LICENSE APPLICATION
ON-SITE THORIUM DISPOSAL AT THE SALZBURG LANDFILL

MIDLAND, MICHIGAN

Prepared For:

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Explanation of Radiological Units Used In Text

Ci   Curies = a measure of the rate of radioactive decay

MCi = millocurie = one thousandth of a curie = 10^{-3}Ci

PCi = picocurie = one trillionth of a curie = 10^{-12} Ci

PCi/g = picocuries/gram of material

PCi/l = picocuries/liter of water

PCi/m^3 = picocuries/cubic meter of material

Rem   Roentgen equivalent man = a quantity used to express the effective dose equivalent to human tissue for all forms of ionizing radiation.

mrem = millirem = one thousandth of a rem = 10^{-3} rem

μrem = microrem = one millionth of a rem = 10^{-6} rem

E + 02 = 10^2

E - 02 = 10^{-2}

Final License Application
On-Site Thorium Disposal at the
Salzburg Landfill, Midland, Michigan

1.0 Introduction

1.1 SUMMARY OF PROPOSED ACTIVITIES

Dow Chemical U.S.A. (Dow), an operating unit of the Dow Chemical Company, is seeking the permission of the United States Nuclear Regulatory Commission (NRC) to dispose of limited quantities of radioactive material at a Dow facility in Midland, Michigan. Dow has decided to apply, under the provision of 10 CFR Part 20.302, to dispose of the material at a Dow owned and operated disposal area, the Salzburg landfill that is currently licensed for the disposal of hazardous and nonhazardous waste by the Environmental Protection Agency (EPA) and the Michigan Department of Natural Resources (MDNR). Materials to be disposed are currently located at two nearby Dow facilities, referred to the Bay City and Midland sites.

The proposed actions required to dispose of the thorium material include excavating the material at the Bay City and Midland sites to residual concentrations of less than 10 pCi/g of thorium-232 above background. This will allow the sites to be released for unrestricted use. The material will then be transported to Salzburg Landfill, and disposed of in a cell meeting hazardous waste landfill design criteria. The disposal cell has been specifically designed for the disposal of thorium contaminated material.

During excavation, health physics monitoring of personnel will be performed in accordance with applicable regulations. Dust suppression using water or other techniques will be employed on an as needed basis. Monitoring for potential airborne releases will be performed. However, due tc the lack of residences near either site the potential for public exposures is minimal. Previous monitoring of earthmoving activities on the slag piles indicated airborne radiation levels to be well below Maximum Permissible Concentrations (MPC's).

Transportation from the two sites to Salzburg will be by truck. The trucks will be covered with tarpaulins to minimize dust releases during transportation. Trucks will be washed, as necessary to remove external contamination, and monitored before they are allowed to leave any of the three sites.

The material will be placed in the disposal cell and compacted to minimize void volume. The disposal cell, while a single connected unit, will be shaped to best fit the designated land area and maintain a necessary separation from the site boundary. The cell is designated as Cell 36/37 in this application. Once all the material has been relocated to Salzburg, any portion of the cell remaining empty will be filled with non-hazardous fill to bring the level in the cell to the elevation on which the cap will be constructed.

It is expected that the proposed action could be completed within a two year period following NRC approval. The first year will be used to construct Cells 36/37. The bulk of the thorium material can be moved to the Salzburg facility in approximately 2-3 months.

After closure, Dow expects that their license for the storage of the thorium-bearing material will be terminated.

1.2 SUMMARY OF PROJECTED IMPACTS

Conservative projections of radiological impacts to remediation workers and members of the public have been made for the steps in the process of excavating and handling the thorium material at Bay City and Midland, transporting it to Salzburg, and disposing it in Cell 36/37. In addition, exposures to an inadvertent human intruder at the Salzburg site after disposal have been modeled. The analyses performed and results obtained are described in section 7.1.2, Performance Assessment, with the detailed calculations being provided in Appendices F and I.

These analyses show that the limited term remediation process will not result in temporary exposures to any worker or member of the public exceeding applicable Federal and State regulatory limits. Upon completion of removal and stabilization of the Bay City and Midland sites, and emplacement and cover of the trench at Salzburg, long term exposures at each location will be at background levels. Table 1.2-1 provides a direct comparison between the projected maximum individual radiological exposures (for Bay City material) and the applicable regulatory limit. In no instance do any remediation workers or members of the public approach the annual limit, nor do the maximum exposures to the public increase the normal annual background radiation exposures of 70 mrem in Michigan by more than 0.6%.

TABLE 1.2-1

Projected Maximum Individual Radiological Exposures

For Remediation Process

(MREM/ACTIVITY)

Individual	Maximum Whole Body Exposure	Regulatory Limit
Nuclear Workers		
1) Bay City remediation worker	198	5000 (1)
2) Truck driver	1980	5000
3) Salzburg construction worker	990	5000
Non-Nuclear Workers and General Public		
4) On-Site non-nuclear worker	0.003	500 (1)
5) Hypothetical Resident at Facility Boundary	0.405	500
6) Bystander (onlooker) during material transport	0.00007	500
Inadvertent Intruder at Salzburg	1.5	25 (2)

1) Based on 10CFR 20 limits

2) Based on 10CFR 61 limits for radioactive waste disposal facilities

2.0 JUSTIFICATION OF THE ON-SITE DISPOSAL ALTERNATIVE

Six alternative disposition schemes were investigated leading to the decision to proceed with an on-site disposal license application. These are:

- No Action.
- Disposal at an existing commercial LLRW disposal site.
- On-site temporary storage followed by off-site permanent disposal at a future commercial LLRW disposal site.
- Treatment of slag and soil by reprocessing to recover the thorium and then dispose of the residual wastes.
- On-site disposal under 10 CFR Part 61.
- On-site permanent disposal under 10 CFR Part 20.302 (the preferred alternative).

The advantages and disadvantages of these alternatives are briefly described below.

2.1 NO ACTION ALTERNATIVE

The no action alternative consists of maintaining the current status of the magnesium-thorium slag piles as continued long term storage with appropriate monitoring and maintenance.

Advantages

The primary advantage of the no action alternative is its low cost. The continued monitoring of ground and surface waters and long term maintenance of the caps on the slag piles would not require major allocation of resources beyond that required to maintain the other Dow facilities in the area. In addition, leaving the material in place minimizes the potential for increased occupational exposures during remediation and removal in the short term.

Disadvantages

The primary disadvantage of the no action alternative is its unacceptability as a long term solution under the NRC's guidance provided in SECY 81-576, for either the Bay City Site or the Midland site. Under SECY 81-576, the activity of most of the material would dictate excavation and reburial at another site and imposition of institutional constraints on future uses of the sites.

The regulators, the public, and Dow are all apparently in agreement that the no action alternative is not an acceptable option, and it has been considered only to serve as a base case.

2.2 DISPOSAL AT AN EXISTING COMMERCIAL LLRW DISPOSAL SITE

This alternative consists of removing the material from both sites and transporting it off-site for disposal at one of the three LLRW disposal sites which are currently operating.

Advantages

This alternative complies with the currently accepted NRC requirements. Public and regulatory concern over ultimate disposition of the thorium bearing material would be alleviated.

Disadvantages

The primary disadvantages of proceeding with this alternative are high cost and uncertainty over waste acceptability. With the large volume of material involved, the cost associated with disposal at one of the currently operating LLRW disposal sites would be at least $80,000,000. A cost estimate is provided in Appendix A. Additionally, there is some uncertainty over whether any of the sites would accept such a large volume of soil with such a low specific activity.

The three operating commercial disposal sites are licensed to accept waste material classified as Class A waste such as the slag. However, the Barnwell, South Carolina facility is operated under a set of disposal practices which may exclude the slag.

Recent experience has shown that the commercial burial sites and their host states are reluctant to accept high volume, low activity Class A material like the slag, primarily because it uses part of the limited amount of disposal volume remaining at the site when it would be more profitable, and in the national interest, to reserve the available burial volume for higher activity waste. This situation is likely to persist until a number of other commercial sites have been developed under the Compact programs thus substantially increasing the available disposal space. A recent example tends to confirm this situation. The States of Nevada and Washington have prevented shipment of radium-contaminated waste from New Jersey to the Beatty or Richland sites run by U.S. Ecology. In a conversation on 6/24/87, with Dames & Moore, U.S. Ecology indicated that the radium shipment was refused because it was not licensed source material. However, U.S. Ecology also indicates that their burial facilities would accept Class A material processed under license (such as the slag) with special cost schedules imposed.

A further disadvantage of this alternative is that transport of the material will require 2,000-5,000 truckloads (depending on size of the truck) to be moved over local and interstate roads for long distances (>1000 miles). This will heighten public concern, cause an incremental increase in routine exposure along the route, and create the potential for accidents resulting in environmental releases based on application of normal accident statistics.

2.3 TEMPORARY STORAGE AND DISPOSAL AT A NEW COMMERCIAL LLRW DISPOSAL SITE

This alternative consists of maintaining the current status of the magnesium-thorium slag piles until the compact's LLRW disposal facility is available. Then, the waste would be excavated, removed, and shipped to the new facility for disposal.

Advantages

The primary advantage of this alternative is its regulatory acceptability. The material would be disposed in a secure facility which will be licensed under 10 CFR Part 61. The long term environmental and public impacts at the two storage locations would be reduced to negligible levels, and public and regulatory concern over the ultimate disposition of the two storage locations would be alleviated.

Disadvantages

The two major disadvantages of this alternative are the uncertainty associated with the Compact siting and licensing process, and the costs associated with disposal at a future commercial LLRW facility. Disposal of the material at a commercial facility requires maintaining the current status of the material storage areas for an uncertain time period (at least 5-7 years) until the compact's site selection, licensing, and development process is completed. Proceeding with this alternative is likely to be the most costly of those considered since disposal fees at a new compact facility would likely exceed those at currently operating sites. In addition, while the distance to a new Compact site would be less then to an existing commercial site, the same disadvantages of increased public concern and accident potential would be associated with transportation of this quantity of material to the site.

In summary, this alternative is not attractive since, although it could meet the regulatory objectives, there would be an uncertain waiting period associated with the start up of a new Compact disposal site and the cost of disposal would be very high.

2.4 TREATMENT BY PROCESSING FOR THORIUM RECOVERY

The treatment and recovery alternative consists of processing the slag and soil to recover the thorium and then disposing of the residual waste at a licensed commercial LLRW disposal facility.

Advantages

The primary advantage of the treatment and recovery alternative is that the waste remaining to be disposed would have a reduced thorium concentration.

Disadvantages

There are many disadvantages to proceeding with this option. First, a site for processing the thorium pile would have to be selected, licensed by NRC, and developed. National Environmental Policy Act (NEPA) requirements for this alternative would have to be fulfilled and may include an environmental assessment (EA) or even an environmental impact statement (EIS).

Following processing, the residual waste would still require disposal and it is likely that the total volume would not be reduced. In addition, the recovered thorium, which has no current economic value, would contain concentrated activity potentially preventing its disposal as LLRW.

In summary, although this alternative is potentially viable, the added cost of developing and licensing a processing facility, which may not reduce the total volume of materials to be disposed of, and could produce a waste stream which would be difficult to dispose of, does not make it a logical choice.

2.5 ON-SITE DISPOSAL UNDER 10 CFR PART 61

This on-site disposal alternative consists of removing the thorium-bearing material from its existing locations and disposing this material in a Dow facility which meets 10 CFR Part 61 standards.

Advantages

The primary advantage of this alternative is that it would alleviate public and regulatory concern over disposal since the potential long term environmental and health impacts would be reduced to As Low as Reasonable Achievable levels (ALARA). There would be no need to acquire additional lands for this purpose assuming that the material could be disposed on land already owned by Dow. The facility could be sited to maximize the distance to potential receptor locations. In addition, the volume of waste requiring shipment off-site would be minimized.

Disadvantages

The primary disadvantage associated with this alternative is the uncertainty of timing. Site selection, characterization, licensing, and facility design and construction could take 6 - 8 years under the new 10 CFR 61 regulatory process before material could be disposed at the new facility. Additionally, given the existence of a state LLRW siting initiative, it is unlikely that a second facility for the Dow thorium-bearing material would be allowed by the State of Michigan.

In summary, while this alternative is potentially technically viable, the uncertainty associated with the regulatory process makes this alternative unattractive.

2.6 ON-SITE PERMANENT DISPOSAL UNDER 10 CFR PART 20.302

This on-site disposal alternative consists of removing the thorium-bearing material from its present locations and disposing this material in a Dow facility under the provisions of 10 CFR Part 20.302. The proposed action entails disposal of the material at Dow's Salzburg Landfill in a cell meeting hazardous waste landfill design criteria. The disposal cell will be specifically designed for the thorium-bearing material.

Advantages

The primary advantage of this alternative is that the site has already been licensed to operate and currently accepts hazardous wastes. Therefore site selection and characterization has already been completed and approved as part of the company's RCRA Part B and Michigan Act 64 permits to operate the Salzburg Landfill. Therefore, the regulatory process associated with a 20.302 application is estimated to take less than six months, permitting an early completion of final disposal of the material. In addition, the public and regulatory concern over disposition of the material would be alleviated because the environmental and public health impacts would be minimized to ALARA standards. There would be no need to acquire additional lands for this purpose since the material would be disposed of at an operating facility already owned by Dow. The location of the Salzburg Landfill adjacent to Dow's Midland facility will minimize the transport distance and thus the disadvantages associated with the offsite transport options. In addition, the occupational exposures associated with this option would be minimized. In preliminary discussions with State and Federal officials, no major regulatory impediments to this preferred alternative have been identified.

Disadvantages

The primary disadvantage associated with this alternative is the fact that there is no precedent in which similar volumes of thorium bearing material have been disposed of under 10 CFR Part 20.302.

Conclusion

The 2.6 alternative is the preferred choice since: 1) this option will best meet occupational, environmental and public ALARA objectives; 2) projected costs are much lower than for off-site disposal; and 3) no major unsolved regulatory issues have been identified.

3.0 DESCRIPTION OF MATERIAL

The radioactive material being considered for disposal at Salzburg consists primarily of foundry slag containing low levels of thorium. This material was produced in the period from 1940 to 1970 as the residual from the production of magnesium-thorium alloy. This lightweight alloy was used for defense purposes, including aircraft engines and aeronautical structural components. The slag was originally stored, with plans of reclamation, on two Dow properties in Michigan. Some other thorium contaminated material from a decommissioned third site was added to the Bay City pile in 1985, under NRC review.

A single license was originally granted by the NRC in 1973 for the two sites (Bay City and Midland) to store up to 200,000 pounds of thorium as slag. This license expired in 1978, but has remained in effect under timely renewal. Currently, Dow is proposing to combine the two slag piles at the Dow-owned Salzburg Landfill under the provisions of 10 CFR 20.302, allowing the current license to be terminated. The Salzburg Landfill is licensed by the Environmental Protection Agency (EPA) under the requirements of the Federal Resource Conservation and Recovery Act, and by the Michigan Department of Natural Resources (DNR), under the state Hazardous Waste Management Act, Public Act 64 and Act 641.

3.1 ISOTOPIC ACTIVITY

The material slated for disposal originally consisted of magnesium with up to two percent thorium. In its present state, portions of the process slag have been mixed with soil or limited amounts of construction debris; in addition, there has been some emplacement of the material outside the boundaries of the Bay City site. As a result of this mixing, the thorium concentrations, as determined by Dow soil sampling, vary from 2 - 7000 pCi/g at the Bay City site, and from 2 - 2000 pCi/g at the Midland site. As summarized in Table 3.1-1, the total activity of 9.7 Ci of Th-232 is distributed through ~52,000 cubic yards of slag, soil, and construction debris.

TABLE 3.1-1

Thorium-232 Activity and Concentrations

	Bay City	Midland
Total Activity (Ci)	9.2	0.46
Volume (cubic yards)	40,000	12,000
Average Concentration (pCi/g)	188	29
Maximum Concentration (pCi/g)	7000	2000

Since the thorium bearing material has been in-place for over 20 years, it is assumed that the thorium-232 daughters are in equilibrium. Table 3.1-2 lists the thorium-232 decay chain.

3.2 METAL CONCENTRATIONS

The concentrations of heavy metals in the Bay City and Midland slag have been determined using the EP-Tox test for these constituents. As shown in Table 3.2-1 the concentration of all metals is within permissible limits.

TABLE 3.2-1

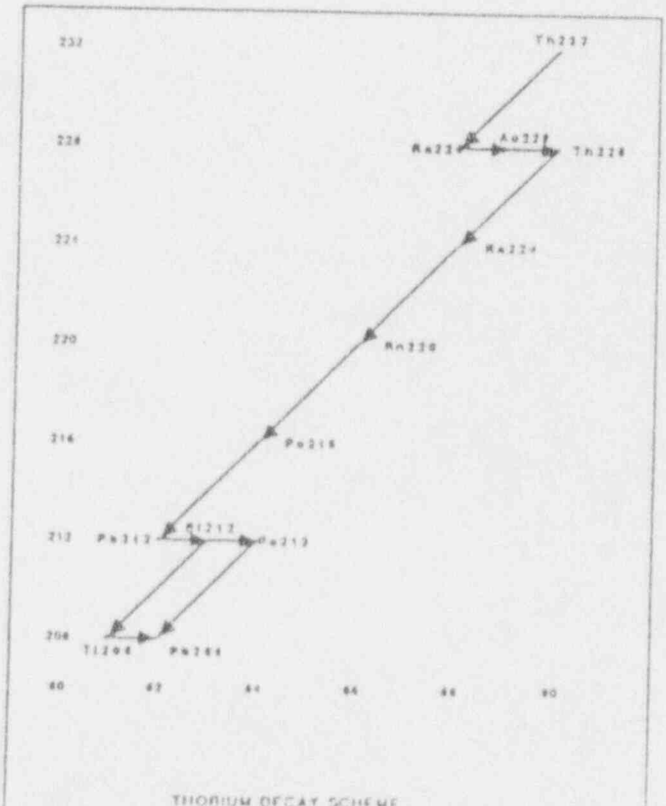
Heavy Metals Concentration

Constituent	Maximum Allowable Concentration (mg/l)	Measured Concentrations (mg/l) Bay City	Midland
Arsenic	5	ND(1)	ND
Barium	100	ND	ND
Cadmium	1	ND	ND
Chromium	5	ND	ND
Copper	100	ND	ND
Cyanide	20	ND	ND
Lead	5	ND	ND
Mercury	0.2	ND	ND
Selenium	1	ND	ND
Silver	5	ND	ND
Zinc	500	ND	ND

(1) Not detected at or above maximum allowable concentrations (± 10% RSD). Bay City results from 5 samples; Midland results from 3 samples.

Table 3.1-2
Thorium Decay Scheme

Element	Atomic Weight	Half-life	Radiation
Thorium	232	1.4×10^{10} yr	Alpha
Radium	228	6.7 yr	Beta
Actinium	228	6.13 hr	Beta
Thorium	228	1.9 yr	Alpha
Radium	224	3.64 days	Alpha
Radon	220	54.5 sec.	Alpha
Polonium	216	0.14 sec.	Alpha
Lead	212	10.6 hrs.	Beta
Bismuth	212	60.5 min.	Alpha Beta
Polonium	212	10 sec.	Alpha
Thallium	208	3.1 min.	Beta
Lead	208	Stable	



THORIUM DECAY SCHEME

3.3 NUMBER OF DISPOSALS

The disposal activity proposed under this application covers only the thorium contaminated material at the Dow facilities in Bay City and Midland, Michigan. Excavation of the piles and subsequent burial at Salzburg is viewed as a single disposal, even considering the volume of material

3.4 MATERIAL VOLUME

The material intended for disposal is presently in two locations. Over time, portions of the material have been mixed with clean soil and, at the Bay City site, with limited amounts of thorium-contaminated construction debris.

