flow conditions. As is the case with the soil samples, sediment samples exhibit a large degree of variability in PBB concentration for samples taken in the same location. This suggests that PBB material is physically mixed in with the sediment (Jacobs, et al., 1978).

The geometric mean of the PBB concentrations of the sediment samples is 0.12 mg/kg. Most of the PBB found in the sediment results from surface runoff and transport by wind with the exception of some contribution from the outfalls, mentioned previously, prior to sealing. Sediment concentrations should, therefore, reflect the PBB concentrations of the soils. The geometric mean of PBB concentrations found in all the soil samples is 12 mg/kg which is two orders of magnitude greater than the PBB concentration in the sediment. The geometric mean of the PBB concentration of the soil samples used in the surface runoff erosion model was 6.8 mg/kg which is over 1-1/2 orders of magnitude greater than the PBB concentration in the sediment. This suggests that average concentrations used in the surface runoff erosion model are probably higher than those that actually exist. This indicates the annual PBB load to the river may be substantially less than that calculated using the surface runoff erosion model.

6.0 CONCLUSIONS

The till layer which underlies the site and extends uniformly throughout the Alma-St. Louis area appears to act as a confining layer that prevents the downward migration of any contamination contained in the ground water.

In general, the ground-water movement on the site is toward the Pine River. Approximately 70 percent of the ground-water contribution to the river from the plant site originates in the disposal pond area. The total ground-water seepage from the site to the river is low, 0.91 l/sec (21,000 gal/day).

The site ground water is contaminated, but the extent and nature of contamination varies and, in general, reflects the activities which occurred in the area monitored. The waste drum storage area contains the most highly contaminated ground water found. The degree of contamination of the water from this area is significantly decreased by the time the ground water moves downgradient and reaches the river. Dilution, dispersion, and sorption appear to be factors that mitigate the degree of contamination which enters the river through the ground-water regime.

By virtue of dilution and dispersion, contaminants which do enter the river are expected to have little or no effect on the overall water quality of the river. The contribution from the dredge pond area to the total ground-water flow of the site is relatively high, but the water quality is higher than that of the balance of the site.

The soils of the waste drum storage area generally contain the highest concentrations for those contaminants found on the site. Isolated high contaminant values were also recorded at various other locations, these

values being attributable to localized plant activities. There is a significant decrease in most of the contaminant concentrations between surface and subsurface samples indicating that, in general, most of the contamination is surficial in nature and that a limited amount of contamination migrates below the surface due to percolating water. This is further supported by the relatively low concentrations of most of these parameters in the ground water.

Upon analyzing all the water and soil chemistry data, it was concluded that the only contaminant having significant environmental concentrations throughout the plant site was PBB. The major migration pathway of PBB is considered to be from the surface soil to the river sediments via surface erosion. However, there are other contaminants present in relatively high concentrations on the site, but they are confined to the waste drum storage area. These contaminants include phenols, tris, copper, chromium, zinc, and magnesium.

PBB loading to the Pine River as a result of storm runoff erosion was calculated to be 260 grams/year (0.57 pound/year) for periods of average rainfall and 440 grams/year (0.97 pound/year) for periods of heavy rainfall. The low concentrations of PBB in the river sediments suggests that the average PBB soil concentrations used in the surface runoff erosion model may be higher than those that actually exist. This suggests that the annual PBB load to the river may be substantially less than calculated here.

Very little PBB is solubilized, as can be seen by the very low PBB concentrations of the ground water and the nondetectable PBB concentrations in recent river water samples. Plant effluent data from samples taken prior to sealing the plant outfalls also reflect relatively low PBB concentrations. The low PBB concentrations of the subsurface soil samples indicate very little

PBB migration downward from the surface. The variability of the surface soil PBB concentrations suggests that PBB material is physically mixed in with the surface soils in addition to that PBB which is bound to the soil particles.

Contaminated surface soil can also be expected to be carried off the site by other agents, such as wind, trucks, and animals. Available data seem to indicate that once the PBB reaches the river sediments, it generally stays in place. Downstream sediment PBB concentrations suggest that the majority of PBB migration as part of the river sediment load probably occurs during periods of high flow.

Wildlife on the site exhibited various levels of contamination of metals, PBB, and, to a very limited extent, hexabromobenzene.

The magnesium concentrations in the mammal tissues are of no particular concern, as the magnesium compounds which occur commonly on the site, particularly in the northwestern portion, are for the most part magnesium oxide and magnesium hydroxide, both dietary supplement food additives and they would appear to pose no threat to local wildlife. Concentrations of other metals in the site mammal population appear to be typical of uncontaminated mammal populations.

Earthworms have been found to bioaccumulate both lead and zinc in their tissues, and relatively high concentrations of these metals were found in the worms collected from the site. Although regular consumption of contaminated individuals could potentially provide toxic doses (Gish and Christensen, 1973), the levels of lead and zinc found in the earthworms from the plant site are below or within the lower ranges for lead or zinc reported for worms collected from roadside soils. However, this potential is diminished by the poor habitat found in the site fill material which

contributes to low worm densities, and the uneven distribution of abnormally high soil concentrations of lead and zinc limits this problem to very localized areas on the site. Consequently, it appears that there is little justification for any environmental concerns in regard to these metals in animal tissue collected from the Velsicol plant site.

The trace amount of hexabromobenzene found in the deer mouse is probably of no significance in regard to area wildlife and food web implications. However, polybrominated biphenyls were found consistently in the animals collected on site and occasionally in relatively high concentrations. These high concentrations are probably a result of bioaccumulation of this chemical due to repeated exposure to PBB associated with on-site soils. However, due to the poor habitat and the proximity of human activities on the plant site, it is reasonable to assume that predatory animals would seldom feed from the native site mammal population. It appears, therefore, that the plant site represents a source of PBB contamination to mammals, but the potential for PBB being dispersed from the site through faunal food pathways is low.

7.0 RECOMMENDATIONS

As is typical of an industrial chemical complex that has been actively operating for 45 years, scattered points of relatively high concentrations of various chemicals are present in the site soils. Among the contaminants studied, however, only PBB appears to be present in relatively high and widespread concentrations that are deemed worthy of particular environmental interest. Like many of the chemicals investigated, it occurred occasionally in soil samples, but was confined to very localized points in the surficial soils. Generally, these points, which cannot be accurately quantified, probably exist as a result of handling PBB during packaging, storing, and shipping activities. However, in one section of the site, the waste drum storage area, the study results indicate that PBB and occasionally other chemicals are variously distributed in concentrations that are typically higher than those concentrations generally found in site soils. Further, this area is particularly susceptible to transport of surficial soil contaminants directly to the Pine River by surface water runoff.

With regard to these considerations, Dames & Moore recommends that mitigating measures be directed at stabilizing or, preferably, removing the contaminated soils of the waste drum storage area. This area consists of approximately 2.6 acres that may be contaminated to a depth locally of as much as 1 or 2 feet. Based on a 2-foot depth, the volume of soil that may be affected is approximately 8,430 cubic yards.

Several methods can be employed to handle this material. Stabilization could be accomplished in place by paving with asphalt or, more effectively, with the construction of a soil-bentonite slurry trench cut-off wall, built to the depth of glacial till, and a clay cap seal. The latter method is the more desirable of the two, since it provides for the complete

encapsulation of the contaminated area. Estimated costs for these two methods are $112,000 and $75,000, respectively. Another alternative is that the surficial soils could also be removed and deposited in an appropriate landfill or on site in the dredge pond. However, since no landfill currently exists in Michigan to handle these contaminants, it appears that the most practical and expeditious alternative is to remove the surficial soils from the waste drum storage area and deposit them into the dredge pond. It is believed that the pond has integrity sufficient to provide an effective containment structure for soils contaminated with quantities of PBB and other chemicals that were identified in samples collected from the waste drum storage area. Although Dames & Moore is aware that Michigan legislation (Act 641, 1978) regulations concerning landfills are now being developed, we have made our recommendations with regard to existing guidelines (Act 87, 1965). Also taken into consideration were the results of the present site study and the Michigan Water Resources Commission's approval of the location and construction of the dredge pond on the St. Louis site in 1972.

This work could probably be accomplished in 2 to 3 days for less than $15,000. However, additional costs will be incurred for subsequent grading of the waste drum storage area. Finally, the dredge pond should be filled and capped with at least 2 feet of compacted clay. The clay should be applied to cover the crest of the embankment to provide an umbrella cap over the entire structure. This cap should be constructed with a 2 to 8 percent slope toward the Pine River. After a layer of topsoil has been applied, this area should be revegetated, preferably with a shallow-rooted, swift-growing grass mix.

Since it was assumed that closing the St. Louis plant would require similar measures to secure the dredge pond, the cost of this task ($120,000 to $140,000) was not considered in cost comparisons of mitigating measures.

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Respectfully submitted,

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TABLE 2-1

CONCENTRATIONS OF CHEMICAL PARAMETERS IN ANIMAL TISSUE COLLECTED FROM THE VELSICOL CHEMICAL CORPORATION PLANT, ST. LOUIS, MICHIGAN

SPECIMEN NUMBER	SPECIMEN	PARTS PER MILLION WET WEIGHT (DRY WEIGHT) CHROMIUM	ZINC	COPPER	LEAD	MAGNESIUM	PBB	HEXABROMOBENZENE*
-	Earthworms	1.0 (3.03)	160 (485)	3.3 (10.0)	9.0 (27.3)	540 (1636)	1.12 (3.39)	ND
1	Raccoon	<0.22 (<0.96)	34 (148)	1.6 (7.0)	<0.5 (<2.2)	150 (652)	0.17 (0.74)	ND
2	White-footed mouse	<0.35 (<0.95)	31 (84)	5.1 (13.8)	<0.5 (<1.4)	290 (784)	1.42 (3.84)	0.70 (1.89)
3	Meadow vole	0.67 (2.31)	37 (128)	4.4 (15.2)	2.0 (6.9)	650 (2241)	0.15 (0.52)	ND
4	Meadow vole	0.60 (2.14)	34 (121)	3.0 (10.7)	1.1 (3.9)	990 (3536)	1.52 (5.43)	ND
5	House mouse	<0.30 (<0.51)	30 (51)	3.0 (5.1)	3.1 (5.3)	340 (576)	3.42 (5.80)	ND
6	House mouse	0.31 (1.07)	32 (110)	3.3 (11.4)	1.1 (3.8)	410 (1414)	0.23 (0.79)	ND
7	House mouse	0.28 (1.00)	31 (111)	3.2 (11.4)	1.4 (5.0)	350 (1250)	17.14 (61.21)	ND
8	House mouse	0.44 (1.42)	36 (116)	3.3 (10.6)	4.4 (14.2)	430 (1387)	1.92 (6.19)	ND
9	House mouse	<0.25 (<0.83)	23 (77)	2.6 (8.7)	1.4 (4.7)	370 (1233)	3.00 (10.00)	ND
10	House mouse	0.30 (1.07)	25 (89)	2.6 (9.3)	0.9 (3.2)	320 (1143)	7.69 (27.46)	ND
11	House mouse	1.0 (3.03)	30 (91)	3.6 (10.9)	1.4 (4.2)	620 (1879)	2.81 (8.52)	ND
12	House mouse	1.0 (3.45)	44 (152)	6.7 (23.1)	1.6 (5.5)	500 (1724)	6.37 (21.97)	ND
13	House mouse	<0.28 (0.93)	37 (123)	4.7 (15.7)	1.0 (3.3)	500 (1667)	1.68 (5.60)	ND
	House mouse Wet weight $\bar{X} \pm$ S.D.	<0.46 ± 0.31	32 ± 6	3.7 ± 1.3	1.8 ± 1.2	427 ± 98	4.92 ± 5.14	
	House mouse Dry weight $\bar{X} \pm$ S.D.	<1.48 ± 1.03	102 ± 29	11.8 ± 5.1	5.5 ± 3.4	1364 ± 386	16.39 ± 18.85	
	House mouse Median	0.30 (1.07)	31 (110)	3.3 (10.9)	1.4 (4.7)	410 (1387)	3.00 (8.52)	

*Detection limit: 0.05 ppm
ND = Not detectable

TABLE 2-2

WILDLIFE MONITORING

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

SPECIES	DATE	LOCATION (COUNTY)	WEIGHT kg	PBB µg/kg	PERCENT FAT
Raccoon	7/18/78	Gratiot	6.7	1600	4.0
Raccoon	7/18/78	Gratiot	1.8	650	3.7
Raccoon	7/18/78	Gratiot	4.8	920	5.7
Raccoon	7/19/78	Gratiot	1.9	1000	2.2
Raccoon	7/14/78	Gratiot	2.5	470	2.2
Muskrat	7/12/78	Gratiot	--	430	0.59

(Source: Shauver, 1978)

TABLE 3-1

PARAMETERS FOR PHASE I CHEMICAL ANALYSIS

Ammonia	DMAE (dimethylaminoethyl alcohol)
Nitrate	Carbon tetrachloride
Chloride	Lead (Pb)
Sulfates	Chromium (Cr)
Phenol	Copper (Cu)
Allyl chloride	Zinc (Zn)
PHT4 (tetrabromophthalic anhydride)	Magnesium (Mg)
PBB (polybrominated biphenyls)	EDTA (ethylene diamine tetraacetic acid)
Tris (tris 2,3-dibromopropylphosphate)	HBB (hexabromobenzene)

TABLE 3-2

PARAMETERS FOR PHASE II CHEMICAL ANALYSIS

SAMPLING LOCATION	PARAMETER								
	CCl_4	PBB	DMAE	PHENOL	HBB	DDT & ANALOGS	TRIS	$SO_4^=$	Cl^-
Water Samples									
DM-1	X								
DM-3	X	X		X					
DM-5		X	X						
DM-6	X								
DM-7	X								
DM-8		X							
DP-1	X	X	X	X				X	X
DP-2S	X			X					
DP-2D	X	X	X	X				X	X
DP-3	X	X	X	X				X	X
DP-4	X	X	X	X				X	X
DP-5	X	X	X	X				X	X
DP-6	X	X	X	X				X	X
Soil Samples									
DS-1-12		X	X		X		X		
SS-3S&D			X						
SS-10S		X			X				
SS-11S&D							X		
SS-12S&D							X		
DP-6#1&2						X			

TABLE 3-3

GENERALIZED COLUMNAR SECTION
DESCRIBING THE LITHOLOGY AND WATER-BEARING CHARACTER
OF THE SOIL AND ROCK UNITS OF THE SITE AREA

AGE			SUBDIVISION		LITHOLOGY (GENERALIZED COLUMN)	WATER-BEARING CHARACTER
CENOZOIC	QUATERNARY	Pleistocene	Glacial lake deposits	Glacial drift	Sand and silt	Source of small supplies of water
					Sandy and silty clay	Not a source of water (leaky aquiclude)
			Outwash		Sand and gravel containing silt and clay lenses	Source of moderate to large supplies of water
			Till		Blue, gray, buff, and red clayey till. Some gravel at base	Not a source of water
PALEOZOIC	PERMIAN(?)		Red beds		Red sandy gypsiferous shales and shaly sandstones	Not a source of water
	? ?					
	PENNSYLVANIAN		Saginaw formation		Black and gray shale Coal Sandy shale Sandstone Limestone Shale Sandstone Shale	Yields moderate supplies of water containing objectionable amounts of chloride
	PRE-PENNSYLVANIAN		Pre-Saginaw rocks		Limestone Shale Sandstone	Yields mineralized water

Reference: Vanlier, K.E., 1963, Ground-water resources of the Alma area, Michigan: U.S. Geological Survey, Water Supply Paper 1619-E.

TABLE 3-4

WATER LEVEL FLUCTUATIONS

BORING NUMBER	DEPTH TO WATER BELOW GROUND SURFACE (feet)					
	09/29/78	10/02/78	02/21/79	03/01/79	03/31/79	04/09/79
DM-1	3.6	3.7	4.3	3.2	2.5	3.2
DM-2	2.2	2.2	2.0	1.6	1.4	2.1
DM-3	3.2	2.9	4.1	3.3	1.0	2.6
DM-4	3.8	3.2	3.9	3.2	2.6	3.2
DM-5	2.8	2.8	3.5	3.0	1.6	2.6
DM-6	0.5	1.8	1.7	0.8	0.4	1.2
DM-7	3.2	3.7	4.3	3.6	1.2	2.1
DM-8S	6.1	6.3	7.6	6.5	5.0	5.8
DM-8D	7.5	9.9				5.4
DM-9	4.8	5.3	6.0	5.0	4.0	5.1
DP-1			17.8	17.3	15.6	15.1
DP-2S			12.7	12.2	10.1	10.1
DP-2D			13.9	13.3	10.0	11.1
DP-3			13.2	13.3	10.8	9.7
DP-4			15.2	14.9	13.8	13.4
DP-5				1.0	0.5	1.0
DP-6			9.2	8.8	5.1	4.7

TABLE 3-5

RESULTS OF FALLING HEAD PERMEABILITY TEST

PIEZOMETER NUMBER	SCREENED INTERVAL (ft below ground surface)	EFFECTIVE INTERVAL (ft below ground surface)	PERMEABILITY	
			cm/sec	gpd/ft^2
DM-1	4.9 - 8.4	3.0 - 20.5	6.8×10^{-5}	1.4
			4.5×10^{-5}	0.96
DM-2	6.1 - 9.6	3.0 - 15.5	3.4×10^{-5}	0.72
			3.2×10^{-5}	0.68
DM-3	6.0 - 9.5	2.0 - 15.5	7.9×10^{-5}	1.7
DM-4	9.3 - 12.8	3.0 - 20.5	1.6×10^{-4}	3.4
DM-5	6.2 - 9.7	3.0 - 15.5	--[a]	
DM-6	3.9 - 7.4	2.0 - 9.5	--[a]	
DM-7	9.7 - 13.2	3.0 - 20.5	1.2×10^{-3}	26
DM-8S	10.1 - 13.6	3.0 - 15.5	1.7×10^{-4}	3.6
DM-9	9.5 - 13.0	2.0 - 20.5	--[a]	
DP-1	25.0 - 28.5	10.0 - 30.0	2.8×10^{-5}	0.59
DP-2D	25.0 - 28.0	22.0 - 30.0	8.2×10^{-6}	0.17
DP-2S	15.5 - 19.0	10.0 - 19.0	1.2×10^{-4}	2.5
DP-3	25.5 - 28.5	12.0 - 28.5	1.9×10^{-5}	0.40
DP-4	25.0 - 28.5	10.0 - 30.0	9.4×10^{-5}	2.0
DP-5	4.0 - 6.0	3.0 - 6.0	--[b]	
DP-6	18.5 - 23.5	14.0 - 25.0	3.9×10^{-5}	0.83

[a] Water level fell too rapidly to measure accurately.

[b] Leaky piezometer pipe prevented falling head test.

TABLE 3-6

SUMMARY OF HAZEN PERMEABILITY APPROXIMATIONS

PIEZOMETER NUMBER	DEPTH (feet)	MATERIAL	HAZEN APPROXIMATION OF PERMEABILITY cm/sec	HAZEN APPROXIMATION OF PERMEABILITY gpd/ft^2
DM-1	19.5	Clayey silt with trace sand	$9x10^{-6}$	0.19
DM-2	3.5	Clayey silt with some fine sand and trace fine gravel	$4x10^{-5}$	0.85
	14.5	Silt with some clay, trace coarse sand and fine gravel	$9x10^{-5}$	1.9
DM-3	14.5	Clayey silt with trace fine gravel	$2x10^{-5}$	0.42
DM-4	3.5	Fine sand with trace fine to coarse gravel	$4x10^{-2}$	850
	10.5	Fine sand	$2x10^{-3}$	42
	19.5	Clayey silt with some fine sand and trace coarse sand	$2x10^{-4}$	4.2
DM-5	3.5	Medium to coarse sand	$6x10^{-2}$	1300
	10.5	Silt with some clay and trace fine gravel	$1x10^{-5}$	0.21
	14.5	Silt with clay, trace fine gravel	$4x10^{-6}$	0.08
DM-7	3.5	Fine sand, trace fine gravel	$2x10^{-2}$	424
	7.5	Clayey silt	$4x10^{-5}$	0.85
	19.5	Silt with some clay and trace fine gravel	$9x10^{-6}$	0.19
DM-8D	3.5	Miscellaneous fill	$2x10^{-3}$	42
	7.5	Silt with trace clay, trace coarse sand and fine gravel	$7x10^{-5}$	1.5
	10.5	Fine sand with trace silt	$2x10^{-3}$	42
	14.5	Silt with some clay, trace fine gravel	$4x10^{-5}$	0.85
	19.5	Silt with some clay, trace fine gravel	$1x10^{-4}$	2.1
	23.5	Silt with some clay, trace fine gravel	$4x10^{-5}$	0.85
	30.5	Silt with some clay and some fine sand	$3x10^{-3}$	64
DM-9	3.5	Fine to coarse sand with some silt, trace fine gravel	$2x10^{-3}$	42
	19.5	Silt with some clay, trace fine gravel	$3x10^{-4}$	6.4

TABLE 4-1

SUMMARY OF GROUND-WATER CHEMICAL ANALYSES

PARAMETER	RANGE (mg/l)	GEOMETRIC MEAN (mg/l)	GEOMETRIC STANDARD DEVIATION (mg/l)	NUMBER OF SAMPLES	EPA CRITERIA DOMESTIC WATER SUPPLY (mg/l)	EPA CRITERIA FRESHWATER AQUATIC LIFE (mg/l)	CALCULATED CONCENTRATION IN PINE RIVER (mg/l)
Ammonia-N	0.14 - 53	4.7	1.3	9	-	0.02	4×10^{-3}
Chloride	82 - 82000	5800	1.0	15	-	-	5
Nitrate-N	<0.01 - 0.11	0.021	21	9	10	-	2×10^{-5}
Sulfates	3 - 2400	150	1.0	15	-	-	0.1
Chromium (Total)	0.060 - 0.14	0.087	13	9	0.050	0.100	7×10^{-5}
Copper	0.035 - 9.0	0.25	2.6	9	1.0	†	2×10^{-4}
Lead	0.015 - 8.1	0.26	2.4	9	0.050	*	2×10^{-4}
Magnesium	26 - 570	220	1.0	9	-	-	0.2
Zinc	0.040 - 1000	26	1.0	9	5	*	2×10^{-2}
Allyl Chloride[a]	ND	ND	ND	9	-	-	ND
Carbon Tetrachloride	<0.01 - 0.08	0.010	27	20	-	-	8×10^{-6}
DMAE	<1.0 - <500	0.66	1.0	16	-	-	5×10^{-4}
EDTA[b]	ND	ND	ND	9	-	-	ND
HBB[c]	ND	ND	ND	9	-	-	ND
PBB	<0.00001 - 0.0013	0.00012	99	11	-	-	3×10^{-8}
Phenols	0.004 - 1.2	0.029	14	17	0.001	0.001	2×10^{-5}
PHT4[d]	ND	ND	ND	9	-	-	ND
Tris[e]	ND	ND	ND	9	-	-	ND

NOTE: ND = not detectable.

†0.1 x 96-hour LC_{50}.

*0.01 x 96-hour LC_{50}.

Detection Limits:

[a] 1.0

[b] 1.0

[c] 0.01

[d] 0.01

[e] 0.01

GROUNDWATER SAMPLE RESULTS FROM THE VELSICOL CHEMICAL COMPANY PLANT IN ST. LOUIS, MICHIGAN COLLECTED ON OCTOBER 31, 1978 RESULTS SHOWN IN PARTS PER BILLION (ppb)

LOCATION	PARAMETER													
Well Sample No.	Cl^-	SO_4	Phenol	Pb	CR	Allyl Chloride	PHT_4	PBB	EDTA	Hexabromobenzene	TRIS	DMAE	CCL_4	
Detection Limit						1,000ppb	10ppb	.01ppb	1,000ppb	10ppb	10ppb	1,000ppb	10ppb	
DM 1	220,000	180,000	4	240	60	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	30	
DM 2	2,600,000	3,000	20	360	75	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
DM 3	-	-	4	-	-	-	-	.083	-	-	-	-	30	March 12, 1979
DM 4	12,000,000	270,000	8	230	110	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
DM 5	1,000,000	320,000	12	180	60	N.D.	N.D.	20	N.D.	N.D.	N.D.	20,000	N.D.	
DM 6	7,800,000	650,000	100	120	64	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	80	
DM 7	47,000,000	95,000	12	60	140	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	20	
DM 8	82,000,000	220,000	76	1,800	110	N.D.	N.D.	130	N.D.	N.D.	N.D.	N.D.	30	
DM 9	6,800,000	260,000	1,200	8,100	130	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
DP 1	9,200,000	100,000	16	-	-	-	-	.17	-	-	-	N.D.[2*]	27	*2 D.L. 4000 ppb
DP 2S	-	-	53	-	-	-	-	-	-	-	-	-	38	
DP 2D	16,000,000	180,000	44	-	-	-	-	.12	-	-	-	N.D.[2*]	30	*2 D.L. 4000 ppb
DP 3	30,000,000	36,000	28	-	-	-	-	.075	-	-	-	N.D.[2*]	22	*2 D.L. 4000 ppb
DP 4	24,000,000	130,000	160	-	-	-	-	.058	-	-	-	N.D.[2*]	.3	*2 D.L. 4000 ppb
DP 5	6,200,000	230,000	12	-	-	-	-	.067	-	-	-	N.D.[2*]	2.6	*2 D.L. 4000 ppb
DP 6	4,000,000	59,000	260					.19				N.D.[2*]	59	*2 D.L. 4000 ppb

TABLE 4-2

WATER QUALITY INDICATORS
OF GROUND WATER SAMPLES

WATER SAMPLE	WATER QUALITY INDICATOR
DM-1	49
DM-2	48
DM-3	*
DM-4	61
DM-5	65
DM-6	86
DM-7	65
DM-8	79
DM-9	65
Plant Water	27

*No sample was taken.

TABLE 4-3

GROUND-WATER PBB CONCENTRATIONS

WATER SAMPLE	PHASE I (µg/l)	PHASE II (µg/l)
DM-1	ND*	—
DM-2	ND*	—
DM-3	—	0.083
DM-4	ND*	—
DM-5	0.02	0.35
DM-6	ND*	—
DM-7	ND*	—
DM-8	0.13	1.3
DM-9	ND*	—
Plant water	ND*	—
DP-1	—	0.17
DP-2S	—	—
DP-2D	—	0.12
DP-3	—	0.075
DP-4	—	0.058
DP-5	—	0.067
DP-6	—	0.19

Notes: ND = Not detectable.
— = No sample taken.
See Figure 4-1 for piezometer locations.

*Detection limit = 0.01 µg/l.

TABLE 4-4

SUMMARY OF SOIL SAMPLES

TYPE OF SAMPLE	NUMBER OF SAMPLES
Surface Soil (Phase I)	24
Subsurface Soil (Phase I)	
0.3 m (1.0 ft)	9
1.1 m (3.5 ft)	11
Surface Soil (Phase II)	19
Subsurface Soil (Phase II)	5
Velsicol Surface Soil	31
Velsicol Subsurface Soil	12
DNR Surface Soil	4
DNR Subsurface Soil	12

TABLE 4-5

SUMMARY OF SURFACE SOIL CHEMICAL ANALYSES

PARAMETER	RANGE (mg/kg)	GEOMETRIC MEAN (mg/kg)	GEOMETRIC STANDARD DEVIATION (mg/kg)	NUMBER OF SAMPLES
Ammonia-N	3.0 - 330	36	1.1	24
Chloride	2.8 - 2900	42	1.0	24
Nitrate-N	<0.01 - 17	0.16	3.1	24
Sulfates	<11 - 5900	38	1.0	24
Chromium (Total)	4.4 - 51	16	1.2	24
Copper	8.4 - 410	47	1.0	24
Lead	7.2 - 11000	92	1.0	24
Magnesium	380 - 120000	6900	1.0	24
Zinc	20 - 2700	86	1.0	24
Allyl Chloride	*	*	*	24
Carbon Tetrachloride	*	*	*	24
DMAE	<7.0 - 14	3.9	1.4	37
EDTA	*	*	*	24
HBB	<0.062 - 58	2.4	1.0	37
PBB	0.13 - 53000	7.9	1.0	37
Phenols	<0.016 - 4.2	0.26	4.3	24
PHT4	*	*	*	24
Tris	<0.60 - 4700	4.7	1.0	38

*Not detectable.

SOIL SAMPLE CHEMICAL ANALYSIS RESULTS FROM THE
VELSICOL CHEMICAL COMPANY PLANT IN ST. LOUIS, MICHIGAN
COLLECTION ON OCTOBER 31, 1978 RESULTS SHOWN IN
PARTS PER BILLION (ppb) DRY

SAMPLE NO.	SAMPLE DEPTH	Phenol	Pb lead	PARAMETER Allyl Chloride	PHT_4	PBB	EDTA	Hexabromobenzene	TRIS	DMAE	CCL_4
Detection Limit				6,000ppb	200ppb	20ppb	1500ppb	1-1400ppb 2-20ppb	1000ppb	7000ppb	30ppb
DM 1	1 ft	700	63,000			600		N.D.[1]	N.D.	N.D.	N.D.
DM 1	3.5 ft	340	19,000			950		N.D.[1]	N.D.	N.D.	N.D.
DM 2	0 ft	340	250,000			12,000 -		940	N.D.	N.D.	N.D.
DM 2	3.5 ft	360	3,700,000			2,500 -		830	N.D.	N.D.	N.D.
DM 3	0 ft	320	7,200			870		220	N.D.	N.D.	N.D.
DM 3	3.5 ft	<200	23,000			430		N.D.[2]	N.D.	N.D.	N.D.
DM 4	1 ft	<160	18,000			3,200 -		1,300	N.D.	N.D.	N.D.
DM 4	3.5 ft	<170	33,000			N.D.		N.D.[2]	N.D.	N.D.	N.D.
DM 5	0 ft	<170	160,000			5,200 -		1,300	N.D.	N.D.	N.D.
DM 5	3.5 ft	<160	3,300			230		420	N.D.	N.D.	N.D.
DM 6	0 ft	780	8,200			190		76	9,300	N.D.	N.D.
DM 6	3.5 ft	<340	6,600			N.D.		N.D.[2]	N.D.	N.D.	N.D.
DM 7	0 ft	620	3,000,000			130		75	N.D.	N.D.	N.D.
DM 7	7.5 ft	<360	11,000			N.D.		N.D.[1]	N.D.	N.D.	40
DM 8	0 ft	1,200	330,000			1,100,000 -		660	N.D.	N.D.	N.D.
DM 8	3.5 ft	<200	7,800			900		64	N.D.	N.D.	N.D.
DM 9	0 ft	<160	24,000			36,000 -		N.D.[1]	N.D.	N.D.	N.D.
DM 9	3.5 ft	2,000	610,000			790		2,700	N.D.	N.D.	N.D.
SS 1A	0 ft	<160	85,000			680		870	N.D.	N.D.	N.D.
SS 1B	1 ft	1,000	54,000			N.D.		23	N.D.	N.D.	N.D.
SS 2A	0 ft	<160	13,000			280		2,400	N.D.	N.D.	N.D.
SS 2B	1 ft	<150	8,000			45		1,900	N.D.	N.D.	N.D.
SS 3A	0 ft	330	210,000			1,200 -		1,200	17,000	14,000	N.D.
SS 3B	1 ft	340	33,000			N.D.		24	2,200	40,000	N.D.
SS 4A	0 ft	330	120,000			92,000 -		44,000	620,000	N.D.	N.D.
SS 5A	0 ft	320	270,000			5,000 -		23,000	66,800	N.D.	N.D.
SS 5B	1 ft	420	170,000			550		N.D.[1]	N.D.	N.D.	60

Non Detectable - Detection Limit 6,000 ppb

Non Detectable - Detection Limit 200 ppb

Non Detectable - Detection Limit 1500 ppb

SS 6A	0 ft	<160	220,000			29,000		15,000		4,700,000	8,000	
SS 6B	1 ft	360	49,000			2,600		N.D.	1	3,200,000	53,000	
SS 7A	0 ft	640	43,000			3,800		720		N.D.	N.D.	
SS 7B	1 ft	320	84,000			420		N.D.	2	N.D.	N.D.	
SS 8A	0 ft	<170	14,000			10,000		1,900		N.D.	N.D.	
SS 8B	2 ft	430	38,000			64		45		N.D.	N.D.	
SS 9A	0 ft	420	64,000			5,800		2,300		2,800	N.D.	
SS 10A	0 ft	4,200	105,000			34,000		56,000		N.D.	N.D.	
SS 10B	1 ft	320	2,900			24		N.D.	2	N.D.	N.D.	
SS 11A	0 ft	650	45,000			1,300		570		1,000,000	N.D.	
SS 12A	0 ft	340	310,000			7,400		2,000		8,900	N.D.	
SS 12B	1 ft	<170	130,000			98		51		11,000	N.D.	
SS 13A	2 ft	<160	11,000,000			1,400		N.D.	1	N.D.	N.D.	
SS 14A	0 ft	<160	17,000			14,000		2,800		N.D.	N.D.	
SS 14B	1 ft	<160	5,200			160		100		N.D.	N.D.	
SS 15A	0 ft	160	120,000			18,000		35,000		N.D.	N.D.	
SS 15B	1 ft	310	3,800			160		300		N.D.	N.D.	

Non Detectable Detection Limit 6,000 ppb

Non Detectable Detection Limit 200 ppb

Non Detectable Detection Limit 1,500 ppb

Non Detectable Detection Limit 30 ppb

MARCH 12, 1979 RESAMPLE RESULTS

											Detection limit 8,000 ppb	
SS 3 S	0 ft	-	-	-	-	-	-	-		-	N.D.	
SS 3 D	1 ft	-	-	-	-	-	-	-		-	N.D.	-
SS 10 S	0 ft	-	-	-	-	2,000	-	1,100		-	-	
SS 11 S	0 ft	-	-	-	-	-	-	-		930,000		
SS 11 D	1 ft	-	-	-	-	-	-	-		1,200,000	-	-
SS 12 S	0 ft	-	-	-	-	-	-	-		2,500	-	-
SS 12 D	1 ft	-	-	-	-	-	-	-		1,300	-	-

TABLE 4-6

SUMMARY OF SUBSURFACE SOIL CHEMICAL ANALYSES

PARAMETER	RANGE (mg/kg)	GEOMETRIC MEAN (mg/kg)	GEOMETRIC STANDARD DEVIATION (mg/kg)	NUMBER OF SAMPLES
Ammonia-N	2.5 - 390	24	1.1	20
Chloride	4.3 - 4700	100	1.0	20
Nitrate-N	<0.01 - 15	0.10	3.9	20
Sulfates	<10 - 740	58	1.0	20
Chromium (Total)	4.8 - 43	13	1.2	20
Copper	5.2 - 380	26	1.1	20
Lead	3.3 - 3700	32	1.0	20
Magnesium	33 - 130000	3100	1.0	20
Zinc	1.2 - 290	32	1.1	20
Allyl Chloride	*	*	*	20
Carbon Tetrachloride	<0.03 - 0.06	0.02	27	20
DDT & Analogs	0.55 - 13	2.7	1.2	2
DMAE	<7.0 - 53	4.5	1.2	21
EDTA	*	*	*	20
HBB	<0.02 - 2.4	0.10	6.2	20
PBB	<0.02 - 2.6	0.13	5.5	20
Phenols	<0.15 - 2.0	0.23	5.5	20
PHT4	*	*	*	20
Tris	<0.60 - 3200	1.5	1.0	22

*Not detectable.

TABLE 4-7

INDICATORS
OF BOREHOLE SOIL SAMPLES

BOREHOLE	INDICATOR	
	SURFACE SOIL	SUBSURFACE SOIL
DM-1	62	65
DM-2	68	89
DM-3	63	52
DM-4	57	40
DM-5	67	30
DM-6	84	41
DM-7	41	45
DM-8	85	65
DM-9	37	73

TABLE 4-8

INDICATORS OF STANDARD SOIL SAMPLES

SOIL SAMPLE	INDICATOR	
	SURFACE SOIL	SUBSURFACE SOIL
SS-1	82	115
SS-2	63	92
SS-3	97	137
SS-4	164	-
SS-5	113	162
SS-6	138	145
SS-7	117	114
SS-8	65	147
SS-9	119	-
SS-10	118	100
SS-11	127	-
SS-12	112	142
SS-13	95	-
SS-14	70	102
SS-15	106	107

TABLE 4-9

SUMMARY OF PBB CONCENTRATIONS IN THE SOIL

SAMPLE	PHASE I SURFACE (mg/kg)	PHASE I SUBSURFACE (mg/kg)	PHASE II SURFACE (mg/kg)	PHASE II SUBSURFACE (mg/kg)
DM-1	0.60	0.95	-	-
DM-2	12	2.5	-	-
DM-3	0.87	0.43	-	-
DM-4	3.2	*	-	-
DM-5	5.2	0.23	-	-
DM-6	0.19	*	-	-
DM-7	0.13	*	-	-
DM-8	1100	0.90	-	-
DM-9	36	0.79	-	-
SS-1	0.68	*	-	-
SS-2	0.28	0.045	-	-
SS-3	1.2	*	-	-
SS-4	92	-	-	-
SS-5	5.0	0.55	-	-
SS-6	29	2.6	-	-
SS-7	3.8	0.42	-	-
SS-8	10	0.064	-	-
SS-9	5.8	-	-	-
SS-10	34	0.024	2.0	-
SS-11	1.3	-	-	-
SS-12	7.4	0.098	-	-
SS-13	1.4	-	-	-
SS-14	1.4	0.16	-	-
SS-15	1.8	0.16	-	-
DS-1	-	-	34	-
DS-2	-	-	*	-
DS-3	-	-	36	-
DS-4	-	-	0.84	-
DS-5	-	-	250	-
DS-6	-	-	3.6	-
DS-7	-	-	4.3	-
DS-8	-	-	53000	-
DS-9	-	-	11	-
DS-10	-	-	240	-
DS-11	-	-	6.5	-
DS-12	-	-	34	-
DS (comp.) 1-12	-	-	3100	-

*Not detectable
-No sample taken

TABLE 4-10

SUMMARY OF SOIL AND SEDIMENT PBB CONCENTRATIONS

TYPE OF SAMPLE	RANGE (mg/kg)	GEOMETRIC MEAN (mg/kg)	GEOMETRIC STANDARD DEVIATION (mg/kg)	NUMBER OF SAMPLES
Surface Soil	0.11 - 53000	12	1.0	74
Subsurface Soil	0.0005 - 2.6	0.041	9.1	39
Sediment	<0.001 - 180	0.12	1.1	55

SUMMARY OF WATER AND EFFLUENT PBB CONCENTRATIONS

TYPE OF SAMPLE	RANGE (μg/1)	GEOMETRIC MEAN (μg/1)	GEOMETRIC STANDARD DEVIATION (μg/1)	NUMBER OF SAMPLES
Pine River Water	<0.01 - 24	0.16	2.5	100
Ground Water	<0.01 - 1.3	0.12	8.1	11
Plant Effluent	<0.1 - 503	1.8	1.0	61

NOTES:
- Surface and subsurface soil samples include all samples taken since 1974.
- Sediment samples were taken in 1975.
- River water samples were taken in 1974 and 1975. Subsequent river water samples have had no detectable PBB concentrations.
- All outfalls which directed plant effluents into the Pine River are no longer active and have been sealed.

TABLE 5-1

SUMMARY OF PLANT SITE SOIL LOSS CONDITIONS

DRAINAGE BASIN	AREA km^2	AREA ACRES	RAINFALL FACTOR (R) AVERAGE	RAINFALL FACTOR (R) RANGE	SOIL ERODIBILITY FACTOR (K)	LENGTH-SLOPE FACTOR (LS) LENGTH (ft)	LENGTH-SLOPE FACTOR (LS) CHANGE IN ELEVATION (ft)	CONSERVATION PRACTICE FACTOR (CP)
A_1	6.537×10^{-5}	1.616	100	31 - 161	0.16	186	2.5	0.45
A_2	1.903×10^{-3}	0.4704	100	31 - 161	0.16	7	5.0	0.011
B_1	3.332×10^{-2}	8.238	100	31 - 161	0.16	422	4.0	0.045
B_2	1.834×10^{-3}	0.4534	100	31 - 161	0.16	7	5.0	0.011
C_1	1.002×10^{-2}	2.477	100	31 - 161	0.16	944	4.0	0.045
C_2	1.033×10^{-2}	2.555	100	31 - 161	0.16	318	4.0	0.045
C_3	9.401×10^{-4}	0.2324	100	31 - 161	0.16	15	5.0	0.011
C_4	1.078×10^{-3}	0.2664	100	31 - 161	0.16	20	12	0.011
D_1	2.360×10^{-3}	0.5835	100	31 - 161	0.16	35	16	0.011
D_2	2.522×10^{-3}	0.6235	100	31 - 161	0.16	33	2.0	0.011
E_1	1.377×10^{-2}	3.404	100	31 - 161	0.16	367	6.0	0.45
E_2	2.222×10^{-3}	0.5493	100	31 - 161	0.16	168	5.0	0.45
E_3	4.356×10^{-4}	0.1077	100	31 - 161	0.16	20	10	0.011
F	1.639×10^{-3}	0.4053	100	31 - 161	0.16	167	5.0	0.011
G	3.795×10^{-3}	0.9381	100	31 - 161	0.16	198	4.0	0.011

TABLE 5-2

SOIL LOSS DUE TO SURFACE RUNOFF EROSION

DRAINAGE BASIN	SOIL LOSS FOR VARIOUS RAINFALL FACTORS (metric tons/year)		
	R = 100	R = 35	R = 161
A_1	1.9	0.67	3.1
A_2	0.34	0.12	0.55
B_1	10	3.6	17
B_2	0.33	0.12	0.53
C_1	3.0	1.0	4.8
C_2	3.4	1.2	5.6
C_3	0.11	0.036	0.17
C_4	0.31	0.11	0.49
D_1	0.68	0.24	1.1
D_2	0.039	0.014	0.063
E_1	5.6	2.0	9.1
E_2	1.2	0.42	1.9
E_3	0.10	0.035	0.16
F	0.022	0.0076	0.035
G	0.037	0.012	0.060
TOTALS	27	9.6	45

TABLE 5-3

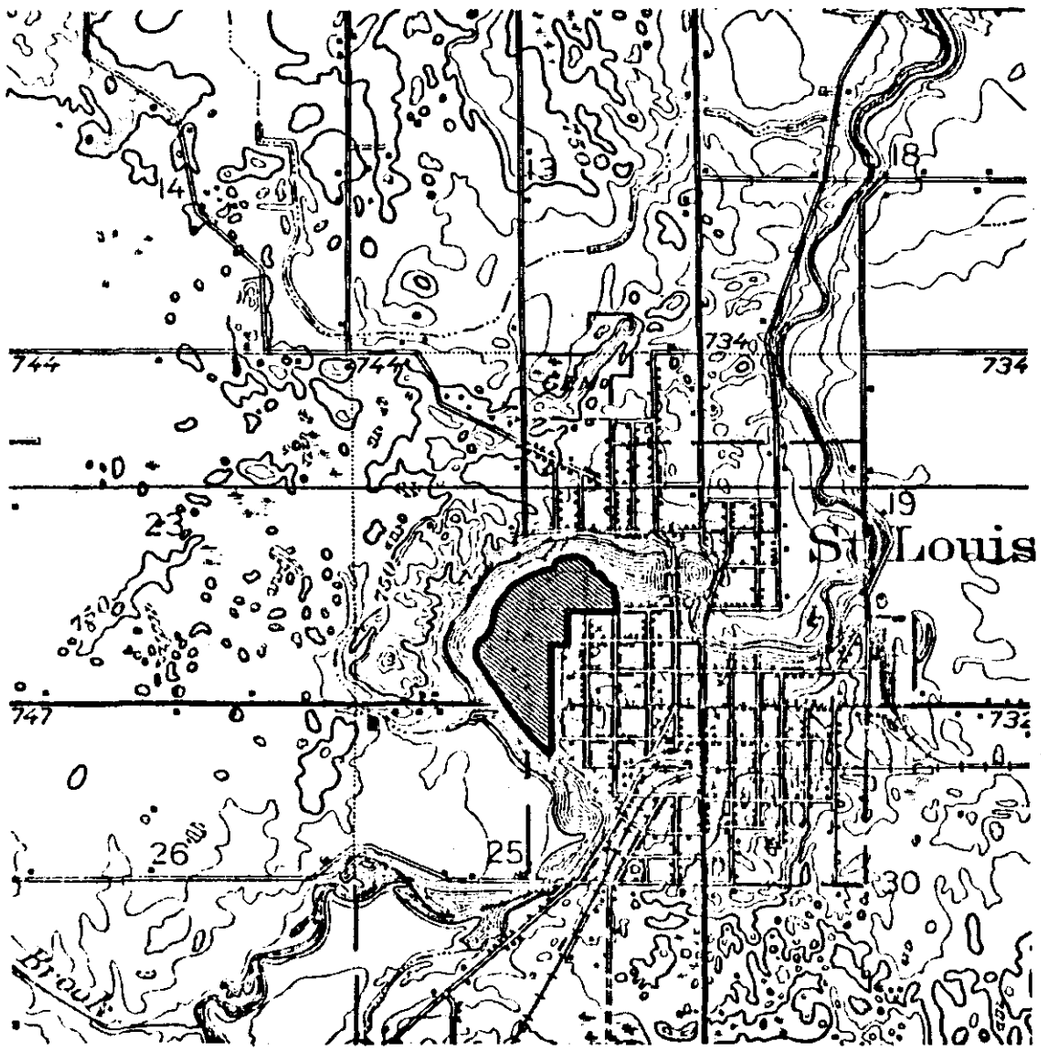
SUMMARY OF SURFACE SOIL PBB CONCENTRATIONS

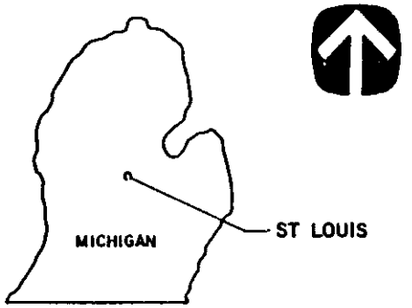
DRAINAGE BASIN	RANGE (mg/kg)	GEOMETRIC MEAN (mg/kg)	GEOMETRIC STANDARD DEVIATION (mg/kg)	NUMBER OF SAMPLES
A_1	1.3 - 36	6.5	1.2	9
A_2	1.5 - 510	12	1.0	3
B_1	0.79 - 92	6.6	1.1	13
B_2	-	10	-	1
C_1	-	0.33	-	1
C_2	0.19 - 53000	31	1.0	11
C_3	-	-	-	0
C_4	-	0.22	-	1
D_1	-	0.28	-	1
D_2	-	0.38	-	1
E_1	-	1.1	-	1
E_2	0.68 - 12	2.2	2.0	3
E_3	-	-	-	0
F	-	-	-	0
G	-	-	-	0

TABLE 5-4

CALCULATED PBB LOADING TO THE PINE RIVER DUE TO SURFACE RUNOFF EROSION

DRAINAGE BASIN	PBB LOADING (g/yr) AVERAGE RAINFALL FACTOR (R = 100)	PBB LOADING (g/yr) HIGH RAINFALL FACTOR (R = 161)
A_1	12	20
A_2	4.1	7.2
B_1	130	221
B_2	3.3	5.3
C_1	0.99	1.6
C_2	100	170
C_3	0	0
C_4	0.068	0.11
D_1	0.19	0.31
D_2	0.015	0.024
E_1	6.2	10
E_2	2.6	4.2
E_3	0	0
F	0	0
G	0	0
TOTALS	260	440





KEY:

VELSICOL PLANT SITE

MILES
0 1/2 1

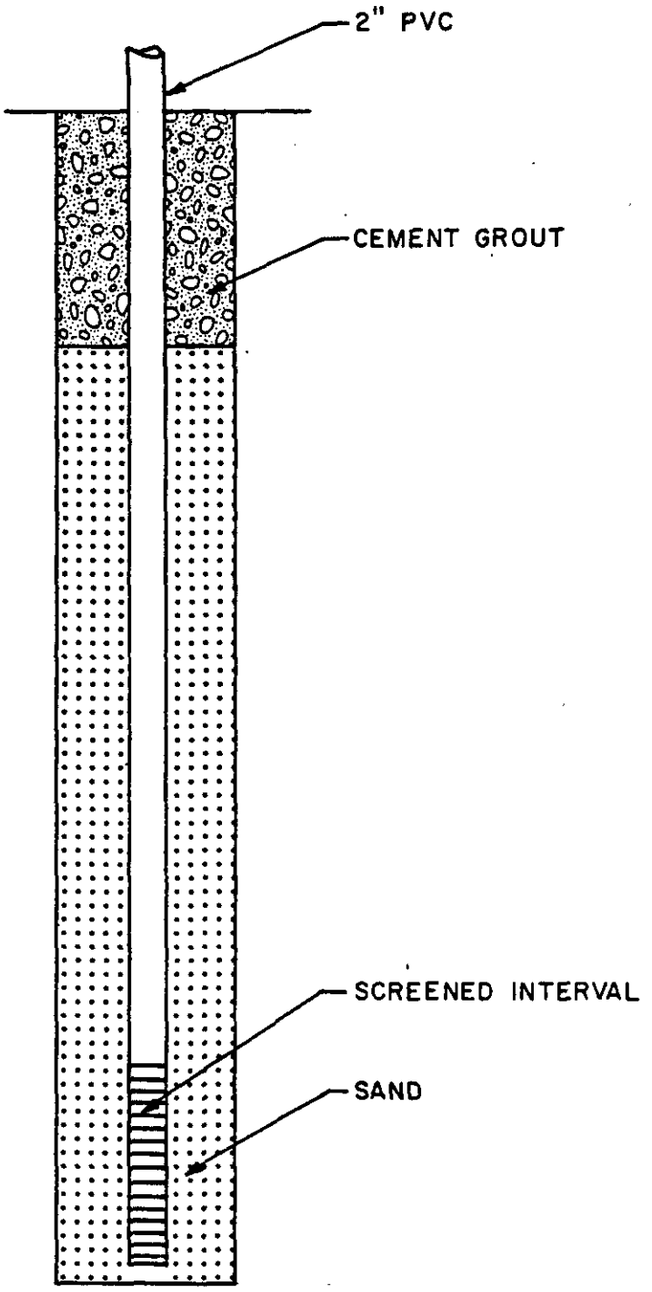
FEET
1000 0 3000

REFERENCE:
BASE MAP FROM USGS SURVEY 1:62500 MAP COVERING THE MICHIGAN ALMA QUADRANGLE.

FIGURE 1-1
VELSICOL PLANT SITE
AND SURROUNDING AREA

DAMES & MOORE

10637-002-07

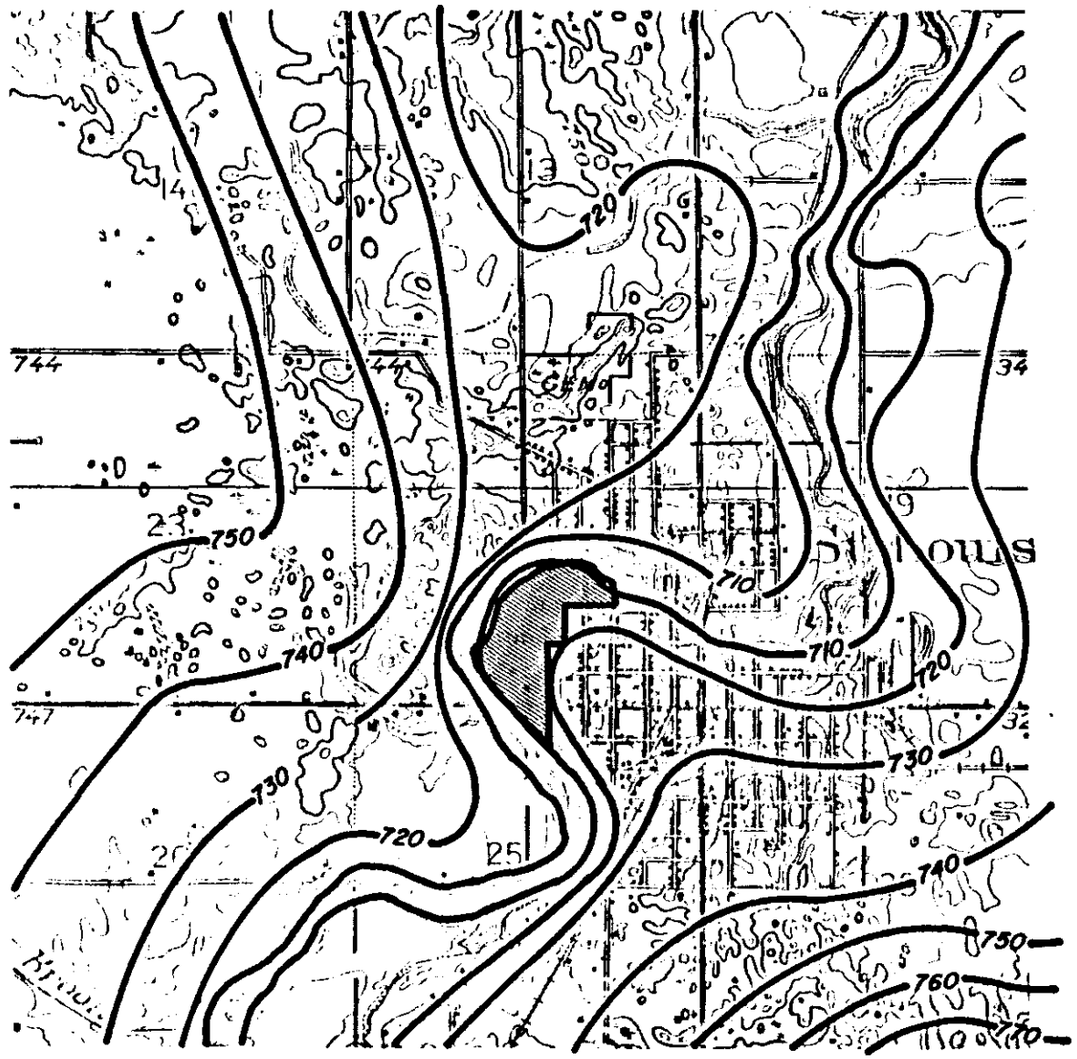


(NOT TO SCALE)

FIGURE 3-2
PIEZOMETER CONSTRUCTION

DAMES & MOORE

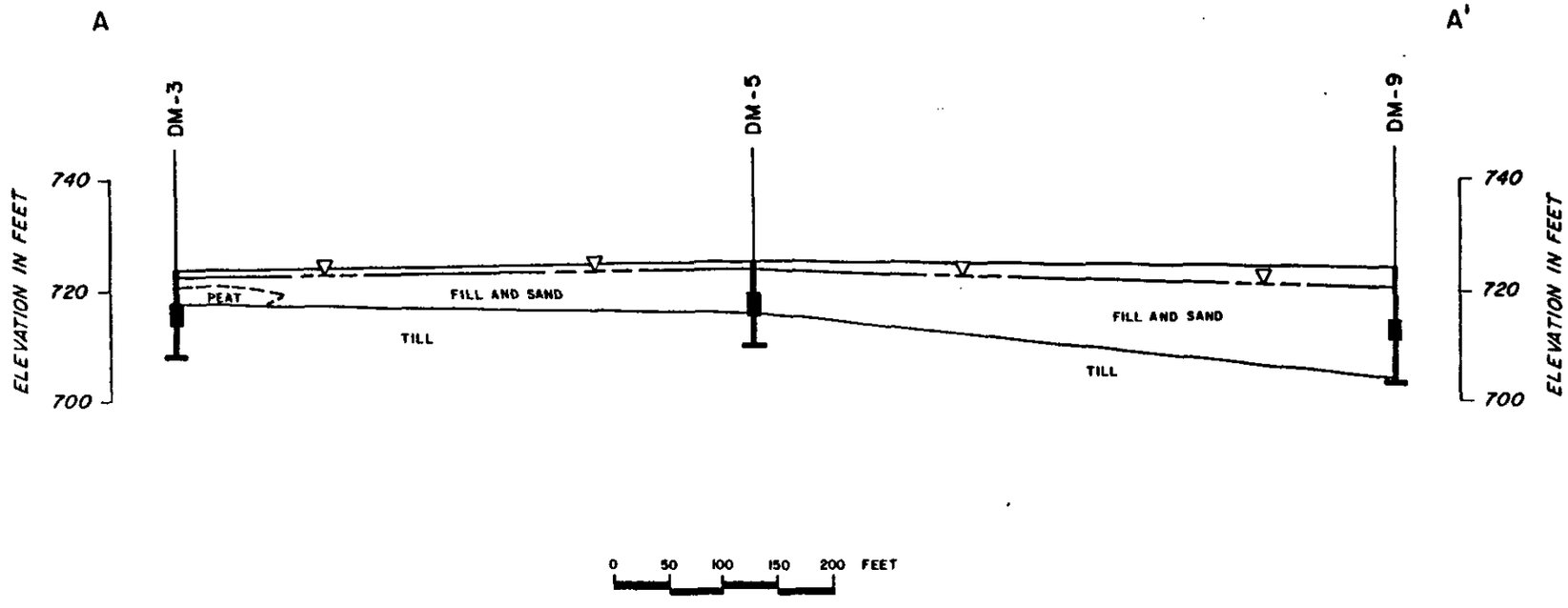
10637-002-07



REFERENCE:
BASE MAP FROM USGS SURVEY 1:62500 MAP COVERING THE MICHIGAN ALMA QUADRANGLE.

10637-002-07

FIGURE 3-4
CONTOURS APPROXIMATING THE TOP OF THE GLACIAL TILL



KEY:

PIEZOMETER LOCATION

INDICATES GROUNDWATER TABLE

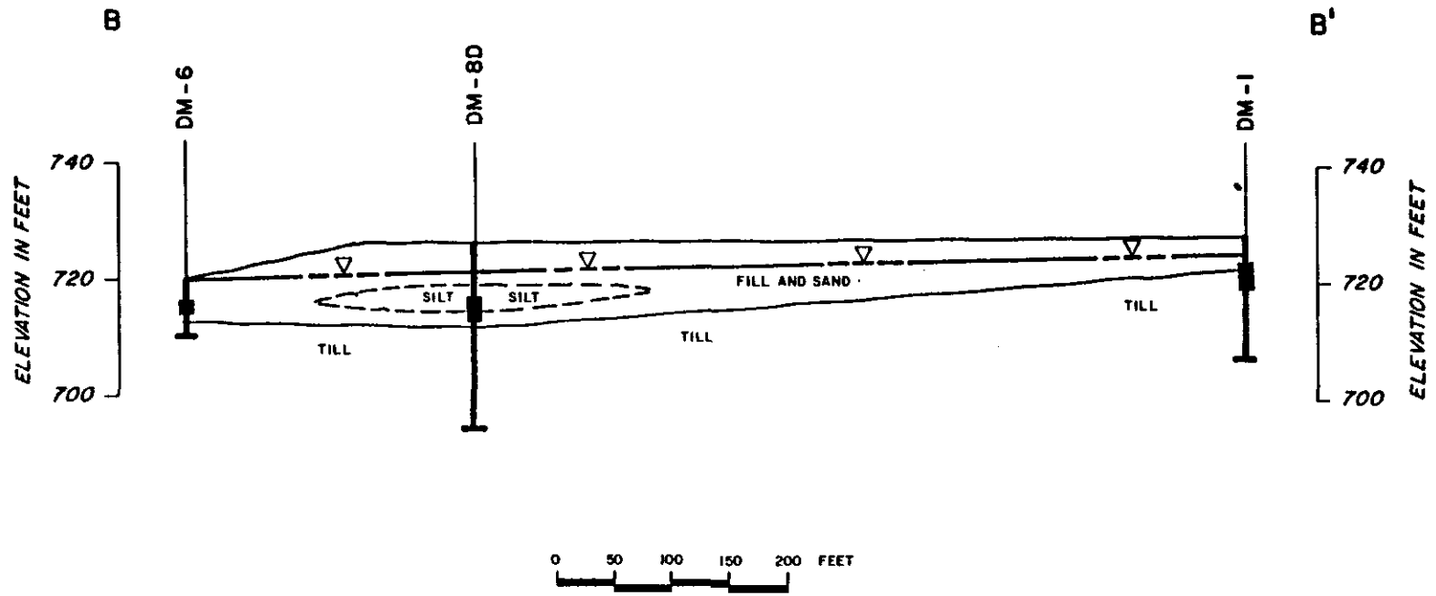
NOTES:

1. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
2. SUBSURFACE SECTIONS ARE INTERPRETED FROM WIDELY SPACED BOREHOLES. CONDITIONS BETWEEN BOREHOLES MAY DIFFER FROM THAT SHOWN.

10637-002-07

FIGURE 3-5
CROSS - SECTION A - A'

DAMES & MOORE



KEY:

PIEZOMETER LOCATION

INDICATES GROUNDWATER TABLE

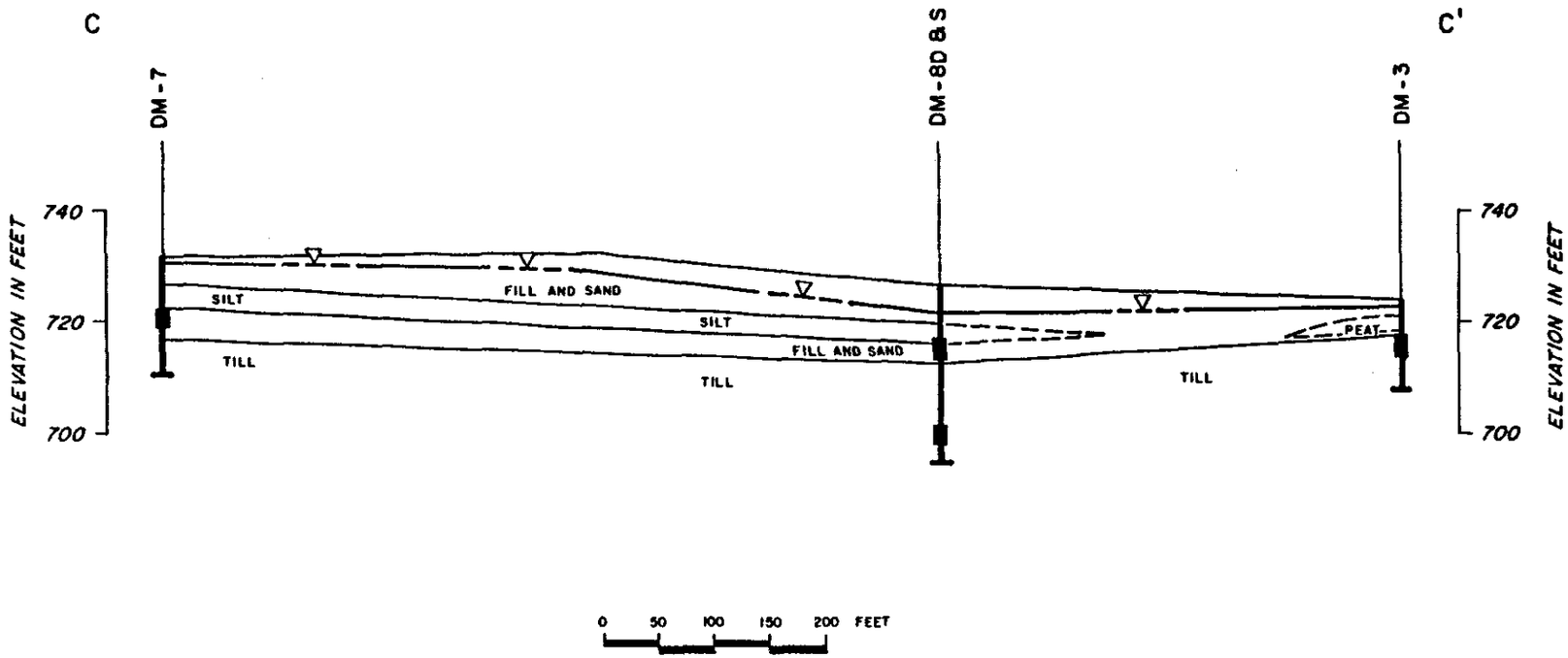
NOTES:

1. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
2. SUBSURFACE SECTIONS ARE INTERPRETED FROM WIDELY SPACED BOREHOLES. CONDITIONS BETWEEN BOREHOLES MAY DIFFER FROM THAT SHOWN.

10637-002-07

FIGURE 3-6
CROSS - SECTION B - B'

DAMES & MOORE



10637-002-07

KEY:

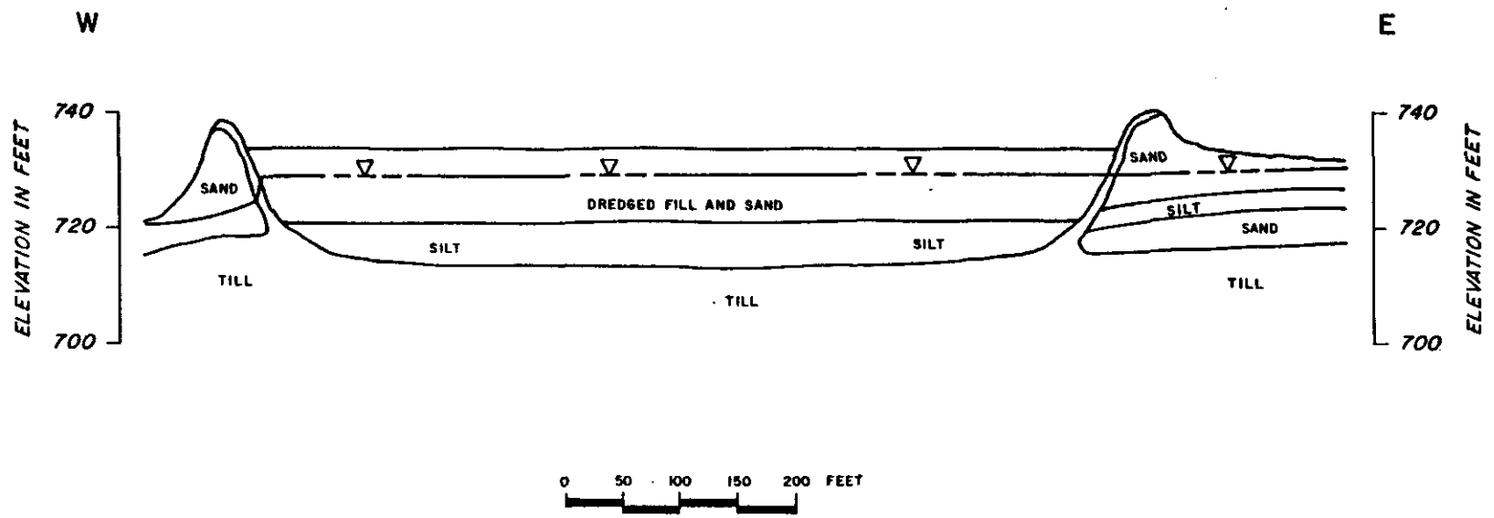
PIEZOMETER LOCATION

INDICATES GROUNDWATER TABLE

NOTES:

1. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
2. SUBSURFACE SECTIONS ARE INTERPRETED FROM WIDELY SPACED BOREHOLES. CONDITIONS BETWEEN BOREHOLES MAY DIFFER FROM THAT SHOWN.

FIGURE 3-7
CROSS - SECTION C - C'



KEY:

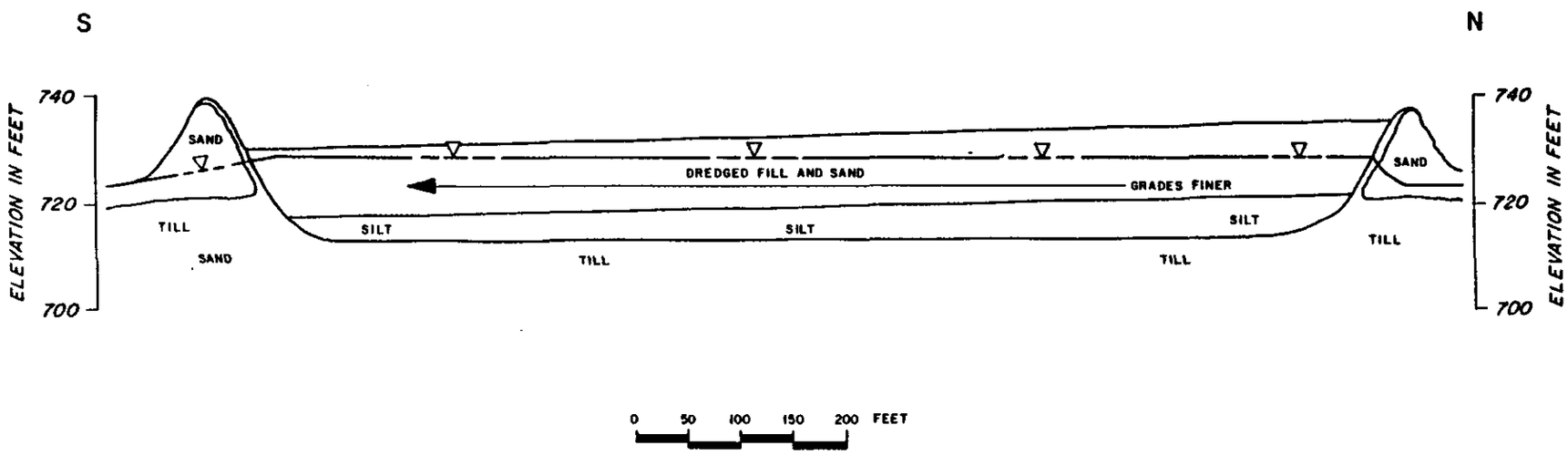
—▽— INDICATES GROUNDWATER TABLE

NOTES:
1. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
2. THE SUBSURFACE SECTION SHOWN REPRESENTS OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

10637-002-07

FIGURE 3-9
GENERALIZED EAST - WEST CROSS - SECTION THROUGH DREDGE POND

DAMES & MOORE



KEY:

—▽— INDICATES GROUNDWATER TABLE

NOTES:
1. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
2. THE SUBSURFACE SECTION SHOWN REPRESENTS OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

10637-002-07

FIGURE 3-10

GENERALIZED NORTH - SOUTH CROSS - SECTION THROUGH DREDGE POND

DAMES & MOORE

APPENDIX A

TERRESTRIAL METHODOLOGY

APPENDIX A

TERRESTRIAL METHODOLOGY

A preliminary reconnaissance was made of the plant site to determine the most suitable habitat areas for trapping small mammals. Generally, the quality of on-site small mammal habitat is poor. However, the border of vegetation along the shoreline of the Pine River appears to provide the best locations for trapping.

Pairs of snap-traps (one large and one small) were baited with an oatmeal-peanut butter mixture and set at each of 45 locations near the river (Figure 3-1). Seven, medium-size, collapsible live-traps were baited with sardines and set at various locations. The traps were concentrated in the western and southwestern regions of the site along the shoreline of the Pine River because the more dense and abundant vegetation in these areas appeared to provide the best small mammal habitat on the site. Trapping was continued for two nights, and traps were checked each morning.