At Bay City, it is estimated that there is a total of up to 40,000 cubic yards of material with thorium concentrations above 5 pCi/g, including soil and construction debris. The average activity is estimated to be about 188 pCi/g of thorium-232, with a range of 2 to 7000 pCi/g. The total activity is estimated to be about 9.2 Ci. Applying a cleanup criteria of 10 pCi/g would permit the volume of material removed from the Bay City Site to be reduced by about one-third.

At the Midland site, the total volume of thorium-bearing material is estimated to be 12,000 cubic yards. Total thorium-232 inventory is about 0.46 Ci, with an average activity estimated at 29 pCi/g, in a range of 2 to 2000 pCi/g.

The volumetric estimates of soil to be removed at each site were obtained by initially performing a walk through gamma survey on a square grid to determine and record the locations having elevated readings. Core samples were then collected at the sites and analyzed for elevated radiation levels. At Midland borings were made on a 50 foot grid and at locations having elevated gamma levels, drilled at 2 foot depth intervals, until 2 consecutive samples showed below 5 pCi/g thorium concentrations. At Bay City, borings were made and samples taken at 1 foot intervals down to natural soil. At Midland 60 borings were made and approximately 400 at Bay City to obtain the data from which cross sections were plotted and the volumetric concentration distribution established.

The sampling and analysis methodology used in these surveys and that will be generally followed to validate the success of the material excavation program is:

1. Core samples are collected using a split spoon tool at sample locations are clearly identified using some type of secure marker for future use.

2. Samples are taken at depth intervals of one foot at the specific locations. Each sample at the represented depth is placed in a labeled one pound tin and sealed. The sample is then analyzed for radioactivity content before any further drilling is performed to determine if additional drilling is necessary to obtain samples at lower depths within the pile. Each sample is numbered and the number coded for each hole and depth definition.

3. The on site analytical tool is a highly shielded sodium iodide crystal. Known concentrations of thorium traceable to the National Bureau of Standards are used as calibration standards. Sample tins are placed in a plastic bag and inserted into the shielded area of the detector with care to avoid contamination of the detector. This will serve to give a good estimate of the activity of the sample and maintain an uncontaminated detection system.

4. To lower the background and to assure no inadvertent contamination of the detection system occurs from wind born dust, etc., the system will be located off the pile itself though in the most convenient place possible.

5. When a sample analysis shows background levels of radioactivity, the sample is set aside for activation analysis to confirm this reading. After a sample shows background levels of radiation at a particular depth, the drilling continues to obtain an additional sample one foot below the previous sample. This sample also is analyzed to obtain an accurate account of the thorium concentration. Samples in which thorium is detected with the use of the onsite calibrated sodium iodide detection system, are labeled with the exposure rate value and stored on site. These samples do not need any further analytical work.

3.5 MATERIAL FORM

The material originally consisted of magnesium with up to two percent thorium. In its present state, portions of the material have been mixed with soil or limited amounts of construction debris. The slag is a soil-like material.

The construction debris found at the Bay City site also contains thorium. The debris came from the Wellman site in Bay City which was previously decommissioned. That decommissioning program was completed under NRC review in 1985. The construction debris consists primarily of masonry with very limited amounts of organic material (wood).

3.6 CHELATING AGENTS

Material to be disposed of under this application consists of thorium-contaminated slag, soil, and construction debris. No chelating agents are known or suspected of having been used, nor will any be used in conjunction with the material disposal.

3.7 PROHIBITION OF HAZARDOUS WASTE

It is acknowledged that disposal of waste defined as hazardous under the regulations of the Environmental Protection Agency, 40 CFR Parts 260 through 265, is not appropriate under 20.302. The radioactive material slated for disposal under this application is not categorized as hazardous. However, the proposed disposal facility is within a landfill sited, designed, constructed, and permitted for disposal of hazardous waste.

3.8 EXISTING MATERIAL STORAGE AREAS

3.8.1 Bay City Site

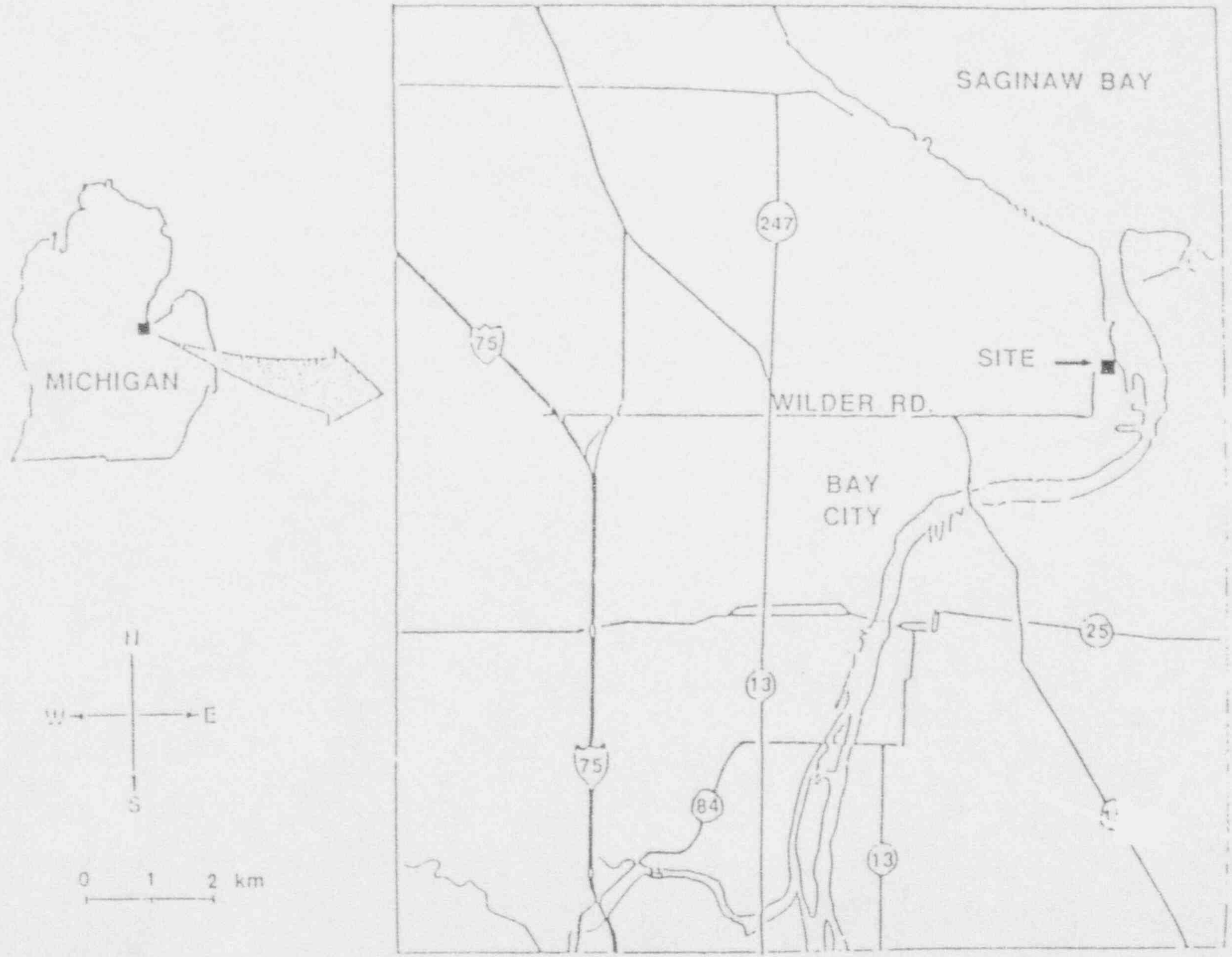
The Bay City site is located near the town of Bay City, Michigan. The site is on property owned by Dow about one mile south of Saginaw Bay. Figure 3.7-1 shows the site location. The site is about 20 miles east of the Salzburg facility.

The magnesium-thorium material is located adjacent to and north of an inlet canal, which enters the Saginaw River to the east. The Saginaw River, as shown on Figure 3.7-2, is located to the north and east of the material.

The area surrounding the material is relatively level, with some marshy areas and ponds. Typically the material sits approximately 5 to 10 feet above the water level in the inlet canal.

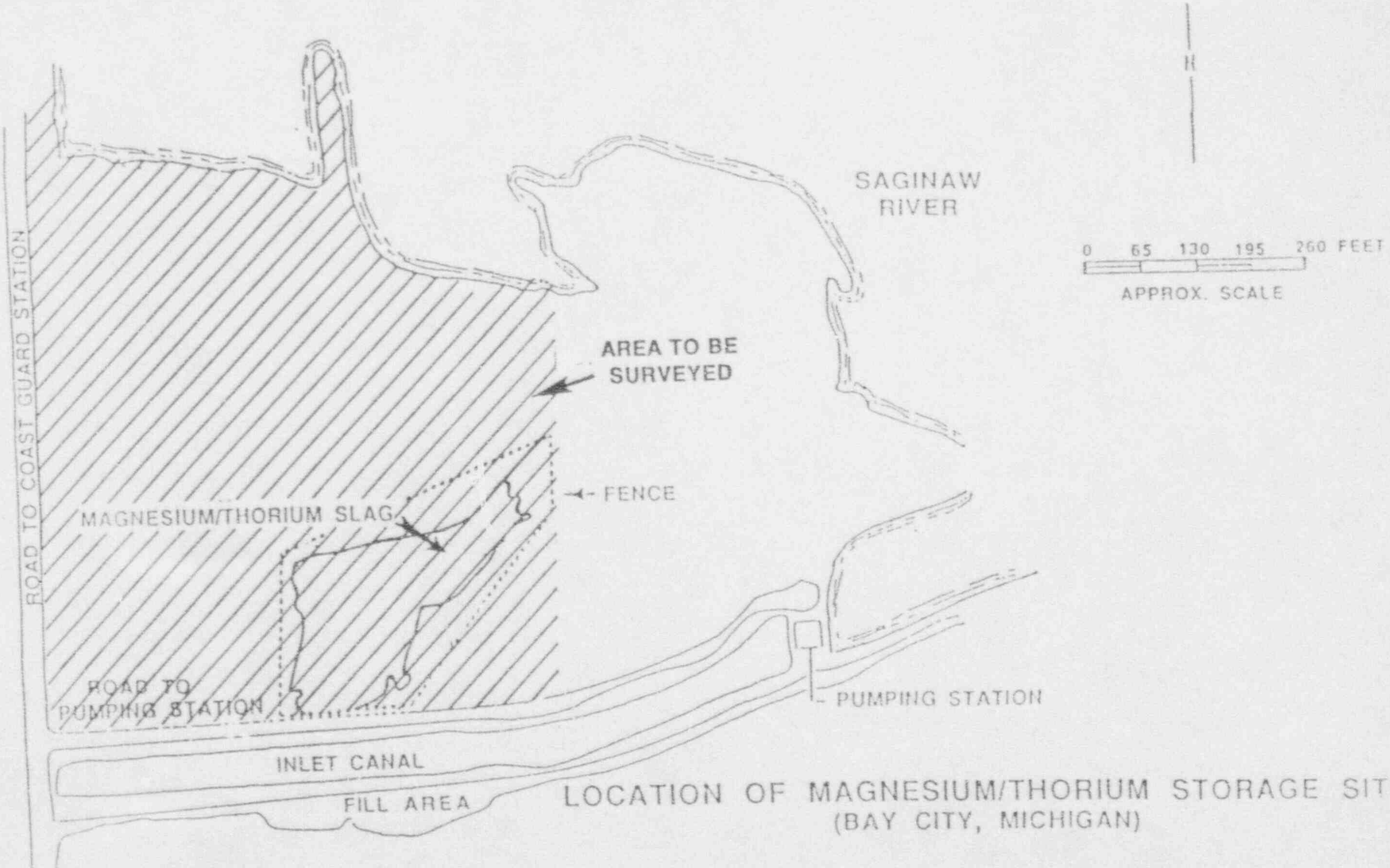
Most of the thorium activity in the material is contained within the fenced area shown on Figure 3.7-2. However, soil sampling conducted by Dow has shown that some thorium-containing material is also present outside of the fenced area in locations to the north, west, and east of the pile.

The highest concentration Bay City material is currently partially covered with an asphaltic sealant and is fenced. However, the cover contains cracks and has weathered, and is no longer impervious. The entire area is posted and delineated with a rope barrier.



MAP OF MICHIGAN AND BAY CITY

Dames & Moore
FIGURE 3.7-1



LOCATION OF MAGNESIUM/THORIUM STORAGE SITE
(BAY CITY, MICHIGAN)

Dames & Moore
FIGURE 3.7-2

3.8.2 Midland Site

The Midland thorium storage site is located at Dow's Midland, Michigan manufacturing facility. The thorium material is located near a closed RCRA licensed surface impoundment previously used in waste water treatment. The Midland and Salzburg sites are shown on Figure 3.7-3.

Dow has completed closure of the Midland Diversion Basin surface impoundment based on the EPA and DNR approved closure plan for the facility. The material removed was sampled to assure that no material having radiological contamination (above 5 pCi/g level) was shipped.

Surrounding the thorium storage site is the Midland manufacturing facility. The entire Midland facility is fenced, with access restricted to authorized personnel. The material is posted as a radiation control area and marked off with rope. This facility is about 1.0 miles from the Salzburg facility.

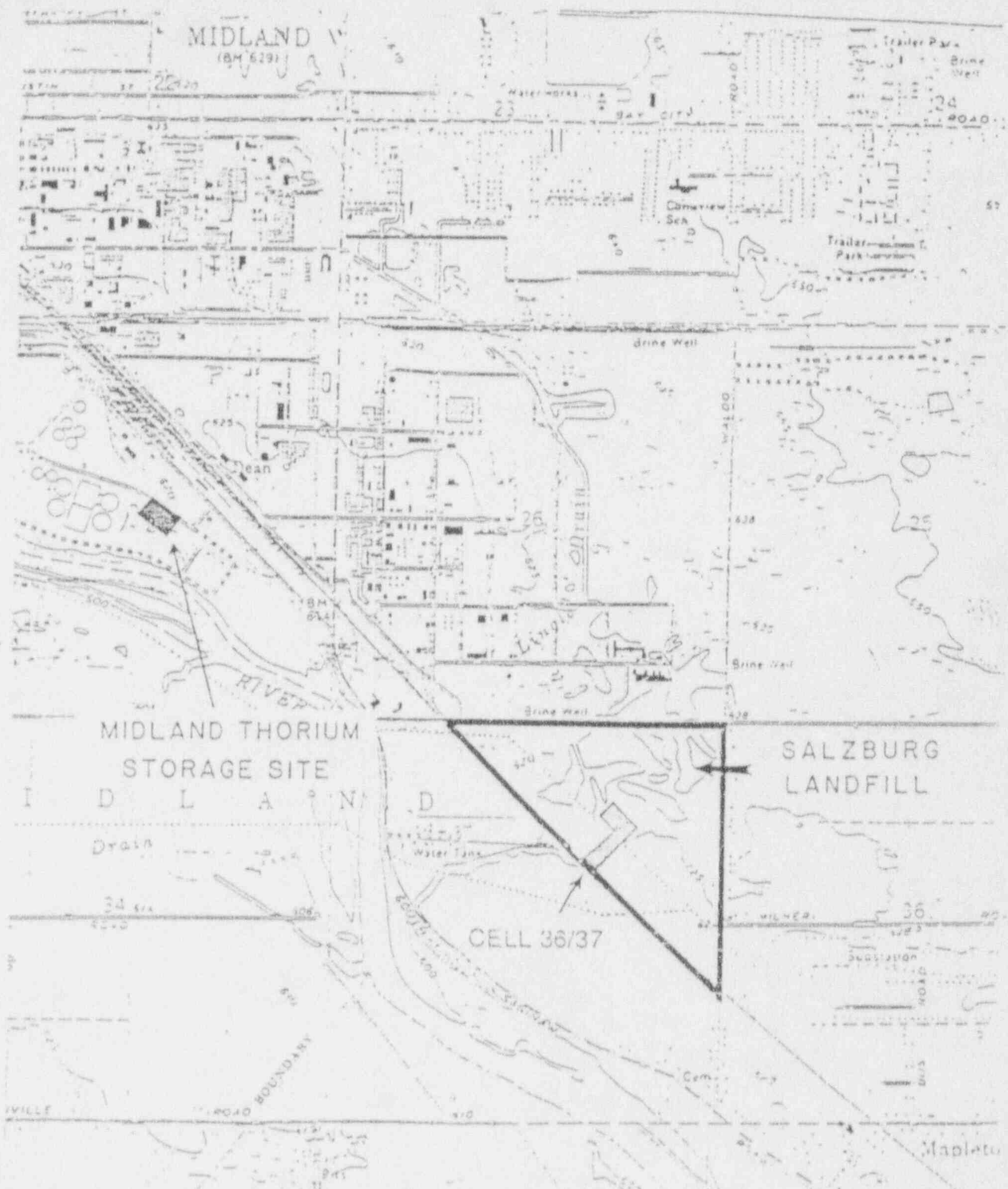
The material was covered with a clay cap in 1983. The cap averages about 1 to 2 feet thick with light vegetative cover.

3.9 STORAGE SITE CLOSURE

The material slated for disposal will be generated during the closure of Dow Chemical Company's storage sites in Midland and Bay City, Michigan. Closure plans have been developed for both sites to ensure that the thorium removal is performed with a high degree of personnel safety and environmental considerations in mind.

3.9.1 In-Process Surveys and Samples

Direct radiation measurements will be performed at the storage sites during thorium removal operations using pressurized ion chambers (PICs). These surveys will provide information for future comparisons between pre- and post-removal radiation levels to determine remediation effectiveness. The survey results will be correlated with soil sample analysis to obtain thorium concentrations in-situ during the excavation process. This provides a means of immediate determination of the need for further excavation if soil levels are above the 10 pCi/g standard.



MIDLAND THORIUM STORAGE SITE LOCATION

Dames & Moore
FIGURE 3.7-3

Direct radiation measurements will be correlated with soil concentrations by comparison with isotopic results. If the correlation is not adequate, additional soil sampling will be made until satisfactory correlation is achieved. This will allow characterization of the site in a much quicker, efficient, and cost-effective way than with numerous soil samples.

Protocols will be established to determine the calibration factor between the soil sample results and the corresponding direct radiation measurements. Such protocols will include measurement techniques, survey patterns, and equipment requirements.

In addition to sampling and surveying of the remaining soil (non-excavated), the excavated soil will be analyzed on a routine basis. These samples will provide information as to the concentration of thorium being removed for determination of remediation effectiveness and also provide required data for shipping purposes.

3.9.2 Post Removal Surveys and Samples

Upon removal of the bulk of the thorium material from within the storage sites more extensive survey and soil sampling programs will be instigated. This will provide the basis for release of the sites for unrestricted use. The criteria for unrestricted use is ≤10 pCi/g Th-232 soil concentration and 10 μrem/hr gamma level above background at 1 meter above the surface. The soil sampling programs will consist of both surface and subsurface soil samples.

A walkover survey of the area beyond the site perimeter (see Figure 3.7-2) will be conducted to assess the potential contamination of such regions. If thorium concentrations in excess of release criteria are identified, further characterization to define the extent of contamination will be done. These further measurements will determine the need for additional remediation efforts.

The surveys will be conducted using a calibrated PIC.

4.0 PACKAGING OF MATERIAL

The applicant does not intend to package the thorium-bearing material prior to emplacement. Increased occupational radiation exposures would occur during packaging of the material that can be avoided by bulk shipment and direct emplacement.