One raccoon and twelve specimens (comprised of three species) of small rodents were collected from the traps. In addition, a composite sample of earthworms was collected from an area adjacent to the northwestern corner of the dredge pond. All animals were tentatively identified in the field, rinsed with distilled water, wrapped in aluminum foil, and frozen. Weights and lengths were recorded for those mammal species collected. Chemical analysis of tissue samples was performed by Environmental Research Group of Ann Arbor, Michigan. From the raccoon, skeletal muscle was analyzed, and whole animal samples were prepared for analysis of the rodents and earthworm tissues.

APPENDIX B

RESULTS OF CHEMICAL ANALYSES FOR SOIL AND WATER SAMPLES

RESULTS OF SOIL ANALYSES

Results reported in parts per million
on wet and dry weight basis

October 31, 1978

ERG#	Sample ID	Date	NH_3-N		NO_3-N		Cl^-	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	250	290	15	17	53	62
AA 25612	10637-002 DM1 #2 3.5"	9/14	13	15	13	15	190	220
AA 25613	DM2 #1 0"	9/15	48	54	<.1	<.11	28	32
AA 25614	DM2 #2 3.5"	9/15	83	97	.24	.29	390	460
AA 25615	DM3 #1 0"	9/18	26	28	1.6	1.7	1500	1600
AA 25616	DM3 #2 3.5"	9/18	65	87	<.1	<.13	3500	4700
AA 25617	DM4 #1 1"	9/18	24	26	.53	.56	270	290
AA 25618	DM4 #2 3.5"	9/18	350	390	<.1	<.11	540	600
AA 25619	DM5 #1 0"	9/21	16	19	.28	.32	51	59
AA 25620	DM5 #2 3.5"	9/21	5.2	5.7	<.1	<.11	23	25
AA 25621	DM6 #1 0"	9/19	60	78	.35	.45	490	640
AA 25622	DM6 #2 3.5"	9/19	26	30	<.1	<.11	700	800
AA 25623	DM7 #1 0"	9/20	4.8	4.9	<.1	<.10	3.0	3.1
AA 25624	DM7 #3 7.5"	9/20	17	20	<.1	<.12	2000	2400
AA 25625	DM8 #1 0"	9/21	41	48	.1	.12	800	930
AA 25626	DM8 #2 3.5"	9/21	2	2.6	.63	.83	2100	2800
AA 25627	DM9 #1 0"	9/22	21	22	<.1	<.11	28	30
AA 25628	DM9 #2 3.5"	9/22	14	16	1.1	1.2	1400	1600

ERG#	Sample ID	Date	SO_4		Phenol		% Moisture
			Wet	Dry	Wet	Dry	
AA 25611	10167-002 DM1 #1 1"	9/14	79	92	.60	.70	14
AA 25612	10637-002 DM1 #2 3.5"	9/14	176	200	.30	.34	12
AA 25613	DM2 #1 0"	9/15	<10	11	.30	.34	11
AA 25614	DM2 #2 3.5"	9/15	490	580	.30	.36	16
AA 25615	DM3 #1 0"	9/18	26	28	.30	.32	7
AA 25616	DM3 #2 3.5"	9/18	35	47	<.15	<.20	25
AA 25617	DM4 #1 1"	9/18	<10	11	<.15	<.16	6
AA 25618	DM4 #2 3.5"	9/18	88	98	<.15	<.17	10
AA 25619	DM5 #1 0"	9/21	430	500	<.15	<.17	14
AA 25620	DM5 #2 3.5"	9/21	35	38	<.15	<.16	9
AA 25621	DM6 #1 0"	9/19	40	52	.60	.78	23
AA 25622	DM6 #2 3.5"	9/19	<10	12	<.30	<.34	13
AA 25623	DM7 #1 0"	9/20	4	4	.60	.62	3
AA 25624	DM7 #3 7.5"	9/20	22	26	<.30	<.36	17
AA 25625	DM8 #1 0"	9/21	5100	5900	1.0	1.2	14
AA 25626	DM8 #2 3.5"	9/21	97	130	<.15	<.20	24
AA 25627	DM9 #1 0"	9/22	<10	11	<.15	<.16	6
AA 25628	DM9 #2 3.5"	9/22	140	160	1.8	2.0	12

ERG#	Sample ID	Date	Total Zn		Total Mg		Total Cu	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	44	51	330	380	19	22
AA 25612	10637-002 DM1 #2 3.5"	9/14	75	85	5400	6100	9.8	11
AA 25613	DM2 #1 0"	9/15	80	90	6300	7100	39	44
AA 25614	DM2 #2 3.5"	9/15	100	120	2000	2400	20	24
AA 25615	DM3 #1 0"	9/18	24	26	4700	5100	11	12
AA 25616	DM3 #2 3.5"	9/18	49	65	9300	12000	9.3	12
AA 25617	DM4 #1 1"	9/18	280	300	4000	4300	4.5	4.8
AA 25618	DM4 #2 3.5"	9/18	20	22	800	890	25	28
AA 25619	DM5 #1 0"	9/21	88	100	7200	8400	20	23
AA 25620	DM5 #2 3.5"	9/21	7.1	7.8	2900	3200	6.4	7.0
AA 25621	DM6 #1 0"	9/19	140	180	8900	12000	12	16
AA 25622	DM6 #2 3.5"	9/19	63	72	1400	1600	27	31
AA 25623	DM7 #1 0"	9/20	19	20	15000	15000	15	15
AA 25624	DM7 #3 7.5"	9/20	34	41	2000	2400	12	14
AA 25625	DM8 #1 0"	9/21	54	63	3100	3600	19	22
AA 25626	DM8 #2 3.5"	9/21	40	53	97000	130000	7.9	10
AA 25627	DM9 #1 0"	9/22	22	23	11000	12000	7.9	8.4
AA 25628	DM9 #2 3.5"	9/22	1.1	1.2	29	33	38	43

ERG#	Sample ID	Date	Total Cu		Total Pb	
			Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	18	21	54	63
AA 25612	10637-002 DM1 #2 3.5"	9/14	33	38	17	19
AA 25613	DM2 #1 0"	9/15	41	46	220	250
AA 25614	DM2 #2 3.5"	9/15	130	160	3100	3700
AA 25615	DM3 #1 0"	9/18	9.3	10	6.7	7.2
AA 25616	DM3 #2 3.5"	9/18	11	15	17	23
AA 25617	DM4 #1 1"	9/18	21	22	17	18
AA 25618	DM4 #2 3.5"	9/18	10	11	30	33
AA 25619	DM5 #1 0"	9/21	35	41	140	160
AA 25620	DM5 #2 3.5"	9/21	9.7	11	3.0	3.3
AA 25621	DM6 #1 0"	9/19	81	110	6.3	8.2
AA 25622	DM6 #2 3.5"	9/19	110	130	5.7	6.6
AA 25623	DM7 #1 0"	9/20	8.1	8.4	2900	3000
AA 25624	DM7 #3 7.5"	9/20	17	20	9.1	11
AA 25625	DM8 #1 0"	9/21	62	72	280	330
AA 25626	DM8 #2 3.5"	9/21	44	58	59	78
AA 25627	DM9 #1 0"	9/22	12	13	23	24
AA 25628	DM9 #2 3.5"	9/22	13	15	540	610

ERG#	Sample ID	Date	Allyl chloride		PHT_4	
			Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25612	10637-002 DM1 #2 3.5"	9/14	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25613	DM2 #1 0"	9/15	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25614	DM2 #2 3.5"	9/15	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25615	DM3 #1 0"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25616	DM3 #2 3.5"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25617	DM4 #1 1"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25618	DM4 #2 3.5"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25619	DM5 #1 0"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25620	DM5 #2 3.5"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25621	DM6 #1 0"	9/19	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25622	DM6 #2 3.5"	9/19	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25623	DM7 #1 0"	9/20	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25624	DM7 #3 7.5"	9/20	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25625	DM8 #1 0"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25626	DM8 #2 3.5"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25627	DM9 #1 0"	9/22	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25628	DM9 #2 3.5"	9/22	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	6.0	.10	.20

ERG#	Sample ID	Date	PBB		EDTA	
			Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	.52	.60	Non Detectable	Non Detectable
AA 25612	10637-002 DM1 #2 3.5"	9/14	.84	.95	Non Detectable	Non Detectable
AA 25613	DM2 #1 0"	9/15	11	12	Non Detectable	Non Detectable
AA 25614	DM2 #2 3.5"	9/15	2.1	2.5	Non Detectable	Non Detectable
AA 25615	DM3 #1 0"	9/18	.81	.87	Non Detectable	Non Detectable
AA 25616	DM3 #2 3.5"	9/18	.34	.43	Non Detectable	Non Detectable
AA 25617	DM4 #1 1"	9/18	3.0	3.2	Non Detectable	Non Detectable
AA 25618	DM4 #2 3.5"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25619	DM5 #1 0"	9/21	4.6	5.2	Non Detectable	Non Detectable
AA 25620	DM5 #2 3.5"	9/21	.20	.23	Non Detectable	Non Detectable
AA 25621	DM6 #1 0"	9/19	.15	.19	Non Detectable	Non Detectable
AA 25622	DM6 #2 3.5"	9/19	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25623	DM7 #1 0"	9/20	.12	.13	Non Detectable	Non Detectable
AA 25623	DM7 #3 7.5"	9/20	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25624	DM8 #1 0"	9/21	960	1100	Non Detectable	Non Detectable
AA 25625	DM8 #2 3.5"	9/21	.73	.90	Non Detectable	Non Detectable
AA 25626	DM9 #1 0"	9/22	34	36	Non Detectable	Non Detectable
AA 25627	DM9 #2 3.5"	9/22	.71	.79	Non Detectable	Non Detectable
Detection Limit:			.02	.02	1.0	1.5

ERG#	Sample ID	Date	Hexabromobenzene		TRIS	
			Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25612	10637-002 DM1 #2 3.5"	9/14	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25613	DM2 #1 0"	9/15	.84	.94	Non Detectable	Non Detectable
AA 25614	DM2 #2 3.5"	9/15	.71	.83	Non Detectable	Non Detectable
AA 25615	DM3 #1 0"	9/18	.20	.22	Non Detectable	Non Detectable
AA 25616	DM3 #2 3.5"	9/18	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25617	DM4 #1 1"	9/18	1.2	1.3	Non Detectable	Non Detectable
AA 25618	DM4 #2 3.5"	9/18	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25619	DM5 #1 0"	9/21	1.1	1.3	Non Detectable	Non Detectable
AA 25620	DM5 #2 3.5"	9/21	.38	.42	Non Detectable	Non Detectable
AA 25621	DM6 #1 0"	9/19	.062	.076	7.1	9.3
AA 25622	DM6 #2 3.5"	9/19	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25623	DM7 #1 0"	9/20	.073	.075	Non Detectable	Non Detectable
AA 25624	DM7 #3 7.5"	9/20	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25625	DM8 #1 0"	9/21	58	66	Non Detectable	Non Detectable
AA 25626	DM8 #2 3.5"	9/21	.051	.064	Non Detectable	Non Detectable
AA 25627	DM9 #1 0"	9/22	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25628	DM9 #2 3.5"	9/22	2.4	2.7	Non Detectable	Non Detectable
Detection Limit:			1. 1.4 2. .02	1. 1.4 2. .02	.60	1.0

ERG#	Sample ID	Date	DMAE		CCl_4	
			Wet	Dry	Wet	Dry
AA 25611	10167-002 DM1 #1 1"	9/14	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25612	10637-002 DM1 #2 3.5"	9/14	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25613	DM2 #1 0"	9/15	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25614	DM2 #2 3.5"	9/15	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25615	DM3 #1 0"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25616	DM3 #2 3.5"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25617	DM4 #1 1"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25618	DM4 #2 3.5"	9/18	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25619	DM5 #1 0"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25620	DM5 #2 3.5"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25621	DM6 #1 0"	9/19	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25622	DM6 #2 3.5"	9/19	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25623	DM7 #1 0"	9/20	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25624	DM7 #3 7.5"	9/20	Non Detectable	Non Detectable	.03	.04
AA 25625	DM8 #1 0"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25626	DM8 #2 3.5"	9/21	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25627	DM9 #1 0"	9/22	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25628	DM9 #2 3.5"	9/22	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	7.0	.02	.03

ERG#	Sample ID	Date	NH_3-N		NO_3-N		Cl^-	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	86	93	<.01	<.01	10	11
AA 25630	SS-1B	9/26	74	82	<.01	<.01	44	49
AA 25631	SS-2A	9/28	48	53	<.01	<.01	27	30
AA 25632	SS-2B	9/28	2.4	2.5	<.01	<.01	10	10
AA 25633	SS-3A	9/28	77	86	<.01	<.01	37	41
AA 25634	SS-3B	9/28	120	140	.05	.06	170	195
AA 25635	SS-4A	9/28	36	40	.38	.42	56	62
AA 25636	SS-5A	9/27	80	85	.14	.15	3.9	4.1
AA 25637	SS-5B	9/27	38	53	.09	.13	4.0	5.6
AA 25638	SS-6A	9/27	93	99	<.01	<.01	43	46
AA 25639	SS-6B	9/27	7.4	8.7	<.01	<.01	140	160
AA 25640	SS-7A	9/27	24	35	2.0	2.9	270	390
AA 25641	SS-7B	9/27	26	28	.57	.61	20	22
AA 25642	SS-8A	9/27	16	18	.13	.15	2.5	2.8
AA 25643	SS-8B	9/27	2.9	4.2	.83	1.2	11	16
AA 25644	SS-9A	9/29	12	17	.82	1.1	2100	2900
AA 25645	SS-10A	9/29	300	330	.24	.26	4.6	5.0
AA 25646	SS-10B	9/29	130	140	.06	.06	4.0	4.3
AA 25647	SS-11A	9/29	33	35	.12	.13	15	16
AA 25648	SS-12A	9/29	2.6	3.0	.06	.07	8.3	9.4
AA 25649	SS-12B	9/29	9.4	11	.04	.05	19	22

ERG#	Sample ID	Date	NH_3-N		NO_3-N		Cl^-	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	29	30	.60	.64	32	34
AA 25651	SS-14A	9/27	6.6	6.9	.13	.14	5.8	6.0
AA 25652	SS-14B	9/27	13	14	.09	.10	8.8	9.7
AA 25653	SS-15A	9/27	14	15	.45	.48	4.0	4.3
AA 25654	SS-15B	9/27	12	12	.03	.03	11	11
AA 25664	DM1 sand	10/16	.80	.85	5.4	5.7	.90	.96
AA 25665	DM2 sand	10/16	1.2	1.3	.62	.66	1.1	1.2
AA 25666	10637-002 mud	10/16	1.6	1.6	5.7	5.7	8.0	8.0
AA 25667	DM8 Portland Cement Grout	10/16	<.4	<.4	.30	.30	14	14

ERG#	Sample ID	Date	SO_4		Phenol		% Moisture
			Wet	Dry	Wet	Dry	
AA 25629	SS-1A	9/26	44	48	<.15	<.16	8
AA 25630	SS-1B	9/26	35	39	.90	1.0	10
AA 25631	SS-2A	9/28	<10	<11	<.15	<.16	9
AA 25632	SS-2B	9/28	40	41	<.15	<.15	3
AA 25633	SS-3A	9/28	13	14	.30	.33	10
AA 25634	SS-3B	9/28	40	46	.30	.34	13
AA 25635	SS-4A	9/28	260	290	.30	.33	9
AA 25636	SS-5A	9/27	74	79	.30	.32	6
AA 25637	SS-5B	9/27	120	170	.30	.42	28
AA 25638	SS-6A	9/27	13	14	<.15	<.16	6
AA 25639	SS-6B	9/27	22	26	.30	.36	15
AA 25640	SS-7A	9/27	44	64	.45	.64	31
AA 25641	SS-7B	9/27	<10	<11	.30	.32	7
AA 25642	SS-8A	9/27	4.1	4.6	<.15	<.17	12
AA 25643	SS-8B	9/27	510	740	.30	.43	31
AA 25644	SS-9A	9/29	230	320	.30	.42	28
AA 25645	SS-10A	9/29	<10	<11	3.9	4.2	8
AA 25646	SS-10B	9/29	13	14	.30	.32	7
AA 25647	SS-11A	9/29	18	19	.60	.65	7
AA 25648	SS-12A	9/29	<10	<11	.30	.34	12
AA 25649	SS-12B	9/29	270	310	<.15	<.17	14

ERG#	Sample ID	Date	SO_4		Phenol		% Moisture
			Wet	Dry	Wet	Dry	
AA 25650	SS-13A	9/27	540	570	<.15	<.16	6
AA 25651	SS-14A	9/27	11	11	<.15	<.16	4
AA 25652	SS-14B	9/27	49	54	<.15	<.16	9
AA 25653	SS-15A	9/27	120	130	<.15	.16	7
AA 25654	SS-15B	9/27	<10	<10	.30	.31	4
AA 25664	DM1 sand	10/16	8.8	9	<.15	<.16	5.6
AA 25665	DM2 sand	10/16	18	19	<.15	<.16	6.0
AA 25666	10637-002 mud	10/16	440	440	.30	.30	2
AA 25667	DM8 Portland Cement Grout	10/16	17000	17000	<.15	<.15	1

ERG#	Sample ID	Date	Total Zn		Total Mg		Total Cr	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	46	50	3100	3400	29	32
AA 25630	SS-1B	9/26	37	41	950	1100	12	13
AA 25631	SS-2A	9/28	21	23	11000	12000	35	38
AA 25632	SS-2B	9/28	13	13	4700	4800	8.9	9.2
AA 25633	SS-3A	9/28	23	26	1800	2000	7.0	7.8
AA 25634	SS-3B	9/28	4.9	5.6	93	110	7.1	8.2
AA 25635	SS-4A	9/28	2500	2700	12000	13000	46	51
AA 25636	SS-5A	9/27	77	82	2300	2400	22	23
AA 25637	SS-5B	9/27	210	290	28000	39000	26	36
AA 25638	SS-6A	9/27	150	160	4600	4900	18	19
AA 25639	SS-6B	9/27	36	42	9500	11000	9.8	12
AA 25640	SS-7A	9/27	55	80	82000	120000	18	26
AA 25641	SS-7B	9/27	26	28	730	780	11	12
AA 25642	SS-8A	9/27	31	35	22000	25000	16	18
AA 25643	SS-8B	9/27	67	97	86000	120000	12	17
AA 25644	SS-9A	9/29	95	130	66000	92000	5.2	7.2
AA 25645	SS-10A	9/29	290	320	8500	9200	7.9	8.6
AA 25646	SS-10B	9/29	19	20	490	530	5.0	5.4
AA 25647	SS-11A	9/29	89	96	2800	3000	4.1	4.4
AA 25648	SS-12A	9/29	220	250	6800	7700	17	19
AA 25649	SS-12B	9/29	82	95	26000	31000	4.1	4.8

ERG#	Sample ID	Date	Total Zn		Total Mg		Total Cr	
			Wet	Dry	Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	90	96	1000	1100	14	15
AA 25651	SS-14A	9/27	36	38	8800	9200	8.4	8.8
AA 25652	SS-14B	9/27	14	15	360	400	4.9	5.4
AA 25653	SS-15A	9/27	120	130	4700	5100	10	11
AA 25654	SS-15B	9/27	15	16	7000	7300	6.9	6.9
AA 25664	DM1 sand	10/16	<.27	<.29	110	120	21	22
AA 25665	DM2 sand	10/16	<.37	<.36	9800	10000	3.0	3.2
AA 25666	10637-002 mud	10/16	12	12	170	170	<.53	<.53
AA 25667	DM8 Portland Cement Grout	10/16	2.7	2.7	11000	11000	46	46

ERG#	Sample ID	Date	Total Cu		Total Pb	
			Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	220	240	78	85
AA 25630	SS-1B	9/26	12	13	49	54
AA 25631	SS-2A	9/28	15	16	12	13
AA 25632	SS-2B	9/28	7.8	8.0	7.8	8.0
AA 25633	SS-3A	9/28	11	12	190	210
AA 25634	SS-3B	9/28	5.0	5.7	29	33
AA 25635	SS-4A	9/28	360	400	110	120
AA 25636	SS-5A	9/27	43	46	250	270
AA 25637	SS-5B	9/27	270	380	120	170
AA 25638	SS-6A	9/27	150	160	210	220
AA 25639	SS-6B	9/27	32	38	42	49
AA 25640	SS-7A	9/27	46	67	30	43
AA 25641	SS-7B	9/27	12	13	78	84
AA 25642	SS-8A	9/27	17	19	12	14
AA 25643	SS-8B	9/27	19	28	26	38
AA 25644	SS-9A	9/29	53	74	46	64
AA 25645	SS-10A	9/29	46	50	97	105
AA 25646	SS-10B	9/29	82	88	2.7	2.9
AA 25647	SS-11A	9/29	76	82	42	45
AA 25648	SS-12A	9/29	360	410	270	310
AA 25649	SS-12B	9/29	48	56	110	130

ERG#	Sample ID	Date	Total Cu		Total Pb	
			Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	100	110	10000	11000
AA 25651	SS-14A	9/27	13	14	16	17
AA 25652	SS-14B	9/27	4.7	5.2	4.7	5.2
AA 25653	SS-15A	9/27	54	58	110	120
AA 25654	SS-15B	9/27	8.1	8.4	3.7	3.8
AA 25664	DM1 sand	10/16	1.4	1.5	<2.2	<2.3
AA 25665	DM2 sand	10/16	4.3	4.6	<1.1	<1.2
AA 25666	10637-002 mud	10/16	1.3	1.3	4.2	4.2
AA 25667	DM8 Portland Cement Grout	10/16	36	36	<1.5	<1.5

ERG#	Sample ID	Date	Allyl chloride		PHT_4	
			Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25630	SS-1B	9/26	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25631	SS-2A	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25632	SS-2B	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25633	SS-3A	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25634	SS-3B	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25635	SS-4A	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25636	SS-5A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25637	SS-5B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25638	SS-6A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25639	SS-6B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25640	SS-7A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25641	SS-7B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25642	SS-8A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25643	SS-8B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25644	SS-9A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25645	SS-10A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25646	SS-10B	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25647	SS-11A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25648	SS-12A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25649	SS-12B	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	6.0	.10	.20

ERG#	Sample ID	Date	Allyl chloride		PHT_4	
			Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25651	SS-14A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25652	SS-14B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25653	SS-15A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25654	SS-15B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25664	DM1 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25665	DM2 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25666	10637-002 mud	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25667	DM8 Portland Cement Grout	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	7.0	.10	.20

ERG#	Sample ID	Date	PBB		EDTA	
			Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	.63	.68	Non Detectable	Non Detectable
AA 25630	SS-1B	9/26	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25631	SS-2A	9/28	.26	.28	Non Detectable	Non Detectable
AA 25632	SS-2B	9/28	.041	.045	Non Detectable	Non Detectable
AA 25633	SS-3A	9/28	1.1	1.2	Non Detectable	Non Detectable
AA 25634	SS-3B	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25635	SS-4A	9/28	84	92	Non Detectable	Non Detectable
AA 25636	SS-5A	9/27	4.7	5.0	Non Detectable	Non Detectable
AA 25637	SS-5B	9/27	.43	.55	Non Detectable	Non Detectable
AA 25638	SS-6A	9/27	27	29	Non Detectable	Non Detectable
AA 25639	SS-6B	9/27	2.3	2.6	Non Detectable	Non Detectable
AA 25640	SS-7A	9/27	2.9	3.8	Non Detectable	Non Detectable
AA 25641	SS-7B	9/27	.39	.42	Non Detectable	Non Detectable
AA 25642	SS-8A	9/27	8.9	10	Non Detectable	Non Detectable
AA 25643	SS-8B	9/27	.048	.064	Non Detectable	Non Detectable
AA 25644	SS-9A	9/29	4.5	5.8	Non Detectable	Non Detectable
AA 25645	SS-10A	9/29	31	34	Non Detectable	Non Detectable
AA 25646	SS-10B	9/29	.022	.024	Non Detectable	Non Detectable
AA 25647	SS-11A	9/29	1.2	1.3	Non Detectable	Non Detectable
AA 25648	SS-12A	9/29	6.6	7.4	Non Detectable	Non Detectable
AA 25649	SS-12B	9/29	.085	.098	Non Detectable	Non Detectable
Detection Limit:			.02	.02	1.0	1.5

ERG#	Sample ID	Date	PBB		EDTA	
			Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	1.3	1.4	Non Detectable	Non Detectable
AA 25651	SS-14A	9/27	13	14	Non Detectable	Non Detectable
AA 25652	SS-14B	9/27	.14	.16	Non Detectable	Non Detectable
AA 25653	SS-15A	9/27	17	18	Non Detectable	Non Detectable
AA 25654	SS-15B	9/27	.15	.16	Non Detectable	Non Detectable
AA 25664	DM1 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25665	DM2 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25666	10637-002 mud	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25667	DM8 Portland Cement Grout	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			.02	.02	1.0	1.5

ERG#	Sample ID	Date	Hexabromobenzene		TRIS	
			Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	.80	.87	Non Detectable	Non Detectable
AA 25630	SS-1B	9/26	.020	.023	Non Detectable	Non Detectable
AA 25631	SS-2A	9/28	2.2	2.4	Non Detectable	Non Detectable
AA 25632	SS-2B	9/28	1.8	1.9	Non Detectable	Non Detectable
AA 25633	SS-3A	9/28	1.1	1.2	15	17
AA 25634	SS-3B	9/28	.021	.024	1.7	2.2
AA 25635	SS-4A	9/28	40	44	580	620
AA 25636	SS-5A	9/27	21	23	5.3	6.8
AA 25637	SS-5B	9/27	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25638	SS-6A	9/27	14	15	4400	4700
AA 25639	SS-6B	9/27	Non Detectable[1]	Non Detectable[1]	2800	3200
AA 25640	SS-7A	9/27	.54	.72	Non Detectable	Non Detectable
AA 25641	SS-7B	9/27	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25642	SS-8A	9/27	1.7	1.9	Non Detectable	Non Detectable
AA 25643	SS-8B	9/27	.034	.045	Non Detectable	Non Detectable
AA 25644	SS-9A	9/29	1.8	2.3	2.1	2.8
AA 25645	SS-10A	9/29	52	56	Non Detectable	Non Detectable
AA 25646	SS-10B	9/29	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25647	SS-11A	9/29	.53	.57	930	1000
AA 25648	SS-12A	9/29	1.8	2.0	7.9	8.9
AA 25649	SS-12B	9/29	.044	.051	9.8	11
Detection Limit:			1. 1.4 2. .02	1. 1.4 2. .02	.60	1.0

ERG#	Sample ID	Date	Hexabromobenzene		TRIS	
			Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	Non Detectable[1]	Non Detectable[1]	Non Detectable	Non Detectable
AA 25651	SS-14A	9/27	2.7	2.8	Non Detectable	Non Detectable
AA 25652	SS-14B	9/27	.09	.10	Non Detectable	Non Detectable
AA 25653	SS-15A	9/27	33	35	Non Detectable	Non Detectable
AA 25654	SS-15B	9/27	.28	.30	Non Detectable	Non Detectable
AA 25664	DM1 sand	10/16	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25665	DM2 sand	10/16	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25666	10637-002 mud	10/16	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
AA 25667	DM8 Portland Cement Grout	10/16	Non Detectable[2]	Non Detectable[2]	Non Detectable	Non Detectable
Detection Limit:			1. 1.4 2. .02	1. 1.4 2. .02	.60	1.0

ERG#	Sample ID	Date	DMAE		CCl_4	
			Wet	Dry	Wet	Dry
AA 25629	SS-1A	9/26	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25630	SS-1B	9/26	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25631	SS-2A	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25632	SS-2B	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25633	SS-3A	9/28	13	14	Non Detectable	Non Detectable
AA 25634	SS-3B	9/28	36	40	Non Detectable	Non Detectable
AA 25635	SS-4A	9/28	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25636	SS-5A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25637	SS-5B	9/27	Non Detectable	Non Detectable	.04	.06
AA 25638	SS-6A	9/27	6.0	8.0	Non Detectable	Non Detectable
AA 25639	SS-6B	9/27	50	53	Non Detectable	Non Detectable
AA 25640	SS-7A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25641	SS-7B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25642	SS-8A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25643	SS-8B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25644	SS-9A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25645	SS-10A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25646	SS-10B	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25647	SS-11A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25648	SS-12A	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25649	SS-12B	9/29	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	7.0	.03	.02

ERG#	Sample ID	Date	DMAE		CCl_4	
			Wet	Dry	Wet	Dry
AA 25650	SS-13A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25651	SS-14A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25652	SS-14B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25653	SS-15A	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25654	SS-15B	9/27	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25664	DM1 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25665	DM2 sand	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25666	10637-002 mud	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25667	DM8 Portland Cement Grout	10/16	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			5.0	7.0	.02	.03

RESULTS OF WATER ANALYSES

Results reported in mg/l.

October 31, 1978

ERG#	Sample ID	Date	NH_3-N	NO_3-N	Cl^-	SO_4	Phenol
AA 25655	DM4	10/2	19	.01	12000	270	.008
AA 25656	DM7	10/2	25	.01	47000	95	.012
AA 25657	DM2	10/2	2.0	.04	2600	3	.020
AA 25658	DM5	10/2	2.8	.08	1000	320	.012
AA 25659	DM6	10/2	12	.02	7800	650	.10
AA 25660	DM8 (9)	10/2	53	.04	82000	220	.076
AA 25661	DM1	10/2	.14	.11	220	180	.004
AA 25662	DM9	10/2	9.9	<.01	6800	260	1.2
AA 25663	W1	10/2	.44	<.01	82	2400	.004

ERG#	Sample ID	Date	Total Zn	Total Mg	Total Cr	Total Cu	Total Pb
AA 25655	DM4	10/2	30	440	.11	.29	.23
AA 25656	DM7	10/2	41	440	.14	.25	.060
AA 25657	DM2	10/2	30	240	.075	.19	.36
AA 25658	DM5	10/2	110	150	.060	.14	.18
AA 25659	DM6	10/2	18	570	.064	.15	.12
AA 25660	DM8 (9)	10/2	84	510	.11	.17	1.8
AA 25661	DM1	10/2	21	92	.060	.26	.24
AA 25662	DM9	10/2	1000	280	.13	9.0	8.1
AA 25663	W1	10/2	.040	26	.076	.035	.015

ERG#	Sample ID	Date	Allyl chloride	PHT_4	PBB	EDTA
AA 25655	DM4	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25656	DM7	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25657	DM2	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25658	DM5	10/2	Non Detectable	Non Detectable	.02	Non Detectable
AA 25659	DM6	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25660	DM8 (9)	10/2	Non Detectable	Non Detectable	.13	Non Detectable
AA 25661	DM1	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25662	DM9	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25663	W1	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			1.0	.01	.00001 ⇊ 0.01 ug/l	1.0

ERG#	Sample ID	Date	Hexabromo-benzene	TRIS	DMAE	CCl_4
AA 25655	DM4	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25656	DM7	10/2	Non Detectable	Non Detectable	Non Detectable	.02
AA 25657	DM2	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25658	DM5	10/2	Non Detectable	Non Detectable	20	Non Detectable
AA 25659	DM6	10/2	Non Detectable	Non Detectable	Non Detectable	.08
AA 25660	DM8 (9)	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25661	DM1	10/2	Non Detectable	Non Detectable	Non Detectable	.03
AA 25662	DM9	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
AA 25663	W1	10/2	Non Detectable	Non Detectable	Non Detectable	Non Detectable
Detection Limit:			.01	.01 ⇓ 10 ug/l	1.0	.01 10 ug/l

Dames & Moore
March 12, 1979
Organic and Inorganic Analysis

Water Samples (30552-64) reported in mg/l

ERG#	Sample ID	CCl_4	PBB	DMAE	Phenol	Cl	SO_4
30352	DM-1	.0026	-	-	-	-	-
30353	DM-5	-	.00035	ND[1]	-	-	-
30354	DM-6	.027	-	-	-	-	-
30355	DM-7	.0016	-	-	-	-	-
30356	DM-8	-	.0013	-	-	-	-
30357	DM-3	.030	.000083	-	.004	-	-
30358	DP-1	.027	.00017	ND[2]	.016	9200	100

Detection Limit:

1. 500
2. 4

ND = Non Detectable

Dames & Moore
March 12, 1979
Organic and Inorganic Analysis

Water Samples (30552-64) reported in mg/1.
Soil Sample 30365 is reported in mg/kg on a dry weight basis.

ERG#	Sample ID	CCl_4	PBB	DMAE	Tris	HBB	Phenol	Cl	SO_4
30359	DP-2D	.030	.00012	ND[1]	-	-	.044	16,000	180
30360	DP-3	.022	.000075	ND[1]	-	-	.028	30,000	36
30361	DP-4	.0003	.000058	ND[1]	-	-	.16	24,000	130
30362	DP-5	.0026	.000067	ND[1]	-	-	.012	6,200	230
30363	DP-6	.059	.00019	ND[1]	-	-	.26	4,000	59
30364	DP-25	.038	-	-	-	-	.053	-	-
30365	DS1-12 Comp	-	3100	ND[2]	390	31	-	-	-

Detection Limit:
1. 4.0
2. 8.0

ND = Non Detectable

Dames & Moore
March 12, 1979
Organic and Inorganic Analysis

Soil Samples (30365-79) reported in mg/kg on a dry weight basis.

ERG#	Sample ID	PBB	DMAE	Tris	HBB
30366	SS-3S	-	ND	-	-
30367	SS-3D	-	ND	-	-
30368	SS-10S	2.0	-	-	1.1
30369	SS-11S	-	-	930	-
30370	SS-11D	-	-	1200	-
30371	SS-11 Comp	-	-	790	-
30372	SS-12S	-	-	2.5	-
	Detection Limit:		8.0		

ND = Non Detectable

Dames & Moore
March 12, 1979
Organic and Inorganic Analysis

Results reported in mg/kg on a dry weight basis.

ERG#	Sample ID	DDT & Analogs	Tris	PBB	DMAE	HBB
30373	SS-12D	-	1.3	-	-	-
30374	SS-12 Comp	-	1.2	-	-	-
30375	DP-6 #1	.55	-	-	-	-
30376	DP-6 #2	13	-	-	-	-
30377	SS-3 Comp	-	-	-	ND	-
30378	DS-1	-	34	34	ND	21
30379	DS-2	-	1400	ND	ND	ND[1]
30380	DS-3	-	ND	36	ND	51
30381	DS-4	-	29	.84	-	ND[2]
30382	DS-5	-	20	250	ND	11
30383	DS-6	-	51	3.6	ND	ND[2]
30384	DS-7	-	39	4.3	ND	ND[2]
30385	DS-8	-	250	53000	ND	ND[3]
30386	DS-9	-	30	11	ND	11
30387	DS-10	-	1.9	240	ND	ND[1]
30388	DS-11	-	.89	6.5	ND	ND[2]
30389	DS-12	-	56	34	ND	33
Detection Limits:			1.6	26	8.0	1.) 7.2 2.) .50 3.) 560

ND = Non Detectable

APPENDIX C

ANALYTICAL CHEMISTRY METHODS

APPENDIX C

ANALYTICAL CHEMISTRY METHODS

The analytical methods and instrumentation employed by Environmental Research Group, Inc. were consistent with published and accepted laboratory procedures. Complete references follow the Summary of Analytical Methodology.

In all cases, analyses were performed within the recommended holding times set in the EPA Manual of Methods for Chemical Analyses of Water and Wastes.

A summary of the methodology for each parameter is shown below.