Bulk disposal of the material also minimizes creation of voids in the landfill which could ultimately lead to subsidence. The thorium contaminated soil and soil-like slag will be compacted to minimize subsidence. If, however, the slag and soil were placed in drums prior to disposal, a higher degree of subsidence would occur since the drums could not be filled 100%, the soil in the drums could not be compacted, and the space between canisters, even if backfilled with clean sand, would provide some additional void space for subsidence. These negative factors would adversely effect cover performance. Bulk management of the material is the preferred approach.

Thus, by foregoing packaging, the radiation exposure is lessened due to the reduction in handling and the integrity of the disposal site is more fully guaranteed.

5.0 DISPOSAL LOCATION

5.1 SITE LOCATION

Dow proposes to place the contaminated material in Cell 36/37 of the Salzburg Landfill, a Dow owned and operated facility licensed by the U.S. EPA and Michigan DNR for disposal of both hazardous and non-hazardous waste. It accepts only wastes produced by Dow operations.

The Salzburg Landfill is located in the southeast portion of the City of Midland, Michigan, as indicated in Figure 5.1-1. The landfill is approximately 1.0 mile from the Midland thorium storage area, and about 20 miles from the Bay City site.

The thorium material will be placed only in Cell 36/37 of the Salzburg Landfill. The Cell location is also shown on Figure 5.1-1. The Salzburg Landfill site map in the upper right hand corner of drawing B2-001 of Appendix G, attached, shows the locations of the other disposal cells in relation to Cell 36/37.

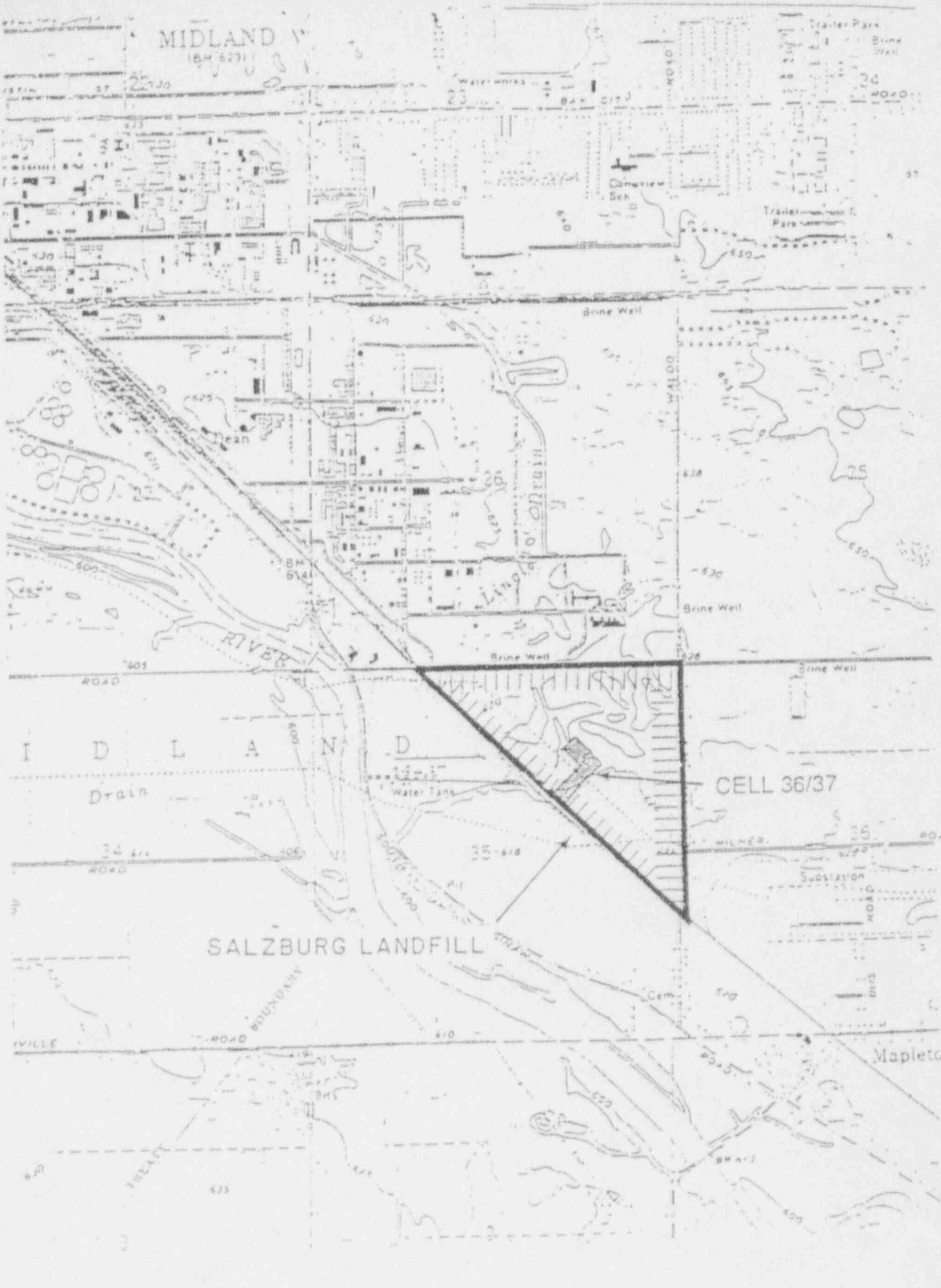
5.2 PROPERTY USES

The Salzburg Landfill is located on a 152 acre parcel of land owned by Dow. The only activity performed on-site is a state-of-the-art hazardous and non-hazardous waste disposal facility operated by Dow

Operation of the landfill is regulated at the state level by the DNR under the Hazardous Waste Management Act, Public Act 64 and Act 641. On the Federal level, it is an EPA-licensed facility which exceeds the requirements of the Resource Conservation and Recovery Act (RCRA). The landfill was recognized by the National Society of Professional Engineers as one of the top ten outstanding engineering achievements in the United States of 1985.

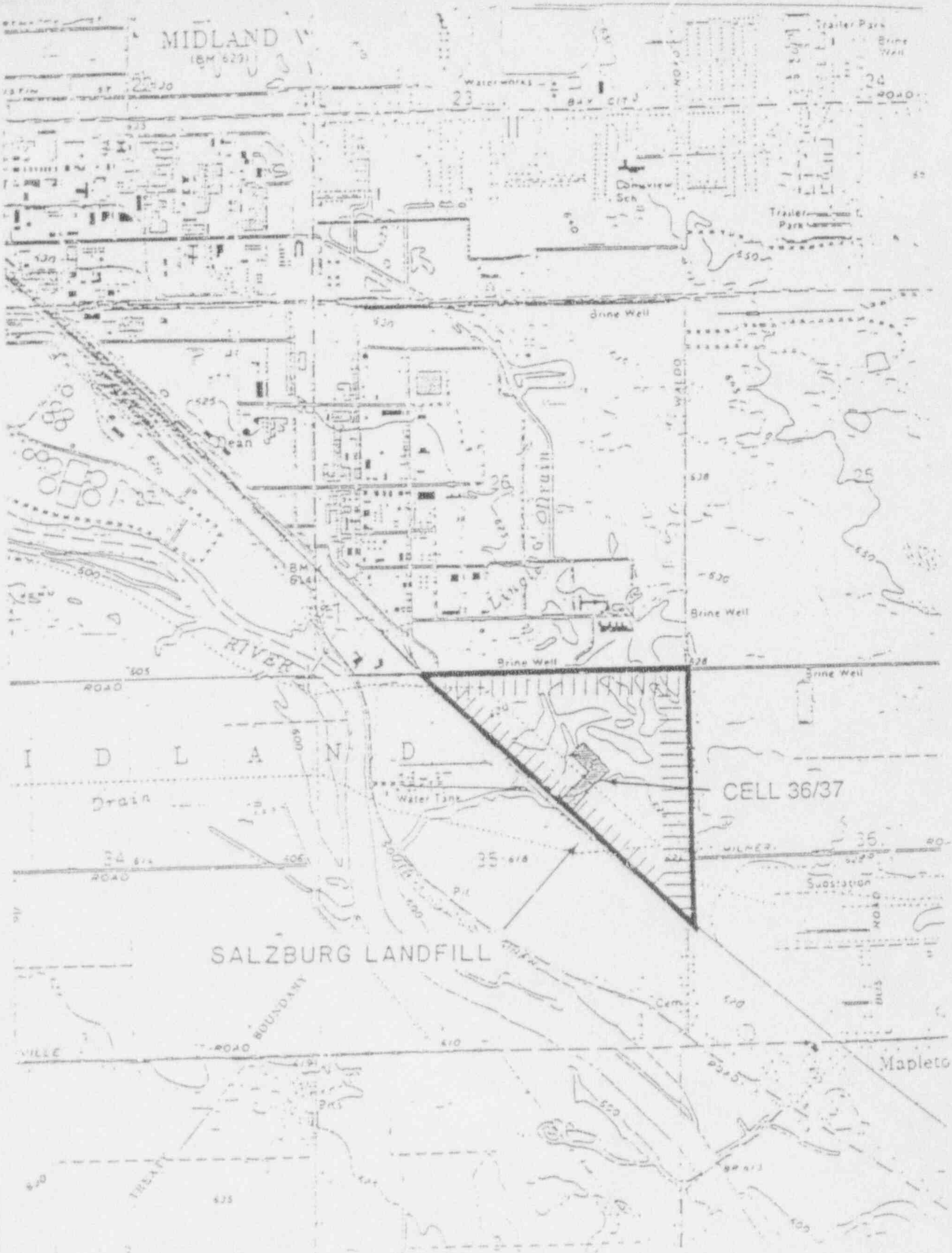
The facility is designed for disposal of the Dow Chemical U.S.A., Michigan Division, Midland location's incinerator ash, waste water treatment plant solids, and other solid production and demolition waste. Liquid wastes are not disposed at Salzburg.

The facility is a hazardous waste and non-hazardous waste co-disposal facility. Included at the facility are landfill cells, buildings containing a vehicle wash, spare



SALZBURG LANDFILL LOCATION

Dames & Moore
FIGURE 5.1-1



SALZBURG LANDFILL LOCATION

Dames & Moore
FIGURE 5.1-1

parts, utilities, lunch room, locker room, and office, control room, construction trailers, and contractor gate house.

5.3 NEIGHBORING ENVIRONS

The proposed site for disposal of the thorium contaminated materials is the Salzburg Landfill, a 152 acre parcel of land owned by the Michigan Division of the Dow Chemical Company. As indicated on Figure 5.3-1, the triangular property is bounded on the north by Salzburg Road, on the east by Waldo Road, and on the southwest by C&O Railroad tracks.

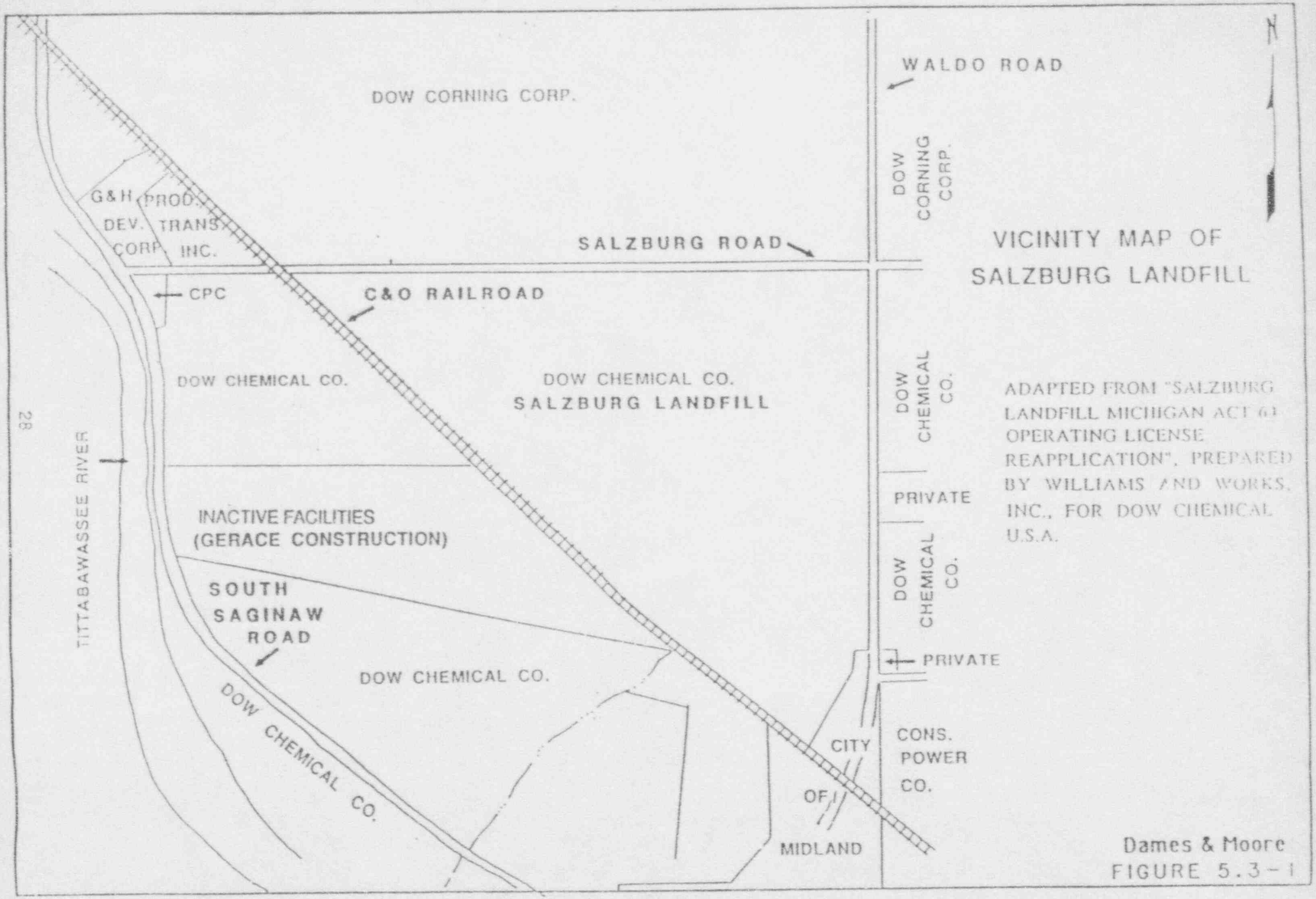
5.3.1 Nearby Properties

The map in Figure 5.3-1 indicates use of the land surrounding the Salzburg Landfill. North of the facility is Dow Corning Corporation production facilities. South of the facility are inactive production facilities and vacant land. East of the facility are vacant land and residential housing. West of the facility is the Waste Water Treatment Plant facility of Dow Chemical, U.S.A., Michigan Division, Midland Location. To the northwest of the facility are the G&H Development Corporation and Prod. Trans, Inc. (EDI, 1983).

The reapplication for an operating license under Michigan Act 64 describes plans for proposed future uses of land in the vicinity of the Salzburg Landfill as follows: (1)

> The site is in the midst of an expanding industrial complex. The majority of property in the area is heavily industrialized. The exception to this is immediately east of Waldo Road where residential structures exist (Dow is purchasing these houses as they become available). The industrial uses in the area are consistent with City and Township development plans [Figures 5.3-2 and 5.3-3].
>
> In August, 1979, the City of Midland Planning Commission approved a Comprehensive Development Plan to guide future growth in and adjacent to the City of Midland. Midland Township has also approved a development guide which generally corresponds to the City Plan. Contacts made with Midland Township Planning Commissioners and Midland City Planning Department during July, 1984, indicate zoning designations and land use have not changed since that time for the area surrounding the site.

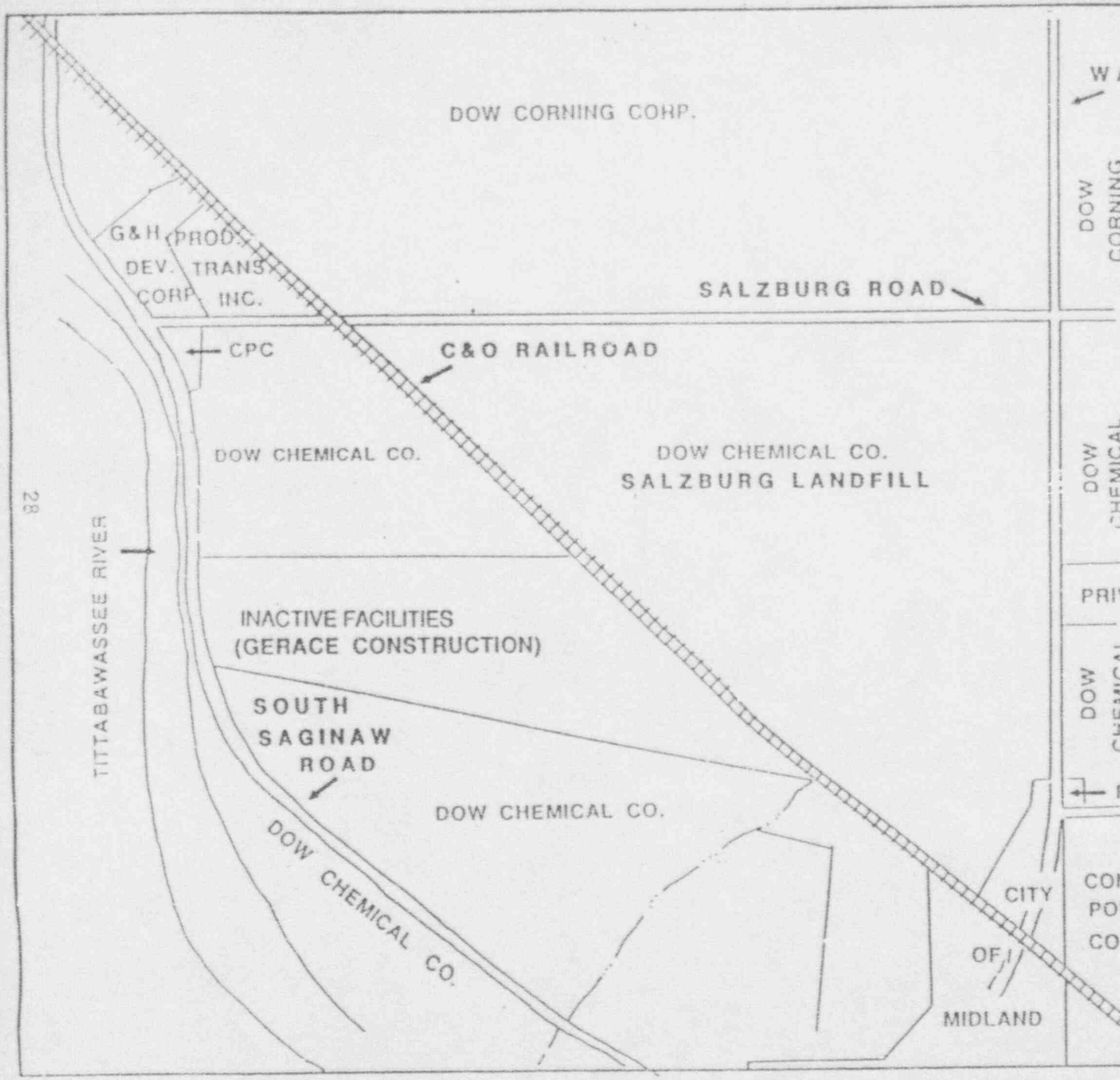
(1) Material quoted from other documents will be set off in the text by use of closely-spaced text as shown here. Quote symbols will not be used.



VICINITY MAP OF SALZBURG LANDFILL

ADAPTED FROM "SALZBURG LANDFILL MICHIGAN ACT 64 OPERATING LICENSE REAPPLICATION", PREPARED BY WILLIAMS AND WORKS, INC., FOR DOW CHEMICAL U.S.A.

FIGURE 5.3-1



VICINITY MAP OF SALZBURG LANDFILL

ADAPTED FROM "SALZBURG LANDFILL MICHIGAN ACT 64 OPERATING LICENSE REAPPLICATION", PREPARED BY WILLIAMS AND WORKS, INC., FOR DOW CHEMICAL U.S.A.

Dames & Moore
FIGURE 5.3-1

DOW CHEMICAL

CITY OF MIDLAND
AND
MIDLAND TOWNSHIP

LEGEND:

- RESIDENTIAL
- INDUSTRIAL
- CELL 36/37

N

NO SCALE

ZONING MAP

ADAPTED FROM "SALZBURG LANDFILL MICHIGAN ACT 64 OPERATING LICENSE REAPPLICATION", PREPARED BY WILLIAMS AND WORKS, INC., GRAND RAPIDS, MICHIGAN, FOR DOW CHEMICAL U.S.A

Dames & Moore

FIGURE 5.3-2

GENERALIZED DEVELOPMENT PLAN

ADAPTED FROM "SALZBURG LANDFILL MICHIGAN ACT 64 OPERATING LICENSE REAPPLICATION", PREPARED BY WILLIAMS AND WORKS, INC., FOR DOW CHEMICAL U.S.A.

Dames & Moore

FIGURE 5.3-3

Specifically, the site and adjacent property (City and Township) are designated for ultimate industrial development. These plans basically state that this land use category (industrial) provides for existing and future development of industry.

The City Zoning Ordinance (a development plan implementation tool) places the site into the Industrial "B" District. This zoning district is intended for a variety of intense industrial uses, including a landfill.

The Midland Township Zoning Ordinance has the property adjacent to the site zoned residential. This should only be considered a temporary zoning designation, since the Township Master Plan proposes this property be developed as industrial in the future". (EDI, 1984).

5.3.2 Nearby Residences

The nearest residences to the facility are along the east side of Waldo Road where there are homes that range in distance from 130 to 400 feet from the facility. Since February, 1980, nine of the homes along Waldo Road and Milner Road, adjacent to the facility, have been purchased by Dow Chemical U.S.A., Michigan Division, Midland location. Of the homes purchased, four were torn down and four homes continue to be occupied. Three of the homes remaining are owned by private individuals.

The remaining private residences are:

1. L. Bober, 4535 Milner Road
2. J. Trout, 1245 South Waldo Road
3. C. Witherspoon, 1131 South Waldo Road" (EDI, 1984)

Since the 1984 application, all but one of the Dow-owned homes have been torn down

5.3.3 Surface Waters

The only surface water in the vicinity of the Salzburg Landfill is the Tittabawassee River, which at closest approach is about 1200 ft. west of the landfill and over 2500 feet from Cell 36/37. The Tittabawassee flows southeast to join the Saginaw River at Saginaw, which then flows northeast to discharge into the Saginaw Bay at Bay City.

Flood flow projections for the Tittabawassee are provided in Appendix H.

5.3.4 Water Wells

All the residences across Waldo Road from the Salzburg Landfill have private wells. These wells range in depth from 35 to 155 feet, [note: some references indicate the deepest well is 160 feet] and the typical aquifer in which these wells are set consists of thin layers or pockets of sand in an otherwise clay formation. These private wells are the nearest to the facility.

In February, 1980 a door-to-door survey was conducted at the homes along Waldo Road and Milner Road to obtain information on the depth and performance of their wells and to obtain a water sample for chemical analysis.† (EDI, 1984).

The location of these homes and the owners names are shown on Figure 5.3-4. Table 5.3-1 summarizes the owner's responses to questions on well depth and performance. The table has been updated to include the most recent information available The wells range in depth from 35 to 160 feet.

5.4 Past Material Disposals

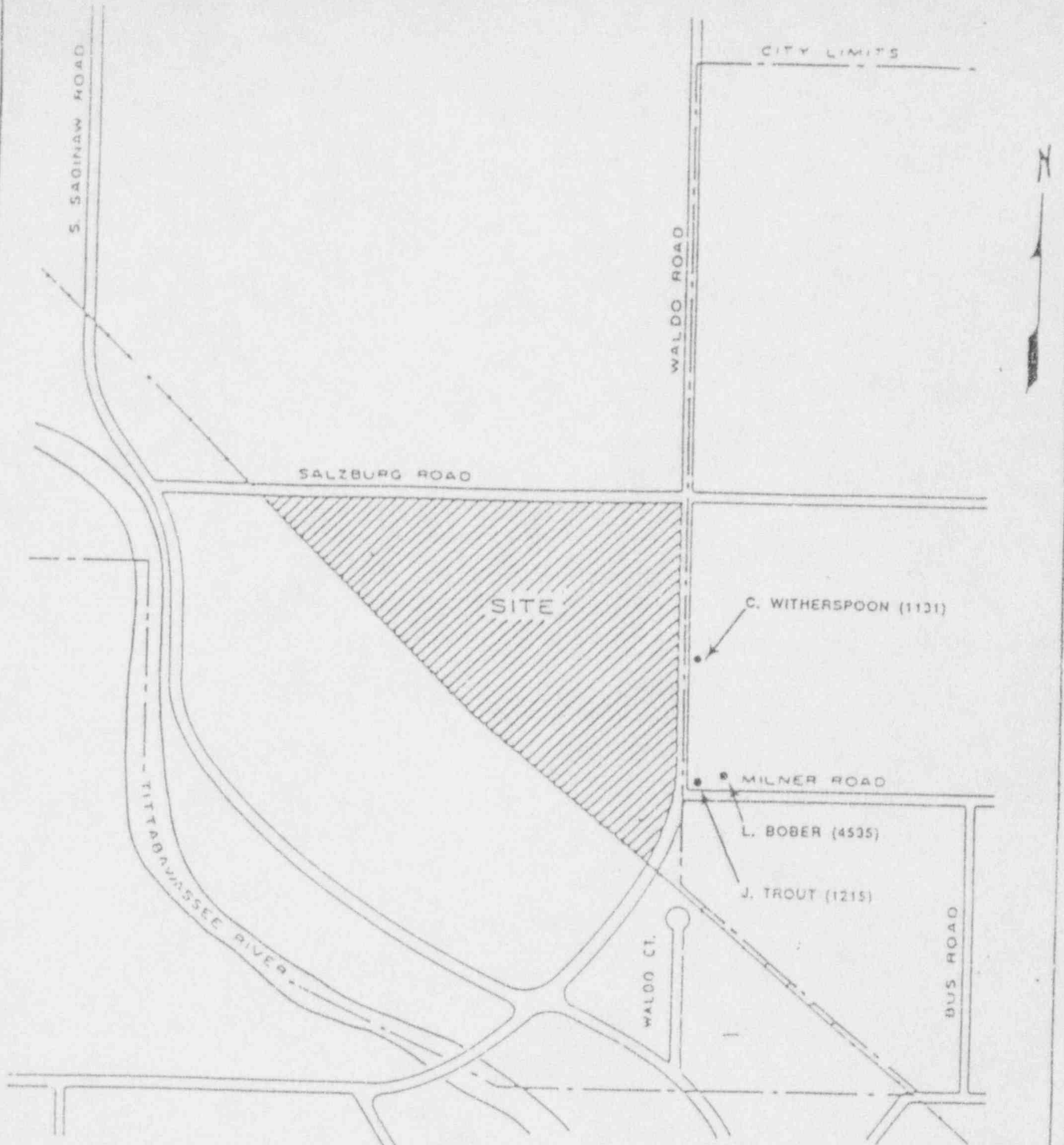
The proposed disposal site is a new cell, Cell 36/37, in a currently operating EPA/MDNR licensed hazardous waste disposal facility. The new cell (36/37) has not yet been constructed, and therefore has not been the site of any waste disposal. The cell will only receive the materials cited in this application. Typically, only solid wastes generated by the licensee are disposed of in cells elsewhere in the Landfill that are designed to a goal of no defects and no leaks.

As described in the RCRA Part B Application:

Hazardous wastes which would be considered for disposal in other cells at this facility are of several types:

- Incinerator ash and dewatered wastewater treatment plant solids,
- Waste containing hazardous concentrations of E.P. Toxic compounds such as chromium,
- Certain soil and spill clean-up materials potentially containing relatively low concentrations of specifically listed hazardous wastes,
- Certain solids containing RCRA listed hazardous wastes in categories F, K, D, and U (1986) such as:
  - Chlorobenzene
  - Benzanthracene
  - Acrylamide

It should be noted that the hazardous wastes for which the Landfill was designed, such as heavy metals, may remain hazardous for an indefinite period of time, since they do not decay.



HOMES EAST OF WALDO ROAD

ADAPTED FROM "SALZBURG LANDFILL MICHIGAN ACT 64 OPERATING LICENSE REAPPLICATION", PREPARED BY WILLIAMS AND WORKS, INC., FOR DOW CHEMICAL U.S.A.

Dames & Moore
FIGURE 5.3-4

Table 5.3-1

RESULTS OF PRIVATE WELL SURVEY (1984)

Map Location	Owner Name	Well Depth	General Comments
	Louis F. Bober	35'	Well is a "dug well", approx. 30" in diameter and located right outside the basement wall in back of the house. Well has perhaps 10 ft of masonry at the top in back of the house. Well has perhaps 10 ft of masonry at the top. Below is an uncased and unscreened open hole. The well dries up sometimes in the summer, and the owner has to use bottled water. Well is 37 years old.
(Removed)	Kenneth Hutfilz	106'	They had a dug well, but that went dry in the summer, so in the early sixties this deep well was drilled.
36-11	James Trout	40' to 60'	Have had problems with their well. Water smells bad. Had an analysis done which said it was high in sulfur. Water at time of this survey has an H_2S odor.
36-8	John Hochstetler (Dow)	134'	Have a water softener. Water has a brine taste, and do not use it for drinking or cooking. Bring in water for those purposes. Log in Appendix C.
Removed	Frank May	?	Has plenty of water. Previous owner sold water to homes on Waldo from Salzburg to Milner Roads. Owner believes pipeline is still in because Mr. Trout hit an underground line in his yard last year and Mr. May lost pressure in his water system until the line was capped.
36-7	J. Lewis Formerly Spencer	65'	Water quality is not adequate. Have trouble when neighbors make prolonged use of their well. Reported that many neighbors do their wash outside the because water supply is not adequate. Log in Appendix C.
36-5	Charles Witherspoon	160'	Well is 6" in diameter, but only yields 2 gals/min. Were out of water frequently until he lowered the drop pipe. Water smells and has a lot of rust sediment in it. In 1973 drilled 232' in an attempt to develop a new well Log of this abandoned well in Appendix C.
36-9	Dow (Formerly Gutchak)	98'	Water is salty and has a "fishy" smell sometimes.
(Removed)	Frank Baker	141'	Owner reports plenty of good quality water. No problems with bad smell or taste.

6.0 INSTITUTIONAL CONTROLS

6.1 Property Ownership

The proposed disposal site, the Salzburg Landfill, is owned and operated by the applicant, Dow Chemical U.S.A., Michigan Division.

The site is operated as a hazardous waste disposal facility, and appropriate notices have been included in the property deed (See Section 11.2).

6.2 PROPERTY ACCESS CONTROL

The facility is surrounded by a fifteen foot high perimeter fence. Normal access is through #90 gate, or #93 gate, the contractors' gate. Possession of gate cards and keys are controlled by the Dow Michigan Division Environmental Services Department. All gates are kept locked/closed, or a gate guard is stationed at the gate. Anyone entering the facility must have business at the facility to gain entrance.

Plant security maintains round-the-clock surveillance of the facility. Included in their responsibilities are routine inspection of fence lines, gate conditions, and surveillance for any unusual facility conditions. The perimeter fence is posted with signs reading "DOW", "PRIVATE PROPERTY NO TRESPASSING", and "WARNING UNAUTHORIZED PERSONNEL KEEP OUT".

Warning signs are posted at the entry point to the facility which instruct all personnel to report to the facility building prior to entering the area.

During periods of operation, Dow personnel in the area provide surveillance for unauthorized personnel.

All personnel are required to display an identification (ID) badge inside the fence line. Visitors are issued temporary badges which must be displayed while at the facility. Temporary ID badges are returned when the visitor leaves the facility. All contractor personnel must sign in and out of the facility at the contractor gate. All other personnel must sign in and out of the facility at the facility building. (Dow, 1986)

6.3 PERIOD OF RESTRICTED ACCESS

The applicant intends to continue operation of the hazardous waste disposal facility beyond the emplacement of the thorium-bearing materials, though no further disposal of radioactive material is intended or anticipated. Dow Chemical has estimated, in the RCRA Part B Application, that final closure activities for the Salzburg Landfill shall begin in the year 2017. Access control beyond 2017 may be required as part of the EPA or State permitting process. Additionally, a covenant to the deed was prepared, which is included as Appendix B.

7.0 NATURE OF DISPOSAL SITE

7.1 TYPES OF SOILS

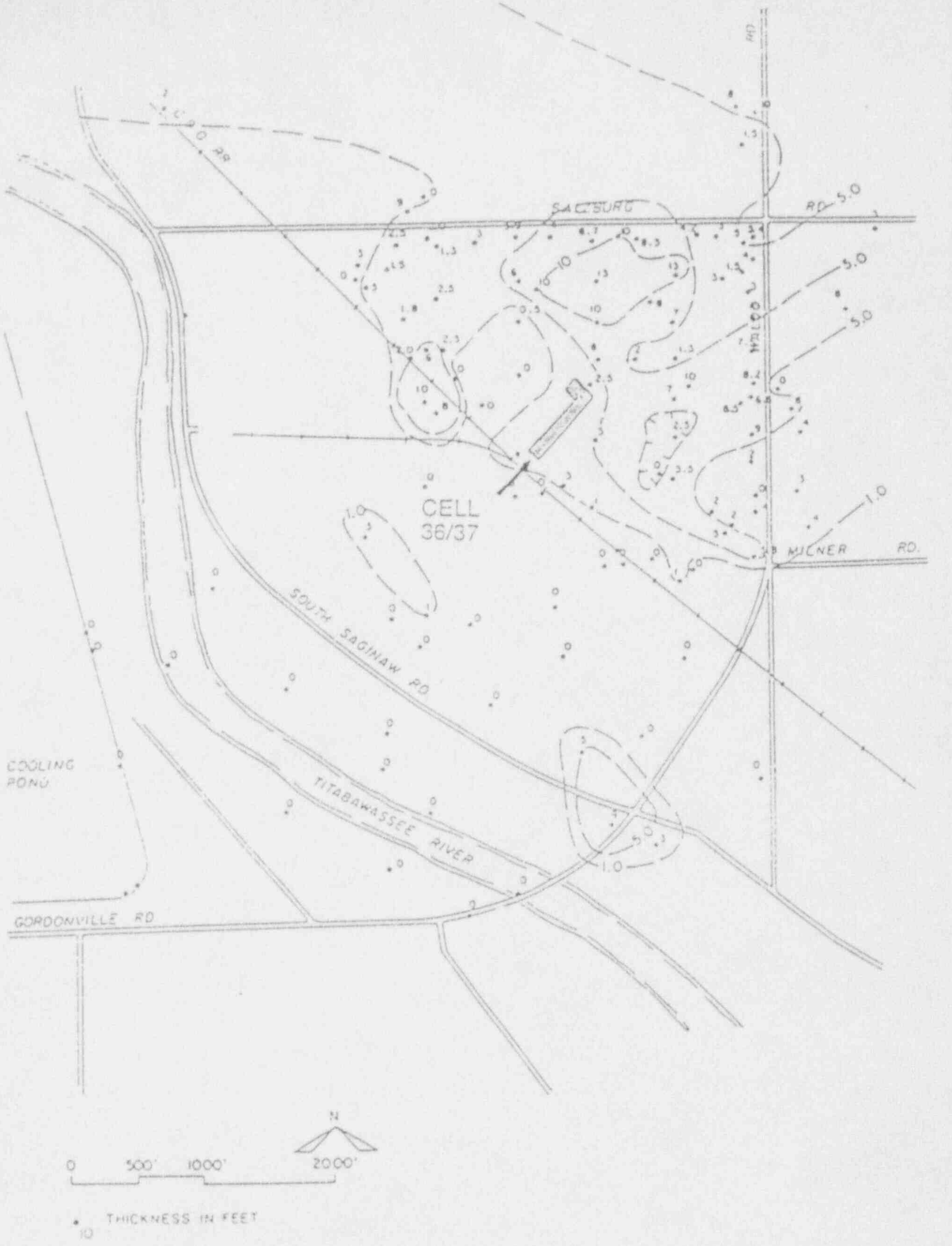
The soils at the Salzburg Landfill have been described and characterized as part of the RCRA Part B Permit Application and the supporting site investigations. Prior to the initiation of construction at the Salzburg Landfill, most of the site was covered with a surficial sand layer. This unit is described in Section E of the Part B Permit Application as follows:

> This surface sand unit consists of highly stratified fine sand and silt and contains thin layers of clay. The unit is particularly silty and clayey near the bottom where it grades into the more massive clay unit which underlies it.
>
> The 49 borings which were drilled for the landfill site evaluation show the surface sand layer to range from 0 to 13 feet in thickness with an average thickness of approximately 4 feet. Figure 7.1-1 is an isopach map showing the occurrence [of] the surface removed during excavation and construction of the liner failure detection system. (EDI, 1984)

As shown on Figure 7.1-1 the sand layer is approximately 2-3 feet thick at the location of Cell 36/37.

Beneath the shallow sand layer is a lakebed clay layer ranging in thickness from 14 to 24 feet. This lakebed clay overlies glacial till. The lakebed clay in the area of the thorium disposal cell will be excavated during construction of the cell. The clay is then used in the subsequent construction of clay liners and caps for the cell. Additional clay may also be used in cell construction if it meets construction specifications.

> During the original engineering study, sixty-three silt and clay samples from this [lakebed clay] unit were collected from the landfill site and analyzed for permeability, Atterberg limits, pH and particle size. Laboratory permeability ranged from 3.1×10^{-6} to 1.4×10^{-8} cm/sec, with 86 percent less than 1.0×10^{-7} cm/sec. Clay particles (less than 5 microns) comprise a significant fraction of all samples ranging from 23.4 to 96.2 percent with an average of 56.3 percent. The liquid limit ranged from 13.0 to 56.5 percent and average 36.2 percent. The plastic index ranged from non-plastic to 35.8 and averaged 16.6. The pH ranged from 7.3 to 8.9.



ISOPACH OF SURFACE SAND UNIT

ADAPTED FROM "SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E"
PREPARED BY EDI ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

Dames & Moore
FIGURE 7.1-1

Using the Unified Soil Classification, the unit is predominantly a CL clay with subordinate amounts of CH, SC, SP-SM, ML-CL, and ML soils.

The [glacial till] unit lies directly below the Lakebed Clay unit and could be identified during drilling by rock fragments (pebbles), hard drilling, and a more uniform, sandy, siltier texture than the overlying Lakebed Clay unit.