Parameter	Summary of Analytical Methodology	Reference
Ammonia Nitrogen (NH_3-N)	Automated Phenate	1
Nitrate Nitrogen (NO_3-N)	Automated Cadmium Reduction	1
Chloride (Cl^-).	Automated Ferric Thiocyanate	1
Phenols	4-AAP Method following Distillation	1
Sulfate (SO_4)	Turbidimetric Method	1
Metals:		
Cr, Cu, Mg, Pb, Zn	Atomic Absorption following nitric acid digestion of waters and Aqua Regia digestion of soils and tissues	1
Polybrominated Biphenyls (PBB)	Extraction, florisil clean-up, Gas Chromatography	2
Tetrabromophthalic anhydride (PHT_4)	Extraction, florisil clean-up, high pressure liquid chromatography	3
Ethylenediamine tetraacetic acid (EDTA)	Extraction, chelation, high pressure liquid chromatography	4
Tris 2,3 dibromopropyl phosphate (TRIS)	Extraction, florisil clean-up, high pressure liquid chromatography	3
Dimethyl aminoethyl alcohol (DMC-OH)	Extraction, gas chromatography	5

Parameter	Summary of Analytical Methodology	Reference
Allyl Chloride	Extraction, gas chromatography	6
Carbon tetrachloride (CCl_4)	Extraction, gas chromatography	6
Hexabromobenzene	Extraction, florisil clean-up, gas chromatography	2
Percent Moisture (%M)	Gravimetric	1

2.0 REFERENCES

1. U.S.E.P.A., Manual of Methods for Chemical Analysis of Water and Wastes, Cincinnati, Ohio. 1974.

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5. Johns Manville Corp., 1974. Chromosorb Century Series Bulletin.

6. Henderson, J.E., G.R. Peyton, and W.H. Glaze, 1976. A Convenient Liquid-Liquid Extraction Method for the Determination of Halomethanes in Water at the Parts Per Million Level, in L.H. Keith, ed., Identification and Analysis of Organic Pollutants in Water. Ann Arbor Science.

VELSICOL CHEMICAL CORPORATION
Research and Development Department
Ann Arbor, Michigan

Analytical Method No. 919-A
Determination of Trace Quantities of
PHT-4 in Waste Waters

919-A-013178

Scope

This method is applicable to the determination of trace quantities of PHT-4 (tetrabromophthalic anhydride) in waste water.

Principle

Waste water suspected of containing PHT-4 is first extracted with methylene chloride. The solvent is evaporated to a 10 ml volume using a Rotovap® and Kuderna-Danish evaporator. A portion of this extract is then injected into a liquid chromatograph which separates PHT-4 from other impurities in the waste water. As PHT-4 emerges from the column, a signal is generated which is recorded as a peak on a strip chart recorder. The peak height is measured and compared with that of a standard to determine the concentration of PHT-4 from the water sample.

Safety

Standard laboratory dress should be worn during this analysis. Avoid breathing the vapors of these chemicals. Avoid open flame; these solvents are extremely flammable.

Apparatus and Reagents

Balance, 1000 gm maximum, 0.1 gm divisions
Balance, semimicro
Rotovap® or equivalent
250 ml Kuderna-Danish evaporator with graduated thimble or equivalent
2-liter separatory funnel
1000 ml beaker
500 ml erlenmeyer flask
1000 ml boiling flask
2-100 ml volumetric flasks
50 ml volumetric flask
25 ml volumetric flask
10 ml volumetric flask
1.0 ml pipettes

Liquid chromatograph with standard 254 nm UV detector and Rheodyne Model 7120 precision injection valve or equivalent
Nitrogen, dry with regulator
Hexane, spectro-grade, UV cut-off approx. 200 nm
Methylene chloride, distilled in glass, UV cut-off approx. 230 nm
Tetrahydrofuran, spectro-grade, UV cut-off approx. 210 nm
Sodium sulfate, anhydrous granular
PHT-4, technical grade, Velsicol Chemical Corp.
Syringe, 100 µl or equivalent
Waters µBondapak CN column, 30 cm x 3.9 mm I.D.

Accuracy and Precision

The accuracy of this method was investigated by determining the % recovery of PHT-4 from spiked water samples. All the water samples were spiked in the range of 1.0 to 1.5 ppm. The extraction efficiency of PHT-4 when extracting immediately after spiking is approximately 93%. The hydrolysis rate of PHT-4 in water was determined by spiking water samples with PHT-4 and allowing them to stir together for a given amount of time. The data obtained from this study indicates a hydrolysis rate of 20 to 25% per day.

Precision has not been thoroughly investigated, but four water samples analyzed immediately after spiking showed the following results:

Sample	PHT-4, ppm added	Efficiency of Extraction, %
1	1.38	91.3
2	1.02	94.7
3	1.39	96.0
4	1.86	90.0

The detection limit of PHT-4 by this method is 1 ppm in solvent or 1 ppb based on a 1000 g water sample at a 1.0 ml dilution. Calibration curves for PHT-4 indicate detector response to be linear over a range of zero to 50 ppm.

Sample Preparation

1. Approximately 900 to 1000 gms of waste water sample is weighed out (±0.1 gm) in a 1000 ml beaker. The sample is then transferred to a 2-liter separatory funnel. The water is then extracted with 3 x 100 mls of methylene chloride and shaken vigorously for at least 2 minutes each time. The organic layer is separated each time into an erlenmeyer flask. After the 3 extractions, the aqueous layer may be discarded.

2. Approximately 5 to 10 gms of sodium sulfate is added to the erlenmeyer flask to dry the organic extract if necessary. Swirl for about 1 minute.

3. The organic extract must be transferred from the erlenmeyer to the 1000 ml boiling flask. A small funnel with a cotton ball plug may be used when transferring to prevent any sodium sulfate from entering the boiling flask. The erlenmeyer is then rinsed with 3 x 5 mls of methylene chloride and these washings are added to the boiling flask also.

4. The organic liquid in the boiling flask is concentrated to 5 to 10 mls using a Rotovap and hot water bath. It is then transferred into a Kuderna-Danish evaporator equipped with a graduated thimble. The boiling flask is rinsed with 3 x 5 mls methylene chloride and these rinses are added to the Kuderna also. Using a dry air or nitrogen current, the organic extract is concentrated to approximately 5 ml and brought back to 10.0 ml volume with methylene chloride. The extract is then poured into a 10 ml vial for HPLC analysis.

Standard Preparation

1. A standard sample is prepared by first weighing out accurately 0.15000 g of PHT-4 in a 100 ml volumetric flask. The PHT-4 is then dissolved in 50 mls of methylene chloride and diluted to the mark with an additional 50 mls of methylene chloride. This may then be labeled as the stock solution having a concentration of 1500 μg/ml or 1500 ppm.

2. The following standard concentrations are then made up by accurately pipetting 1.00 ml of the above stock solution into the appropriate volumetric flask and diluting to the mark with methylene chloride.

Dilutions: $1 \rightarrow 100 = 15$ ppm
$1 \rightarrow 50 = 30$ ppm
$1 \rightarrow 25 = 60$ ppm
$1 \rightarrow 10 = 150$ ppm

Further dilutions may be accomplished in the same manner as shown above.

Liquid Chromatographic Analysis

1. Operating Conditions

Column..... Water's μBondapak CN, 30 cm x 3.9 mm I.D.
Mobile phase..... 80% Hexane, 20% $MeCl_2$, 1% THF
Pressure/Flow..... 450 psi/$\approx$ 1 ml per min.
Detector..... UV 254 nm
Chart speed..... 5 mm/min.
Injection volume..... 20 μl*

*For increased sensitivity, a maximum of 50 μl may be injected. However, an increase in sample volume may result in an increase in peak broadening and peak tailing.

2. Calculations

a. Inject 20 µl of standard (15 ppm at 0.1 AUFS) and measure the retention time of the peak in the standard (i.e., measure the distance from time of injection to peak maximum).

b. Measure the peak area for the standard [i.e., area (mm^2) = peak ht. (mm) x peak width at ½ peak ht. (mm)].

c. Inject 20 µl of sample into the liquid chromatograph. Measure the retention time of the peak(s) and compare this retention time to that of the standard to identify the peak.

d. Measure the peak area of this peak as in 2b above.

e. Calculate the PHT-4 concentration in the waste water as follows:

$$\text{Conc. of PHT-4 (ppm)} = \frac{\text{PHT-4 peak area in sample } (mm^2) \times \text{volume of extract (ml)} \times \text{conc. of PHT-4 in std. ppm}}{\text{PHT-4 peak area in std. } (mm^2) \times \text{sample wt. (g)}}$$

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Analytical Method 900-A 900-A-081977
Determination of Trace Quantities of LV-T23P and
LV-T23P Low Boilers in Waste Waters

Scope

This method is applicable to the determination of trace quantities of tris(2,3-dibromopropyl)phosphate, 1,2-dibromo-3-chloropropane, 1,2,3-tribromopropane, 1,3-dibromo-2-propanol and 2,3-dibromo-1-propanol in waste waters.

Principle

Samples should be analyzed as soon as possible after being taken due to the slow hydrolysis of LV-T23P in water. Waste water suspected of containing LV-T23P and LV-T23P low boilers is first extracted with 15% diethyl ether in hexane, then concentrated to a known volume. One half of this concentrate is submitted for the gas chromatographic analysis of LV-T23P low boilers while the other half is evaporated to near dryness then brought back to its original volume with methanol. A portion of each extract is injected into either a gas chromatograph or a liquid chromatograph which separates the components from each other and from other impurities in the waste water. As each component emerges from the column, a signal is generated which is recorded as a peak on a strip chart recorder. The area under each peak (for GC) or the height of each peak (for LC) is compared with that of a standard sample to determine the concentration of each component present in the waste water.

Safety

Standard laboratory dress should be worn during this test. Avoid breathing the vapors of these chemicals. CAUTION: Avoid open flame; these solvents are extremely flammable.

Accuracy and Precision

The accuracy of this method was investigated by determining the recovery of LV-T23P and LV-T23P low boilers from spiked water samples. The results showed that LV-T23P begins hydrolysis immediately upon contact with water. Recovery of LV-T23P is approximately 20% when the solubility of LV-T23P in water (1-2 ppm) is not exceeded. However, when the

solubility is exceeded, the recovery is approximately 85% up to the 10 ppm level where the efficiency then drops to 50%. This decrease in efficiency at the 10 ppm level is probably due to the limited solubility of LV-T23P in hexane. This data indicates that this method of extraction is capable of recovering about 80% LV-T23P when present in water between 2 and 6 ppm. Recovery above and below these levels is significantly less.

The LV-T23P low boilers show the following extraction efficiencies:

Dibromochloropropane	66%
Tribromopropane	68%
1,3-Dibromopropanol	8%
2,3-Dibromopropanol	9%

The poor efficiencies of the alcohols is due to their fair solubility in water.

The detection limit for these compounds is as follows:

LV-T23P	~ 50 ppb
DBCP	~ 600 ppb
TBP	~ 960 ppb
1,3-DBP	~ 14 ppm
2,3-DBP	~ 12 ppm

The precision data for this method was obtained from the first four extractions in which the LV-T23P concentration was in the range of 1 to 2 ppm. The precision was calculated using the extraction efficiencies (percentages) since these take into account the slight differences in the amounts of LV-T23P added to the water.

The precision was calculated as follows:

$$S = \sqrt{\frac{E(Xi-\bar{X})^2}{N-1}}$$

where Xi = the extraction efficiency of each sample spiked in the 1 ⟶ 2 ppm range.

$N = 4$

$\bar{X} = 20.43$

$\bar{X}$ = average extraction efficiency of samples spiked in the 1⟶2 ppm range

$S = 0.659$

S = standard deviation

$$\text{Rel. error} = \frac{S}{\bar{X}} \times 100$$

R = relative error

$R = 3.22\%$

Therefore, the extraction efficiency at the 1⟶2 ppm level is $20.43\% \pm .659$.

Apparatus and Reagents

a. Sample Preparation

Balance 1000 g maximum, 0.1 g divisions
Rotovap® or equivalent
250 ml Kuderna-Danish evaporator equipped with a graduated thimble or equivalent
2 liter separatory funnel
1000 ml beaker
500 ml erlenmeyer flask
1000 ml round bottom flask
Diethyl ether, pesticide analysis grade
Hexane, pesticide analysis grade
Methanol, spectro-grade, U.V. cutoff approx. 205 nm
Sodium sulfate, anhydrous granular

b. Standard Preparation, Gas Chromatographic Analysis

2,3-dibromo-1-propanol, pure
1,3-dibromo-2-propanol, pure
1,2-dibromo-3-chloropropane, pure
1,2,3-tribromopropane, pure
1.0 ml pipettes
250.0 ml pipettes
8 dram vials
Gas chromatograph equipped with a flame ionization detector or equivalent
Helium, dry with regulator
Hydrogen with regulator
Air, dry with regulator
Washed 100/120 mesh glass column
6' - 10% Reoplex 400 on Chromosorb W AW DMCS
Syringe, Hamilton 10 μ

c. Standard Preparation, Liquid Chromatographic Analysis

Tris (2,3-dibromopropyl)phosphate, low volatile
2-100 ml volumetric flasks
50 ml volumetric flask
25 ml volumetric flask
10 ml volumetric flask
1.0 ml pipettes
Balance, semi-micro
Liquid chromatograph equipped with variable wavelength ultraviolet detector and Rheodyne Model 7120 precision injection valve; or equivalent
Nitrogen, dry with regulator
Methanol, spectro-grade; UV cutoff approx, 205 nm
Distilled H_2O
Syringe, Hamilton, 250 μl or equivalent
DuPont Permaphase ODS column, 1m x 2.1 mm I.D.

Sample Preparation

Samples should be analyzed as soon as possible after being taken due to the slow hydrolysis of LV-T23P in water (~ 0.7 ppm per day).

1. Approximately 900 to 1000 g of waste water sample is weighed (± 0.1 g) in a 1000 ml beaker. The sample is then transferred into a 2 liter separatory funnel. The water solution is extracted with 3 x 100 mls of 15% diethyl ether in hexane by shaking vigorously for approximately 2 minutes each time. The organic layer is separated each time into an erlenmeyer flask (500 ml). The aqueous layer may be discarded after extraction.

2. Approximately 5 to 10 g of sodium sulfate may be added to dry the organic extract if necessary. Swirl for about 1 minute.

3. The organic extract must be transferred from the erlenmeyer to a 1000 ml round bottom flask. The erlenmeyer is then rinsed with 3 x 5 ml of 15% diethyl ether in hexane and these washings are added to round bottom flask also.

4. The organic liquid in the round bottom flask is concentrated to 5-10 mls using a Rotovap® and hot water bath. It is then transferred into a Kuderna-Danish evaporator equipped with a graduated thimble. The flask is rinsed with 3 x 5 ml 15% diethyl ether in hexane and these rinses are added to the Kuderna. Using a dry air or nitrogen current, the organic extract is concentrated to 5 ml and brought back up to exactly 10.0 ml using hexane. Exactly 5.0 ml of this concentrate is submitted for gas chromatographic analysis of LV-T23P low boilers.

5. The remaining 5 ml of the extract is concentrated to approximately 0.5 ml (near dryness) and then brought back to exactly 5.0 ml with methanol. This concentrate is now ready for liquid chromatographic analysis.

Standard Preparation

a. GC Standards

1. A standard sample is prepared by pipetting 1.0 ml of each of the following components into a 250 ml volumetric flask:

2,3-dibromo-1-propanol	density = 2.11 g/ml
1,3-dibromo-2-propanol	density = 2.12 g/ml
1,2-dibromo-3-chloropropane	density = 2.09 g/ml
1,2,3-tribromopropane	density = 2.44 g/ml

2. The standard sample is now diluted to the mark with 15% diethyl ether in hexane and labeled as "Standard I."

3. A second standard sample is prepared by pipetting 1.0 ml of Standard I into a 250 ml volumetric flask and diluting to volume with 15% diethyl ether in hexane. This may be labeled as "Standard II."

The above standards contain the following concentrations:

	Standard I*	Standard II**
2,3-dibromo-1-propanol	0.8440	33.76
1,3-dibromo-2-propanol	0.8480	33.96
1,2-dibromo-3-chloropropane	0.8360	33.44
1,2,3-tribromopropane	0.9760	39.04

* % (w/v)
** ppm

$$\text{Conc. of component (ppm)} = \frac{\text{density of component (g/ml) X volume (ml) X } 10^6}{\text{total volume (ml)}}$$

Note: If these standards are not in the range of interest, others may be prepared in a similar manner.

b. LC Standards

1. A standard sample is prepared by first weighing out accurately 0.15000 g of LV-T23P in a 100 ml volumetric flask. The LV-T23P is then dissolved in 50 ml of methanol and diluted to the mark with an additional 50 ml of methanol. This may be labeled as the stock solution having a concentration of 1500.0 μg/ml or 1500.0 ppm.

2. The following standard concentrations are made up by accurately pipetting 1 ml of the above stock solution into the appropriate volumetric flask and diluting to the mark with 55% methanol/H_2O (v/v).

Dilutions:
1 ⟶ 100 = 15 ppm
1 ⟶ 50 = 30 ppm
1 ⟶ 25 = 60 ppm
1 ⟶ 10 = 150 ppm

Gas Chromatographic Analysis

1. Operating Conditions

Column Temperature	180°C
Detector Temperature	250°C
Injector Temperature	235°C
Carrier Gas Flow	100 ml/min
Sample Size	2 µl
Chart Speed	0.5 in/min
Sensitivity	Attenuate as needed to keep peaks on scale

2. Calculations

a. Inject 2 µl of the standard into the gas chromatograph. Measure the retention time of each peak in the standard, i.e., measure the distance from time of injection to peak maximum of each peak.

b. Measure the peak height and width at ½ the height of each peak in the standard. Multiply the height times the width at ½ height of each peak to obtain the area.

c. Inject 2 µl of sample into the gas chromatograph. Measure the retention time of each peak. Match these retention times to the retention times of the four peaks in the standard to identify the peaks.

d. Measure the peak areas of each peak as in 2b above.

e. Calculate the concentration of each component as follows:

$$\text{conc. of comp., ppm} = \frac{\text{peak area of comp. in sample } (mm^2) \times \text{volume of extract (ml)} \times \text{conc. of comp. in std. (ppm)}}{\text{peak area of comp. in standard } (mm^2) \times \text{sample wt. (g)}}$$

A typical chromatogram of the above is attached.

Liquid Chromatographic Analysis

1. Operating Conditions

Column	1 m x 2.1 mm I.D. DuPont Permaphase ODS
Mobile Phase	55% MeOH/H_2O (v/v)
Pressure	1000 psi
Detector	220 nm
Sensitivity	0.02 AUFS
Chart Speed	2 mm/min
Injection Volume	100 µl

2. Calculations

a. Inject 100 µl of standard into liquid chromatograph. Measure the retention time of the peak in standard (i.e., measure distance from time of injection to peak maximum).

b. Measure the peak height for the standard.

c. Inject 100 µl of the sample into the liquid chromatograph. Measure the retention time of peak(s) and compare this retention time to that of the standard to identify the peak.

d. Measure the peak height as in 2b above.

e. Calculate the LV-T23P concentration as follows:

$$\text{nc. of LV-T23P (ppm)} = \frac{\text{LV-T23P peak ht. in sample (mm)} \times \text{volume of extract (ml)} \times \text{conc. of LV-T23P in std. (ppm)}}{\text{LV-T23P peak height in standard (mm)} \times \text{sample wt., (g)}}$$

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APPENDIX D

GEOTECHNICAL FIELD PROCEDURES

APPENDIX D

GEOTECHNICAL FIELD PROCEDURES

In order to minimize the dangers of any fugitive contamination of soil and water samples during the course of the drilling program, the following procedures were stringently practiced in the field:

I. PREDRILLING PREPARATION

Upon arrival at the plant site and prior to going to the specific drilling locations, the drill rig, drill rods, bits, subs, auger flights, Dames & Moore samplers, wrenches, clamps, vise, and miscellaneous tools, bath troughs, table, drying racks, casing, and piezometer screens were steam cleaned. The drill rods, auger flights, samplers, casing, and piezometer screens were then wrapped in PVC before proceeding to the drilling site. In moving on site, the rig was driven slowly to minimize the contamination by dust.

Upon reaching the site and laying out the ground covers for the drilling and cleaning sites (as described below), the cleaning area was set up. The cleaning area contained the following equipment:

1. A table for disassembling the samplers consisting of a table with a vise, wrench, cleaning brush, and container for hexane used for cleaning;

2. Trough, containing soap and water, with drainboard, gloves, and cleaning brush;

3. Two troughs containing hexane with drainboards, gloves, and cleaning brushes;

4. Drying rack with gloves;

5. Containers of fresh water and unused hexane;

6. Waste containers for used soap and water, hexane, rags, etc.; and

7. Grounding clamps.

Gloves remained at and were used only at one cleaning station. Whenever hexane was transferred from the container to the bath or from the bath to the waste container, grounding clamps were used to minimize the risk of fire.

II. PREPARATION OF DRILLING SITES

Before drilling began at any location, the area was sprayed with water in order to control the dust. Next, a PVC ground cloth was lain over the entire work area in order to catch any solid or liquid wastes produced in the course of drilling. When possible, the drill rig was located on the ground cloth upgradient from the point where the hole was to be drilled. The downgradient portion of the ground cloth was supported on stakes or by using some other appropriate measure in order to contain any liquid wastes. When the ground around the proposed site was level, the ground cloth was supported around the entire perimeter in order to provide a catchment.

In preparation for drilling the hole, the auger flights were unwrapped and cleaned in the following manner:

1. The auger flights were placed in the soap and water bath and scrubbed with the brush assigned to that cleaning station. When finished scrubbing, the auger flight was placed on the drainboard and allowed to drain for a minute or two.

2. The auger flight from the previous station was then placed in the first hexane bath, scrubbed down with the brush assigned to this cleaning station, and then placed on the drainboard to drain.

3. Step 2 was repeated for the second hexane bath.

4. The auger flight was retrieved from the previous station and placed on the drying rack, allowing it to air dry before use. In order to minimize the possibility of airborne contamination, the auger flights were lightly draped with PVC while drying.

Prior to drilling, a hole was cut in the ground cover large enough to accommodate the auger flights. Before the actual drillig took place, a surface soil sample was taken. Thereafter, subsurface soil samples were taken at 5-foot intervals or when changes in material occurred.

III. DRILLING

The upper portion of the deep boring and the entire depth of the 25-foot borings were drilled using a 3-3/4-inch ID (9-inch OD) hollow stem auger. The hollow stem auger was effective in isolating the sidewall materials from the undisturbed materials being sampled using a drive sampler. A positive pressure of clean and uncirculated drilling mud was maintained in the auger flights to minimize infiltration into the auger by possibly contaminated ground water.

The deep hole drilled was completed in two steps. The first step was to drill a 9-inch OD hole, using the hollow stem auger, into the clayey till. A 4-inch prewashed (using the method described above for the auger flights) steel casing with casing centralizers was placed in the hole and pressure grouted with neat cement slurry containing 6 to 8 percent bentonite through the casing from bottom to top. An appropriate-sized gate valve was attached to the top of the 4-inch ID casing in order to shut in the pressure and prevent the cement from siphoning back into the casing. After the calculated (+30 percent) quantity of grout was placed in the casing, a

bentonite-water drilling mud mixture was pumped into the casing to force the cement grout out. A 2- or 3-foot-thick cement plug was left in the casing. No activities were permitted in the hole or casing for at least 24 hours.

The second step involved drilling out the cement plug in the casing and drilling to a depth of about 4 feet below the base of the casing. The hole was then thoroughly flushed with water of known quality before proceeding. The hole was deepened to an approximate depth of 30 feet using the rotary wash method. During this deepening process, the drilling mud was used only once and not recirculated. At the completion of drilling, a piezometer was set. Next to the deep hole and piezometer, a shallow hole was augered without taking samples to the required depth of about 12 feet and a shallow piezometer installed.

IV. SAMPLING

The actual sampling proceeded in the following manner: first, the hollow stem auger was advanced to the top of the desired sampling interval. The auger flights were kept filled with clean, uncirculated drilling mud to prevent infiltration of possibly contaminated ground water. The prewashed Dames & Moore sampler was then lowered to the bottom of the hole on drilling rods and driven using a drive hammer. A record of the blows required to drive the sampler was recorded. When the sampler was removed from the hole and broken from the rods, it was wiped down with cloths or paper towels to remove all traces of mud from the exterior of the sampler. The sampler was then taken to the table in the cleaning area where the exterior of the sampler was wiped with paper towels wetted in hexane. The joints were then broken loose using a hexane-washed wrench and vise. If the sample was to be used for

chemical analysis, the center six rings were removed as one piece, wrapped in tin foil, enclosed in a plastic bag, and placed in the Dames & Moore sample container prior to freezing. Of the remaining four rings, the outer two were discarded and the other two were transported to the Dames & Moore laboratory for soil analysis. The surface sample and the sample taken at the 5-foot interval were the only samples used for chemical analysis; therefore, only the sample taken at the 5-foot interval was handled as described below. All other samples were transported directly to the Dames & Moore laboratory for soil analysis.

After the 5-foot sample was prepared, it, along with the surface soil sample, was taken directly to the Velsicol quality control laboratory and frozen prior to transfer to the Environmental Research Group (ERG) laboratory for chemical analysis.

After each sampling, the work table and tools were scrubbed with hexane. The sampler was then put through the soap and water bath, followed by two hexane baths and air drying before being wrapped in PVC prior to reuse.

All samples were carefully logged and labeled. The log included date, boring number, sample number, Dames & Moore representative's name, sample depth, blow count, visual sample description, and soil classification, as well as any other pertinent details of the drilling.

V. PIEZOMETER INSTALLATION

Piezometers (prewashed using the method described above for the auger flights) constructed of 2-inch ID galvanized iron pipe and 2-foot-long steel well points were installed in each of the borings. These piezometers were used to determine ground water levels, to make in-situ permeability

tests, and to obtain water samples for chemical analysis. The piezometers were installed using the following procedure: the hollow stem auger was withdrawn to the top of the clay layer, and the portion of the hole in the clay was grouted with concrete. The drilling mud in the auger flights was replaced by clean water of known quality by pumping in clean water through a rod extending to near the hole bottom. A clean piezometer was then lowered into the auger flights to the desired depth and a sand pack was added as the auger was gradually pulled from the hole. When the sand pack extended a foot or two above the top of the well point, the remainder of the annulus between the piezometer and the walls of the boring was grouted with concrete. A sample of the water in the piezometer was collected using a teflon bailer, and the piezometer was capped and allowed to sit for at least 24 hours before further development, testing, or sampling. The location of each piezometer was marked using a 2 x 4 sticking up at least 4 feet above ground surface.

VI. SECURING THE DRILLING SITE

Once a hole had been drilled and the piezometer installed, the site was secured in the following manner:

1. As the auger flights came out of the hole, the excess material was cleaned off and each flight was wiped down with water. It was then wrapped in the PVC wrapper used originally. The auger flights were then ready for transportation to the steam cleaning area for steam cleaning prior to moving on to the next site.

2. All baths were drained into proper waste containers using grounding clamps.

3. All solid wastes, including gloves and brushes, were placed in a container for disposal.

4. All equipment was removed from the cleaning area and transported to the steam cleaning area for cleaning prior to setting up at the next site.

5. When the ground cover for the cleaning area contained any spilled liquids, these were drained into a proper container before disposing of the cover.

6. All drilling equipment was removed from the drilling site and transported to the steam cleaning area for cleaning prior to setting up at the next site.

7. Step 5 was repeated for the ground cover at the drill site.

8. After all equipment was steam cleaned, the equipment proceeded to the next site.

APPENDIX E

PIEZOMETER DATA

APPENDIX E

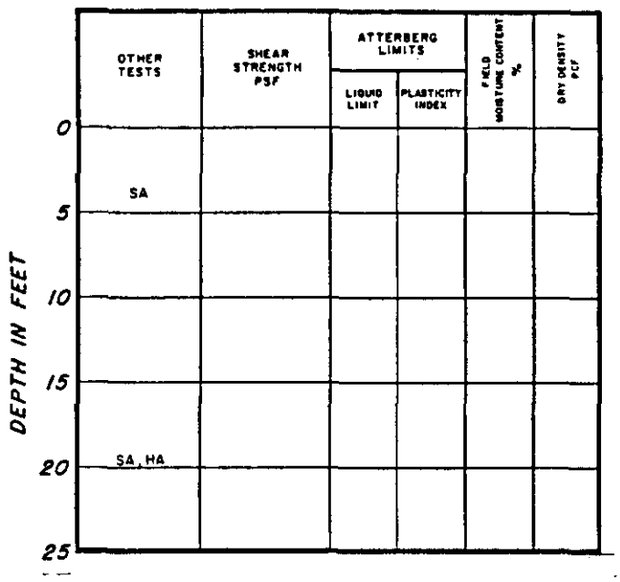
PIEZOMETER DATA

PIEZOMETER NUMBER	ELEVATION TO TOP OF PIEZOMETER (feet)	ELEVATION OF GROUND SURFACE (feet)	DEPTH OF BORING (feet)	SCREENED INTERVAL (feet below ground surface)	EFFECTIVE INTERVAL (feet below ground surface)	DIAMETER (inches)	DEPTH TO WATER (3/31/79) (feet below top of casing)
DM-1	728.14	727.38	20.5	4.9 - 8.4	3.0 - 20.5	2	3.3
DM-2	728.39	723.94	15.5	6.1 - 9.6	3.0 - 15.5	2	5.8
DM-3	727.79	723.56	15.5	6.0 - 9.5	2.0 - 15.5	2	5.2
DM-4	723.28	722.15	20.5	9.3 - 12.8	3.0 - 20.5	2	3.7
DM-5	730.17	725.66	15.5	6.2 - 9.7	3.0 - 15.5	2	6.1
DM-6	721.87	720.26	9.5	3.9 - 7.4	2.0 - 9.5	2	2.0
DM-7	732.73	731.86	20.5	9.7 - 13.2	3.0 - 20.5	2	2.1
DM-8S	726.99	726.55	15.5	10.1 - 13.6	3.0 - 15.5	2	5.4
DM-8D	728.52	726.36	31.5	25.5 - 29.0	20.0 - 31.5	2	5.4*
DM-9	724.95	723.91	20.5	9.5 - 13.0	2.0 - 20.5	2	5.0
DP-1	739.10	738.12	30.0	25.0 - 28.5	10.0 - 30.0	2	16.6
DP-2D	738.62	738.10	30.0	25.0 - 28.0	22.0 - 30.0	2	10.5
DP-2S	738.88	737.89	30.0	15.5 - 19.0	10.0 - 19.0	2	11.1
DP-3	740.44	739.94	30.0	25.5 - 28.5	12.0 - 28.5	2	11.3
DP-4	738.55	737.74	30.0	25.0 - 28.5	10.0 - 30.0	2	14.6
DP-5	725.76	720.83	6.0	4.0 - 6.0	3.0 - 6.0	2	5.4
DP-6	737.60	734.19	25.0	18.5 - 23.5	14.0 - 25.0	2	8.5

*Water level taken 4/9/79.

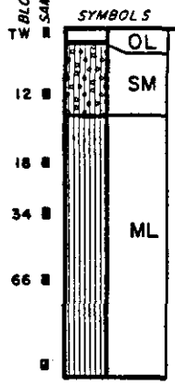
APPENDIX F

BORING LOGS



BORING DM-1

SURFACE ELEVATION 727.38



DESCRIPTIONS

BLACK HIGHLY ORGANIC TOPSOIL

LIGHT BROWN FINE TO MEDIUM SAND WITH TRACE CLAY AND TRACE FINE GRAVEL (LOOSE)

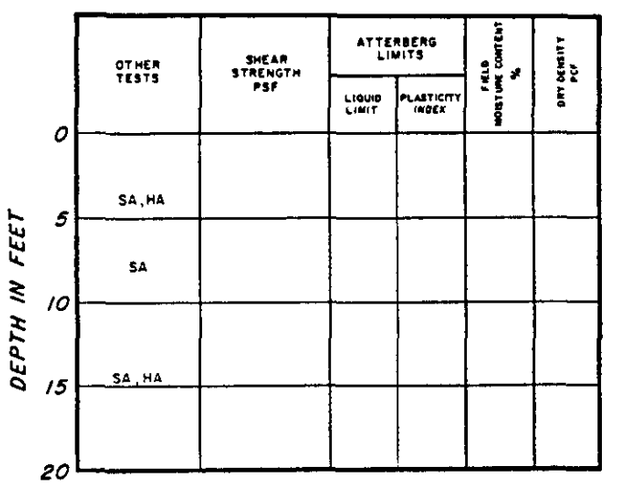
GRADES WITH OCCASIONAL LENSE OF CLAYEY SILT

GRAY CLAYEY SILT WITH TRACE COARSE SAND (STIFF)

GRADES VERY STIFF

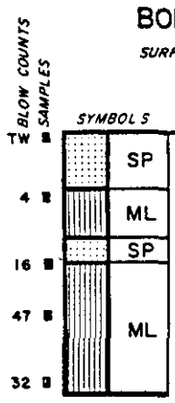
GRADES WITH SOME CLAY AND TRACE FINE GRAVEL (BLOW COUNTS NOT RECORDED)

BORING COMPLETED AT A DEPTH OF 20.5 FEET ON 9-14-78.
PIEZOMETER INSTALLED ON 9-14-78.
SCREENED INTERVAL: 4.9 FEET TO 8.4 FEET.
SAND PACK: 3.0 FEET TO 20.5 FEET
GROUT: 0 TO 3.0 FEET
WATER LEVEL RECORDED AT A DEPTH OF 3.2 FEET ON 4-9-79.



BORING DM-2

SURFACE ELEVATION 723.94



DESCRIPTIONS

DARK BROWN FINE SAND WITH TRACE CLAYEY SAND AND ORGANIC MATTER

GRAYISH BROWN CLAYEY SILT WITH SOME FINE SAND AND TRACE FINE GRAVEL (SOFT)

GRAY FINE SAND WITH TRACE MEDIUM TO COARSE SAND

GRAY SILT WITH SOME CLAY AND TRACE FINE GRAVEL (STIFF)

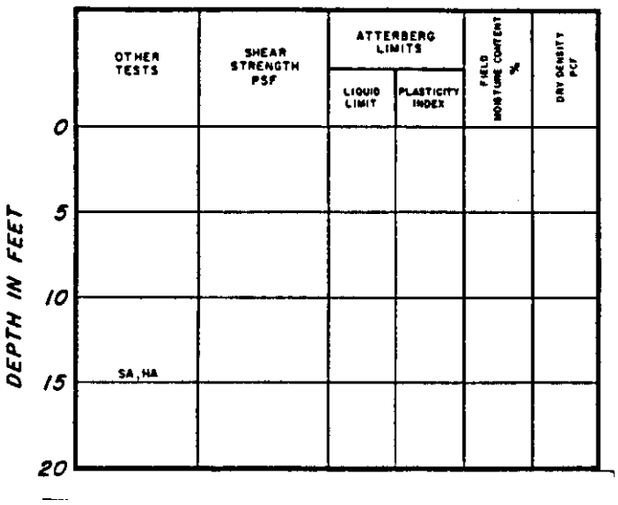
GRADES WITH TRACE COARSE SAND AND FINE GRAVEL

BORING COMPLETED AT A DEPTH OF 15.5 FEET ON 9-15-78.
PIEZOMETER INSTALLED ON 9-15-78.
SCREENED INTERVAL: 6.1 FEET TO 9.6 FEET.
SAND PACK: 3.0 FEET TO 15.5 FEET.
GROUT: 0 TO 3.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 2.1 FEET ON 4-9-79.