The matrix material of the Glacial Till unit is predominantly sand and silt, with a clay fraction that averages about 30 percent. This is in direct contrast to the Lakebed Clay unit where the clay fraction usually exceeded 50%. Twelve samples were collected from the upper 15 feet of the unit on the site and analyzed for permeability, Atterberg limits, pH, and particle size. Permeability ranged from 1.2×10^{-7} to 2.5×10^{-8} cm/sec, with 82% less than 1.0×10^{-7} cm/sec. The liquid limit and plastic index averaged 20.4 and 8.4, respectively, which are notably lower than for the Lakebed Clay. The pH ranged from 8.0 to 9.0, and the unit is a mix between the SM, SC, SC-SM, CL-ML and CL unified classes.

The deeper rotary borings within the landfill (Dow boring #'s 2708, 3009, 3010, 3011, 3012) and the older coal borings penetrate the entire Glacial Till unit in several places. The borings indicate an average thickness of the unit is approximately 125 feet beneath the Salzburg Landfill. (EDI, 1984)

7.2 STRATIGRAPHY

The stratigraphy of the soil is partially described in Section 7.1. This section repeats some of that information along with a more detailed stratigraphic description including descriptions of the deeper sandy aquifer and bedrock found beneath the landfill.

The glacial stratigraphy of the area underlying the Salzburg Landfill has been determined from coal boring and water well records dating back 80 years and from recent hydrogeological investigations conducted at the landfill. The deeper borings in these recent investigations were logged by geophysical methods which included electrical resistivity and gamma-ray methods. The records of these geophysical logs are included in Appendix [C]. During the original engineering study for the landfill, twenty-two continuous split-spoon borings were drilled on a 600-foot grid pattern. Although the original intention was to drill each of these borings to a depth of 40 feet, actual depths ranged between 21 and 40 feet due to hard drilling in the stiff till layer underlying the site. Twenty-one shallow auger borings were also drilled between the split-spoon borings to help determine the areal extent and depth of the surface layer of sand which blankets most of the site. These borings were drilled at least 5 feet into the clay and range from 8 feet to 19 feet in depth. From this information, four stratigraphic units have been identified above the bedrock. These units are termed, from top to bottom, "Surface Sand", "Lakebed Clay", "Glacial Till", and "Regional Aquifer". The unit names are derived from the relative position and/or geologic genesis of each unit.

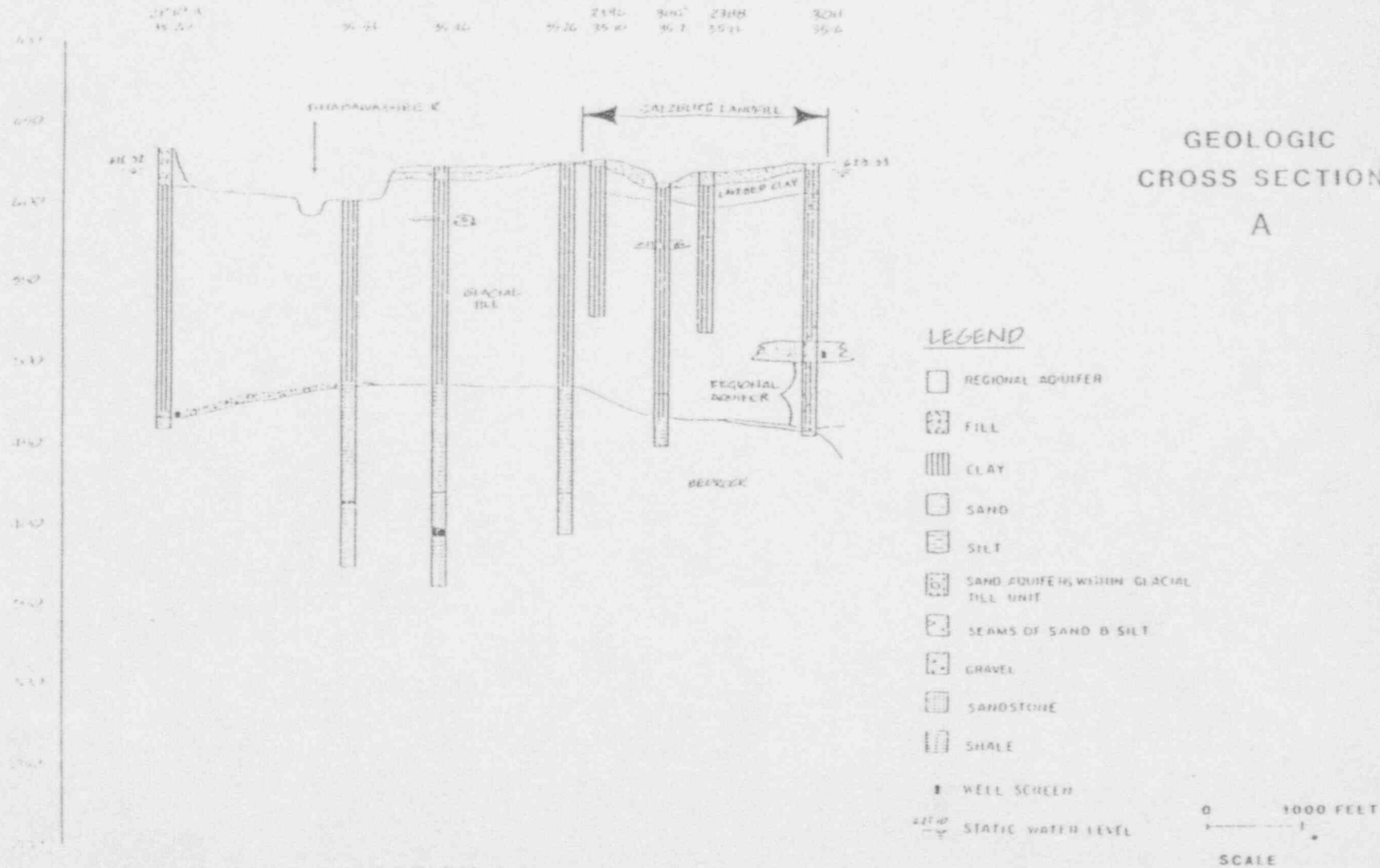
Four geologic cross-sections have been assembled from logs of wells and borings in the Salzburg Landfill area to aid in the interpretation of the hydrogeology and stratigraphy under the landfill [see Figures 7.2-1 through 7.2-4]. The cross section locations are shown on [Figure 7.2-5]. Geologic cross section A-A extends from the southwest corner of Section 35 across the Tittabawassee River and the Salzburg Landfill to the northeast corner of Section 35. Cross section B-B extends from the southeast corner of Section 35 north along the east boundary of the Salzburg Landfill, north along Waldo Road 3/4 mile in Section 26, to the north-northeast to Monroe Well #23 (24-2) in Section 24. Cross section C-C extends from west of Poseyville Road by the Westside Power Plant along the west bank of the Tittabawassee River, along the Consumers Power Cooling Pond berm, east-southeast across the Sludge Dewatering Facility, the Salzburg Landfill, and Waldo Road to the corner of Milner Road and Bus Road. Cross section D-D extends from west of the Sludge Dewatering Facility to the northeast corner of the Salzburg Landfill along the south side of Salzburg Road.

Surface Sand Unit: A surficial sand layer covers most of the landfill site. This surface sand unit consists of highly stratified fine sand and silt and contains thin layers of clay. The unit is particularly silty and clayey near the bottom where it grades into the more massive clay unit which underlies it.

The 49 borings which were drilled for the landfill site evaluation show the surface sand layer to range from 0 to 13 feet in thickness with an average thickness of approximately 4 feet. The landfill borings were drilled in late October and early November, 1979, following several months of dry weather, so the surface sand was dry. However, a seasonal saturated zone can be expected in this unit when water from rainfall or snowmelt is "perched" on the underlying clay. Figure [7.1-1] is an isopach map showing the occurrence the surface sand unit. Under the Salzburg Landfill, the Surface Sand will be completely removed during excavation and construction of the liner failure detection system.

Lakebed Clay Unit: The Lakebed Clay unit underlies the entire site directly below the surface sand and ranges from 14 to 24 feet thick. The contact between the Lakebed Clay and the Glacial Till is very sharp and distinct in the geophysical logs, particularly the resistivity measurements. The top of the unit lies at elevations between 617 and 622 feet. Bottom elevations are between 594 and 605 feet. For comparison, the bottom of the landfill's liner failure detection system is at an approximate elevation of 600 feet.

The unit is stratified and consists of clay layers mixed with varying fractions of sand and silt. Less than 10 percent of the unit consists of distinct sand, sandy gravel and silt layers. These layers are usually 0.5 feet or less in thickness and are interbedded within the clay. The sandy layers are often wet and are the source of most of the water in site borings. The clay is plastic due to high moisture content. During the excavation of the first 4 landfill cell groups (7 acres total), several saturated sand and gravel layers were encountered. The largest was about 25 feet wide, extending across several cells, and 2 to 3 feet thick on an average. These layers drained readily when first cut into, however the flow was temporary because there is essentially no hydraulic connection between layers.



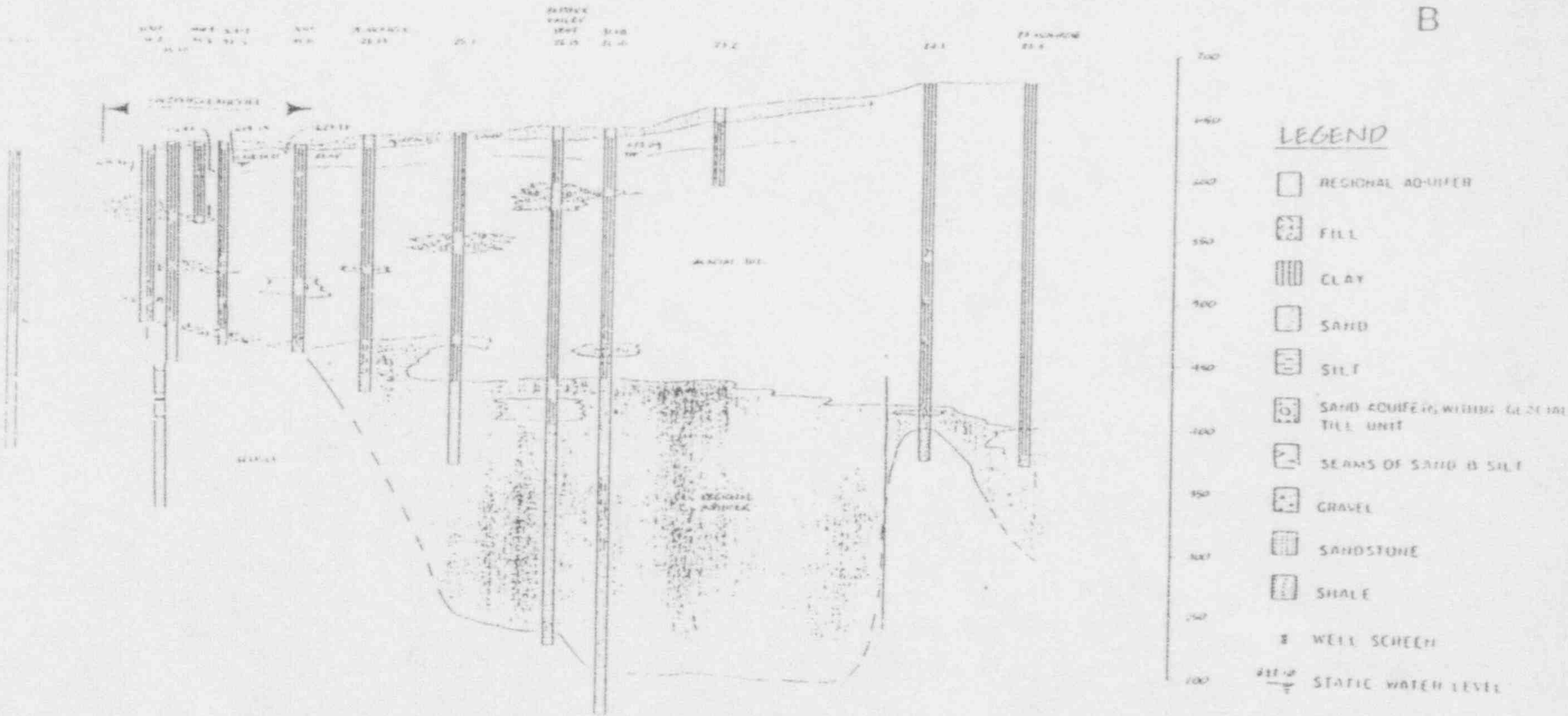
SECTION A

ADAPTED FROM "SA[illegible]BURG LANDFILL RCRA PART B APPLICATION, SECTION E"
PREPARED BY [illegible] ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

FIGURE 7.2-1

Dames & Moore

GEOLOGIC CROSS SECTION B



SECTION B

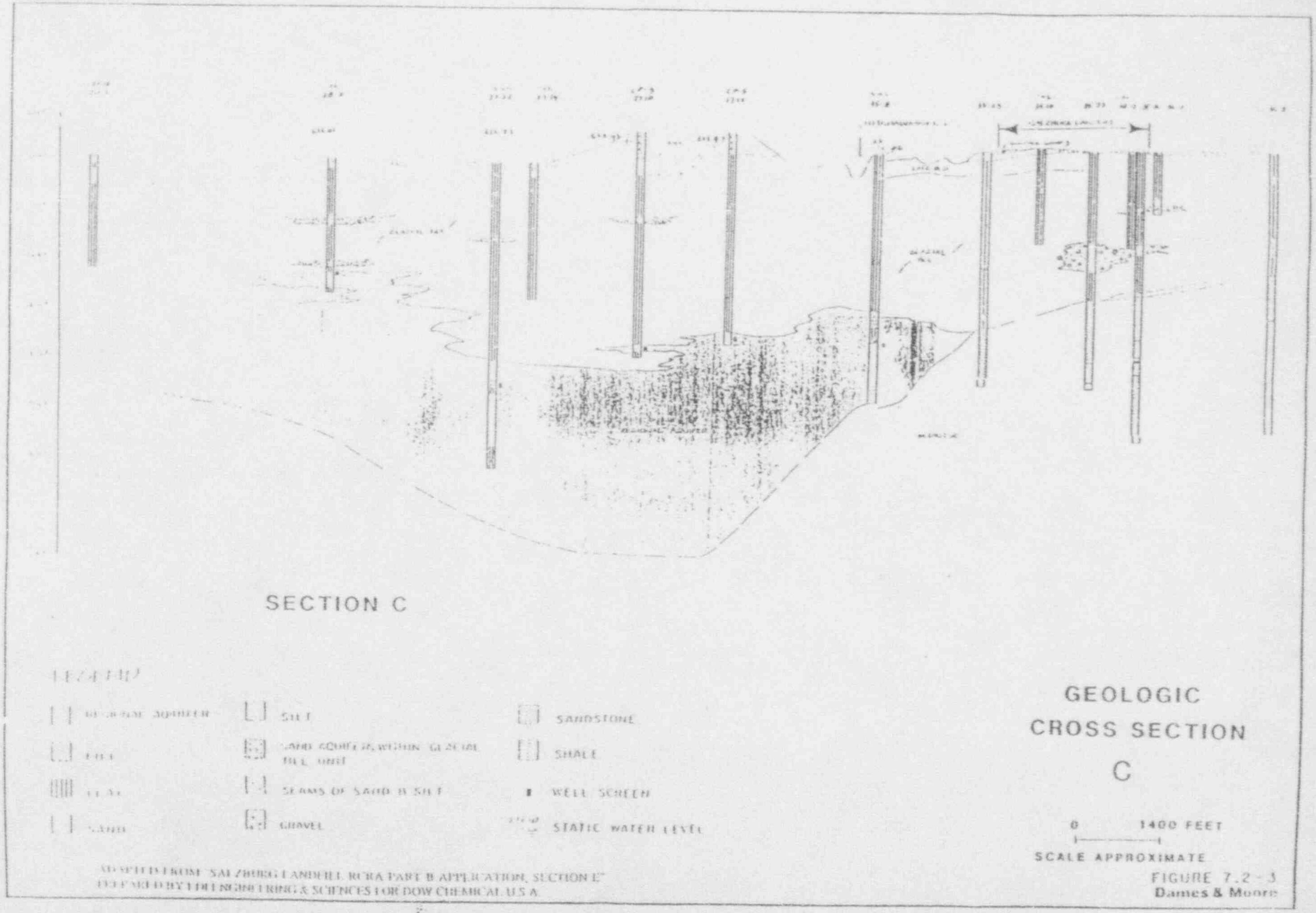
0 1400 FEET

SCALE APPROXIMATE

ADAPTED FROM "SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E" PREPARED BY [illegible] ENGINEERING & SCIENCE FOR DOW CHEMICAL U.S.A.

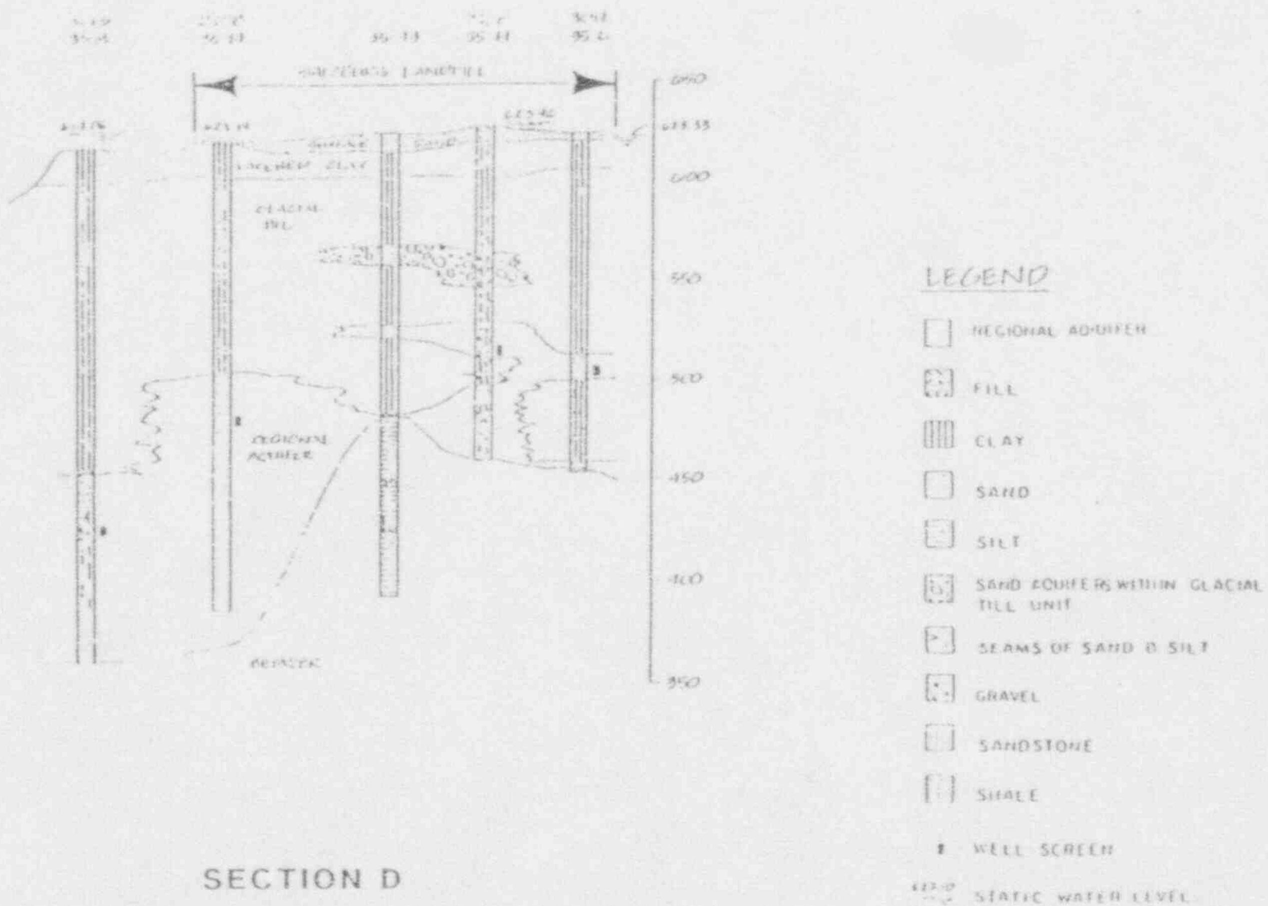
FIGURE 7.2-2

Dames & Moore



GEOLOGIC CROSS SECTION C

FIGURE 7.2-3
Dames & Moore



SECTION D

GEOLOGIC CROSS SECTION D

0 1000 FEET
SCALE

ADAPTED FROM: SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E
[illegible] ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