LOG OF BORINGS

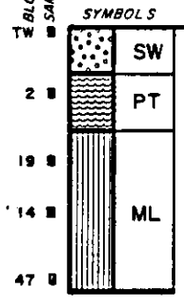
DAMES & MOORE

FIGURE F-1



BORING DM-3

SURFACE ELEVATION 723.56



DESCRIPTIONS

LIGHT BROWN FINE TO MEDIUM SAND WITH SOME COARSE SAND AND TRACE GRAVEL (FILL)

BLACK PEAT WITH OCCASIONAL LENSE OF GRAY SANDY SILT

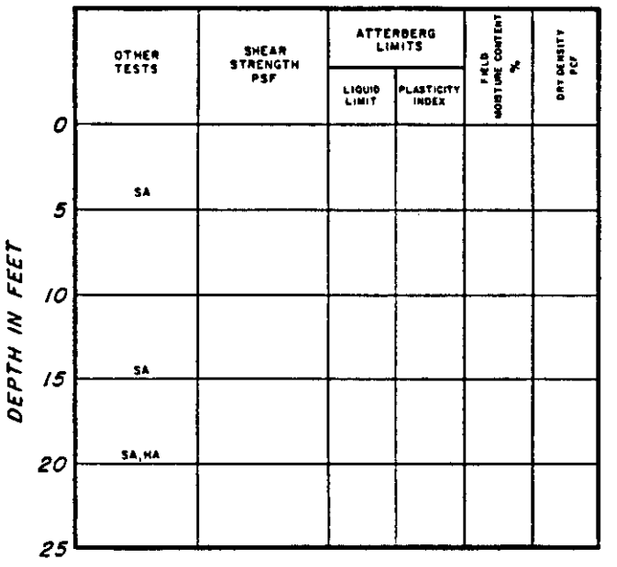
SILT GRADES OUT

GRAY CLAYEY SILT WITH TRACE FINE GRAVEL (STIFF)

GRADES BROWN (MEDIUM STIFF)

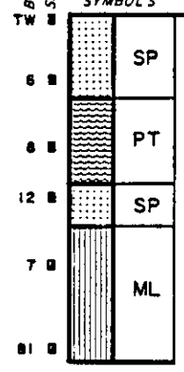
GRADES GRAY WITH SOME CLAY (HARD)

BORING COMPLETED TO A DEPTH OF 15.5 FEET ON 9-18-78.
PIEZOMETER INSTALLED ON 9-18-78.
SCREENED INTERVAL: 6.0 FEET TO 9.5 FEET.
SAND PACK: 2.0 FEET TO 15.5 FEET.
GROUT: 0 TO 2.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 2.6 FEET ON 4-9-79.



BORING DM-4

SURFACE ELEVATION 722.15



DESCRIPTIONS

BROWN FINE SAND WITH TRACE FINE TO COARSE GRAVEL AND BLACK CINDERS (LOOSE)

BLACK HIGHLY ORGANIC PEAT CONSISTING OF (PREDOMINATELY DECOMPOSED WOOD FRAGMENTS AND SAWDUST)

YELLOW BROWN FINE SAND (MEDIUM DENSE)

GRAY CLAYEY SILT WITH SOME FINE SAND AND TRACE COARSE SAND (MEDIUM STIFF)

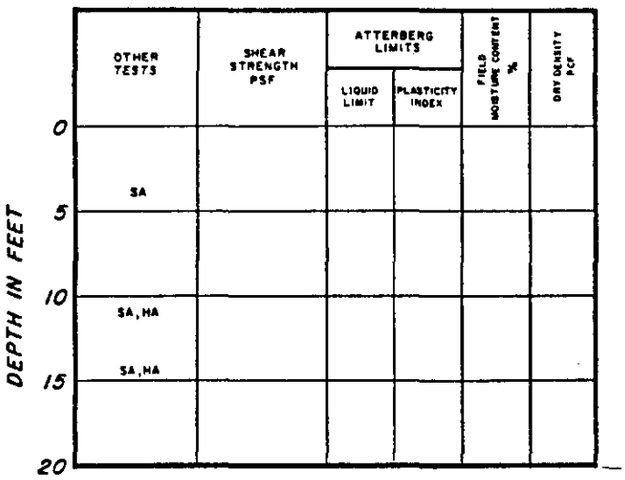
GRADES HARD

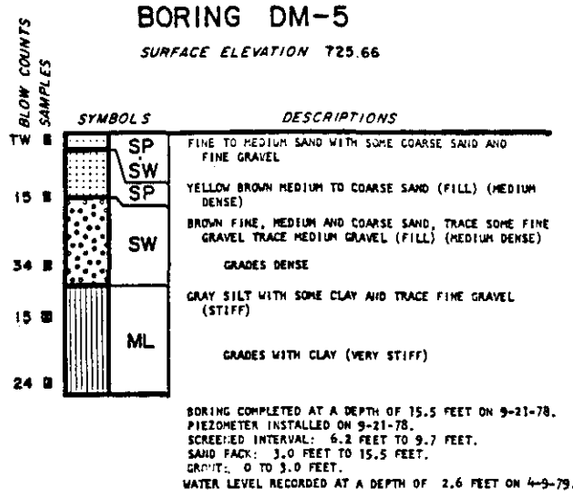
BORING COMPLETED AT A DEPTH OF 20.5 FEET ON 9-19-78.
PIEZOMETER INSTALLED ON 9-19-78.
SCREENED INTERVAL: 9.3 FEET TO 12.8 FEET.
SAND PACK: 3.0 FEET TO 20.5 FEET
GROUT: 0 TO 3.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 3.2 FEET ON 4-9-79

LOG OF BORINGS

DAMES & MOORE

FIGURE F-2

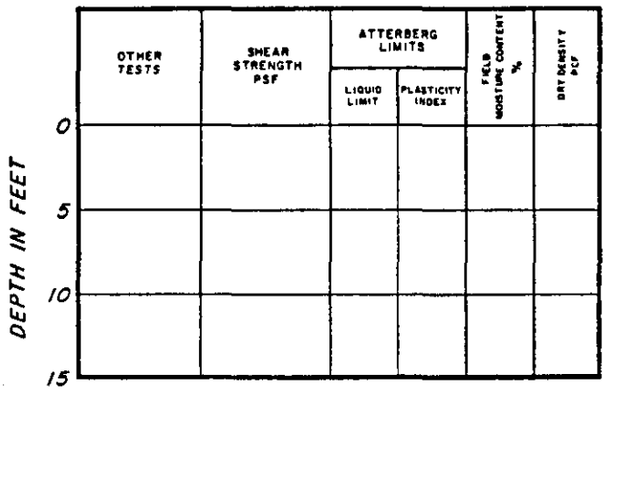


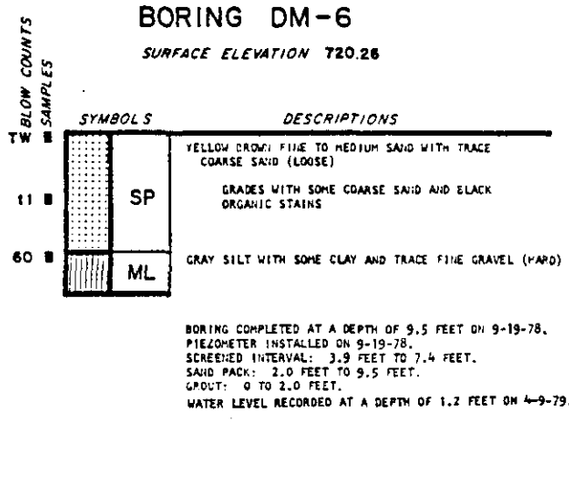


BORING DM-5

SURFACE ELEVATION 725.66

BORING COMPLETED AT A DEPTH OF 15.5 FEET ON 9-21-78.
PIEZOMETER INSTALLED ON 9-21-78.
SCREENED INTERVAL: 6.2 FEET TO 9.7 FEET.
SAND PACK: 3.0 FEET TO 15.5 FEET.
GROUT: 0 TO 3.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 2.6 FEET ON 4-9-79.





BORING DM-6

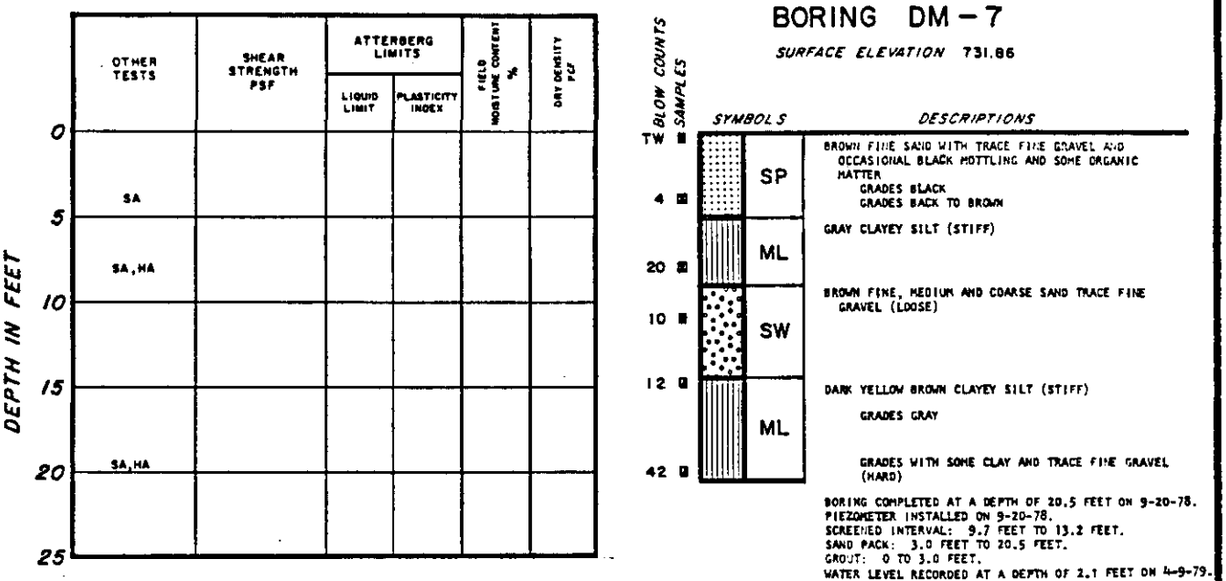
SURFACE ELEVATION 720.26

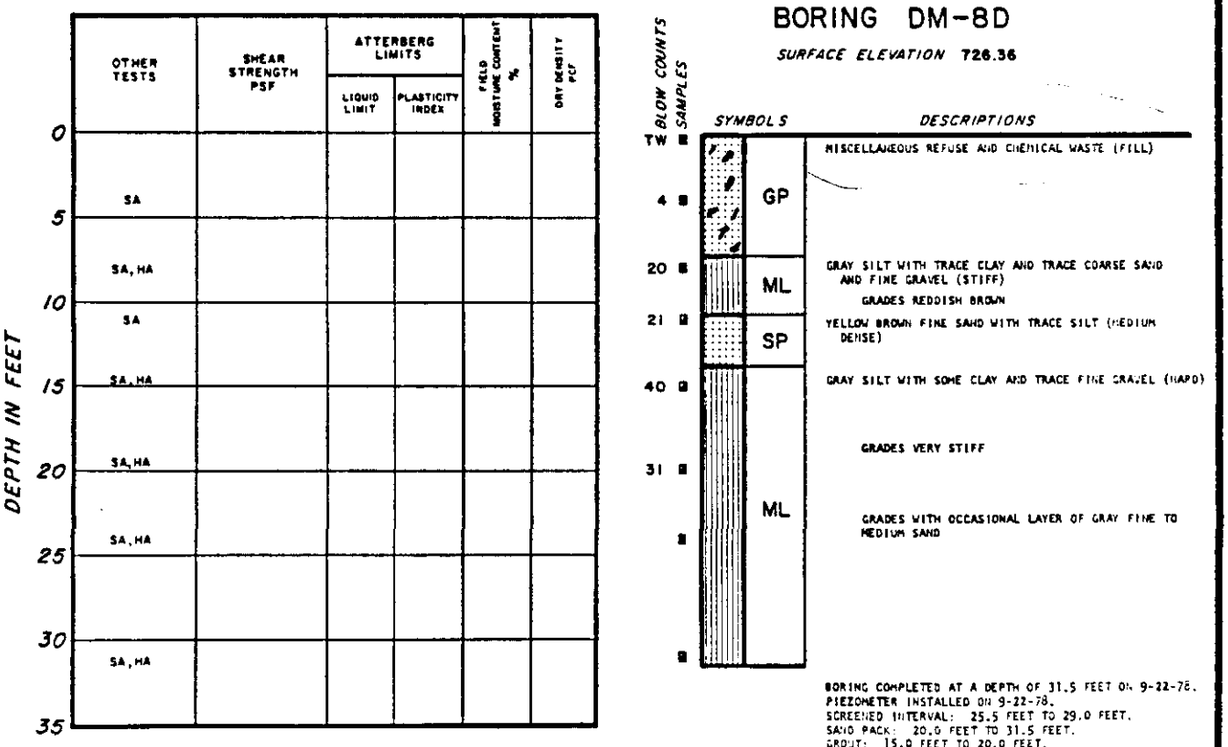
BORING COMPLETED AT A DEPTH OF 9.5 FEET ON 9-19-78.
PIEZOMETER INSTALLED ON 9-19-78.
SCREENED INTERVAL: 3.9 FEET TO 7.4 FEET.
SAND PACK: 2.0 FEET TO 9.5 FEET.
GROUT: 0 TO 2.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 1.2 FEET ON 4-9-79.

LOG OF BORINGS

DAMES & MOORE

FIGURE F-3

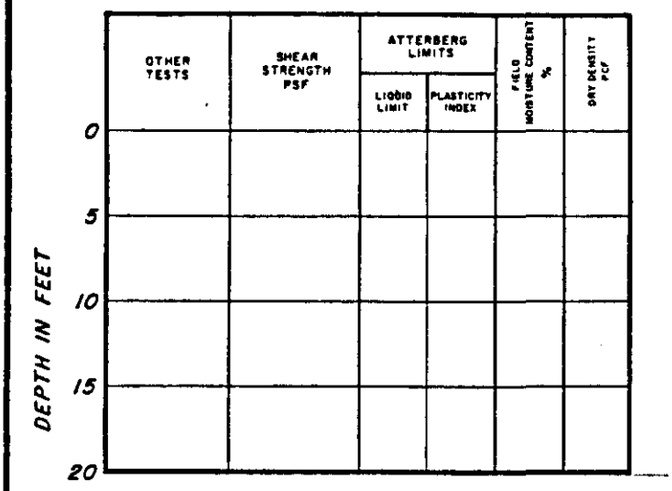




LOG OF BORINGS

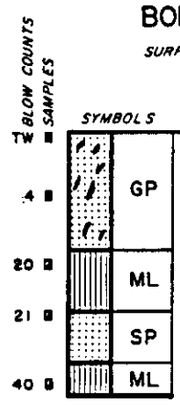
DAMES & MOORE

FIGURE F-4



BORING DM-8S

SURFACE ELEVATION 726.55



DESCRIPTIONS

MISCELLANEOUS REFUSE AND CHEMICAL WASTE (FILL)

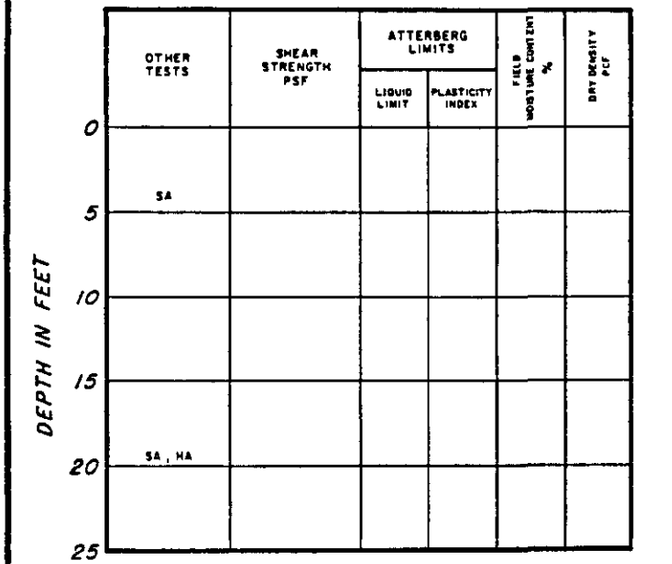
GRAY SILT WITH TRACE CLAY AND COARSE SAND AND FINE GRAVEL (STIFF)

GRADES REDDISH BROWN

YELLOW BROWN FINE SAND WITH TRACE SILT (MEDIUM DENSE)

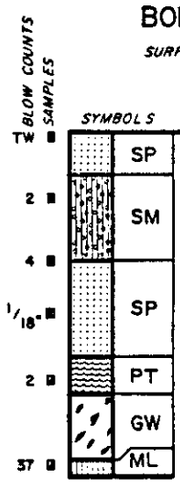
GRAY SILT WITH SOME CLAY AND TRACE FINE GRAVEL (HARD)

BORING COMPLETED AT A DEPTH OF 15.5 FEET ON 9-21-78.
PIEZOMETER INSTALLED ON 9-21-78.
SCREENED INTERVAL: 10.1 FEET TO 13.6 FEET.
SAND PACK: 3.0 FEET TO 15.5 FEET.
GROUT: 0 TO 3.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 5.8 FEET ON 4-9-79.



BORING DM-9

SURFACE ELEVATION 723.91



DESCRIPTIONS

BROWN FINE TO MEDIUM SAND WITH TRACE SOME GRAVEL (FILL)

BLACK FINE TO COARSE SAND WITH SOME SILT AND TRACE FINE GRAVEL (CINDERS) (VERY LOOSE)

GRADES WITH GRAY TO WHITE CHALKY MATERIAL

GRAY BROWN FINE TO MEDIUM SAND (VERY LOOSE)

GRADES DARK PURPLE WITH GRAVEL

BLACK DECOMPOSED WOOD AND FILL

GRAY SILTY SAND AND GRAVEL (FILL)

GRAY SILT WITH SOME CLAY AND TRACE FINE GRAVEL (HARD)

BORING COMPLETED AT A DEPTH OF 20.5 FEET ON 9-22-78.
PIEZOMETER INSTALLED ON 9-22-78.
SCREENED INTERVAL: 9.5 FEET TO 13.0 FEET.
SAND PACK: 2.0 FEET TO 20.5 FEET.
GROUT: 0 TO 2.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 5.1 FEET ON 4-9-79.

LOG OF BORINGS

DAMES & MOORE

FIGURE E-5

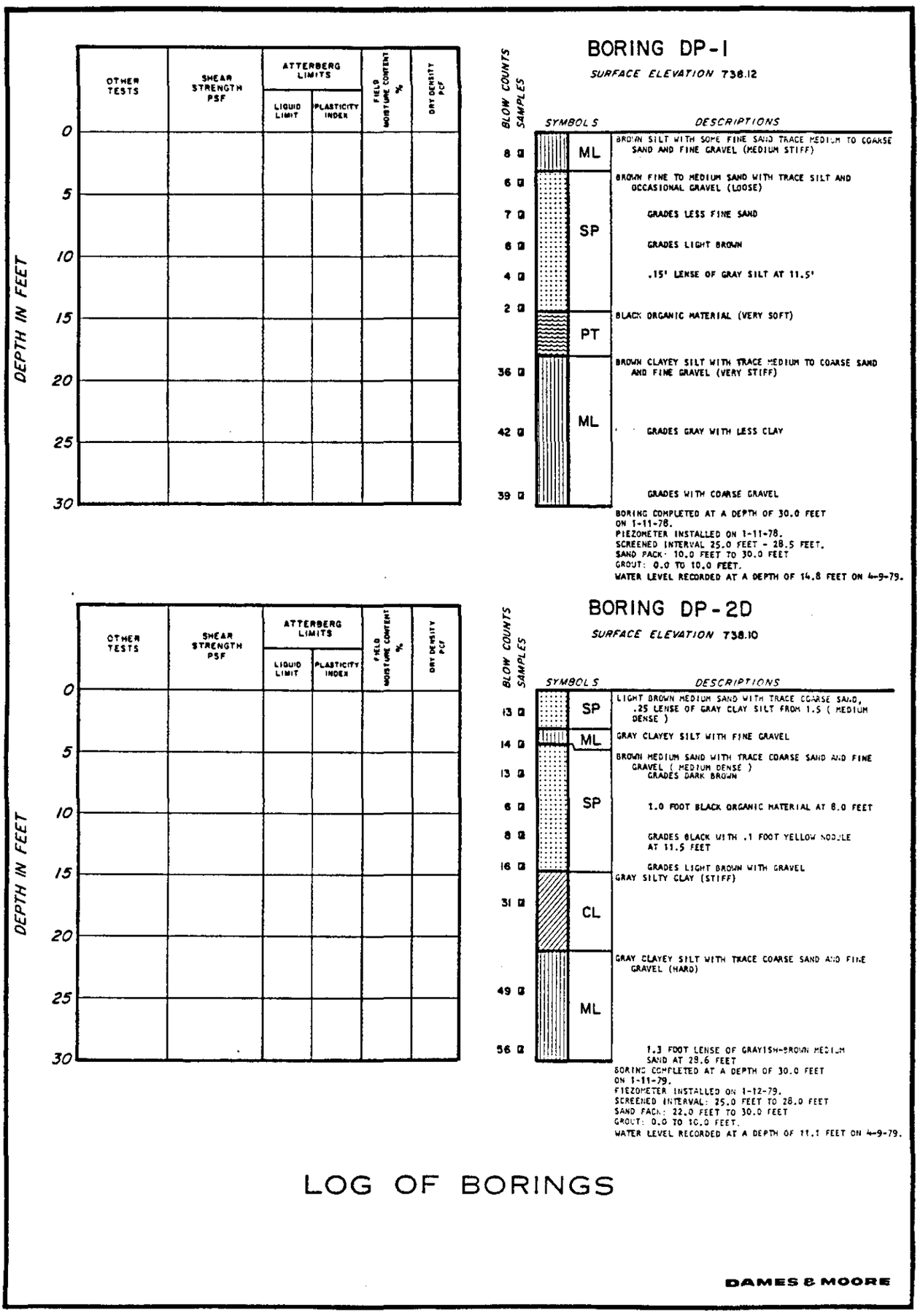

BORING DP-1
SURFACE ELEVATION 738.12
OTHER TESTS
SHEAR STRENGTH PSF
ATTERBERG LIMITS
LIQUID LIMIT
PLASTICITY INDEX
FIELD MOISTURE CONTENT %
DRY DENSITY PCF
DEPTH IN FEET
0
5
10
15
20
25
30
BLOW COUNTS
SAMPLES
SYMBOLS
DESCRIPTIONS
8
6
7
6
4
2
36
42
39
ML
SP
PT
ML
BROWN SILT WITH SOME FINE SAND TRACE MEDIUM TO COARSE SAND AND FINE GRAVEL (MEDIUM STIFF)
BROWN FINE TO MEDIUM SAND WITH TRACE SILT AND OCCASIONAL GRAVEL (LOOSE)
GRADES LESS FINE SAND
GRADES LIGHT BROWN
.15' LENSE OF GRAY SILT AT 11.5'
BLACK ORGANIC MATERIAL (VERY SOFT)
BROWN CLAYEY SILT WITH TRACE MEDIUM TO COARSE SAND AND FINE GRAVEL (VERY STIFF)
GRADES GRAY WITH LESS CLAY
GRADES WITH COARSE GRAVEL
BORING COMPLETED AT A DEPTH OF 30.0 FEET ON 1-11-78.
PIEZOMETER INSTALLED ON 1-11-78.
SCREENED INTERVAL 25.0 FEET - 28.5 FEET.
SAND PACK: 10.0 FEET TO 30.0 FEET
GROUT: 0.0 TO 10.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 14.8 FEET ON 4-9-79.
BORING DP-2D
SURFACE ELEVATION 738.10
13
14
13
6
8
16
31
49
56
SP
ML
SP
CL
ML
LIGHT BROWN MEDIUM SAND WITH TRACE COARSE SAND, .25 LENSE OF GRAY CLAY SILT FROM 1.5 (MEDIUM DENSE)
GRAY CLAYEY SILT WITH FINE GRAVEL
BROWN MEDIUM SAND WITH TRACE COARSE SAND AND FINE GRAVEL (MEDIUM DENSE)
GRADES DARK BROWN
1.0 FOOT BLACK ORGANIC MATERIAL AT 8.0 FEET
GRADES BLACK WITH .1 FOOT YELLOW NODULE AT 11.5 FEET
GRADES LIGHT BROWN WITH GRAVEL
GRAY SILTY CLAY (STIFF)
GRAY CLAYEY SILT WITH TRACE COARSE SAND AND FINE GRAVEL (HARD)
1.3 FOOT LENSE OF GRAYISH-BROWN MEDIUM SAND AT 28.6 FEET
BORING COMPLETED AT A DEPTH OF 30.0 FEET ON 1-11-79.
PIEZOMETER INSTALLED ON 1-12-79.
SCREENED INTERVAL: 25.0 FEET TO 28.0 FEET
SAND PACK: 22.0 FEET TO 30.0 FEET
GROUT: 0.0 TO 10.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 11.1 FEET ON 4-9-79.
LOG OF BORINGS
DAMES & MOORE

FIGURE E-6

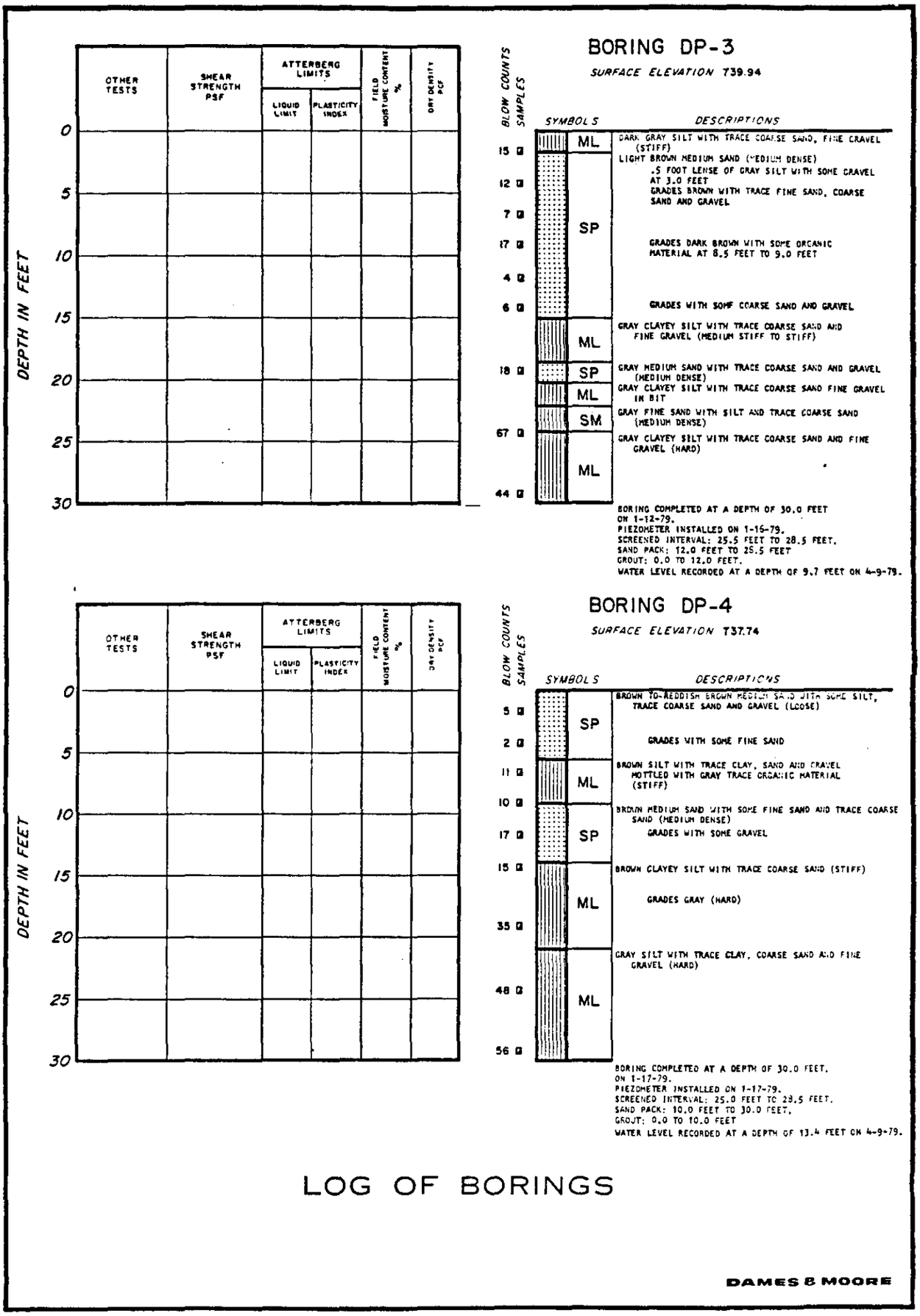
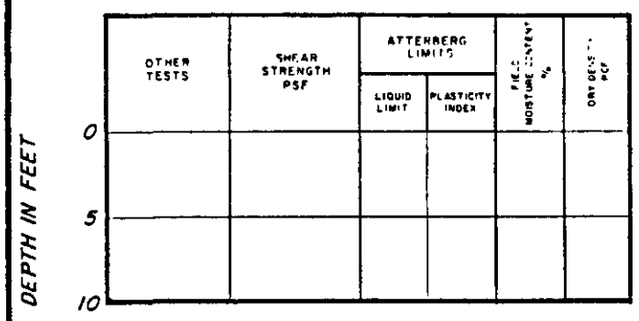

BORING DP-3
SURFACE ELEVATION 739.94
DEPTH IN FEET
OTHER TESTS
SHEAR STRENGTH PSF
ATTERBERG LIMITS
LIQUID LIMIT
PLASTICITY INDEX
FIELD MOISTURE CONTENT %
DRY DENSITY PCF
0
5
10
15
20
25
30
BLOW COUNTS
SAMPLES
15
12
7
17
4
6
18
67
44
SYMBOLS
DESCRIPTIONS
ML
DARK GRAY SILT WITH TRACE COARSE SAND, FINE GRAVEL (STIFF)
SP
LIGHT BROWN MEDIUM SAND (MEDIUM DENSE)
.5 FOOT LENSE OF GRAY SILT WITH SOME GRAVEL AT 3.0 FEET
GRADES BROWN WITH TRACE FINE SAND, COARSE SAND AND GRAVEL
GRADES DARK BROWN WITH SOME ORGANIC MATERIAL AT 8.5 FEET TO 9.0 FEET
GRADES WITH SOME COARSE SAND AND GRAVEL
ML
GRAY CLAYEY SILT WITH TRACE COARSE SAND AND FINE GRAVEL (MEDIUM STIFF TO STIFF)
SP
GRAY MEDIUM SAND WITH TRACE COARSE SAND AND GRAVEL (MEDIUM DENSE)
ML
GRAY CLAYEY SILT WITH TRACE COARSE SAND FINE GRAVEL IN BIT
SM
GRAY FINE SAND WITH SILT AND TRACE COARSE SAND (MEDIUM DENSE)
ML
GRAY CLAYEY SILT WITH TRACE COARSE SAND AND FINE GRAVEL (HARD)
BORING COMPLETED AT A DEPTH OF 30.0 FEET ON 1-12-79.
PIEZOMETER INSTALLED ON 1-16-79.
SCREENED INTERVAL: 25.5 FEET TO 28.5 FEET.
SAND PACK: 12.0 FEET TO 25.5 FEET
GROUT: 0.0 TO 12.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 9.7 FEET ON 4-9-79.
BORING DP-4
SURFACE ELEVATION 737.74
DEPTH IN FEET
OTHER TESTS
SHEAR STRENGTH PSF
ATTERBERG LIMITS
LIQUID LIMIT
PLASTICITY INDEX
FIELD MOISTURE CONTENT %
DRY DENSITY PCF
0
5
10
15
20
25
30
BLOW COUNTS
SAMPLES
5
2
11
10
17
15
35
48
56
SYMBOLS
DESCRIPTIONS
SP
BROWN TO REDDISH BROWN MEDIUM SAND WITH SOME SILT, TRACE COARSE SAND AND GRAVEL (LOOSE)
GRADES WITH SOME FINE SAND
ML
BROWN SILT WITH TRACE CLAY, SAND AND GRAVEL MOTTLED WITH GRAY TRACE ORGANIC MATERIAL (STIFF)
SP
BROWN MEDIUM SAND WITH SOME FINE SAND AND TRACE COARSE SAND (MEDIUM DENSE)
GRADES WITH SOME GRAVEL
ML
BROWN CLAYEY SILT WITH TRACE COARSE SAND (STIFF)
GRADES GRAY (HARD)
ML
GRAY SILT WITH TRACE CLAY, COARSE SAND AND FINE GRAVEL (HARD)
BORING COMPLETED AT A DEPTH OF 30.0 FEET, ON 1-17-79.
PIEZOMETER INSTALLED ON 1-17-79.
SCREENED INTERVAL: 25.0 FEET TO 28.5 FEET.
SAND PACK: 10.0 FEET TO 30.0 FEET.
GROUT: 0.0 TO 10.0 FEET
WATER LEVEL RECORDED AT A DEPTH OF 13.4 FEET ON 4-9-79.
LOG OF BORINGS
DAMES & MOORE

FIGURE E-7



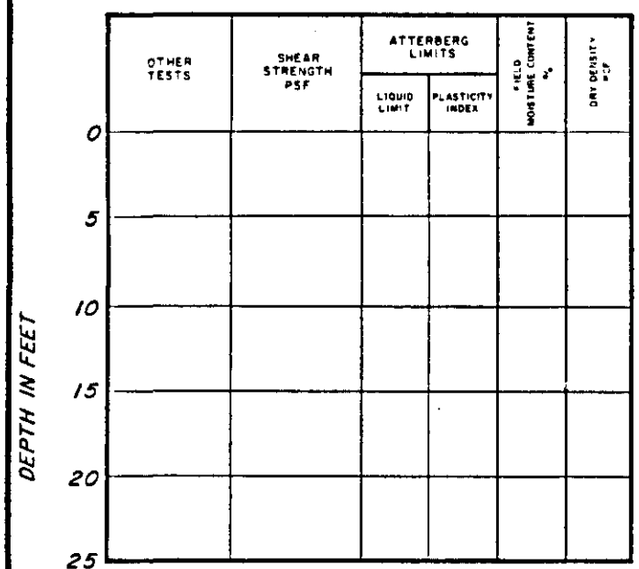
BORING DP-5

SURFACE ELEVATION 720.83

BLOW COUNTS SAMPLES

SYMBOLS	DESCRIPTIONS
SP	BROWN MEDIUM SAND WITH TRACE FINE TO MEDIUM GRAVEL AND ORGANIC MATERIAL
ML	GREENISH-GRAY SILT WITH TRACE CLAY AND FINE GRAVEL GRADES MORE CLAY
SP	BROWN FINE SAND WITH TRACE GRAVEL

BORING COMPLETED AT A DEPTH OF 6.0 FEET ON 2-21-79.
PIEZOMETER INSTALLED ON 2-22-79.
SCREENED INTERVAL: 4.0 FEET TO 6.0 FEET.
SAND PACK: 3.0 FEET TO 6.0 FEET.
GROUT: 1.0 FEET TO 3.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 1.0 FEET ON 4-9-79.



BORING DP-6

SURFACE ELEVATION 734.19

BLOW COUNTS SAMPLES

SYMBOLS	DESCRIPTIONS
FILL	9.5 FEET OF ALTERNATING LAYERS OF BROWN FINE TO MEDIUM FINE SAND WITH GRAYISH CHEMICAL RESIDUES AND GRAY TO DARK GRAY CLAYEY SILT (VERY SOFT)
SP	BLACK ORGANIC MATERIAL AT 9.8 FEET. BROWN MEDIUM SAND WITH TRACE GRAVEL (LOOSE) GRADES COARSER SAND AND MORE GRAVEL
ML	BROWN CLAY SILT (VERY STIFF) GRADES GRAY (HARD)
ML	GRAY SILTY CLAY WITH TRACE COARSE SAND AND FINE GRAVEL (HARD)

1/18" 5 10 23 44 63

BORING COMPLETED AT A DEPTH OF 25.0 FEET ON 2-21-79.
PIEZOMETER INTERVAL: 18.5 FEET TO 23.5 FEET.
SAND PACK: 14.0 TO 25.0 FEET.
GROUT: 0.0 TO 14.0 FEET.
WATER LEVEL RECORDED AT A DEPTH OF 5.1 FEET ON 4-9-79.

LOG OF BORINGS

DAMES & MOORE

FIGURE F-8

APPENDIX G

WELL LOGS

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL: NE¼ OF SE¼

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pine River	NE¼ NE¼ SE¼	14	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: WEST OF N JEROME RD ½ MI. N. OF MADISON RD.

Street address & City of Well Location: 940 N. JEROME, RD

OWNER No.

3 OWNER OF WELL: RICHARD HEKDEN

Address: 940 N JEROME, RD

NOVEMBER 22

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
0 to 14' soft gray clay	14	14
14 to 88' gray clay & gravel	74	88
88 to 98 coarse sand	10	98

4 WELL DEPTH: (completed) ft. Date of Completion: 1967

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

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

7 CASING: Diam. 4 in. to ___ ft. Depth; Threaded ☒ Welded ☐; Height: Above/Below surface ___ ft.; Weight 11 lbs/ft.; Drive Shoe? Yes ☒ No ☐

___ in. to ___ ft. Depth

8 SCREEN: JOHNSON

Type: RED BRASS Dia.: 4"

Slot/Gauze 12 Length 5'

Set between 93 ft. and 98 ft.

Fittings: 2 6" 3" PIPE + PACKER

9 STATIC WATER LEVEL: 65 ft. below land surface

10 PUMPING LEVEL below land surface

___ ft. after ___ hrs. pumping ___ g.p.m.

70 ft. after 1 hrs. pumping 20 g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING: Well Grouted? ☐ Yes ☒ No FILL AROUND PIPE WITH CLAY + SAND

Material: ☐ Neat Cement ☐ ___

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination: 65 feet N Direction SEPTIC TANK Type

Well disinfected upon completion ☐ Yes ☒ No

15 PUMP: [illegible]

Manufacturer's Name: TAIT

Model Number: A 1½ M 4 HP: 1

Length of Drop Pipe 35 ft. capacity 18 G.P.M.

Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, [illegible]

CORRECTED BY: [illegible]

ADDITION [illegible]

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Russell Tait — REGISTERED BUSINESS NAME

416 — REGISTRATION NO.

Address: R 2 St Louis

Signed: Russell Tait — AUTHORIZED REPRESENTATIVE Date: Nov 22 1967

D67D 100M 6-56

DEC 21 1967 GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

MAR 2 8 1975

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

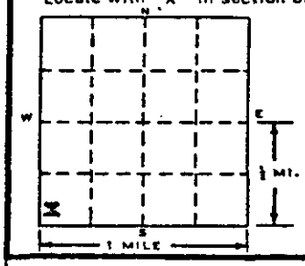
1 LOCATION OF WELL

County	Township Name	Fraction		Section Number	Town Number	Range Number
Gratiot	Pine River	SW ¼	SW ¼	I3	TI2N/S.	B3W E/W.

Distance And Direction from Road Intersections: I/IO E of Jerome Rd on Madison Rd && N I25 ft.

Street address & City of Well Location: Same

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



3 OWNER OF WELL:
Mr Raymond Alward
Address: 878 W Madison Rd
RFD: St Louis Mi 48880

4 WELL DEPTH: (completed) Date of Completion
I08 ft. — Dec 74

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

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

7 CASING: Threaded ☒ Welded ☐
Diam. 4 in. to 98 ft. Depth
3 7/8 in. to I08 ft. Depth
Height: Above/Below Surface I ft.
Weight ____ lbs./ft.
Drive Shoe? Yes ☒ No ☐

2 FORMATION

FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sandy	0	9	9	9
Clay	9	78	69	78
Sand	78	94	I6	94
" & Fine stone	94	I08	I4	I08
Clay.				

USE A 2ND SHEET IF NEEDED

8 SCREEN: Johnson
Type: Stainless st Dia.: 3 7/8 OD
Slot/Gauze 5' 30, 5' 25 Length IO
Set between 98 ft. and I08 ft.
Fittings: 3 in K Packer

9 STATIC WATER LEVEL
50 ft. below land surface

10 PUMPING LEVEL below land surface
I08 ft. after 2 hrs. pumping 50 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No
☐ Neat Cement ☐ Bentonite ☒ Drlg mud
Depth: From 0 ft. to 78 ft.

14 Nearest Source of possible contamination
50 feet SE Direction Septic Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
☐ Not installed
Manufacturer's Name Demings, his pump
Model Number ____ HP 3/4 or 1 Volts 230
Length of Drop Pipe 84 ft. capacity 20 G.P.M.
Type: ☒ Submersible
☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.
ADDED BY DRILLER, ITEM NO.
ACCEPTED BY
DATE

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

C S Oberlitner — REGISTERED BUSINESS NAME — REGISTRATION NO. 9 34I

Address 4664 N State Rd Alma Mi 4880I.

Signed C S Oberlitner — AUTHORIZED REPRESENTATIVE — Date Dec 74

D67d 100M (Rev. 12-68)

2

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No. [ ]

DEC 14 1975

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

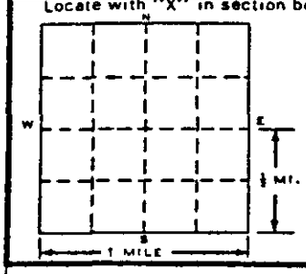
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	NE¼ NE¼ SE¼	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Riverton State Rd + McGregor Rd 1/2 mile South 98' west off Road

Street address & City of Well Location

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



3 OWNER OF WELL: John Pavlick
Address RR 3
St. Louis, Mich

4 WELL DEPTH: (completed) 47 ft. Date of Completion 7-12-75

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 3 in. to 43 ft. Depth; ____ in. to ____ ft. Depth
Height: Above/~~Below~~ Surface 1 ft. Weight 7.70 lbs./ft. Drive Shoe? Yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	15	15
Gravelly clay	10	25
Blue clay	15	40
Water Sand	7	47

8 SCREEN: Type: Johnson Dia.: 2" Slot ~~Gauge~~ 10 Length 4' Set between 43 ft. and 47 ft.
Fittings: Tail Pipe Rubber Packer

9 STATIC WATER LEVEL 17 ft. below land surface

10 PUMPING LEVEL below land surface 25 ft. after 1 hrs. pumping 15 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ clay + sand
Depth: From 0 ft. to 13 ft.

14 Nearest Source of possible contamination 52 feet W Direction Septic tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Rapid Clayton
Model Number 5 CA HP ½ Volts 110
Length of Drop Pipe 42 ft. capacity 8 G.P.M.
Type: ☐ Submersible ☒ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY CP
**ADDITION BY
ELEVATION
DEPTH TO ROCK

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

Wayne Miller Well Drilling — REGISTERED BUSINESS NAME — 0977 REGISTRATION NO.
Address RR 2
St Louis, Mich
Signed ____ AUTHORIZED REPRESENTATIVE Date 7-15-75

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

SEP 12 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

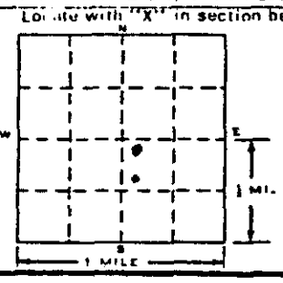
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	SW¼ NW¼ SE¼	13	12 N/S.	3 E/W.

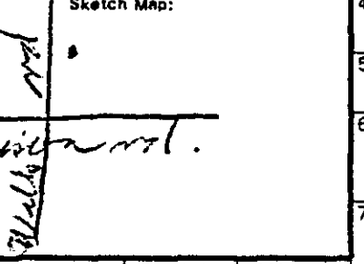
Distance And Direction from Road Intersections: Madison rd + Wetherell North on Wetherell 3/10 mi East 93'

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL: Freed + Waldron

Address 91

4 WELL DEPTH: (completed) 98 ft. Date of Completion 7-12-72

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 2 in. to 87 ft. Depth; ____ in. to ____ ft. Depth. Height: Above/Below Surface 4 ft. Weight 2.75 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	16	16
Clay	16	32
Sand	3	35
Clay	53	88
Sand + Gravel	5	93
Water Sand	5	98

8 SCREEN: Type: Johnson Dia.: 1¼ Slot/Gauze 10 Length 5 Set between 93 ft. and 98 ft. Fittings: Brenner check

9 STATIC WATER LEVEL 30 ft. below land surface

10 PUMPING LEVEL below land surface 30 ft. after ½ hrs. pumping 10 g.p.m. ____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

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

14 Nearest Source of possible contamination: 50' feet N.E. Direction Septic Tank Type. Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed. Manufacturer's Name Pumpington. Model Number 5SA HP ½ Volts 115. Length of Drop Pipe 42 ft. capacity ____ G.P.M. Type: ☐ Submersible ☒ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED [illegible] BY DRILLER. [illegible]

RECORDED BY:

**ADDITION BY

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

Waldron Drilling 0936
REGISTERED BUSINESS NAME REGISTRATION NO.

Address Riverdale Mich.

Signed Lester Waldron Date 7-12-72
AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

3

GEOLOGICAL SURVEY COPY

(R)

Brine Well
13-12N-3W TD 1307 in Marshall
Pine River Twp. (Gratiot Co.)

Michigan Chemical Co.

Fee No. 8

Location: NE¼ SE¼ NE¼ section 13, T. 12N., R. 3W.
150' from North and 200' from East line of quarter section

Elevation: 727.9 feet above sea level

Record by: L. Hale from driller's log

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
Drift	207	207
PERMO-CARBONIFEROUS (?):		
"Red Beds":		
Mud, red	66	273
Gypsum shell	6	279
No record	56	335
	(122)	
PENNSYLVANIAN:		
Saginaw:		
Sand, white	37	372
Shale, blue	56	428
Sand, white	132	560
Mud, blue	20	580
Sand	10	590
Mud, gray	6	596
Mud, blue	64	660
	(325)	
Parma (?):		
Sand, white	50	710
MISSISSIPPIAN:		
Bayport:		
Lime, hard, white	15	725
Sand	25	750
Shale	5	755
Lime	15	770
Sand	15	785
	(75)	
Michigan (?):		
Shale, brown	5	790
Sand, white	at	790
Shale, green	70	860
Shale, gray	50	910
Shale, blue; shells, and gypsum	48	958
Shale, blue	33	991
Shale, blue and gypsum	9	1000
Lime and gypsum	20	1020
Lime, gray, hard	10	1030
Shale, gray and lime	22	1052
Lime and gypsum shells	35	1087

COMPLETED

CASING RECORD

10" 335'
8¼" 424'
5½" 880'
5-3/16" 1137'

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

13-

1 LOCATION OF WELL 9846 N. Jerome Rd

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	PINE RIVER	NW NW NW	13	12 N	3 W

Distance And Direction from Road Intersections: 76' E of RD 250' S of INTERSETION, JEFFERSON RD

Street address & City of Well Location

OWNER No. 2

3 OWNER OF WELL: RUSSELL LUTZ

Address: R2 ST. LOUIS MICH 9846 JEROME RD

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
0 to 75' Clay	75	75
75' To 102' Clay & gravel	27	102
102 To 105' Clay & sand	3	105
105' To 125' Clay & gravel	20	125
125' To 143' sand & gravel & clay	18	143
143 To 144 Hard gravel	1	144

4 WELL DEPTH: (completed) 144 ft. Date of Completion April 19 – 70

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

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

7 CASING: Diam. 4 in. to 143 ft. Depth; Threaded ☒ Welded ☐; ___ in. to ___ ft. Depth

Height: Above/Below surface 1 ft.; Weight 11 lbs/ft.; Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: NONE Dia.: ___

Slot/Gauze ___ Length ___

Set between ___ ft. and ___ ft.

Fittings:

9 STATIC WATER LEVEL 32 ft. below land surface

10 PUMPING LEVEL below land surface 80 ft. after 2 hrs. pumping 45 g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING: Well Grouted? ☐ Yes ☐ No FILL AROUND PIPE WITH SAND CLAY

Material: ☐ Neat Cement ☒ ___

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination SEPTIC TANK

70 feet N W Direction SEPTIC Type

Well disinfected upon completion ☐ Yes ☒ No

15 PUMP:

Manufacturer's Name TAIT

Model Number 75 CT HP ¾

Length of Drop Pipe 60 ft. capacity ___ G.P.M.

Type: ☐ Submersible ☐ ___ ☒ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED IN G. BY DRILLER, ITEM NO.

•CORRECTED BY:

••ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Russell Lutz — REGISTERED BUSINESS NAME

0416 — REGISTRATION NO.

Address ___

Signed ___ June 15-70 — AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

AUG 10 1970

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

AUG 01 1973

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	N½ SE ¼ SE ¼	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Intersection State Rd + McGregor 1/2 mile South 76 ft. West of Road

Street address & City of Well Location

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

N / W / E / S — 1 MI. — 1 MILE

3 OWNER OF WELL: Paul Erskine

Address 632 Corinth St. St Louis Mich

4 WELL DEPTH: (completed) 64 ft. Date of Completion Feb 23, 1973

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

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

7 CASING: Threaded [X] Welded [ ] Diam. 6 in. to 59 ft. Depth; ___ in. to ___ ft. Depth. Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes [X] No [ ]

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top Soil & Sand	3	3
Clay	12	15
Stony Hard Clay	10	25
Sandy Clay	9	34
Soft Clay + Sand	15	49
Water Sand	15	64

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: Johnson SS Dia.: 4" Slot/Gauze 12 Length 5' Set between 59 ft. and 64 ft. Fittings: Tail pipe Rubber packer

9 STATIC WATER LEVEL 5 ft. below land surface

10 PUMPING LEVEL below land surface 20 ft. after 1 hrs. pumping 15 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? [X] Yes [ ] No [ ] Neat Cement [ ] Bentonite [X] Clay + Sand Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination 65 feet W Direction Septic tank Type. Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not installed. Manufacturer's Name Gould. Model Number 5P31? HP 1/2 Volts 230. Length of Drop Pipe 70 ft. capacity ___ G.P.M. Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ... JC

CORRECTED BY

ADDITION BY

Elevation 750±10

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

Wayne Mills Well Drilling — REGISTERED BUSINESS NAME — 977 REGISTRATION NO.

Address 939 W Jefferson Rd St Louis, Mich

Signed ___ AUTHORIZED REPRESENTATIVE Date Feb 27, 1973

D67d 100M (Rev. 12-68)

4

GEOLOGICAL SURVEY COPY

AUG 01 1973

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

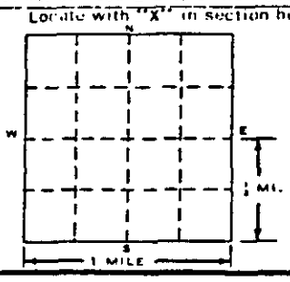
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	NE¼ NE¼ SE¼	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersection: Intersection State Rd + Mc. Gregory Rd 50 ft South and 96 ft. West off Road

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL: Lottie Lobin
Address: State Rd
St. Louis, Mich

4 WELL DEPTH: (completed) 61 ft. Date of Completion Jan 24, 1973

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

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

7 CASING: Threaded ☐ Welded ☐ Diam. 3 in. to 58 ft. Depth; ____ in. to ____ ft. Depth
Height: Above ~~Below~~ Surface 1 ft. Weight 170 lbs./ft. Drive Shoe? Yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top Soil	2	2
Clay	24	26
Stony clay	18	44
Hard Blue Clay	12	56
Water Sand	5	61

8 SCREEN: Type: Johnson Dia.: 2" Slot/~~Gauge~~ 10 Length 3' Set between 58 ft. and 61 ft. Fittings: Foot Piece + Rubber Packer

9 STATIC WATER LEVEL 17 ft. below land surface

10 PUMPING LEVEL below land surface 35 ft. after 1 hrs. pumping 15 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ clay + sand
Depth: From 0 ft. to 17 ft.

14 Nearest Source of possible contamination ____ feet ____ Direction ____ Type
Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Rapid Systems
Model Number 5CA HP ½ Volts 110
Length of Drop Pipe 42 ft. capacity 6 G.P.M.
Type: ☐ Submersible ☒ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of ~~data~~, etc.
Elevation 750 ± 10

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Wayne Mulder Well Drilling 0977
REGISTERED BUSINESS NAME REGISTRATION NO.
939 W Jefferson Rd
St. Louis Mich
Signed ____ AUTHORIZED REPRESENTATIVE Date March 8, 1973

D67d 100M (Rev. 12-68)

5

GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL — NE SE NE

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pinerinver	~~N½ S½ NE¼~~	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: 80 rods N of mc Gregor rd

Street address & City of Well Location: W V Sleford St Louis Michigan

OWNER No.

3 OWNER OF WELL: John W Baker

Address 403 Orchard ct. St Louis Michigan 48880

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	170	
Water sand	170	180

4 WELL DEPTH: (completed) 180 ft. Date of Completion April 25 1970

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

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

7 CASING: Diam. Threaded ☐ Welded ☐
2 in. to 174 ft. Depth
___ in. to ___ ft. Depth
Height: Above/Below surface 2 ft.
Weight 2 3/4 lbs/ft.
Drive Shoe? Yes ☑ No ☐

8 SCREEN:
Type: SSS 6 ft Dia.: 1¼
Slot/Gauze 60 Length 6 ft
Set between 174 ft. and 180 ft.
Fittings:

9 STATIC WATER LEVEL
30 ft. below land surface

10 PUMPING LEVEL below land surface
30 ft. after 4 hrs. pumping 6 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

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

14 SANITARY:
Nearest Source of possible contamination
___ feet ___ Direction ___ Type
Well disinfected upon completion ☑ Yes ☐ No

15 PUMP:
Manufacturer's Name Myers
Model Number ___ HP ½
Length of Drop Pipe 42 ft. capacity 5 G.P.M.
Type: ☐ Submersible ☐ ___
☑ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

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

Elmer Gould Well Drilling — REGISTERED BUSINESS NAME
0612 — REGISTRATION NO.

Address St Louis Michigan Zip 48880

Signed Elmer Gould — AUTHORIZED REPRESENTATIVE
Date May 5, 1970

D67D 100M 6-66

SEP 0 · 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	PINE RIVER	NW¼ NW¼ SW¼	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: 300 E ROAD, 100 RDS N OF INT. OF MADISON & N JEROME

OWNER No. 1

Street address & City of Well Location: 9254 N JEROME

3 OWNER OF WELL: LOYAL STEEL
Address: 9254 N JEROME, RD

2 FORMATION — 9254 N JEROME

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
0-14 CLAY	14	14
14-28 CLAY & SAND	28	14
28-42 CLAY	42	14
RAVEL 42-43	43	1
43-54 CLAY	54	11
LITTLE GRAVEL	59	5
54-59 VERY HARD	91	22
59-81 CLAY		
GRAVEL, MOIE		
CLAY, 81-91	91	10
WATER SAND		

4 WELL DEPTH: (completed) 91 ft. Date of Completion: JULY 4-72

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

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

7 CASING: Diam. 2 in. to 84 ft. Depth; Threaded ☒ Welded ☐; Height: Above/Below surface ___ ft.; Weight 2.5 lbs/ft.; ___ in. to ___ ft. Depth; Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type RED JOHNSON TOP Dia.: 2" Slot/Gauze 12+10 Length 7½ Set between 91 ft. and 84 ft. Fittings: K.P. + 3' 2" PIPE

9 STATIC WATER LEVEL 67 ft. below land surface

10 PUMPING LEVEL below land surface: 73 ft. after 1 hrs. pumping 8 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 GROUTING: Well Grouted? ☐ Yes ☒ No FILLIN CLAY; Material: ☐ Neat Cement ☐ ___; Depth: From ___ ft. to ___ ft.

14 SANITARY: Nearest Source of possible contamination 55 feet 5 Direction SEPTIC Type TANK; Well disinfected upon completion ☐ Yes ☒ No

15 PUMP: Manufacturer's Name TAIT; Model Number ___ HP 3/4; Length of Drop Pipe 15 ft. capacity 5 G.P.M.; Type: ☐ Submersible ☐ ___ ☒ Jet ☐ Reciprocating

ADDED ITEM BY DRILLER ITEM 15

•CORRECTED BY

••ADDITION BY

16 Remarks, elevation, source of data, etc.
12 slot screen on bottom
EXTON TOP 10 SLOT

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

Registered Business Name: Russell Fitz — Registration No.: 0416

Address: R2 Alma

Signed ___ (Authorized Representative) Date: July 5, 1972

D67D 100M 6-66

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No. [ ]

DEC 19 1975

WATER WELL RECORD
ACT 294 PA 1965

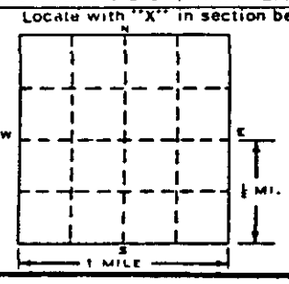
MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	E½ SW¼ NW¼	13	12 N/S.	3 E/W.

Distance And Direction from Road Intersections
Ambrester Wells Rd + Jefferson Rd
½ mile South 106' East on Rd
Street address & City of Well Location

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



3 OWNER OF WELL: John Stanley
Address RR 9
St. Louis Mich

4 WELL DEPTH: (completed) 103 ft. Date of Completion 6-25-75

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

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

7 CASING: Threaded ☒ Welded ☐ Height: Above/~~Below~~ Surface ____ ft.
Diam. 4 in. to 98 ft. Depth — Weight 11 lbs./ft.
____ in. to ____ ft. Depth — Drive Shoe? yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	6	6
Blue clay	40	46
Stony clay	41	87
Sandy clay	10	97
water Sand	~~97~~ 6	103

8 SCREEN: Type: Johnson Dia.: 4" Slot/Gauze 10 Length 5'
Set between 98 ft. and 103 ft.
Fittings: End Pipe + Rubber Packer

9 STATIC WATER LEVEL 18 ft. below land surface

10 PUMPING LEVEL below land surface 40 ft. after 1 hrs. pumping 20 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ Clay + Sand
Depth: From 6 ft. to 14 ft.

14 Nearest Source of possible contamination 80 feet N Direction Septic tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Gould
Model Number 10PE4 HP ½ Volts 230
Length of Drop Pipe 60 ft. capacity 10 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Wayne Mills Well Drilling 0977
REGISTERED BUSINESS NAME — REGISTRATION NO.
Address RR 2
St. Louis Mich
Signed ____ AUTHORIZED REPRESENTATIVE Date 6-30-75

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

NOV 01 1973

WATER WELL RECORD
ACT 294 PA 1965

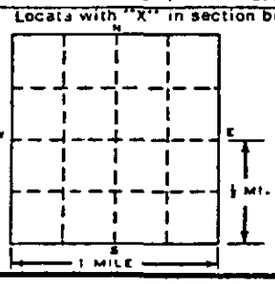
MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Bethany	NW ¼ SW ¼ SE ¼	18	12 N/S.	2 E/W.

Distance And Direction from Road Intersections
Intersection McGregor Rd & Alma Rd
½ Mile South 97' west off Road
Street address & City of Well Location

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL:
Boyle Huntsman
Address RR
St. Louis, Mich

4 WELL DEPTH: (completed) Date of Completion
80 ft. Aug 6, 1973

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

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

7 CASING:
Threaded ☒ Welded ☐
Diam. 2 in. to 76 ft. Depth
____ in. to ____ ft. Depth
Height: Above/~~Below~~ Surface 1 ft.
Weight 7.70 lbs./ft.
Drive Shoe? Yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	18	18
Stony clay	31	49
Soft Blue clay	16	65
Sandy clay	8	73
Water Sand	7	80

8 SCREEN:
Type: Johnson Dia.: 2"
Slot ~~Gauze~~ 12 Length 4'
Set between 76 ft. and 80 ft.
Fittings: Tail Pipe, Rubber Packer

9 STATIC WATER LEVEL
56 ft. below land surface

10 PUMPING LEVEL below land surface
67 ft. after 1 hrs. pumping 15 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No
☐ Neat Cement ☐ Bentonite ☒ Clay + Sand
Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination:
78 feet SW Direction Septic tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
☐ Not installed
Manufacturer's Name Reda
Model Number 553T HP ½ Volts 110
Length of Drop Pipe 75 ft. capacity 9 G.P.M.
Type: ☒ Submersible
☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
9C
Elevation 730 I 10
Wayne RR 2
St Louis, Mich

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

Mills Well Drilling — 0977
REGISTERED BUSINESS NAME — REGISTRATION NO.

Address ____

Signed ____ AUTHORIZED REPRESENTATIVE Date Aug 8, 1973

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY SAMPLE No.

NOV 01 1973

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Bethany	SE ¼ SW ¼ SW ¼	18	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Intersection River Road Drive + McGregor Rd ½ mile South / 127' East off Road

Street address & City of Well Location

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

N / W / E / S — ½ MI. — 1 MILE

3 OWNER OF WELL: Ward Ellicott

Address: RR St. Louis Mich

4 WELL DEPTH: (completed) 85 ft. Date of Completion July 9, 1973

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

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

7 CASING: Threaded [X] Welded [ ] Diam. 3 in. to 81 ft. Depth ___ in. to ___ ft. Depth. Height: Above/Below Surface 1 ft. Weight 7.70 lbs./ft. Drive Shoe? Yes [X] No [ ]

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	7	7
Clay Stoney	32	39
Soft Blue Clay	15	54
Sandy Clay	25	79
Water Sand	6	85

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: Johnson Dia.: 2" Slot/Gauze 12 Length 4' Set between 81 ft. and 85 ft. Fittings: tail Pipe + Rubber Packer

9 STATIC WATER LEVEL 55 ft. below land surface

10 PUMPING LEVEL below land surface 65 ft. after 1 hrs. pumping 15 g.p.m. ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? [X] Yes [ ] No [ ] Neat Cement [ ] Bentonite [X] Clay + Sand Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination 64 feet W Direction Septic tank Type. Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] not installed Manufacturer's Name Reda Model Number 5535 HP ½ Volts 110 Length of Drop Pipe 74 ft. capacity 9 G.P.M. Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM ...

...ECTED BY JC

...ADDITION ... Elevation 730±10

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

Wayne Miller Well Drilling — REGISTERED BUSINESS NAME — 0977 REGISTRATION NO.

Address RR 2 St. Louis, Mich

Signed ___ AUTHORIZED REPRESENTATIVE Date July 10, 1973

D67d 100M (Rev. 12-68)

9

GEOLOGICAL SURVEY SAMPLE NO.

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

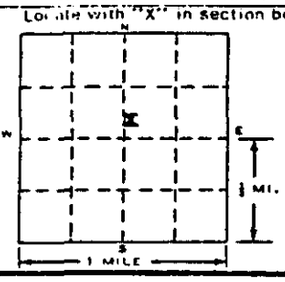
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Bethany	SW ¼ SW ¼ ¼	18	T12N N/S.	R2W E/W.

Distance And Direction from Road Intersections: I20 ft E of Union Rd & I50 ft N of Madison Rd

Street address & City of Well Location:

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



3 OWNER OF WELL:

Address: Mr Jerry Mayer
9020 N Union Rd
RFD St Louis Mi 48880

4 WELL DEPTH: (completed) Date of Completion

I02 ft. Nov 73

5

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

6 USE:

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

7 CASING:

Threaded ☒ Welded ☐

4 in. to 95 ft. Depth
3 7/8 to I02 ft. Depth

Height: Above/Below Surface I ft.
Weight II8 lbs./ft.
Drive Shoe? Yes ☒ No ☐

12 FORMATION

FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	7	7	7
ClayYellow	7	I9	I2	I9
" Blue	I9	70	6I	70
Sand	70	I02	32	I02

USE A 2ND SHEET IF NEEDED

8 SCREEN: Johnson

Type: Red Brass Dia.: 3 7/8 OD
Slot/Gauze 20 Length 7
Set between 95 ft. and I02 ft.
Fittings: #3 in K Packer

9 STATIC WATER LEVEL

68 ft. below land surface

10 PUMPING LEVEL below land surface

95 ft. after 2 hrs. pumping 40 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION:

☐ In Approved Pit
☒ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No

☐ Neat Cement ☒ Bentonite ☐ clay
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination

50 feet E Direction septi c Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

☐ Not installed
Manufacturer's Name Reda
Model Number 7DI8P07I HP 3/4 Volts 230
Length of Drop Pipe 80 ft. capacity I2 G.P.M.
Type: ☒ Submersible
☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

C S Oberlitner (REGISTERED BUSINESS NAME) 034I (REGISTRATION NO.)

Address 4664 N State Rd Alma Mi 4880I

Signed [signature] (AUTHORIZED REPRESENTATIVE) Date Nov 73

D67d 100M (Rev. 12-68)

9

GEOLOGICAL SURVEY COPY

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

SE NE SW 18 *

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Bethany	~~SE ¼ SW¼~~ ¼	21	12 (N) S.	2 E (W)

Distance And Direction from Road Intersections: 100ft. W. of N. Union Rd.
80 rods South MacGregor Rd.& Union Rd. Intersection

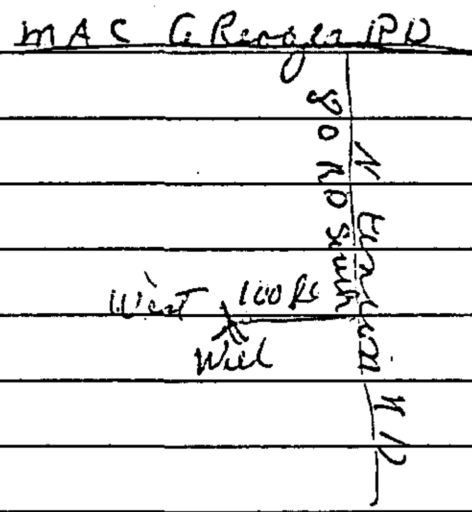
OWNER No. 3033

Street address & City of Well Location: Union Rd. ST. LOUIS, MICH.

3 OWNER OF WELL: EDWARD FLESS
Address: 116 E. Washington
ST. LOUIS, MICHIGAN.

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top Soil	6	6
Sand & Clay	32	38
Clay	30	68
Sand & Gravel	15	83



4 WELL DEPTH: (completed) 83 ft. Date of Completion: July 31 -67

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

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

7 CASING: Threaded ☐ Welded ☐
Diam. 2 in. to 78 ft. Depth
___ in. to ___ ft. Depth
Height: Above/Below surface 12 above ft.
Weight 375 lbs/ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN:
Type: Slot Dia.: 1¼
Slot/Gauze 60 Length 5ft.
Set between 78 ft. and 83 ft.
Fittings: Check Valve 479

9 STATIC WATER LEVEL
26 ft. below land surface

10 PUMPING LEVEL below land surface
36 ft. after 2 hrs. pumping 12 g.p.m.
36 ft. after 2 hrs. pumping 12 g.p.m.

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

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

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

14 SANITARY:
Nearest Source of possible contamination
60 feet north Direction septic Type
Well disinfected upon completion ☒ Yes ☐ No

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

16 Remarks, elevation, source of data, etc.
ADDED INFO. BY DRILLER. ITEM NO.
*CORRECTED BY: DES
**ADDITION BY: Good water supply.

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

Lewis Gould — REGISTERED BUSINESS NAME — 0266 — REGISTRATION NO.

Address 509 Maple St. Louis, Mich.

Signed [signature] AUTHORIZED REPRESENTATIVE Date Aug. 21-67

D67D 100M 6-66

SEP 12 1967

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE NO.

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL NW NE SE *

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Bethany	¼	18	TI2N/S.	R2W E/W.

Distance And Direction from Road Intersections: I & 2/10 E Bagley Rd on Mc Greoger & S 80 ft.

Street address & City of Well Location: 862 E Mc Greoger Rd St Louis Mich $8801

OWNER No.

3 OWNER OF WELL: Joseph Trgina

Address: 862 E Mc Gregor Rd RFD St Louis Mich

2 FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Yellow clay	9	22	22	22
Blue "	22	27	5	27
Sand	27	29	2	29
Blue clay	29	I40	III	I40
"	I40	I70	30	I70
Sand fine	I70	I90	20	I90
"	I90	215	25	215

4 WELL DEPTH: (completed) 215 ft. Date of Completion: Oct 68

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

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

7 CASING: Threaded ☒ Welded ☐

4 in. Diam. to 205 ft. Depth

37/8 in. to 215 ft. Depth

Height: Above/Below surface I ft.

Weight II89 lbs/ft.

Drive Shoe? Yes ☒ No ☐

8 SCREEN:

Type: Johnson Red Brass Dia.: 37/8

Slot/Gauze I8 Length I0

Set between 205 ft. and 215 ft.

Fittings: 3" FPThread

9 STATIC WATER LEVEL 24 ft. below land surface

10 PUMPING LEVEL below land surface

225 ft. after 4 hrs. pumping I00 g.p.m.

" ft. after " hrs. pumping " g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING:

Well Grouted? ☒ Yes ☐ No

Material: ☐ Neat Cement ☐ Beonite & clay

Depth: From 0 ft. to 30 ft.

14 SANITARY:

Nearest Source of possible contamination

50 feet S Direction Septic Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name None *

Model Number ___ HP ___

Length of Drop Pipe ___ ft. capacity ___ G.P.M.

Type: ☐ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

* CORRECTED BY DRILLER, ITEM NO.

** ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

FM & CS Oberlitner — REGISTERED BUSINESS NAME — 034I — REGISTRATION NO.

Address 4664 N State Rd Alma Mich

Signed Carl C Oberlitner — AUTHORIZED REPRESENTATIVE — Date Oct 68

D67D 100M 6-66

JAN 14 1969

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

MAR 1 5 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

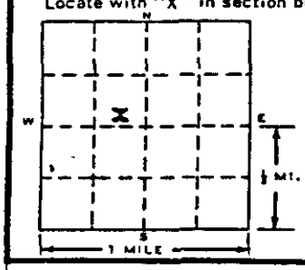
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Bethany	SW¼ NW¼ SW¼	I8	TI2N N.	R2W W.

Distance And Direction from Road Intersections: 8 th S of Mc Gregor Rd on Riverside Dr & E 75 Ft.

Street address & City of Well Location: Same

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



3 OWNER OF WELL:
Address Mr Paul Bean
RFD, 9I87 Riverside, St Louis Mi.

4 WELL DEPTH: (completed) 86 ft. Date of Completion Jan 7I

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 78 ft. Depth; 3 7/8 to 86 ft. Depth
Height: Above/Below Surface I ft. Weight II89 lbs./ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: Johnson Everdure Dia.: 3 7/8 OD
Slot/Gauze I2 Length 8 8ft
Set between 78 ft. and 86 ft.
Fittings: 3in K Packer

9 STATIC WATER LEVEL I8 ft. below land surface

10 PUMPING LEVEL below land surface
86 ft. after 3 hrs. pumping 40 g.p.m.
" ft. after " hrs. pumping " g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☒ Bentonite ☐ Clay
Depth: From 0 ft. to 40 ft.

14 Nearest Source of possible contamination
50 feet E Direction Septic Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Reda
Model Number 9D HP I/2 Volts 230
Length of Drop Pipe 60 ft. capacity I4 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	3	3	3
Clay	3	68	65	68
Sand	68	86	I8	86

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
ADDED INFO. BY DRILLER, ITEM #15
CORRECTED BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
C S Oberlitner — REGISTERED BUSINESS NAME — 034I — REGISTRATION NO.
Address 646 64 N State Rd Alma Mich
Signed Carl S. Oberlitner — AUTHORIZED REPRESENTATIVE — Date Jan 7I

D67d 100M (Rev. 12-68)

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GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	BETHANY	¼ NE¼ SW¼	18	12 (N) S.	2 E (W)

Distance And Direction from Road Intersections: 150 EAST OF RD

Street address & City of Well Location: 9496 RIVERSIDE DRIVE

OWNER No.