FIGURE 7.2-4
Dames & Moore

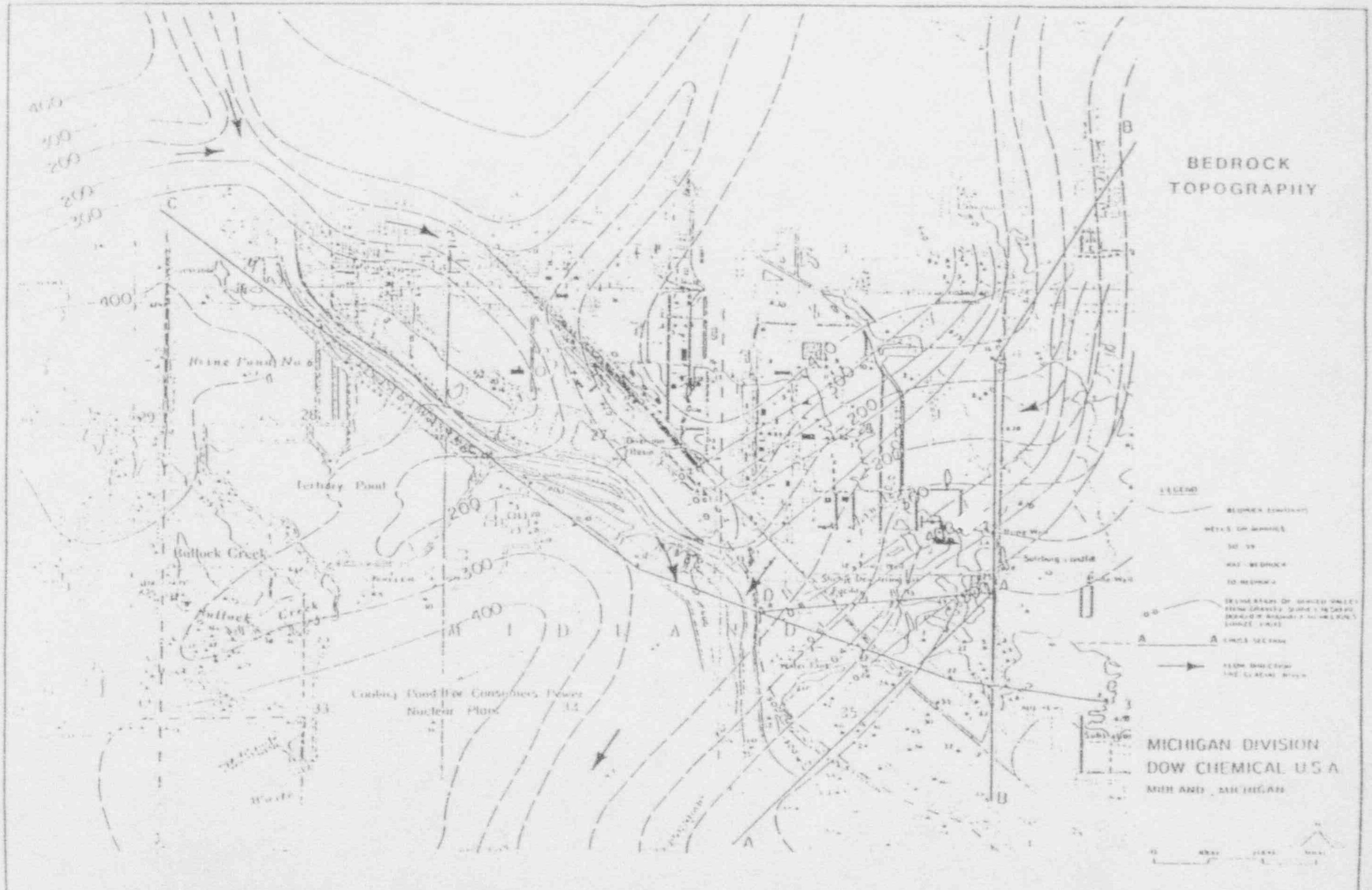


FIGURE 7.2-5
Dames & Moore

During the original engineering study, sixty-three silt and clay samples from this unit were collected from the landfill site and analyzed for permeability, Atterberg limits, pH and particle size. Laboratory permeability ranged form 3.1 x 10^{-6} to 1.4 x 10^{-8} cm/sec, with 86 percent less than 1.0 x 10^{-7} cm/sec. Clay particles (less than 5 microns) comprise a significant fraction of all samples ranging from 23.4 to 96.2 percent with an average of 56.3 percent. The liquid limit ranged from 13.0 to 56.5 percent and average 36.2 percent. The plastic index ranged from non-plastic to 35.8 and averaged 16.6. The pH ranged from 7.3 to 8.9. Using the Unified Soil Classification, the unit is predominantly a CL clay with subordinate amounts of CH, SC, SP-SM, ML-CL, and ML soils.

Glacial Till Unit: This unit lies directly below the Lakebed Clay unit and could be identified during drilling by rock fragments (pebbles), hard drilling, and a more uniform, sandy, siltier texture than the overlying Lakebed Clay unit. The unit is typically extremely tight, with local, infrequent saturated interbedded seams of permeable material. The geophysical logs in Appendix [C] show that considerable intervals of the glacial till unit have very uniform characteristics; however, there are also intervals which are clay rich and intervals which are more sandy. These sandy intervals form a sand subunit in the Glacial Till unit.

It is difficult to find an aquifer within the Glacial Till unit. However, evaluation of the boring and well logs drilled to date indicate that there are areas where the sand subunit within the Glacial Till unit is more prevalent. Figure [7.2-6] outlines the area in which sand was found between the 590 and 550 foot elevations. Several residential wells along Waldo Road are screened in this sand subunit. Water chemistry suggests these localized aquifers are recharged from the higher head Regional Aquifer below.

The matrix material of the Glacial Till unit is predominantly sand and silt, with a clay fraction that averages about 30 percent. This is in direct contrast to the Lakebed Clay unit where the clay fraction usually exceeded 50%. Twelve samples were collected from the upper 15 feet of the unit of the site and analyzed for permeability, Atterburg limits, pH, and particle size. Permeability ranged from 1.2 x 10^{-7} to 2.5 x 10^{-8} cm/sec, with 82% less than 1.0 x 10^{-7} cm/sec. The liquid limit and plastic index averaged 20.4 and 8.4, respectively, which are notably lower than for the Lakebed Clay. The pH ranged from 8.0 to 9.0, and the unit is a mix between the SM, SC, SC-SM, CL-ML and CL unified classes.

The deeper rotary borings within the landfill (Dow boring #'s 2708, 3009, 3010, 3011, 3012) and the older coal borings penetrate the entire Glacial Till unit in several places. The borings indicate an average thickness of the unit is approximately 125 feet beneath the Salzburg Landfill.

Regional Aquifer: This unit lies below the Glacial Till unit primarily in the bedrock valleys. The top of the unit lies at elevations between 420 and 460 feet in the area of the Salzburg Landfill. This unit pinches out against the bedrock hill under the landfill so that the Glacial Till rests directly on the bedrock hill. The elevation of the top of the hill under the landfill is approximately 500 feet. The elevations of the tops of the bedrock hills range

AREAS WITH SAND LAYERS BETWEEN 550 & 590 FOOT ELEVATIONS WITHIN THE GLACIAL TILL UNIT

ADAPTED FROM "SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E"
PREPARED BY EDI ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

Dames & Moore

FIGURE 7.2-6

between 400 and 520 feet. The bottoms of the bedrock valleys are between 150 and 200 feet above sea level. The Regional Aquifer underlies 30-35% of the area within the boundary of the landfill, or approximately the northwestern one-third of the landfill (Figure [7.2-7])". (EDI, 1984) The regional aquifer is not present beneath the proposed disposal cell.

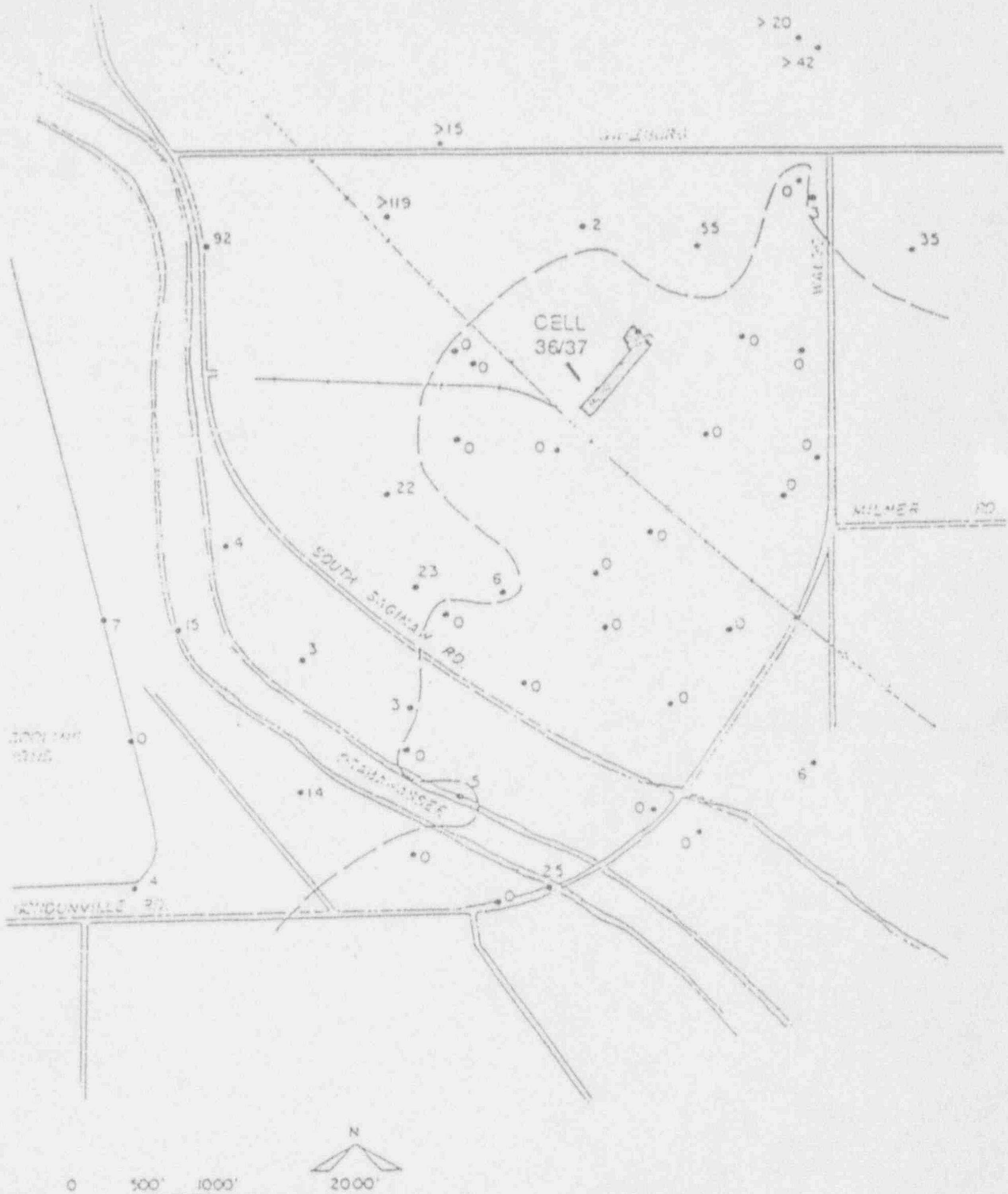
The sand and gravel which compose the regional aquifer were deposited as glacio-fluvial material in the bedrock valleys. The thickness of the aquifer in the center of the valley north of the landfill is on the order of 250 feet. The source area of the sand and gravel in the aquifer is not from the local shale in the bedrock formation except in the deepest parts of the valleys. The sand and rock fragments brought up in drilling are composed of a wide range of rock types. Igneous, metamorphic and sedimentary rocks are all represented in samples from Bedrock Valley Well #1 (26-15) and Dow well #3138 (26-16). The amount of shale in the samples from the Bedrock Valley Well #1 increased downward. Coal fragments began to be picked up at an elevation of 280 feet. At an elevation of 240 feet siltstone and sandstone recognizable as being of the Saginaw Formation were found in the sample. At an elevation of 225 feet, twenty percent of the sample was fine grained sandstone of the Saginaw formation. Drilling was terminated at this level in sandstone. In Dow Well #3138 (26-16) shale fragments began to be encountered at an elevation of 200 feet and were mixed with sand and clay down to an elevation of 165 feet where drilling was terminated. The driller indicated that drilling was not consistently slow as would be the case in solid shale. There are two possible explanations for the driller's findings, 1) he was drilling through interbedded shale and sandstone in the bedrock, 2) he was drilling into shale, sand and clay alluvium of the original bedrock valley. Either explanation would place the "bedrock" boundary near an elevation of 200 feet.

The Regional Aquifer is composed dominantly of fine sand to gravel. In most locations the sand or gravel is well sorted and clean. The unit also has thin interbedded clay and silt stringers. These show clearly on the geophysical logs for Dow #3137 (22-3) and #3138. Some of these clays are only 1 to 2 feet thick but they comprise 10 to 15 percent of the unit. The stringers are discontinuous and, therefore, not identifiable over an extended area through either the drilling records or the geophysical logs.

Clay Mineralogy and Cation Exchange Capacity

Samples from both the Lakebed Clay Unit and the Glacial Till Unit, collected from the landfill site, were analyzed for their clay mineralogy and cation exchange capacity. X-ray diffraction analyses indicated that 62 to 64 percent of the clay in both units is illite; 17 to 25 percent is chlorite plus kaolinite; and 11 to 20 percent are expandable clays, which, in these samples, are alteration products of chlorite. The cation exchange capacity measured low in all samples ranging from 6.2 to 14 milliequivalents (meq) per 100 grams.

The structure of illite is characterized by "fixed" potassium ions between two planes of oxygen atoms. This forms a very rigid crystalline unit that impedes water penetration between crystal layers. Because of this rigid structure, only limited swelling occurs when saturated. The low cation exchange capacity is due to the high percentage of illite in which the



• THICKNESS OF REGIONAL AQUIFER IN FEET

> THICKNESS GREATER THAN MEASURED WELL PENETRATION OF UNIT INCOMPLETE

BOUNDARY OF REGIONAL AQUIFER IN SECTION 35

ADAPTED FROM "SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E" PREPARED BY EDI ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

Dames & Moore

FIGURE 7.2-7

potassium ions between successive crystal layers are "fixed" or non-exchangeable.

Calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) were also found in the samples, although no quantitative measurements were made. The presence of these minerals contributes to the buffering capacity of the clay, which means that the alkaline pH of the clay is not easily lowered.

These tests, along with the permeability tests discussed in preceding sections, indicate that this clay is well suited for such uses as landfill or lagoon liners and as the natural soil base for land treatment, storage, and disposal facilities. It is basically a non-swelling clay with high chemical stability and low permeability. The clay will not swell or shrink appreciably with changing moisture content. Naturally occurring, continuous layers of this clay underlying the Salzburg Landfill site provide a barrier to prevent migration of chemicals to ground-water aquifers. (EDI, 1984)

7.3 PRECIPITATION

7.3.1 Climatic Conditions

The average annual precipitation is about 28.8 inches (EDI, 1983) as described in the RCRA Part B Application:

> The record maximum monthly amount of precipitation received was in August 1975, with a total of 12.76 inches. Minimum monthly precipitation was recorded in September 1979, with only a trace received for the month. The mean Total Annual Snowfall is 36.3 inches, with the maximum monthly amount being received in February 1949, which totaled 29.4 inches. The average date for Midland's first 1-inch snow depth is November 29; first 3-inch snow depth, December 20; and first 6-inch snow depth, January 8. The average date of the last freezing temperature in spring is May 12, while the average day of the first freezing temperature is October 2.

Since the completion of the Part B Application, a higher maximum monthly amount of precipitation occurred in September 1986 at over 18.0 inches. This equates to a 500 year flood event.

7.3.2 Water Balance

A water balance for the cover of Cell 36/37 was performed.

> Precipitation normals for the Midland area were obtained from the National Oceanic and Atmospheric Administration, National Climatic Center. Potential evapotranspiration (PE) estimates for a bare soil were made using the method of Mather and Rodriquez (1978). Potential evapotranspiration is

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$$PE = 16(10t/I)^a$$

Where PE=monthly unadjusted potential water loss in millimeters (divide by 25.4 to obtain values in inches)
t=mean monthly temperature in °C
I=annual heat index. This value is the sum of the 12 monthly heat indices (i) where $i=(t/5)^{1.514}$
$a=6.75(E\text{-}7) \times I^3 \text{-} 7.71(E\text{-}5) \times I^2 + 1792(E\text{-}2) \times I + 0.49239$"

(EDI, 1983)

The results of the calculations are presented in Table 7.3-1. The estimated amount of the annual precipitation available for infiltration into the drain above the clay cover is 8.07 inches. This will infiltrate primarily in the months of March and April. However, these calculations assume bare soil and no runoff. Actual infiltration should be somewhat lower.

The storage estimate was based on an assumption that two inches of water may be stored in one foot of soil used to cover the waste and that 24 inches of topsoil are used above the drain. The storage change is the month-to-month change in the moisture stored in the cover layer of soil placed over the drain following cell closure. The surplus is calculated as the excess of precipitation above the potential evapotranspiration for a month. The month of March has two values; the top value is the estimated snowmelt accumulated over the winter months.

7.3.3 Leachate Handling

The amount of radionuclides expected to be leached from the emplaced thori... bearing material is minimal. However, the leachate system for Cell 36/37 (the intended disposal site) will be separate from the system serving the remainder of the Salzburg facility. Cell 36/37 leachate will be tested to assure conformance with 10 CFR 20 Appendix B criteria before release to the facility's main leachate treatment system.

If Cell 36/37 leachate exceeds the unrestricted release criteria, the applicant, after consultation with the NRC, intends to treat the material in a manner appropriate to

TABLE 7.3-1

AVERAGE CLIMATIC WATER BALANCE COMPUTATIONS FOR SALZBURG LANDFILL

	MONTHS												
	J	F	M	A	M	J	J	A	S	O	N	D	Annual
P	1.46	1.31	2.18	2.86	2.47	2.92	2.56	3.37	2.83	2.57	2.19	2.03	28.75
PE	0	0	0	1.34	3.43	5.03	5.46	4.68	3.12	1.71	0.48	0	25.25
P-PE	1.46	1.31	2.18	1.52	-0.96	-2.11	-2.90	-1.31	-0.29	0.86	1.71	2.03	
Storage	3.00	3.00	3.00	3.00	2.04	0.00	0	0	0	0.86	2.57	3.00	
Storage Change	0	0	0	0	-0.96	-2.04	0	0	0	0.86	1.71	0.43	
Surplus	0	0	4.37 2.18	1.52	0	0	0	0	0	0	0	0	8.07

P = Precipitation
PE = Potential Evapotranspiration
PE estimated using the method of Mather and Rodriguez, 1978.
Assumption: 2 inches of water can be stored in 1 foot of soil used to cover the landfill. Assume 24 inches of soil used to cover the drainage media

REFERENCE: Mather, J.R. and P.A. Rodriquez. The Use of the Water Budget in Evaluating Solid Waste Landfills. Water Resources Center, Univertisty of Delaware, Newark, DE. 1978. NTIS Pub. No. PB 80-180888.

allow ultimate disposal. Conventional treatment techniques, such as use of precipitants and/or filtering, or other chemical or mechanical techniques will be employed.