3 OWNER OF WELL: GENE GILBERT

Address: 318 CLINTON ST ST LOUIS MICH

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
DIG 12: HARD CLAY	12	12
12 TO 24: Clay & Gravel	12	24
24 TO 31: Clay & Sand	7	31
31 TO 51: Clay	20	51
51 TO 63: Water Sand	12	63

4 WELL DEPTH: (completed) 63 ft. Date of Completion

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

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

7 CASING: Threaded ☒ Welded ☐

Diam. 4 in. to 57 ft. Depth

___ in. to ___ ft. Depth

Height: Above/Below surface 16" ft.

Weight 12 lbs/ft.

Drive Shoe? Yes ☒ No ☐

8 SCREEN:

Type: Johnson Dia.: 4"

Slot/Gauge 12 Length 4'

Set between 59 ft. and 63 ft.

Fittings: 2" Pak-Pac

9 STATIC WATER LEVEL

___ ft. below land surface

10 PUMPING LEVEL below land surface

22 ft. after 1 hrs. pumping 30 g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING:

Well Grouted? ☐ Yes ☐ No Full around pipe with Clay mud

Material: ☐ Neat Cement ☐ ___

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination

25 feet NW Direction Tile Line Type

Well disinfected upon completion ☐ Yes ☒ No

15 PUMP: Owner to install own pump

Manufacturer's Name ___

Model Number ___ HP ___

Length of Drop Pipe ___ ft. capacity ___ G.P.M.

Type: ☐ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM NO.

CORRECTED BY:

ADDITION BY: RTS

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Richard Pratt — REGISTERED BUSINESS NAME

416 — REGISTRATION NO.

Address 12 E Ross Ave

Signed ___ — AUTHORIZED REPRESENTATIVE

Date Dec 18-1967

D67D 100M 6-66

JAN 12 1968

GEOLOGICAL SURVEY COPY

Bethany (Gratiot County)

Michigan Chemical Company

Beach #6

Location: NW¼ of NE¼ of SW¼ of section 18, T. 12 N., R. 2 W.

Elevation: 709.7 feet above sea level.

Record by: L. Hale from driller's log.

	Thickness (Feet)	Depth (Feet)
PLEISTOCENE:		
Drift:		
Drift	325	325
PENNSYLVANIAN:		
Saginaw:		
Sand	209	534
Shale	14	548
Sand, gray and white	46	594
Sand	171	765
Shale	10	775
Sand	11	786
Shale	80	866
Shale and lime	39	905
MISSISSIPPIAN:		
Bayport:		
Lime	41	946
Michigan:		
Shale, blue	29	975
Lime	25	1000
Shale	42	1042
Lime, white and blue shells	15	1057
Shale, gray	28	1085
Shells, dark	6	1091
"Stray" sand (?)	5	1096
No record	34	1130
Shale, blue	4	1134
Shale, blue and shells	23	1157
Napoleon (Upper Marshall):		
Marshall, white	46	1203
Sand	21	1224
Lower Marshall:		
Sand, red	11	1235
Red rock	29	1264
	TOTAL DEPTH	1264

Casing record:
10" 316'
6-5/8" 791'
5-3/16" 1096'

Commenced: 8-26-36
Completed: 9-4-36
Initial production: Brine well.

GEOLOGICAL SURVEY SAMPLE NO. [ ]

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	PINE RIVER	¼ ¼ ¼	23	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: 2 MILE OF ROAD ½ MI EAST OF INTERSECTION BEGOLT + W MONROE

Street address & City of Well Location: 1270 ST LOUIS

OWNER No.

3 OWNER OF WELL: EDGEWOOD HILLS GOLF COURSE, 1270 WEST MONROE ST LOUIS

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
0-15' sand & little gravel	15	15
15-32 sticky clay	17	32
32-60 sticky clay		
Lite gravel water	28	60
60-65 hard clay + gravel	5	65
65-75 sand + gravel	10	75
75-80 clay sand + gravel	5	80
80-110 sand water	30	110
Lt. sticky bottom	6	116
110-116 very sticky clay	19	135
116-135 clay + gravel	6	141
135-141 clay + gravel	7	148
141-148 clay gravel	2	150
148-150 clay + sand	4	154
150-154 clay + gravel	5	159
154-159 sticky clay	2	161
159-161 sand + clay	5	166
161-166 water sand		
Set well head		

4 WELL DEPTH: (completed) 166 ft. Date of Completion Nov 16-72

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

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

7 CASING: Diam. 4 in. to 154 ft. Depth; Threaded ☒ Welded ☐; Height: Above/Below surface 1 ft.; Weight 11 lbs/ft.; ___ in. to ___ ft. Depth; Drive Shoe? Yes ☑ No ☐

8 SCREEN: Type: JOHNSON Dia.: 3" Slot/Gauze 12 Length 5' Set between 161 ft. and 166 ft. Fittings: 2" 2" 3x4" PACKER

9 STATIC WATER LEVEL 26 ft. below land surface

10 PUMPING LEVEL below land surface 100 ft. after 2 hrs. pumping 10 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

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

14 SANITARY: Nearest Source of possible contamination DRAIN FIELD 25 feet SE Direction LEACH BED Type; Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: Manufacturer's Name Baldor Model Number EJ0542 HP ½ Length of Drop Pipe 150 ft. capacity 10 G.P.M. Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc. Recon

ADDED INFO. BY DRILLER ITEM No. 7

CORRECTED BY

ADDITION BY

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

Russell Co — REGISTERED BUSINESS NAME — 0411a REGISTRATION NO.

Address RR 4 St Louis Michigan

Signed ___ AUTHORIZED REPRESENTATIVE Date Dec 11 72

D67D 100M 6-66

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No. [ ]

MAR 05 1974

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	NW¼ NW¼ NE¼	23	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Madison and Fremont rd / Weston Madison rd 3/10 mi 140 ft South

Street address & City of Well Location

Locate with "X" in section below — Sketch Map: Madison rd. / Fremont rd. / 1 MILE

3 OWNER OF WELL: Albert Knoppa

Address: St Louis

4 WELL DEPTH: (completed) 122 ft. — Date of Completion: 9-5-73

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 2 in. to 112 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/Below Surface 4 ft. Weight 3.75 lbs./ft. Drive Shoe? Yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	44	44
Sand	6	50
Clay	55	105
Sand	10	115
Gravel	7	122

8 SCREEN: Type: Johnson Dia.: 1¼" Slot/Gauze 10 Length ____ Set between 112 ft. and 122 ft. Fittings: Brenner check

9 STATIC WATER LEVEL 80 ft. below land surface

10 PUMPING LEVEL below land surface: 80 ft. after 1 hrs. pumping 10 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

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

14 Nearest Source of possible contamination: 60 feet N Direction Septic tank Type. Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed. Manufacturer's Name Rapidaire. Model Number 9 stages HP 1 Volts 115. Length of Drop Pipe 24 ft. capacity ____ G.P.M. Type: ☐ Submersible ☒ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Waldron Drilling — REGISTERED BUSINESS NAME — 0936 — REGISTRATION NO.

Address: Russendale Mich

Signed: Lester Waldron — AUTHORIZED REPRESENTATIVE — Date: 9-5-73

D67d 100M (Rev. 12-68)

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GEOLOGICAL SURVEY COPY

FEB 24 1971

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	PINE RIVER	SW¼ SW¼ SW¼	23	7N 12 N/S.	3W E/W.

Distance And Direction from Road Intersections: 2 RDS EAST OF BEGOLE ON MONROE -NORTH SIDE

OWNER No. 1

Street address & City of Well Location

3 OWNER OF WELL: Moriarty Buildings

Address: St Louis Box 347

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Stony clay	90	90
White marl	15	105
Blue clay	30	135
Sand & Gravel	12	147

4 WELL DEPTH: (completed) 147 ft. — Date of Completion:

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

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

7 CASING: Diam. 5 in. to 141 ft. Depth — Threaded ☐ Welded ☐ — in. to — ft. Depth

Height: Above/Below surface 2 ft. Weight 77 lbs/ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: MIDWEST Dia.: 2-3/4

Slot/Gauze Slot 2 Length 6

Set between 141 ft. and 147 ft.

Fittings: 4 FT PIPE - K PACKER

9 STATIC WATER LEVEL 25 ft. below land surface

10 PUMPING LEVEL below land surface

95 ft. after ½ hrs. pumping 30 g.p.m.

— ft. after — hrs. pumping — g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) — Chlorides (Cl) —

Hardness NO TEST

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

13 GROUTING: Well Grouted? ☐ Yes ☒ No

Material: ☐ Neat Cement ☐ —

Depth: From — ft. to — ft.

14 SANITARY:

Nearest Source of possible contamination

100 feet S Direction Sep Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name Ted

Model Number 3626 HP ½

Length of Drop Pipe 45 ft. capacity 15 G.P.M.

Type: ☐ Submersible ☐ — ☒ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM —

CORRECTED BY:

ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Douglas and Lea — REGISTERED BUSINESS NAME — 0973 — REGISTRATION NO.

Address Ronald P1

Signed — AUTHORIZED REPRESENTATIVE — Date 5-23-70

D67D 100M 6-66

GEOLOGICAL SURVEY COPY

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GEOLOGICAL SURVEY SAMPLE No. [ ]

JUN 16 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

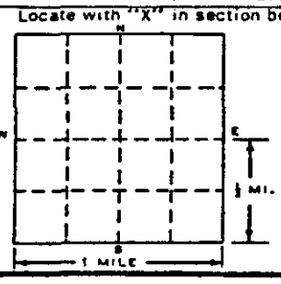
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	SW¼ SW¼ SE¼	22	12 N/S.	3 E/W.

Distance and Direction from Road Intersection: Intersection Bogole & Monroe Rd 3/5 mile East & 113 feet North off Road

Street address & City of Well Location

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



3 OWNER OF WELL: Delbert Hutchinson
Address: 1684 W Monroe Rd St. Louis Mich

4 WELL DEPTH: (completed) 135 ft. Date of Completion March 17, 1972

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

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

7 CASING: Threaded ☐ Welded ☐ Diam. 4 in. to 130 ft. Depth; ____ in. to ____ ft. Depth
Height: Above Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	8	8
Stoney Clay	33	41
Hard - Stoney clay	55	96
Soft Fine Clay	25	121
Sandy Clay	7	128
Water Sand	7	135

8 SCREEN: Type Johnson SS Dia.: 4" Slot ____ Length 5' Set between 130 ft. and 135 ft. Fittings: Tail Pipe + Rubber Packer

9 STATIC WATER LEVEL 32 ft. below land surface

10 PUMPING LEVEL below land surface 65 ft. after 1 hrs. pumping 25 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ Sand + Clay Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination 80 feet NW Direction Septic Tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name F & W
Model Number IP320 HP 1 Volts 220
Length of Drop Pipe 84 ft. capacity 15 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM 7&8

CORRECTED BY:

ADDITION BY:

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

Wayne Mills Well Drilling — REGISTERED BUSINESS NAME — 0977 — REGISTRATION NO.

Address RR 2 St. Louis, Mich

Signed ____ AUTHORIZED REPRESENTATIVE Date May 3, 1972

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY SAMPLE No. [ ]

JUN 6 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

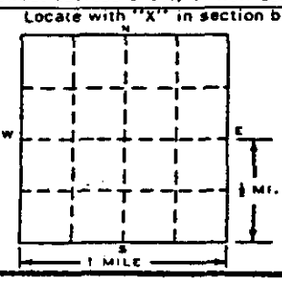
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	E½ E½ SW¼	23	12 N.	3 W.

Distance And Direction from Road Intersections: Intersection Bigole + Monroe Rd 5 mile East and 121 feet North off Road

Street address & City of Well Location

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



3 OWNER OF WELL:
Delbert Hutchinson
Address 1654 W Monroe Rd
St Louis, Mich

4 WELL DEPTH: (completed) Date of Completion
147 ft. March 28, 1972

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

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

7 CASING: Threaded [X] Welded [ ]
Diam. 4 in. to 142 ft. Depth
___ in. to ___ ft. Depth
Height: Above/Below Surface 1 ft.
Weight 11 lbs./ft.
Drive Shoe? Yes [X] No [ ]

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	7	7
Stoney clay	30	37
Hard clay	60	97
Soft clay	23	120
Sand + clay	18	138
Water Sand	9	147

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type Johnson SS Dia.: 4"
Slot/~~Size~~ 12 Length 6'
Set between 142 ft. and 147 ft.
Fittings: Tail Pipe + Rubber Packer

9 STATIC WATER LEVEL
33 ft. below land surface

10 PUMPING LEVEL below land surface
66 ft. after 1 hrs. pumping 20 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? [X] Yes [ ] No
[ ] Neat Cement [ ] Bentonite [X] Clay + Sand
Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination
200 Feet NW Direction Septic tank Type
Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not installed
Manufacturer's Name F + W
Model Number LP320 HP 1 Volts 220
Length of Drop Pipe 84 ft. capacity 15 G.P.M.
Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.
ADDRESS OF DRILLER, ITEM No.
*CORRECTED BY:
**ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Wayne Milbourn Well Drilling 2977
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 882
St Louis, Mich
Signed ___ AUTHORIZED REPRESENTATIVE Date May 3, 1972

D67d 100M (Rev. 12-68)

15

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

23-1

1 LOCATION OF WELL

NE NW NE

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	PINE RIVER	~~NE NW NE~~ ¼	23	12 N/~~S~~.	3 ~~E~~/W.

Distance And Direction from Road Intersections: ~~SEVEN~~ & MADISON

OWNER No.

1/4 MILE ~~S~~ WEST & 100 FT. SOUTH

Street address & City of Well Location

3 OWNER OF WELL:

Address DEWEY O'BOYCE

ST. LOUIS, MICH.

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
CLAY	30	30
CLAY & GRAVEL	40	70
CLAY	35	105
WATER SAND	105	109

4 WELL DEPTH: (completed) 109 ft. **Date of Completion** 7-28-69

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

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

7 CASING: Diam. 2 in. to 105 ft. Depth; Threaded ☒ Welded ☐; ___ in. to ___ ft. Depth

Height: ~~Above~~/Below surface 4 ft.; Weight 3.75 lbs/ft.; Drive Shoe? Yes ☒ No ☐

8 SCREEN:

Type: JOHNSON Dia.: 1¼"

Slot/Gauze 10 Length 4'

Set between 105 ft. and 109 ft.

Fittings:

9 STATIC WATER LEVEL

70 ft. below land surface

10 PUMPING LEVEL below land surface

___ ft. after ___ hrs. pumping ___ g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING:

Well Grouted? ☐ Yes ☐ No

Material: ☐ Neat Cement ☐ ___

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination

60 feet NW Direction SEPTIC Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name RAPIDAYTON

Model Number ___ HP 3/4

Length of Drop Pipe 84 ft. capacity ___ G.P.M.

Type: ☐ Submersible ☐ ___ ☒ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM 16

*CORRECTED BY: 2

**ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

LESTER WALDRON 0936

REGISTERED BUSINESS NAME — REGISTRATION NO.

Address EIKERDALE, MICH.

Signed Lester Waldron Date 7-28-69

AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

16

GEOLOGICAL SURVEY SAMPLE NO.

3

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

12-1-73

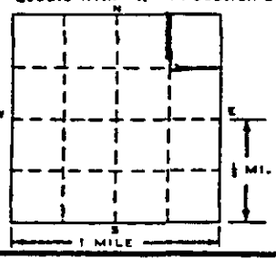
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratoit	Pine River	~~SW¼ NE¼ NE¼~~	24	T ~~13~~ S.	R3 E/W.

Distance And Direction from Road Intersections: Berea and Olney coner

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL: Maynard Danks
Address 210 Olney street
St. Louis, Michigan 48880

4 WELL DEPTH: (completed) 110 ft. Date of Completion June 1973

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 100 ft. Depth; ____ in. to ____ ft. Depth
Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: Johnson Dia.: 2" Slot/Gauze 10 Length 9
Set between 100 ft. and 110 ft.
Fittings: overall 15 ft.

9 STATIC WATER LEVEL 60 ft. below land surface

10 PUMPING LEVEL below land surface 70 ft. after 1 hrs. pumping 900 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

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

14 Nearest Source of possible contamination ____ feet ____ Direction ____ Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Ranidayton
Model Number 5-P-37 HP ½ Volts 220
Length of Drop Pipe 80 ft. capacity 700 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	16	16
Clayand gravel	31	47
Sand and clay	3	50
Clay	30	87
Sand and gravel	13	100
Some clay , sand and gravel	10	110

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
GATES WELL DRILLING & SERVICE 0655
REGISTERED BUSINESS NAME REGISTRATION NO.
Address Mt. Pleasant Phone 7733-677
Signed Ivan Gates AUTHORIZED REPRESENTATIVE Date 12-8-73

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

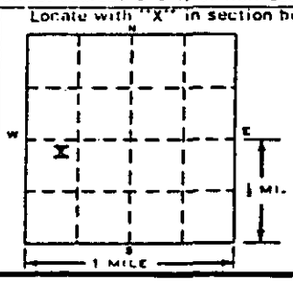
County	Township Name	Fraction	Section Number	Town Number	Range Number
Cratiot	Pine River	NW ¼ SW ¼ ¼	24	T12N N/S.	R3W E/W.

Distance And Direction from Road Intersections: 4 ths N M46 at 407 Orchard Ct

Street address & City of Well Location: Same

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL: Mr Wm Osgood

Address: 407 Orchard ct.

St Louis Mi 48880

4 WELL DEPTH: (completed) 216 ft. Date of Completion: June 73

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

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

7 CASING: Threaded ☒ Welded ☐

Diam. 4 in. to 208 ft. Depth; 3 7/8 in. to 216 ft. Depth

Height: Above/Below Surface 1 ft.

Weight 1189 lbs./ft.

Drive Shoe? Yes ☒ No ☐

2 FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	11	11	11
Clay	11	178	167	178
Sand	178	196	18	196
Clay	196	199	3	199
Sand	199	216	14	216

8 SCREEN: Type: Johnson Red Brass Dia.: 3 7/8 OD

Slot/Gauze 18 Length 8

Set between 208 ft. and 216 ft.

Fittings: 3in K Packer

9 STATIC WATER LEVEL 57 ft. below land surface

10 PUMPING LEVEL below land surface 216 ft. after 2 hrs. pumping 70 g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ____ Chlorides (Cl) ____

Hardness ____ Other ____

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

13 Well Grouted? ☒ Yes ☐ No

☐ Neat Cement ☒ Bentonite ☐ clay

Depth: From 0 ft. to 178 ft.

14 Nearest Source of possible contamination

50 feet S Direction Septic Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed

Manufacturer's Name: Reda

Model Number 14DI'PI5I HP 1 1/2 Volts 230

Length of Drop Pipe 90 ft. capacity 26 G.P.M.

Type: ☒ Submersible ☐ Jet ☐ Reciprocating

Unable to verify Orchard Ct. address

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.

*CORRECTED BY

**ADDITION BY

ELEVATION

DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

C S Oberlitner (REGISTERED BUSINESS NAME) 0341 (REGISTRATION NO.)

Address 4664 N State Rd Alma Mi 48801

Signed Carroll Oberlitner (AUTHORIZED REPRESENTATIVE) Date June 73

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE NO.

JUNE - 1966

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

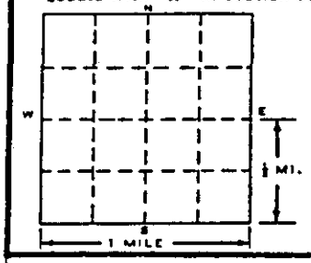
County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	¼ acre ¼	24	12 N/S.	3W E/W

Distance And Direction from Road Intersections

861 Berea St. St Louis Michigan

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL: Mr. Marvin D. Woodcock

Address 861 Berea St. St Louis Michigan 48880

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

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

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

7 CASING: Threaded ☑ Welded ☐ Diam. 2 in. to 89 ft. Depth ____ in. to ____ ft. Depth | Height: Above/Below Surface ____ ft. | Weight 3 3/4 lbs./ft. | Drive Shoe? Yes ☑ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	1	89
Water sand	89	93

8 SCREEN: Type: C.M. Dia.: 1¼" Slot/Gauze 60 Length 4 ft Set between 89 ft. and 93 ft. Fittings:

9 STATIC WATER LEVEL 60 ft. below land surface

10 PUMPING LEVEL below land surface 60 ft. after 4 hrs. pumping 6 g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

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

14 Nearest Source of possible contamination 60 feet W Direction Septic tank Type Well disinfected upon completion ☐ Yes ☐ No

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

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM #8.

CORRECTED BY:

ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Elmer Gould Well Drilling 06/2

REGISTERED BUSINESS NAME REGISTRATION NO.

Address St Louis Michigan 48880

Signed Elmer E. Gould Date June 5-72

AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

SUBSEQUENT SURVEY SAMPLE NO.

APR 17 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	NW¼ SW¼ SW¼	24	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Intersection Monroe and Beegole Rd 1 mile East and ⅘ mile north off Road

Street address & City of Well Location

Locate with "X" in section below — Sketch Map: (N, W, E, S; ½ MI.; 1 MILE)

3 OWNER OF WELL: Michael Linn
Address: AR 2
St Louis, Michigan

4 WELL DEPTH: (completed) 104 ft. Date of Completion: July 20, 1971

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 99 ft. Depth; ___ in. to ___ ft. Depth
Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	11	11
Clay	20	31
water Sand	3	34
Stony clay	15	49
Soft clay	20	69
Hard clay	30	99
Water Sand	5	104

8 SCREEN: Type: Johnson Dia.: 4" Slot Size 17 Length 5' Set between 99 ft. and 104 ft. Fittings: Tail Pipe, Bubbler Poker

9 STATIC WATER LEVEL 46 ft. below land surface

10 PUMPING LEVEL below land surface: 65 ft. after 1 hrs. pumping 20 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ clay + sand
Depth: From 0 ft. to 17 ft.

14 Nearest Source of possible contamination: 65 feet N Direction Septic tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ not installed
Manufacturer's Name: Rapid System
Model Number: JP512 HP 1 Volts 230
Length of Drop Pipe 70 ft. capacity 18 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM NO.

CORRECTED BY:

ADDITION BY:

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

Wayne Miller Well Drilling 0977
REGISTERED BUSINESS NAME — REGISTRATION NO.

939 W Jefferson Rd
Address

St. Louis, Mich
Signed ___ AUTHORIZED REPRESENTATIVE Date July 25, 1971

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE NO.

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

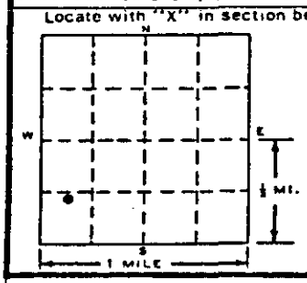
MAR 24 1969

1 LOCATION OF WELL					
County: Gratiot	Township Name: Pine River	Fraction: SW ¼ SW ¼ ¼	Section Number: 24	Town Number: T I2N N/S.	Range Number: R3W E/W.

Distance And Direction from Road Intersections: I MI & I tenth E of Begole Rd, &2 tenths N of W Monroe Rd, on Orchard Ct.

Street address & City of Well Location: 403 Orchard Ct St Louis Mich.

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



3 OWNER OF WELL:
John W Baker
Address 403 Orchard Ct
St Louis Mich.

4 WELL DEPTH: (completed) 203 ft. Date of Completion Mar I8 69

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

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

7 CASING: Threaded ☒ Welded ☐ Height: Above/Below ☒ Surface I ft.
Diam. 4 in. to I93 ft. Depth; Weight I89 lbs./ft.
3 3/4 in. to 203 ft. Depth; Drive Shoe? Yes ☒ No ☐

12 FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	23	23	23
Blue clay	23	97	74	97
Brn "	97	I54	57	I54
Sand fine	I54	I84	30	I84
" Med	I84	203	I9	203
Porisity Good.				
* Well was approvied by Mr Barns				
due to drainage conditions, &				
with provisions for perodical				
checks.				

USE A 2ND SHEET IF NEEDED

8 SCREEN: Johnson R Brass
Type: ____ Dia.: 3 3/4
Slot/Gauze 25 Length I0
Set between I93 ft. and 203 ft.
Fittings: 3in K Packer

9 STATIC WATER LEVEL
73 ft. below land surface

10 PUMPING LEVEL below land surface
203 ft. after 3 hrs. pumping 70 g.p.m.
" ft. after " hrs. pumping " g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No
☐ Neat Cement ☒ Bentonite ☐ clay
Depth: From 0 ft. to Inf ft.

14 Nearest Source of possible contamination
* ____ feet NW Direction Sink drain field/pe
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name Reda
Model Number I4RI8PIOI HP I I/2 Volts 230
Length of Drop Pipe I30 ft. capacity I8 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER 4/24/69

*CORRECTED BY:

**ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Carl S Oberlitner (REGISTERED BUSINESS NAME) 034I (REGISTRATION NO.)
Address 4664 N State Rd Alma Mich.
Signed Carl Oberlitner (AUTHORIZED REPRESENTATIVE) Date Mar I8 69

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pine River	SW Lot 788 ¼ ¼	24	12 N/S.	3 E/W

Distance And Direction from Road Intersections: last house on Cornith St in City. right next to the gates of the Cemetery. OWNER No.

Street address & City of Well Location: 720 Cornith St St Louis

3 OWNER OF WELL: Samuel R Colvor

Address: Edith M. Davis 488. 720 Cornith St St Louis Michigan

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay - ~~Sand~~	86	86
Sand	8	94
MAIN ST. North of M-46 To Prospect ST		
west to Cornith ST. - North		
To Last house		

4 WELL DEPTH: (completed) 94 ft. Date of Completion: Nov 5 - 67

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

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

7 CASING: Diam. 2 in. to 86 ft. Depth; Threaded ☐ Welded ☑; ___ in. to ___ ft. Depth

Height: Above/Below surface 6 ft.; Weight 3 3/4 lbs/ft.; Drive Shoe? Yes ☑ No ☐

8 SCREEN: Type Clayton Marks Dia.: 1¼"; Slot/Gauze ___ Length 2, -4ft.; Set between ___ ft. and ___ ft.; Fittings:

9 STATIC WATER LEVEL 36 ft. below land surface

10 PUMPING LEVEL below land surface: 40 ft. after 4 hrs. pumping 6 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

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

14 SANITARY: Nearest Source of possible contamination: 55 feet N Direction Septic tank Type; Well disinfected upon completion ☐ Yes ☑ No

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

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER. ITEM NO. 1, 2, 7

*CORRECTED BY:

**ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Elmer Gould Well Drilling — REGISTERED BUSINESS NAME — 0612 REGISTRATION NO.

Address: St Louis Michigan 48880

Signed: Elmer Gould — AUTHORIZED REPRESENTATIVE — Date: Dec 13-1967

D67D 100M 6-66

DEC 21 GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Bern Rivers	~~Fraction~~ SE ¼	24	12 N/S.	~~Sec~~ 3 W.

Distance And Direction from Road Intersections
OWNER No.
at 841 Berea St in the City of St Louis Michigan
Street address & City of Well Location

3 OWNER OF WELL: Arthur Lane
Address 841 Berea St St Louis Michigan 48880

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	85	
Water Sand	85	92

4 WELL DEPTH: (completed) 92 ft. Date of Completion

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

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

7 CASING: Diam. 2 in. to 88 ft. Depth; Threaded ☑ Welded ☐
___ in. to ___ ft. Depth
Height: Above/Below surface 1 ft.
Weight 3¾ lbs/ft.
Drive Shoe? Yes ☑ No ☐

8 SCREEN:
Type: SS. C.R. Dia.: 1¼"
Slot/Gauze 60 Length 4 ft
Set between 88 ft. and 92 ft.
Fittings:

9 STATIC WATER LEVEL
35 ft. below land surface

10 PUMPING LEVEL below land surface
40 ft. after 3 hrs. pumping 6 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

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

14 SANITARY:
Nearest Source of possible contamination
60 feet N Direction S T. Type
Well disinfected upon completion ☑ Yes ☐ No

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

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, SEPT. 19

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Elmer Gould Well Drilling 0612
REGISTERED BUSINESS NAME REGISTRATION NO.
Address St Louis Michigan
Signed Elmer Gould Date Sept 11-69
AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

SEP 19 1969

GEOLOGICAL SURVEY COPY

24-12N-3W
Pine River Twp., (Gratiot County)

TD 4545 in Sylvania (?)
(Dry)

Michigan Chemical Corporation

Fee No. 9

Permit No. 5067

Drilling Contractor: J. C. Arthurs, Inc.

Location: S½ SW¼ NW¼ section 24, T.12N., R.3W.
135' from south and 665' from west line of quarter section

Elevation: 746 feet above sea level

Record by: L. Hale from driller's log

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
Mud and gravel	80	80
Sand and gravel, heaving	35	115
Mud	10	125
Mud and gravel	20	145
Sand and gravel, heaving	100	245
PERMO-CARBONIFEROUS (?):		
"Red Beds":		
Mud, pink	60	305
Sand, red	35	340
PENNSYLVANIAN:		
Saginaw:		
Sand, white (water)	10	350
Mud, blue	13	363
Sand, white	12	375
Mud, blue, dark	5	380
Sand	5	385
Mud, blue	30	415
Shale, gray, muddy	23	438
Sand, white	12	450
Shale, gray	15	465
Sand, white and shale streaks	110	575
Sand, white	15	590
Shale, blue, muddy	10	600
Shale, gray, muddy	60	660
Shale, blue, muddy	6	666
Lime, hard	3	669
Shale, gray	6	675
Sand	5	680
Shale, gray	5	685
MISSISSIPPIAN:		
Bayport (?):		
Lime, sandy	65	750
Lime, hard	54	804
Michigan:		
Shale, gray	3	807

COMPLETED
9-9-38
CASING
RECORD
10" 357'
8½" 807'
5⅝" 1421'
3/16" 3934'

GEOLOGICAL SURVEY SAMPLE No. [ ]

DEC 7 1973

WATER WELL RECORD
ACT 284 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

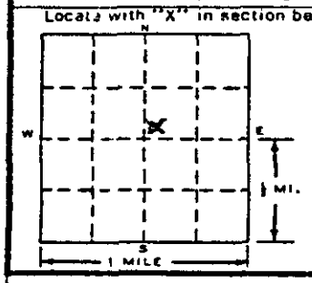
County	Township Name	Fraction	Section Number	Town Number	Range Number
GRATIOT	BETHANY	SW ¼ SW ¼ NE ¼	19	12 N/S.	2 E/W.

Distance And Direction from Road Intersections
0.6 MI. NORTH OF M-46
150' EAST OF UNION RD.
8614 N. UNION

Street address & City of Well Location RR 1 St. Louis, Mich.

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL:
MR. JOHN KINGDON
Address 8614 N. UNION
RR 1 St. Louis, Mich.

4 WELL DEPTH: (completed) Date of Completion
97 ft. 11-10-1973

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

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

7 CASING:
Threaded ☑ Welded ☐
Diam. 4 in. to 91 ft. Depth
____ in. to ____ ft. Depth
Height: Above/Below Surface 1 ft.
Weight 11 lbs./ft.
Drive Shoe? Yes ☑ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND & GRAVEL	10'	10'
GRAY CLAY & STONE	50'	60'
SANDY BROWN CLAY	25'	85'
FINE TO MEDIUM SAND W/SOME CLAY	12'	97'

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type: PLASTIC Dia.: 3 7/8"
Slot/~~Sauze~~ 10 Length 6'
Set between 91 ft. and 97 ft.
Fittings: 3"X3" GALV. PIPE, FIG. K. PACKER

9 STATIC WATER LEVEL
65' ft. below land surface

10 PUMPING LEVEL below land surface
70 ft. after 2 hrs. pumping 40 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) 0.5 Chlorides (Cl) ____
Hardness 14 Other ____

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

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

14 Nearest Source of possible contamination
____ feet ____ Direction ____ Type
Well disinfected upon completion ☑ Yes ☐ No

15 PUMP:
☐ Not installed
Manufacturer's Name RED JACKET
Model Number 50W1-9BC HP 1/2 Volts 230
Length of Drop Pipe 80 ft. capacity 12 G.P.M.
Type: ☑ Submersible
☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.
ADDED INFO. BY DRILLER FROM ORIG. QC
CORRECTED BY E Curtiss 7/31/10
CONDITION BY

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

ROGER OBERLITNER 1104
REGISTERED BUSINESS NAME REGISTRATION NO.

Address RR 2 ITHACA Mich.

Signed Roger Oberlitner Date 11-10-1973
AUTHORIZED REPRESENTATIVE

Q67d 100M (Rev. 12-68)

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

SW NW SE**

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Bethany	N ½ SE¼ ¼	19	12 N/S	2W E/W

Distance And Direction from Road Intersections: N. of M. 46 1760' on Hubbard St. & 520 Est.

Street address & City of Well Location

OWNER No.

3 OWNER OF WELL: Rainbow Hatchery

Address: 603 E. Washington Ave St Louis Mich

2

FORMATION		THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand & Stone	0 30	30	30
Blue Clay	30 - 52	22	52
Sand w/Clay	52 - 73	21	73
Red sand	73 - 92	19	92

ADDED INFO. BY DRILLER, ITEM NO.

CORRECTED BY:

ADDITION BY ... 3/9/67

4 WELL DEPTH: (completed) 92 ft. Date of Completion: Oct 66

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

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

7 CASING: Threaded ☒ Welded ☐ Height: Above/Below surface 1 ft.
Diam. 4 in. to 82 ft. Depth; 3½ in. to 92 ft. Depth
Weight 10.89 lbs/ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: Wilson Red B Dia.: 3½ O.D
Slot/Gauze 18 Length 10'
Set between 82 ft. and 92 ft.
Fittings: 3" Female

9 STATIC WATER LEVEL 65 ft. below land surface

10 PUMPING LEVEL below land surface
75 ft. after 2 hrs. pumping 40 g.p.m.
ft. after hrs. pumping g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) 2.5 Chlorides (Cl)
Hardness 17 Ph. 7.0

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

13 GROUTING: Well Grouted? ☐ Yes ☐ No
Material: ☐ Neat Cement ☒ Beonite
Depth: From 0 ft. to 30 ft.

14 SANITARY:
Nearest Source of possible contamination 50 feet So Direction Type
Well disinfected upon completion ☐ Yes ☒ No

15 PUMP:
Manufacturer's Name Tait
Model Number 16 E 2 HP 1½
Length of Drop Pipe 87 ft. capacity 14 G.P.M.
Type: ☐ Submersible ☐ ☒ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

Not for Human use.

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

F M & C L Whitaker — REGISTERED BUSINESS NAME — 0341 REGISTRATION NO.

Address: Ashley Mich

Signed: C C Whitaker (AUTHORIZED REPRESENTATIVE) Date: Oct 66

D67D 100M 6-66

FEB 9 1967

GEOLOGICAL SURVEY COPY

DEC 1 9 1975

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

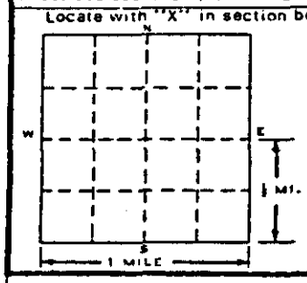
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Bethany	SE¼ SE¼ SE¼	19	12 N/S.	2 E/W

Distance And Direction from Road Intersections: Intersection Monroe Rd & Crosswell 10 mile West 215' north off Road

Street address & City of Well Location

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



3 OWNER OF WELL: Robert McGinnis

Address: St. Louis Mich

4 WELL DEPTH: (completed) 113 ft. Date of Completion 5-16-75

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 108 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: Johnson Dia.: 4" Slot/Gauze 12 Length 5' Set between 108 ft. and 113 ft. Fittings: Tail Pipe + Bull Dog Packer

9 STATIC WATER LEVEL 14 ft. below land surface

10 PUMPING LEVEL below land surface: 50 ft. after 1 hrs. pumping 60 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ Clay + Sand Depth: From 0 ft. to 13 ft.

14 Nearest Source of possible contamination: 130 feet S Direction Septic Tank Type. Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed. Manufacturer's Name Gould. Model Number 10PS1 HP ½ Volts 230. Length of Drop Pipe 70 ft. capacity 5 G.P.M. Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand clay	4	4
Clay	40	44
Stony clay	50	94
Sandy clay	12	106
water sand	7	113

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

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

Wayne Williams Drilling — REGISTERED BUSINESS NAME — 0977 REGISTRATION NO.

Address: St. Louis Mich

Signed ____ AUTHORIZED REPRESENTATIVE Date 5-16-75

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

Bethany (Gratiot County)

Michigan Chemical Company

Fee #4

Location: SW¼ of SE¼ of NE¼ of section 19, T. 12 N., R. 2 W.

Elevation: 735 feet above sea level.

Record by: L. Hale from driller's log.

	Thickness (Feet)	Depth (Feet)
No record	750	750
MISSISSIPPIAN:		
Michigan:		
Shale, blue	25	775
Sand, white	20	795
Shale, blue	15	810
Slate, gray	25	835
Slate, blue and gray	28	863
Slate, blue	47	910
Lime shells	16	926
Slate, blue	27	953
Slate, blue and gypsum shells	15	968
Lime	5	973
Lime, broken	20	993
Slate, black	30	1023
Lime	26	1048
Slate, blue	3	1052
Lime, gritty	6	1058
Sand	5	1063
Slate, blue	7	1070
Lime	15	1085
Lime and sand	3	1088
Sand	3	1091
Sand, dark gray	2	1093
Sand, light gray	39	1132
Shale, blue	6	1138
Sand, gray and shale	9	1147
Slate, blue, hard	3	1150
Napoleon (Upper Marshall):		
Sand, gray, gritty	25	1175
Sand, red	17	1192
Sand, light	23	1215
Sand, red	5	1220
Sand, red, gritty	10	1230
	TOTAL DEPTH	1230

Casing record:
5-3/16" 1091'

Initial production: Brine Well

GEOLOGICAL SURVEY SAMPLE No. [ ]

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

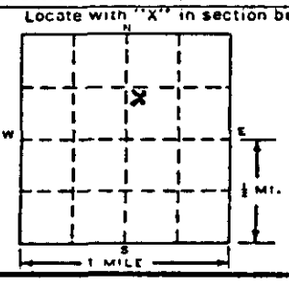
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRATIOT	BETHANY	NW¼ SW¼ NE¼	19	12 N/S.	2 E/W.

Distance And Direction from Road Intersections
0.3 M. SOUTH OF MADISON RD.
150' WEST OF UNION RD.

Street address & City of Well Location R#1 St. Louis, Mich.

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



3 OWNER OF WELL: INDUSTRIAL SOLVENTS INC.
Address R#1 ST. LOUIS, Mich.

4 WELL DEPTH: (completed) 94 ft. **Date of Completion** 12-4-1974

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

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

7 CASING: Threaded ☑ Welded ☐ Diam. 4 in. to 86 ft. Depth; ____ in. to ____ ft. Depth
Height: Above/~~Below~~ Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☑ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND, GRAVEL & STONE	8'	8'
GRAY CLAY	47'	55'
SANDY BROWN CLAY	23'	78'
SAND WITH SOME CLAY	16'	94'

8 SCREEN: Type: 304 STAINLESS Dia.: 3 7/8" O.D.
Slot/~~Gauge~~ 10 Length 8'
Set between 86 ft. and 94 ft.
Fittings: FIG. K. PACKER - 3"x3" PIPE

9 STATIC WATER LEVEL 60 ft. below land surface

10 PUMPING LEVEL below land surface
65 ft. after 2 hrs. pumping 15 g.p.m.
70 ft. after 2 hrs. pumping 30 g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) 0.1 Chlorides (Cl) ____
Hardness 15 Other ____

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

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

14 Nearest Source of possible contamination
50 feet WEST Direction DRAIN FIELD Type
Well disinfected upon completion ☑ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name REDA
Model Number 7018P071 HP ¾ Volts 230
Length of Drop Pipe 74 ft. capacity 30 G.P.M.
Type: ☑ Submersible ☐ Jet ☐ Reciprocating

974-1888

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
ROGER OBERLITNER (REGISTERED BUSINESS NAME) 1104 (REGISTRATION NO.)
Address R#2 ITHACA, Mich.
Signed Roger Oberlitner (AUTHORIZED REPRESENTATIVE) Date 12-4-1974

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

FEB 24 1971

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

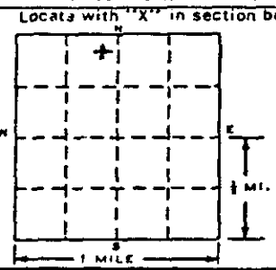
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRATIOT	PINE RIVER	NE¼ NW¼	26	12 N/S.	3 W.

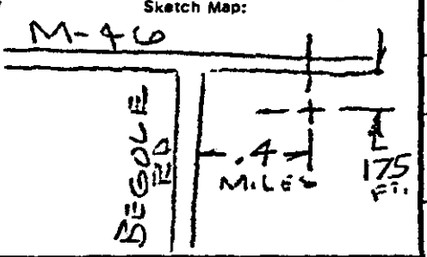
Distance And Direction from Road Intersections: M-46 & BEGOLE RD. .4 MILES EAST, 175 FT. SOUTH

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL: VIRGIL GOETZINGER
Address ALMA, MICH

4 WELL DEPTH: (completed) 86 ft. Date of Completion 9-6-70

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 2 in. to 81 ft. Depth; ____ in. to ____ ft. Depth
Height: ~~Above~~/Below Surface 3 ft.
Weight 3.75 lbs./ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: JOHNSON Dia.: 1¼"
Slot/~~Gauge~~ 10 Length 4'-6"
Set between 81 ft. and 85½ ft.
Fittings:

9 STATIC WATER LEVEL 50 ft. below land surface

10 PUMPING LEVEL below land surface
____ ft. after ____ hrs. pumping ____ g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

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

14 Nearest Source of possible contamination
60 feet SW Direction SEPTIC Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name RUPIDA JET
Model Number 7CH HP ¾ Volts 115
Length of Drop Pipe 63 ft. capacity ____ G.P.M.
Type: ☐ Submersible ☒ Jet ☐ Reciprocating

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
GRAVEL	20'	20'
CLAY	10'	30'
WATER SAND	10'	40'
CLAY	30	70'
WATER SAND	16'	86'

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
ADDED INFO. BY DRILLER, ITEM 11
CORRECTED BY:
ADDITIONAL

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
ROGER TRAVER WATER WELL DRILLING INC
REGISTERED BUSINESS NAME ____ REGISTRATION NO.
Address RR1 VESTABURG MICH
Signed ____ (AUTHORIZED REPRESENTATIVE) Date 9-6-70

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
CHARLEVOIX	PINE RIVER	NW¼ NW¼ SE¼	36	32N N/S.	8W E/W.

Distance And Direction from Road Intersections: 1199 CHESMAN ROAD ¼ MI EAST OF BEGOLE

Street address & City of Well Location

OWNER No. 1

3 OWNER OF WELL: ST LOUIS
EDWARD BEDNARICK
Address: 1199 CHESMAN RD

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
CLAY 110	110	110
CLAY AND STONE	100	210
SAND - GRAVEL	4	214

4 WELL DEPTH: (completed) 214 ft. Date of Completion NOV 1-69

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

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

7 CASING: Diam. 4 in. to 211 ft. Depth; Threaded ☐ Welded ☐
___ in. to ___ ft. Depth
Height: Above/Below surface 1 ft.
Weight 11 lbs/ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN:
Type ST STEEL Dia. 3-4
Slot/Gauze 10 Length 5
Set between 210 ft. and 214 ft.
Fittings: SEAL

9 STATIC WATER LEVEL
10 ft. below land surface

10 PUMPING LEVEL below land surface
10 ft. after 4 hrs. pumping 40 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ___ Chlorides (Cl) ___
Hardness 4

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

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

14 SANITARY: 100
Nearest Source of possible contamination
100 feet E Direction SEPT Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
Manufacturer's Name REDA SUB
Model Number 562 03101 HP ½
Length of Drop Pipe 27 ft. capacity 15 G.P.M.
Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY [illegible]

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

[illegible] 0922
REGISTERED BUSINESS NAME — REGISTRATION NO.

Address [illegible] MI

Signed [illegible] Date 11-6-69
AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

NOV 12 1969

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

DEC 01 1972

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	SW¼ SW¼ SW¼	26	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Intersection Cheeseman Rd + ~~Gar~~ Rd 1 mile South 165' East off Road

Street Address & City of Well Location

Locate with "X" in section below — Sketch Map: (1 MILE)

3 OWNER OF WELL: Earl Van Nortwick
Address 7030 N Begole Rd
Alma, Mich

4 WELL DEPTH: (completed) 142 ft. Date of Completion Nov 14, 1972

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

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

7 CASING: Threaded [X] Welded [ ]
Diam. 3 in. to 138 ft. Depth; ___ in. to ___ ft. Depth
Height: Above/Below Surface 1 ft.
Weight 7.70 lbs./ft.
Drive Shoe? Yes [X] No [ ]

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top Soil	3	3
Clay	45	48
Stoney clay	54	102
Soft Blue Clay	28	130
Sandy + Clay	6	136
Water Sand	6	142

ADDED INFO. BY DRILLER, ITEM ...

CORRECTED BY:

ADDITION BY

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type Johnson Dia.: 2"
Slot/Gauge 12 Length 4'
Set between 138 ft. and 142 ft.
Fittings: Tail Pipe + Baffle Packer

9 STATIC WATER LEVEL 18 ft. below land surface

10 PUMPING LEVEL below land surface
35 ft. after 1 hrs. pumping 20 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? [X] Yes [ ] No
[ ] Neat Cement [ ] Bentonite [X] Sand + Clay
Depth: From 0 ft. to 17 ft.

14 Nearest Source of possible contamination
51 feet N Direction Septic tank Type
Well disinfected upon completion [X] Yes [ ] No

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

16 Remarks, elevation, source of data, etc.

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

Wayne Miller Well Drilling — REGISTERED BUSINESS NAME — 0977 REGISTRATION NO.

Address 939 N Jefferson Rd
St. Louis, Mich

Signed ___ AUTHORIZED REPRESENTATIVE Date Nov 14, 1972

067d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

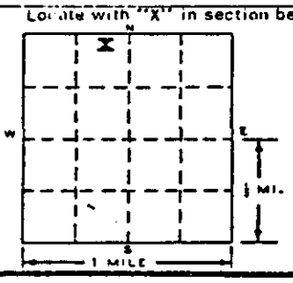
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	NE ¼ NW ¼	26	T12N N/S.	R3W E/W.

Distance And Direction from Road Intersections: 4 ths E of Begole Rd on W Monroe Rd

Street address & City of Well Location: St Louis Mi 48880

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL:
Church Christ
Address I26 E Saginaw St
St Louis Mi 48880

4 WELL DEPTH: (completed) ft. Date of Completion: June 73

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

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

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

8 SCREEN:
Type: ____ Dia.: ____
Slot/Gauze ____ Length ____
Set between ____ ft. and ____ ft.
Fittings:

9 STATIC WATER LEVEL
____ ft. below land surface

10 PUMPING LEVEL below land surface
____ ft. after ____ hrs. pumping ____ g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☐ Yes ☐ No Back filled w/ drlg mud.
☐ Neat Cement ☐ Bentonite ☐ ____
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination
____ feet ____ Direction ____ Type
Well disinfected upon completion ☐ Yes ☐ No

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

2 FORMATION

FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
No 1 Sand	0	II	II	II
Clay	II	20	9	20
No 2 Sand	0	3	3	3
Clay Brn	3	II	8	II
" Blue	II	2I	I0	2I
No 3 Sand	0	7	7	7
Clay Wht	7	I2	5	I2
" Blue	I2	2I	9	2I
4 Sand	0	5	5	5
Clay Wht	5	I0	5	I0
" Blue	I0	2I	I0	2I
Test holes for buildings.				

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY
**ADDITION BY
ELEVATION
DEPTH TO ROCK

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

C S Oberlitner — REGISTERED BUSINESS NAME — 0341 — REGISTRATION NO.

Address 4664 N state Rd Alma MI 48801

Signed Carl S Oberlitner — AUTHORIZED REPRESENTATIVE — Date June 73

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

NOV 01 1973

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	SW ¼ SE ¼ NE ¼	26	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: Intersection Sheesmon Rd + Riegle Rd ¾ Mile East + 71' North off Road

Street address & City of Well Location:

Locate with "X" in section below (N, W, E, S, ½ MI., 1 MILE)

Sketch Map:

3 OWNER OF WELL: J.C. Smith

Address: St. Louis, Mich

4 WELL DEPTH: (completed) 230 ft. Date of Completion: Aug 8, 1973

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

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

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 230 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	21	21
Gravel clay	115	136
Soft clay	90	226
Sandy clay	2	228
Water Sand	2	230

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: NONE Dia.: ____ Slot/Gauze ____ Length ____ Set between ____ ft. and ____ ft. Fittings: Gravel Pack

9 STATIC WATER LEVEL 35 ft. below land surface

10 PUMPING LEVEL below land surface: 54 ft. after 1 hrs. pumping 10 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ clay + sand Depth: From 0 ft. to 15 ft.

14 Nearest Source of possible contamination: NONE ____ feet ____ Direction ____ Type

Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: ☒ Not installed

Manufacturer's Name ____ Model Number ____ HP ____ Volts ____ Length of Drop Pipe ____ ft. capacity ____ G.P.M.

Type: ☐ Submersible ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

Elevation 740 ± 10

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Wayne Miller Well Drilling 0977
REGISTERED BUSINESS NAME REGISTRATION NO.

Address: B 3 7

St. Louis, Mich

Signed ____ AUTHORIZED REPRESENTATIVE Date Aug 13, 1973

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

26-12N-3W (C) TD 3360 in Dundee
Pine River Twp., (Gratiot County) (Dry)

Vestor Leonard
Ernest R. Sheppler #1 Permit #1867
Drilling Contractor: C. C. Hilliard

Location: SE¼ NW¼ NW¼ section 26, T.12N., R.3W.
1020' from north and 881' from west line of quarter section.

Elevation: 748.5 feet above sea level.

Record by: Lyle W. Price from driller's log.

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
No record	382	382
PENNSYLVANIAN:		
Saginaw:		
Shale, blue	60	442
Sandstone	153	595
Shale, blue	85	680
Parma:		
Sandstone	30	710
MISSISSIPPIAN:		
Bayport:		
Limestone	50	760
Sandstone	40	800
Shale, green	5	805
Sandstone	10	815
Shale, green	20	835
Shale, blue	70	905
Limestone	10	915
Shale, blue	5	920
Limestone	25	945
Shale, blue	20	965
Limestone	30	995
"Shells"	50	1045
Napoleon (Upper Marshall):		
No record	80	1125
Lower Marshall:		
Red rock	35	1160
Coldwater:		
Limestone	20	1180
Red rock	20	1200
Limestone	30	1230
Red rock	35	1265
Shale, blue	55	1320
Red rock	33	1352
Shale, green	17	1370
Limestone	45	1415
Shale, gray	10	1425
Shale, blue	125	1550
Limestone; "shells"	20	1570
Shale, gray	60	1630
Limestone "Shells"	95	1725
Shale, gray	15	1740

COMPLETED
3-12-34
CASING
RECORD
10" 387'
8¼" 835'
5⅝" 1328'

GEOLOGICAL SURVEY SAMPLE No.

APR - 6 1976

3

WATER WELL RECORD

ACT 294 PA 1965 2E/1W

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	~~NW~~ ¼ ~~NE~~ ¼ / ¼	26	T12N N/S.	R3W E/W.

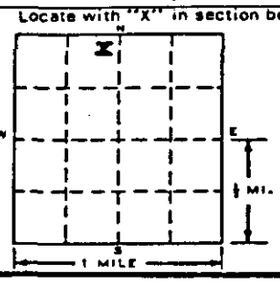
Distance And Direction from Road Intersections

5.0 W of Jerome Rd on W Monroe Rd & S 400 ft.

RFD W Monroe Rd or M46 St Louis, Mich.

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL: Church of Christ

Address: I26 E Saginaw St, St Louis Mi 48880

4 WELL DEPTH: (completed) 240 ft. Date of Completion: June 75

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

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

7 CASING: Threaded ☒ Welded ☐

4 in. Diam. to 231 ft. Depth

3 7/8 in. to 240 ft. Depth

Height: Above/Below Surface 1 ft.

Weight 1189 lbs./ft.

Drive Shoe? Yes ☒ No ☐

8 SCREEN: Johnson Stainless steel

Type: ____ Dia.: 3 7/8 OD

Slot/Gauze 5ft18, 4ft20 Length 9

Set between 231 ft. and 240 ft.

Fittings: 3 in K packer FPT.

9 STATIC WATER LEVEL 27 ft. below land surface

10 PUMPING LEVEL below land surface

240 ft. after 3 hrs. pumping 100 g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ____ Chlorides (Cl) ____

Hardness ____ Other ____

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

13 Well Grouted? ☒ Yes ☐ No

☐ Neat Cement ☒ Bentonite ☐ Drlg mud

Depth: From 0 ft. to 221 ft.

14 Nearest Source of possible contamination

75 feet N Direction Septic Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed

Manufacturer's Name Red Jacket

Model Number 10 HP 1 Volts 208 230

Length of Drop Pipe 73 ft. capacity 18 G.P.M.

Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION

FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand & clay fill	0	9	9	9
Blue clay	9	92	83	92
Sand	92	101	(9	101
Brown clay	101	221	120	221
Fine gravel	221	240	39	240
Porisity good, large well aviable.				

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.

*CORRECTED BY

**ADDITION BY

ELEVATION

DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Carl S Oberlitner — REGISTERED BUSINESS NAME

0341 — REGISTRATION NO.

Address 4664 N Sate Rd Alma Mi 48801

Signed Carl S Oberlitner — AUTHORIZED REPRESENTATIVE

Date June 75

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY SAMPLE No.

MAR 2 6 1975

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

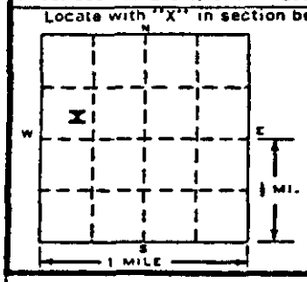
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Gratiot	Pine River	SW ¼ NW ¼ ¼	25	T12N N/S.	R3W E/W.

Distance And Direction from Road Intersections: 2/10 E of Jerome Rd on Cheesman Rd & S 60 ft.

Street address & City of Well Location: Same

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



3 OWNER OF WELL
Mr D M Robins
Address: 841 Cheesman Rd
St Louis Mi 48880 .

4 WELL DEPTH: (completed) Date of Completion
227 ft. — Dec 74

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

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

7 CASING: Threaded ☒ Welded ☐
Diam.
4 in. to 218 ft. Depth
3 7/8 to 227 ft. Depth
Height: Above/Below Surface 1 ft.
Weight 1189 lbs./ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN: Johnson
Type: Stainless st Dia.: 3 7/8 OD
Slot/Gauze 18 Length 9'
Set between 218 ft. and 227 ft.
Fittings: 3 K Packer

9 STATIC WATER LEVEL
27 ft. below land surface

10 PUMPING LEVEL below land surface
227 ft. after ___ hrs. pumping 70 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 Well Grouted? ☒ Yes ☐ No
☐ Neat Cement ☐ Bentonite ☒ Drlg mud
Depth: From 0 ft. to 157 ft.

14 Nearest Source of possible contamination
50 feet SE Direction Septic Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
☐ Not installed
Manufacturer's Name: Reda
Model Number 9D9P051 HP 1/2 Volts 230/ 1ph
Length of Drop Pipe 84 ft. capacity 11 G.P.M.
Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION

FORMATION			THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	15	15	15
Blue Clay	15	155	140	155
Brn Clay & lens Sand	155	210	55	210
Sand	210	227	17	227

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.
ANSWER NEED BY DRILLER, ITEM NO.
*CONTRACTOR BY
*EXPLANATION BY
FILE FOR BOOK

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

C S Oberlitner — REGISTERED BUSINESS NAME
0341 — REGISTRATION NO.

Address: 4664 N State Rd Alma Mi 48801

Signed C S Oberlitner — AUTHORIZED REPRESENTATIVE
Date: Dec 74

D67d 100M (Rev. 12-68)

27

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

SE/NW

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pine River	~~SW 1/4 SE 1/4 NW 1/4~~ corrected	25	12 N/S	3 E/W

Distance And Direction from Road Intersections

OWNER No.

Street address & City of Well Location 680 Chesaning rd St Louis

3 OWNER OF WELL: Mrs Fern Pulcher

Address 680 Chesaning road St Louis Michigan

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	210	
Sand	210 to	220

4 WELL DEPTH: (completed) 220 ft. Date of Completion 4-20-68

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

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

7 CASING: Diam. 2 in. to 216 ft. Depth; Threaded ☒ Welded ☐; Height: Above/Below surface 2 ft.; Weight 3¾ lbs/ft.; ___ in. to ___ ft. Depth; Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type: C.M. Dia.: 1¼"; Slot/Gauze 60 Hanger Length 4'; Set between 216 ft. and 220 ft.; Fittings:

9 STATIC WATER LEVEL 24 ft. below land surface

10 PUMPING LEVEL below land surface 38 ft. after 4 hrs. pumping 4 g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ___ Chlorides (Cl) ___ Hardness ___ none

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☐ Pitless Adapter ☐ 12" Above Grade none

13 GROUTING: Well Grouted? ☐ Yes ☐ No none; Material: ☐ Neat Cement ☐ ___; Depth: From ___ ft. to ___ ft.

14 SANITARY: Nearest Source of possible contamination 60 feet W Direction Septic Type; Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: Manufacturer's Name none; Model Number ___ HP ___; Length of Drop Pipe ___ ft. capacity ___ G.P.M.; Type: ☐ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

I dident put the pump on

ADDED INFO. BY DRILLER. ITEM NO.

CORRECTED BY: P

ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Elmer Harold Well Driller 0612

REGISTERED BUSINESS NAME REGISTRATION NO.

Address St Louis Michigan 48880

Signed Elmer Harold Date 6-3-68

AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pine River	NW¼ NW¼ SW¼	25	T I2 N/S/	R 3 WE/W.

Distance And Direction from Road Intersections: 5280 ft E of Beggle Rd on Cheesman Rd, 2 ft S

OWNER No.

Street address & City of Well Location: 2591 Cheesman RD St Louis Mich.

3 OWNER OF WELL: D K Barstow

Address: 2591 Cheesman Rd. St Louis Mich.

2 FORMATION		THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0-9	9	9
Blue clay	9 – 36	25	36
Sand	36 – 37	I	37
Blueclay	37 – II0	73	II0
own clay	II0 – I90	80	I90
and	I90 – 205	I5	205
Sand w/ stone	205 – 215	I0	215

4 WELL DEPTH: (completed) 215 ft. Date of Completion 6 6 67

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

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

7 CASING: Threaded ☐ Welded ☐

4 in. to 210 ft. Depth

37/8 in. to 215 ft. Depth

Height: Above/Below surface I ft.

Weight I089 lbs/ft.

Drive Shoe? Yes ☐ No ☐

8 SCREEN: Johnson Silicon Redbrass

Type: ___ Dia.: 37/8 O.D.

Slot/Gauze 30 Length 5 ft

Set between 210 ft. and 215 ft.

Fittings: 3 in Felmale Top end.

9 STATIC WATER LEVEL I9 ft. below land surface

10 PUMPING LEVEL below land surface

I50 ft. after 3 hrs. pumping 85 g.p.m.

I50 ft. after 3 hrs. pumping 85 g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) .20 Chlorides (Cl) PH 7.9

Hardness 21

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

13 GROUTING:

Well Grouted? ☒ Yes ☐ No

Material: ☐ Neat Cement ☐ ~~Bentonite & Clay~~

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination

~~Nw~~ feet 50 Direction ~~Septic~~ Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name Reda

Model Number 4II0I HP I/2

Length of Drop Pipe 42 ft. capacity I4 G.P.M.

Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

Good Porisity.

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

F M& CS Oberlitner — REGISTERED BUSINESS NAME

0341 — REGISTRATION NO.

Address 4664 N State Rd Alma mich

Signed ___ (AUTHORIZED REPRESENTATIVE) Date 6-6-67

D67D 100M 6-66

JAN 4 1968

GEOLOGICAL SURVEY

GEOLOGICAL SURVEY SAMPLE No. [ ]

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Gratiot	Pine River	WE ¼ NE ¼ SE ¼	25	12 N/S.	3 E/W.

Distance And Direction from Road Intersections: 3000 ft South of Monroe Rd on Alger Rd. (27A) 30' West side of Alger

Street address & City of Well Location

OWNER No.

3 OWNER OF WELL: Production Credit Association

Address: Alma Michigan

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sandy Clay	0	20
Sand	20	22
Clay	22	30
Sand Stringers	30	35
Clay Stringers	35	60
Clay	60	85
Sand	85	88
Clay	88	100
Gravel + Sand	100	110

4 WELL DEPTH: (completed) 110 ft. Date of Completion 10/28/68

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

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

7 CASING: Diam. 4 in. to 105 ft. Depth; Threaded ☐ Welded ☐; Height: Above/Below surface 1 ft.; Weight 4.9 lbs/ft.; ___ in. to ___ ft. Depth; Drive Shoe? Yes ☒ No ☐

8 SCREEN: Type SS. Johnson Dia.: 3"x4"

Slot/Gauge 12 Length 5'

Set between 105 ft. and 110 ft.

Fittings: K-Packer 36" Set Link

9 STATIC WATER LEVEL 60 ft. below land surface

10 PUMPING LEVEL below land surface

95 ft. after 3 hrs. pumping 15 g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___

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

13 GROUTING:

Well Grouted? ☐ Yes ☐ No

Material: ☐ Neat Cement ☐ ___

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination

75 feet W Direction Septic Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name Rapidaytor

Model Number D63143 HP 1

Length of Drop Pipe 80 ft. capacity 12 G.P.M.

Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER, ITEM No.

CORRECTED BY:

ADDITION BY:

17 WATER WELL CONTRACTOR'S CERTIFICATION:

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

Mead Well Drilling — REGISTERED BUSINESS NAME

0572 — REGISTRATION NO.

Address Route 1 Mt. Pleasant, Mich

Signed ___ — AUTHORIZED REPRESENTATIVE

Date 10/28/68

GEOLOGICAL SURVEY SAMPLE No. [ ]

SEP 1 6 1972

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

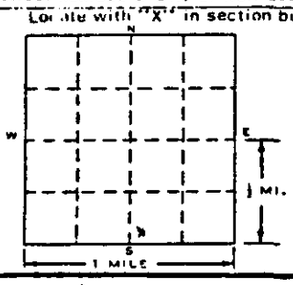
County	Township Name	Fraction	Section Number	Town Number	Range Number
GRATIOT	BETHANY	SW¼ SW¼ SE¼	30	12 N/S.	2 E/W.

Distance And Direction from Road Intersections
0.6 MI EAST OF STATE RD.
30 NORTH OF JACKSON RD
E JACKSON RD

Street address & City of Well Location RFD ST LOUIS, MICH.

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL: LANDFILLS INC
Address MR KEITH CANFIELD
RFD. ST LOUIS, MICH

4 WELL DEPTH: (completed) 52 ft. Date of Completion JUNE 28, 1972

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

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

7 CASING: Threaded ☑ Welded ☐ Diam. 4 in. to 42 ft. Depth; ___ in. to ___ ft. Depth
Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☑ No ☐

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
YELLOW CLAY & STONE	12'	12'
GRAY CLAY	14'	26'
FINE RED SAND	3'	29'
GRAY CLAY	4'	36'
MEDIUM TO COARSE SAND	16'	52'

USE A 2ND SHEET IF NEEDED

8 SCREEN: JOHNSON
Type: STAINLESS Dia.: 4"
Slot/Gauze 15 Length 5'
Set between 47 ft. and 52 ft.
Fittings: 2"x3" GALV. BLANK - FIG. K PACKER

9 STATIC WATER LEVEL 38 ft. below land surface

10 PUMPING LEVEL below land surface 40 ft. after 2 hrs. pumping 35 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) 3 Chlorides (Cl) ___
Hardness 25 Other ___

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

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

14 Nearest Source of possible contamination
75 feet WEST Direction DRAIN FIELD Type
Well disinfected upon completion ☑ Yes ☐ No HTH

15 PUMP: ☐ Not installed
Manufacturer's Name DEMINGS (USED)
Model Number UNKNOWN HP 1 Volts 230
Length of Drop Pipe 50 ft. capacity 12 G.P.M.
Type: ☐ Submersible ☑ Jet ☐ Reciprocating
2 PIPE, DEEP WELL

16 Remarks, elevation, source of data, etc.
ADDED INFO. BY DRILLER, ITEM 15
CORRECTED BY: KS
ADDITION BY

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
ROGER OBERLITNER 1104
REGISTERED BUSINESS NAME REGISTRATION NO.
Address R#3 ITHACA, MICH
Signed Roger Oberlitner Date 6-23-1972
AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

SW SW SW

County	Twp.	Fraction	Section No.	Town	Range
Gratit	Bethney	~~S E/2 NW~~ ¼ ¼	30	T I2 N N/S.	R 2 W E/W.

Distance And Direction from Road Intersections: 685 ftN of Jackson Rd, on State Rd, I20 ft East. Street ~~North~~ State Rd, St Louis Mich.

OWNER No.

3 OWNER OF WELL: Leo Simon. Address 1021W Superior. Alma Mich.

2 FORMATION		THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay Yellow	0 – 7	7	7
Sand Gray	7 – I5	8	I5
Blue Clay	I5 –95	80	95
Brown Clay	95 –I50	55	I50
Course Gravel	I50 – I70	20	I70
I50 –I70 Course Gravel Mixed With Fine Sediment, Porisity Poor.			

4 WELL DEPTH: (completed) I70 ft. Date of Completion 7 5 67

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

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

7 CASING: Threaded ☒ Welded ☐ Height: Above surface I ft.
Diam. 4 in. to I60 ft. Depth. Weight I089 lbs/ft.
37/8 in. to I70 ft. Depth. Drive Shoe? Yes ☒ No ☐

8 SCREEN: Silicon Red Brass
Type: Dia.: 37/8 OD.
Slot/Gauze 25 Length IO ft.
Set between I60 ft. and I70 ft.
Fittings: 3in female top end, Johnson packe

9 STATIC WATER LEVEL 45 ft. below land surface

10 PUMPING LEVEL below land surface
I60 ft. after 8 hrs. pumping 40 g.p.m.
I60 ft. after 8 hrs. pumping 40 g.p.m.

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

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

13 GROUTING:
Well Grouted? ☒ Yes ☐ No Beonite &Clay.
Material: ☐ Neat Cement ☐
Depth: From 0 ft. to 70 ft.

14 SANITARY:
Nearest Source of possible contamination
55 feet E Direction Septic Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
Manufacturer's Name Reda
Model Number 41311 HP 3/4
Length of Drop Pipe I20 ft. capacity I4 G.P.M.
Type: ☒ Submersible ☐ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
FM & CS Oberlitner (REGISTERED BUSINESS NAME) 034I (REGISTRATION NO.)
Address 4664 N State Rd Alma Mich.
Signed (AUTHORIZED REPRESENTATIVE) Date 7 5 67.

D67D 100M 6-66 JAN 4 1968

GEOLOGICAL SURVEY COPY

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
GRATIOT	BETHANY	NE¼NE¼SW	30	12 N/S	2 E/W

Distance And Direction from Road Intersections: 72' S. OF ROAD. 506 E STATE ST ST LOUIS. 3. BLOCKS. OF. OLD 27

Street address & City of Well Location

OWNER No.

3 OWNER OF WELL: CHRIST OF

Address: PARSONAGE SAME

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
0 TO 4' MUCK	4	4
4' TO 48' CLAY	44	48
48 TO 74 HARD CLAY		
+ GRAVEL	26	74
74' TO 190' CLAY		
+ GRAVEL	116	190
190' TO 198' Gravel		
+ WATER SAND	8	198

4 WELL DEPTH: (completed) 198 ft. Date of Completion MAR. 27-1968

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

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

7 CASING: Diam. 4 in. to 193 ft. Depth; ___ in. to ___ ft. Depth; Threaded ☒ Welded ☐; Height: Above/Below surface 1 ft.; Weight 11 lbs/ft.; Drive Shoe? Yes ☒ No ☐

8 SCREEN: JOHNSON Type: REDBRASS Dia.: 4" Slot/Gauze 12 Length 5' Set between 193 ft. and 198 ft. Fittings: 3" PIPE + PACKER

9 STATIC WATER LEVEL ___ ft. below land surface

10 PUMPING LEVEL below land surface 56 ft. after 1 hrs. pumping 40 g.p.m. ___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

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

14 SANITARY: Nearest Source of possible contamination 60 feet N Direction SEPTIC TANK Type Well disinfected upon completion ☐ Yes ☒ No

15 PUMP: Manufacturer's Name TAIT Model Number A5D48 HP ½ Length of Drop Pipe 84 ft. capacity 10 G.P.M. Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

ADDED INFO. BY DRILLER. ITEM NO. map 12

CORRECTED BY:

ADDITION BY:

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

REGISTERED BUSINESS NAME ___ REGISTRATION NO. 416

Address R 2 ST Louis Mich 48880

Signed Russell Fox Date June 7 1968

AUTHORIZED REPRESENTATIVE

D67D 100M 6-66

JUN 13 1968

GEOLOGICAL SURVEY COPY

WATER WELL
ACT 294 PA 1965
PUBLIC HEALTH

WELL

Twp.	Fraction	Section No.	Town	Range
Bethany	SW¼SW¼SW¼	30	12 N/S.	2 E/W.

Direction from Road Intersections: Corner of Jackson + State Rd 232 Dr. State and 45 ft East of Road
City of Well Location
OWNER No.

3 OWNER OF WELL: Geo Simon
Address: 1931 W Superior
Alma, Mich

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	5	5
Sand + Clay	1	6
Clay + Stones	20	26
Hard clay	15	41
Hard Clay	12	53
Clay Sandy	8	61
Stoney Clay	21	82
Clay + Sand	13	95
Water Sand	6	101

4 WELL DEPTH: (completed) 101 ft. Date of Completion Jan. 30, 1970

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

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

7 CASING: Diam. 4 in. to 96 ft. Depth; Threaded ☐ Welded ☒
___ in. to ___ ft. Depth
Height: Above/Below surface 1 ft.
Weight 11 lbs/ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN:
Type: Johnson 55 Dia.: 4 11
Slot/Gauge 10 Length 5'
Set between 96 ft. and 101 ft.
Fittings: Drive Shoe, Puddin Packer
Sand Pipe

9 STATIC WATER LEVEL
40 ft. below land surface

10 PUMPING LEVEL below land surface
53 ft. after 1 hrs. pumping 15 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

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

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

13 GROUTING:
Well Grouted? ☒ Yes ☐ No
Material: ☐ Neat Cement ☒ Clay + Sand
Depth: From 9 ft. to 17 ft.

14 SANITARY:
Nearest Source of possible contamination
76 feet NE Direction Septic tank Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
Manufacturer's Name Gould
Model Number VE30641B HP ½
Length of Drop Pipe 63 ft. capacity 15 G.P.M.
Type: ☒ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Wayne Wells Drilling 0977
REGISTERED BUSINESS NAME REGISTRATION NO.
939 W Address DeLauer Rd
St Louis, Mich
Signed ___ Date Jan. 30, 1970
AUTHORIZED REPRESENTATIVE

067D 100M 6-66

MAR 17 1970 GEOLOGICAL SURVEY COPY

GEOLOGICAL SURVEY COPY