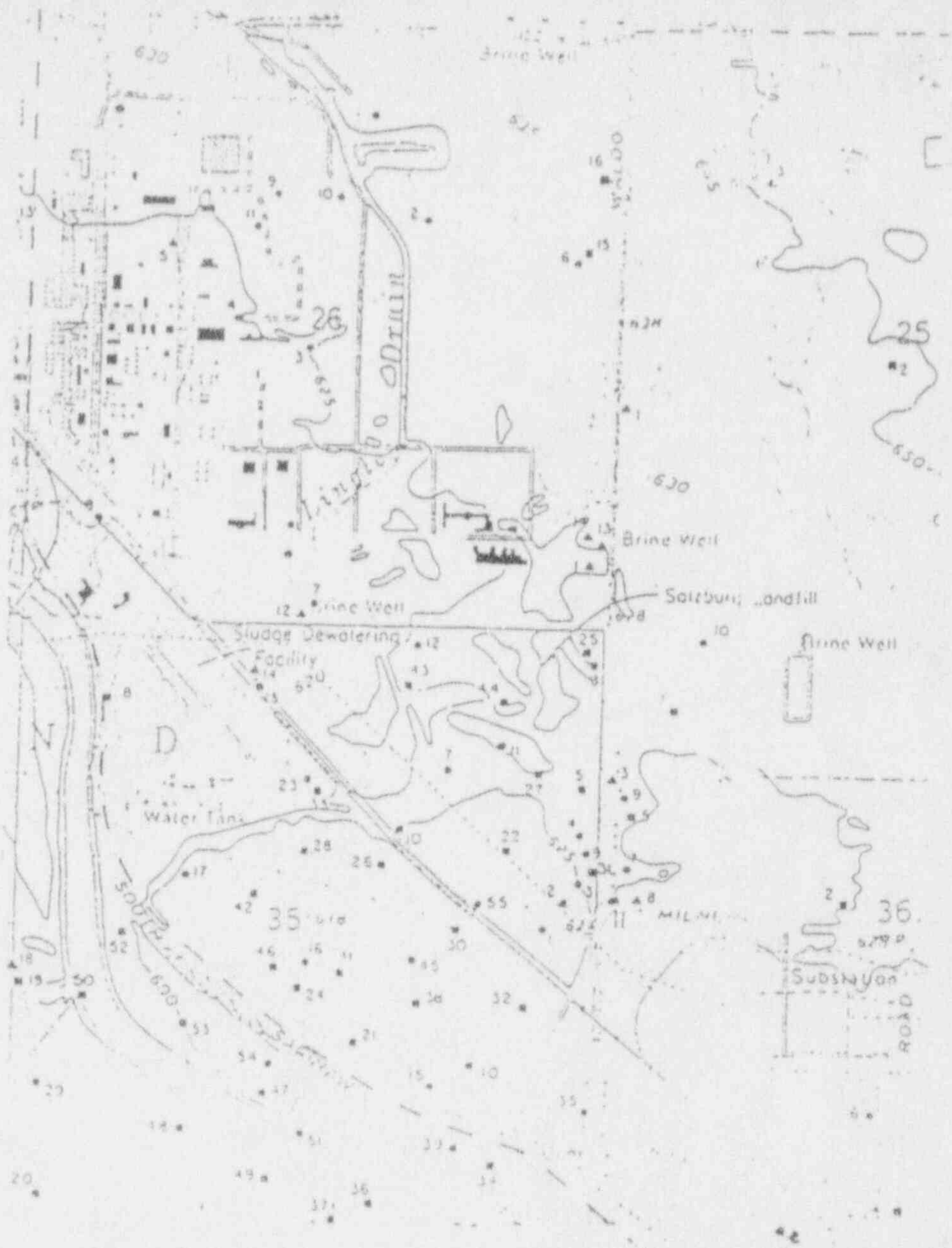
7.4 WATER WELLS

An inventory of wells and soil borings in the vicinity of the Salzburg landfill was made as part of the Part B Permit Application (EDI, 1984). Figure 7.4-1 presents the locations of wells and borings deeper than 50 feet within 3000 feet of the landfill. Table 7.4-1 lists each of these wells and borings and relevant data regarding them. The wells and borings are designated by the section in which they are located and a second number for each well in that section (i.e. 35-12 indicates a twelfth well in section 35). Other wells less than 50' in depth are described in section 7.4.1 and 7.4.2.

7.4.1 Domestic Wells

Table 7.4-2 provides some additional data and descriptions of the 9 current or former domestic wells found to the east of the Salzburg Landfill. The well descriptions are based on comments by the residents at the time of the survey and currently available data.

> In general, most of the wells are not capable of producing water in satisfactory quantity or quality. Many of the owners are dissatisfied with the taste and smell of the water, and several did their laundry outside the home because the wells will not produce enough water. Out of the nine residents surveyed, two said they had good wells. These owners, Mr. May and Mr. Baker, said they have plenty of water and they felt their wells are capable of supplying water to the entire neighborhood. [Both wells have since been removed] In fact, Mr. May said the previous owner of his home sold water to residences on Waldo Road from Salzburg Road to Milner Road.
>
> All of the wells have very hard water and, with the exception of the shallow Bober well, they all exceed U.S. EPA secondary maximum contaminant limits of 250 milligrams per liter for chloride. This limit is a taste threshold only and the high level of chloride found does not have adverse health implications. Sodium is also high and, with the exception of the Bober well, ranges from 230 to 470 milligrams per liter. At present, there are no maximum state or Federal levels for sodium; however, for persons on a sodium restricted diet, use of this water for drinking could present a problem.
>
> All of the heavy metals, with the exception of zinc, were non-detectable. The low levels of zinc found are probably from well casings and household plumbing. The chemical oxygen demand was low in all wells although, relative to the other wells, the Dow (36-9) well was somewhat higher at 27 milligrams per liter. This is also the well of which the resident complained of a 'fish' odor. (EDI, 1984a)



WELLS OR BORINGS

- 50 - 99
- ▲ 100 - BEDROCK
- ■ TO BEDROCK

WELLS ARE NUMBERED BY SECTION

TOPOGRAPHY AND LOCATION OF WELLS AND BORINGS DEEPER THAN 50 FT.

ADAPTED FROM SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E PREPARED BY EDEN ENGINEERING & SERVICES FOR DOW CHEMICAL U.S.A.

Dames & Moore

FIGURE 7.4-11

TABLE 7.4-1

DOW CHEMICAL
BORING AND WELL LOG SUMMARY

Map Location	Well Log No.	Owner's Name	Location	Boring or Well	Approx. Elev.	Depth (Ft.)	Static W.L. Elev.	Drift or Rock	Remarks
25-1	----	Handy Bros.	NW NW SW	Boring	635	265	----	Drift	Coal Co. 1905
25-2	----	Handy Bros.	NE NE SW	Boring	648	310	----	Rock	Coal Co. 1906
25-3	----	Handy Bros.	SE NW NW	Boring	650	243	----	Drift	Coal Co.1906
26-1	DH-1	Dow Corning	SE SE SE	Boring	624	111	----	Drift	
26-2	DH-2	Dow Corning	NE SW NE	Boring	630	100	----	Drift	
26-3	DH-3	Dow Corning	NE NE SW	Boring	625	100	----	Drift	
26-4	DH-4	Dow Corning	SW SE NW	Boring	625	100	----	Drift	
26-5	DH-5	Dow Corning	NE SW NW	Boring	624	140	----	Drift	
26-6	MW-1	Dow Corning	NE SE NE	Observ.	638	100	581	Drift	Well set at 62'
26-7	MW-2	Dow Corning	SW SW SE	Observ.	615	100	Dry	Drift	Well set at 73'
26-8	MW-3	Dow Corning	NW SW SW	Observ.	615	85	----	Drift	Well set at 78'
26-9	MW-4	Dow Corning	NE SE NW	Observ.	630	75	620	Drift	
26-10	MW-5	Dow Corning	NW SW NE	Observ.	631	78	----	Drift	Well set at 68'
26-11	MW-6	Dow Chemical	NW SE NW	Observ.	627	78	----	Drift	Well set at 75'
26-12	7 Monroe	Dow Chemical	SE SE SW	Ind.	615	177	607	Drift	Well set at 177'
26-13	8 Monroe	Dow Chemical	SE SE SE	Ind.	632	207	624	Drift	Well set at 199'
26-14	----	Dow Chemical	NE SE SE	Ind.	630	155	618	Drift	Old Monroe #8
26-15	----	Dow Chemical	NE SE NE	Ind.	638.7	417	619.2	Rock	
26-16	3138	Dow Chemical	SE NE NE	Observ.	640	475		Rock	
35-1	MW-7	Dow Chemical	SE SE NE	Observ.	623.3	65	568.2	Drift	
35-2	3010	Dow Chemical	SE SE NE	Observ.	624.9	142	592	Drift	Well set at 127'
35-3	MW-8	Dow Chemical	SE SE NE	Observ.	625.4	68	605.8	Drift	
35-4	MW-9	Dow Chemical	NE SE NE	Observ.	628.7	63	605.6	Drift	
35-5	3009	Dow Chemical	NE SE NE	Observ.	628	166	609.5	Rock	Well set at 158'
35-6	3011	Dow Chemical	NE NE NE	Observ.	624.4	170	624	Rock	Well set at 122'
35-7	3012	Dow Chemical	SW NE NE	Boring	611	164	----	Rock	
35-8	3013	Dow Chemical	NE NW NW	Observ.	615.6	256	618.7	Rock	Well set at 193'

TABLE 7.4-1
DOW CHEMICAL
BORING AND WELL LOG SUMMARY (continued)

Map Location	Well Log No.	Owner's Name	Location	Boring or Well	Approx. Elev.	Depth (Ft.)	Static W.L. Elev.	Drift or Rock	Remarks
35-9	2402	Dow Chemical	NE SE NE	Boring	624.9	100	616.9	Drift	
35-10	2396	Dow Chemical	NE SW NE	Boring	627.7	100	616.7	Drift	
35-11	2388	Dow Chemical	SW NE NE	Boring	626.8	100	617.8	Drift	
35-12	2366	Dow Chemical	NE NW NE	Boring	626.2	100	617.2	Drift	
35-13	2373	Dow Chemical	NE NE NW	Boring	620.9	100	615.9	Drift	
35-14	2708	Dow Chemical	NE NE NW	Observ.	620.0	235	620	Drift	Well set at 142'
35-15	2201	Dow Chemical	NE SW SE	Boring	618	50	----	Drift	
35-16	2202	Dow Chemical	NW NW SE	Boring	617	50	----	Drift	
35-17	2199-A	Dow Chemical	SW SE NW	Boring	625	50	----	Drift	
35-18	CP-7	Consumers Power	NW NW SW	Observ.	632.4	120	----	Drift	Well set at 115'
35-19	CP-8	Consumers Power	NW NW SW	Observ.	632.9	190	----	Rock	Well set at 180'
35-20	CP-10	Consumers Power	SW SW SW	Observ.	631.3	173	----	Rock	Well set at 168'
35-21	----	Consolidated Coal	SW NW SE	Boring	616	239	----	Rock	1913 Coal
35-22	----	Consolidated Coal	NW SE NE	Boring	623	241	----	Rock	1913 Coal
35-23	----	Consolidated Coal	NE SE NW	Boring	624	242	----	Rock	1913 Coal
35-24	----	Consolidated Coal	SE NE SW	Boring	619	240	---	Rock	1913 Coal
35-25	----	Consolidated Coal	NE NE NE	Boring	626	235	----	Rock	1913 Coal
35-26	----	Consolidated Coal	SW SW NE	Boring	622	230	----	Rock	1913 Coal
35-27	----	Consolidated Coal	S NE NE	Boring	624	238	----	Rock	1913 Coal
35-28	----	Consolidated Coal	W SW NE	Boring	622	233	----	Rock	1913 Coal
35-29	----	Consolidated Coal	NW SW SW	Boring	609	179	----	Rock	1913 Coal
35-30	3170	Dow Chemical	SW SE NE	Boring	620	136	----	Rock	No well set
35-31	----	Handy Bros.	SE SE NE	Boring	625	301	----	Rock	1907 Coal
35-32	----	Handy Bros.	SW NE SE	Boring	618	234	----	Rock	1904 Coal
35-33	----	Handy Bros.	NE SE NW	Boring	624	227	----	Rock	1906 Coal
35-34	----	Handy Bros.	SW SE SE	Boring	605	258	----	Rock	1904 Coal
35-35	----	Consolidated Coal	NE SE SE	Boring	619	239	----	Rock	1904 Coal

TABLE 7.4-1

DOW CHEMICAL
BORING AND WELL LOG SUMMARY (continued)

Map Location	Well Log No.	Owner's Name	Location	Boring or Well	Approx. Elev.	Depth (Ft.)	Static W.L. Elev.	Drift or Rock	Remarks
35-36	----	Consolidated Coal	SW SW SE	Boring	595	220	----	Rock	1904 Coal
35-37	----	Handy Bros.	SW SW SE	Boring	605	210	----	Rock	1904 Coal
35-38	----	Handy Bros.	NE NW SE	Boring	617	223	----	Rock	1904 Coal
35-39	----	Handy Bros.	NW SE SE	Boring	605	230	----	Rock	1904 Coal
35-40	----	Handy Bros.	SW NE SE	Boring	617	254	----	Rock	1904 Coal
35-41	----	Handy Bros.	NW NW SE	Boring	616	265	----	Rock	1904 Coal
35-42	----	Handy Bros.	SE SE NW	Boring	622	230	----	Rock	1904 Coal
35-43	----	Handy Bros.	NE NW SE	Boring	625	232	----	Rock	1904 Coal
35-44	3168	Dow Chemical	NW NE NE	Observ.	627	168	623.46	Rock	Screen set at 114'
35-45	----	Handy Bros.	NE NW SE	Boring	615	199	----	Rock	1904 Coal
35-46	----	Handy Bros.	NE NE SW	Boring	619	260	----	Rock	1904 Coal
35-47	----	Handy Bros.	NE NE SW	Boring	595	215	----	Rock	1904 Coal
35-48	----	Handy Bros.	SW SE SW	Boring	605	233	----	Rock	1904 Coal
35-49	----	Handy Bros.	SE SE SW	Boring	605	210	----	Rock	1904 Coal
35-50	----	Handy Bros.	SW NW SW	Boring	595	226	----	Rock	1904 Coal
35-51	----	Handy Bros.	NE SE SW	Boring	600	209	----	Rock	1904 Coal
35-52	----	Handy Bros.	NE NW SW	Boring	605	204	----	Rock	1904 Coal
35-53	----	Handy Bros.	SW NE SW	Boring	600	228	----	Rock	1904 Coal
35-54	----	Handy Bros.	SE NE SW	Boring	600	214	----	Rock	1904 Coal
35-55	3169	Dow Chemical	SW SE NE	Boring	621	96	----	Drift	No well set
36-1	----	Handy Bros.	SW NW NW	Boring	630	290	----	Rock	1906 Coal
36-2	----	Handy Bros.	SW SE NW	Boring	625	287	----	Rock	1905 Coal
36-3	----	Handy Bros.	NW SW NW	Boring	626	173	----	Drift	1905 Coal
36-4	----	Dow Chemical	SW SW SE	Oil-Brine	621.5	4406	----	Rock	Dry
36-5	1131 Waldo	C.W. Witherspoon	NW SW NW	Dom.	625	232	535	Rock	Salt Water at 232' Well set at 160'
36-6	1428 Bus	W. LaFever	NE SE SW	Dom.	620	50	608	Drift	
36-7	1185 Waldo	J. Lewis	SW SW NW	Dom.	625	65	609	Drift	

TABLE 7.4-1

DOW CHEMICAL
BORING AND WELL LOG SUMMARY (continued)

Map Location	Well Log No.	Owner's Name	Location	Boring or Well	Approx. Elev.	Depth (Ft.)	Static W.L. Elev.	Drift or Rock	Remarks
36-8	1215 Waldo	M. Hochstetler	NW NW SW	Dom.	623	134	603	Drift	
36-9	1119 Waldo	Dow Chemical	SW NW NW	Dom.	625	98	595	Drift	
36-10	Salzburg Rd	Central Transport	NE NW NW	Comm.	630	75	608	Drift	
36-11	----	J. Trout		Dom.	----	40-60	----	Drift	

The currently used domestic wells are all regularly sampled as part of the landfill's monitoring program. No contamination of these wells has been detected.

7.4.2 Monitoring Wells

RCRA and Act 64 monitoring wells surround the Salzburg Landfill Figure 7.4-2).. Selected logs from these wells are included in Appendix D.

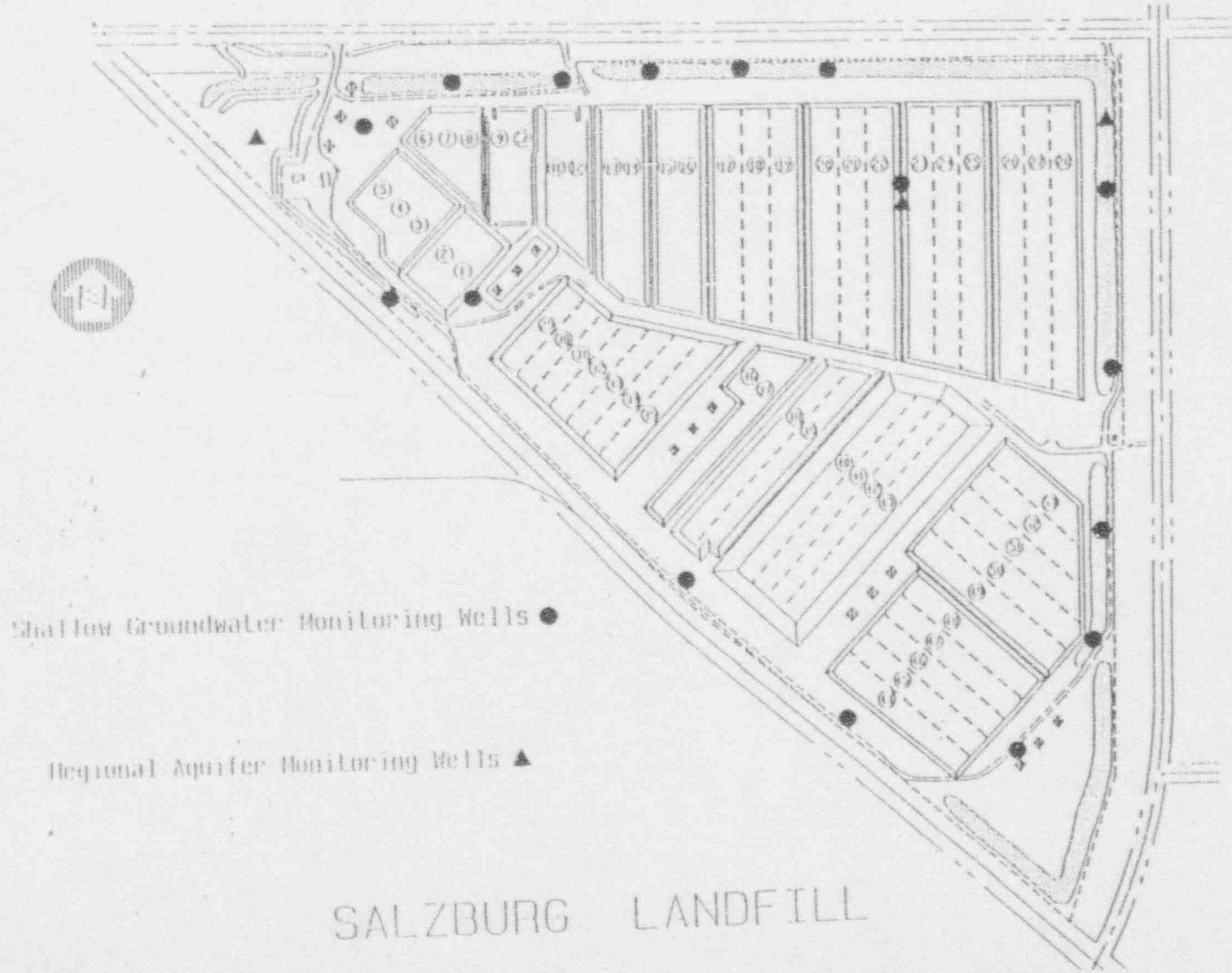
> From these wells, ground-water elevations are measured in the Lakebed Clay unit and in a localized aquifer found in the Glacial Till unit. The Act 64 monitor wells [Figure 7.4-2] were constructed with a thick sand pack so that the wells are open to approximately 25 feet of formation in most cases. The exceptions are monitor wells 3, 4 and 7A which are open to a thickness of 15 feet, and monitor well 8 which is open to 35 feet of formation. For all of the monitor wells, except 7A, 8, and 9, the depth is 41 feet or less and the open interval straddles the boundary between the Lakebed Clay and the Glacial Till units. Because of this method of well construction, the water in these monitor wells can be either from the Lakebed Clay or the Glacial Till or both. Because the Lakebed Clay contains saturated silty layers and the Glacial Till or both. Because the Lakebed Clay contains saturated silty layers and the Glacial Till generally yields very little water, the source of most of the water to the monitor wells is expected to be the Lakebed Clay.
>
> Monitor wells 8 (35-3) and 9 (35-4) are in a localized aquifer within the Glacial Till unit at an approximate elevation of 560 feet. This is the only sand layer (aquifer) found within the Glacial Till unit that is known to underlie the waste management boundary. (EDI, 1984)

Monitor well 5 is the well closest to Cell 36/37, the cell which will be used for the disposal of the thorium contaminated materials.

7.5 GROUND WATER

There are no aquifers or other useable sources of groundwater beneath the specified location for Cell 36/37. As shown on the boring logs and wells in the vicinity, the region containing Cell 36/37 is underlain by a recompacted lakebed clay layer, dense glacial till and bedrock.

The surficial sand layer and lakebed clay layers are not known to be used as a water source by any of the residential wells to the east of the site. The sand layer is generally unsaturated and hence these are no groundwater discharge points. The lakebed clay is generally saturated. Several of the Act 64 monitor wells are screened across the



LOCATION OF RCRA AND ACT 64 MONITORING WELLS

Dames & Moore
FIGURE 7.4-2

lakebed clay and till interface and yield limited quantities of water. The yields are very low and the unit is not considered an aquifer. Groundwater flow directions and discharge locations have not been identified within the lakebed clay. However, it is likely that flow is toward the Tittabawassee River, south of the site. No springs or seeps have been identified on or adjacent to the site.

Water levels and their fluctuations in the Act 64 wells from 1981, '82 and '83 are shown on Figure 7.5-1.

Currently, flow in the sand lense within the till to the east of the landfill is eastward toward the domestic wells along Waldo Road. However, it is not known if this is the natural gradient or a gradient imposed by the pumping of these wells.

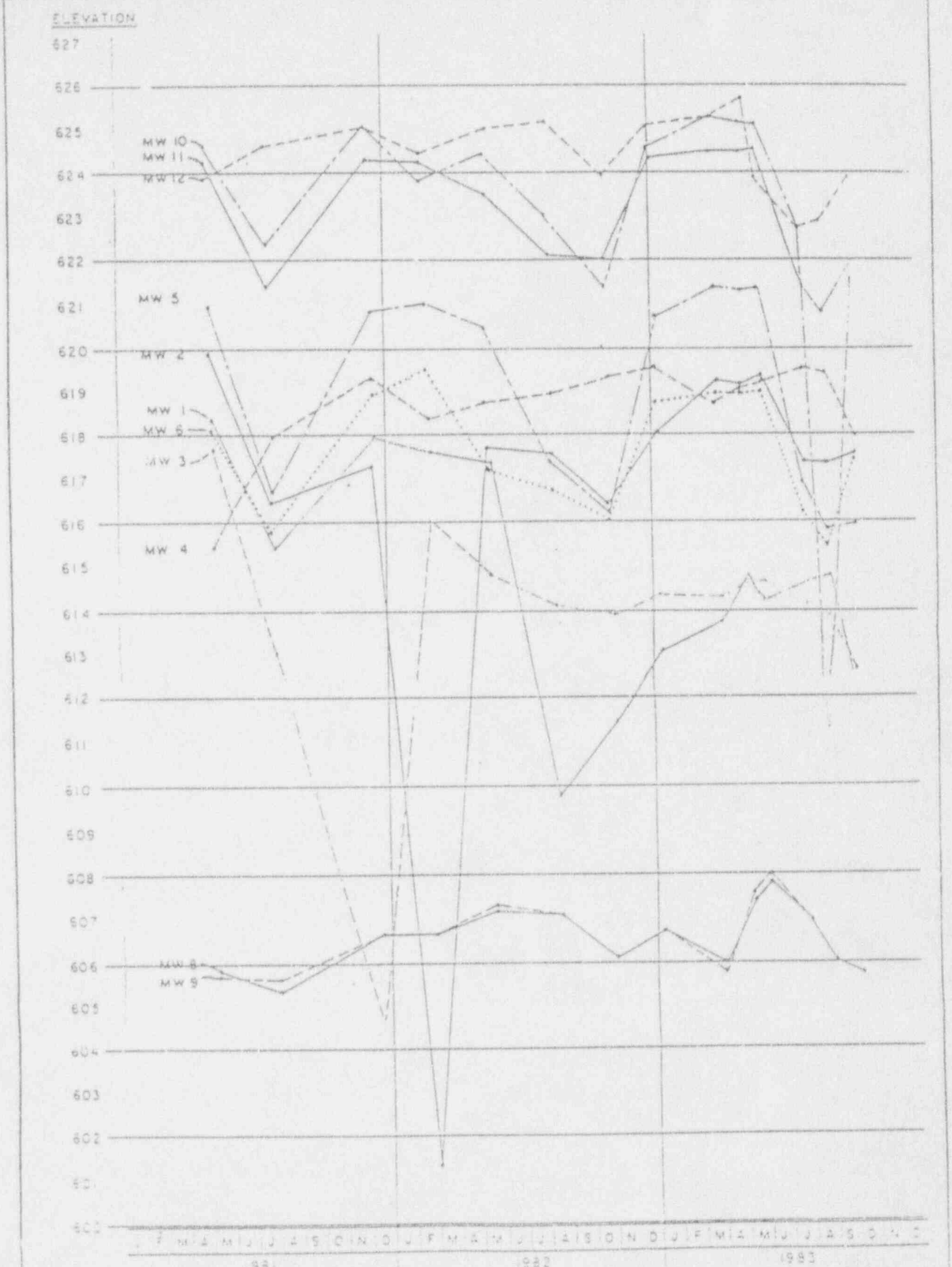
Bedrock composed predominantly of shale is found below the till beneath Cell 36/37. This bedrock unit is not used as a source of water in the area.

West of the disposal cell, below the till is a locally thick, sand aquifer. The aquifer is found at a depth of over 125 feet. Figure 7.2-7 shows the extent and thickness of this unit in the vicinity of the site. The discharge location of the aquifer is not known but is suspected to be the Saginaw Bay. However, the aquifer is confined, and some water is undoubtedly lost to the overlying till. Flow is generally to the northeast in the aquifer, as shown on Figure 7.5-2. This aquifer is used as a drinking water supply.

7.6 SURFACE WATERS

The only surface water in the vicinity of the Salzburg Landfill is the Tittabawassee River, which at closest approach is about 1200 ft. west of the Landfill and 2,500 feet from Cell 36/37. The Tittabawassee flows southeast to join the Saginaw River at Saginaw, which then flows northeast to discharge into the Saginaw Bay at Bay City.

In September, 1986, a flood of the Tittabawassee River occurred that at its peak had a river height that approximated a "500 year" flood. The top of the dike wall of Cells 36 and 37 are an additional 16.5 feet above that 500 year flood level.



WATER LEVEL FLUCTUATIONS OF MONITOR WELLS

ADAPTED FROM SALZBURG LANDFILL RCRA PART B APPLICATION SECTION C
PREPARED BY EDI ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

FIGURE 7.5 –
Dames & Moore

PIEZOMETRIC SURFACE OF THE REGIONAL AQUIFER

ADAPTED FROM "SALZBURG LANDFILL RCRA PART B APPLICATION, SECTION E PREPARED BY EDI ENGINEERING & SCIENCES FOR DOW CHEMICAL U.S.A.

FIGURE 7.5-2

Dames & Moore

7.7 HYDROGEOLOGIC DATA

7.7.1 Ground-Water Occurrence

Although ground water is present in all four of the stratigraphic units at the Salzburg Landfill site, the circumstances and characteristics of those waters are different. The occurrence of ground water can be divided into the following three categories:

1. Surface Sand and Lakebed Clay Waters: Ground water seasonally saturates the lower portion of the surface sand above the Lakebed Clay. Precipitation forms a seasonally variable perched saturated zone, as the water is retarded from downward infiltration by the Lakebed Clay.

   The Lakebed Clay is saturated as well. However, due to its clay content and highly stratified nature, the water is held within the clay and thin lenses of silt, sand and sandy gravel. These seams are poorly connected; however, they will seep water into wells placed in the Lakebed Clay.

2. Glacial Till Waters: The Glacial Till unit is composed dominantly of low permeable till which will not yield water to wells and through which water can move only very slowly. Within the till, however, are saturated sand and silt layers. The amount of water available to a well that penetrates one of these layers is extremely variable. Some of them provide little more than a seep; others in a sand subunit will support pumping rates greater than 15 gallons per minute. The permeability and the extent of the sand and silt layers affect the yield of wells in the unit as well as the degree of connection with a source of recharge. Most of these layers are apparently not interconnected or poorly so, and water chemistry suggests that the recharge which does occur is largely from the underlying Regional Aquifer.

3. Regional Aquifer Water: The Regional Aquifer is an artesian (confined) aquifer. It fills the bedrock valleys and pinches out against the bedrock hills. Wells penetrate this unit around the Consumers Power cooling pond, the landfill, and throughout the south Midland industrial area. In all cases the artesian head is high, on the order of 625 feet elevation. Where the land surface elevations are low, the artesian head is above the land surface and flowing wells result. The artesian head is 35 feet above the river west of the Salzburg landfill site. (EDI, 1984).

7.7.2 Ground-Water Movement

Static ground-water elevations can be used as an aid to determine the degree of hydraulic connection between various occurrences of ground water. Also, the direction of ground-water movement in an aquifer can be estimated with knowledge of the difference in static water elevations measured at various locations. To determine the rate of flow, the permeability of the aquifer has to be known as well. The water elevations only have meaning for flow rate calculations when all measurements are in the same or hydraulically connected aquifer(s). Recent water level data for the Consumers Power cooling pond wells and Dow monitoring wells are given in [Table 7.4-1].

In the Surface Sand unit, the water table is variable in time and location due to topographic control of discharge (i.e., location of drainage ditches), and variation in infiltration of precipitation and evapotranspiration. This seasonal, perched water table is generally a subdued image of the topography. In the general area of the Salzburg Landfill, the discharge is south to the Tittabawassee River or northwest to Lingle Drain in Section 26.

The locations of the current monitoring wells (required for licensing the landfill under Michigan Act 64) are shown in Figure [7.4-2], and the logs for these monitoring wells are included in Appendix [D]. From these wells, ground-water elevations are measured in the Lakebed Clay unit and in a localized aquifer found in the Glacial Till unit. The Act 64 monitor wells were constructed with a thick sand pack so that the wells are open to approximately 25 feet of formation in most cases. The exceptions are monitor wells 3, 4 and 7A which are open to a thickness of 15 feet, and monitor well 8 which is open to 35 feet of formation. For all of the monitor wells, except 7A, 8, and 9, the depth is 41 feet or less and the open interval straddles the boundary between the Lakebed Clay and the Glacial Till units. Because of this method of well construction, the water in these monitor wells can be either from the Lakebed Clay or the Glacial Till or both. Because the Lakebed Clay contains saturated silty layers and the Glacial Till generally yields very little water, the source of most of the water to the monitor wells is expected to be the Lakebed Clay.

Monitor wells 8 (35-3) and 9 (35-4) are in a localized aquifer within the Glacial Till unit at an approximate elevation of 560 feet. This is the only sand layer (aquifer) found within the Glacial Till unit that is known to underlie the waste management boundary.

The original monitor well 7 (35-1) yielded very little water and was easily bailed dry. This well was screened in clay within the Glacial Till, so there was very little seepage into the well. Monitoring well 7 was abandoned in November of 1985 and monitoring well 7A was installed in January of 1986 to yield more representative samples of the groundwater quality. Monitoring well 7A is screened at the base of the Glacial Till.

The static water elevations of the Act 64 monitor wells for the years 1981 through 1983 are plotted in Figure [7.5-1]. The water elevations from these wells plot into five distinct groups. The wells which straddle the boundary between the Lakebed Clay and Glacial Till (Wells 1 through 6 and 10 through 12) comprise three of these groups. Monitor wells 10, 11, and 12 (Group 1) have the highest water elevations and reflect the higher elevation of the ground surface where these wells are located; i.e., the northeast part of the landfill site. These water elevations exhibit a seasonal variation of approximately four feet. The differing seasonal response of the individual wells of Group 1 indicate poor or no hydraulic connection between these wells.

Monitor wells 2, 4, 5, and 6 form Group 2. Here the average water elevations are about six feet lower than the Group 1 wells. These lower water elevations reflect the lower land elevations of the southwest side of the landfill, which is the area where these wells are located. The seasonal water level variation for these wells is approximately five feet.

Monitor wells 1 and 3 form Group 3. These wells appear to be affected by the construction and operation of the landfill. These wells are located close to the active part of the landfill. The construction and operation of the landfill may have diminished some of the recharge to these wells. All of the precipitation that falls on the active and developed portions of a landfill is collected and is no longer available for ground-water recharge. In addition, the liner failure detection system has probably lowered the hydrostatic head in the Lakebed Clay adjacent to the landfill. Although there is a definite trend of decreasing static water level in the Group 3 wells, there still is some seasonal variation.

The wells in the first three groups indicate that sand lenses in the Lakebed Clay are poorly connected hydraulically, and their seasonal response indicates that the recharge of water is from precipitation.

Monitor wells 8 and 9 form the fourth group and are in a localized aquifer within the Glacial Till. The correlation of elevations and fluctuations of water levels in these two wells is much greater than for any of the other wells in Figure [7.5-1]. The average water elevation is approximately 606 feet. The fluctuation of the water elevations is two feet in range, which is half that of the shallower wells. In addition to the difference in water elevations, the water from monitor wells 8 and 9 has a distinctly different water quality than the other monitor wells. The water quality is similar to that of the Regional Aquifer. There is insufficient data to correlate the fluctuation of these water levels with that of the Regional aquifer below.

Based on water level measurements from monitor wells 8 and 9 and the well at 1207 Waldo Road, ground water in this localized aquifer has an easterly flow direction, with a gradient of approximately 0.002, or ten feet per mile. Whether this direction of flow is a natural gradient or the result of ground water withdrawal from private wells along Waldo Road is not known.

The flow rate of ground water in this localized aquifer can be estimated from the measured gradient (dh/dl) of the water. The estimated hydraulic conductivity (K) of the fine sands is 100 gallons per day per square foot. The porosity (q) is estimated at 25%. The velocity of flow is given by the following equation:

$$V = \frac{K \times (dh/dl)}{q \times 7.48\ (gal/cf)} = \text{velocity in ft/day}$$

$$V = \frac{100\ gal/day/sf \times 0.002}{.025 \times 7.48\ gal/cf} = 0.1\ \text{ft/day}$$

→ 0.25

This is very rough approximation of ground water flow rate; however, it is the best that can be given until the variability of the gradient with time is known.

Based on similarities in water chemistry, it is concluded that localized aquifers in the lower portion of the Glac' .l Till unit are hydraulically connected to the Regional Aquifer. These sands can be hydraulically connected to the Regional Aquifer by two means. First, the boundary between the two units is not uniformly flat, but varies in elevations so that a sand which appears separated in one well is connected at another point. Secondly, some of the Glacial Till sand layers may be separated from the Regional Aquifer by sediment which is more sandy and permeable than is typical of the upper section of Glacial Till unit, thereby allowing some hydraulic connection with the Regional Aquifer. The sand which is screened at 120 feet in Well 3011 (35-6) is an example of the first type. It appears disconnected in cross sections A and B [Figures 7.2-1 and 7.2-2] but is connected in the area of Well 3168 (35-44) in cross section D [Figure 7.2-4]. The screen in Well 3168 was set at 112 feet to 117 feet of depth (elevation 510 to 515) in a sand and gravel zone with some clay. The static water elevation is 623.46, which is that of the Regional Aquifer. Above the sand and gravel zone is clay and stone and above that is a sandy clay and gravel zone which is part of a sand layer within the Glacial Till Unit. This section from 560 feet to the Regional Aquifer drilled faster than the normal Glacial Till, indicating it may be a zone of marginal hydraulic connection between the Regional Aquifer and the localized sand layer within the Glacial Till.

[Figure 7.5-2] is a contour map of the static water levels in wells that penetrate the Regional Aquifer. The most striking feature of this aquifer is the high static water level or head. This aquifer must have a high recharge area which supplies the head. The contours on Figure [7.5-2] show the head is the highest southwest of the landfill in the area of the Consumers Power cooling pond. This indicates a recharge area that must be to the south and/or west. The direction of flow in the Regional Aquifer is to the northeast under the cooling pond. The flow then diverges to the northwest and northeast into the branches of the bedrock valley. The limit of the Regional Aquifer against the bedrock hill in Sections 35 and 36 is indicated on the map. Water level data from the wells in the Regional Aquifer around the Consumers Power cooling pond for the years 1979 through 1981 show a fluctuation range of three feet. The recent water elevations are near the top of that range, and the record indicates that neither the gradient direction nor steepness have changed appreciably from 1979 to the present. The gradient under the cooling pond is approximately 0.00033 or 1.7 feet per mile based on the most recent data.

The flow rate of the water in the Regional Aquifer can also be roughly estimated. The estimated value for K is 100 gal/day/sf and the porosity is estimated at 25%. Given these values,

$$V = \frac{100 \text{ gal/day/sf} \times 0.00033}{0.25 \times 7.48 \text{ gal/cf}} = 0.018 \text{ ft/day}$$

Within the study area, the Regional Aquifer does not discharge directly to any surface water body; unless the aquifer extends all the way to Saginaw Bay, it is unlikely to have a direct surface water discharge anywhere. It is believed that the primary discharge for the Regional Aquifer is to shallower aquifers in the Glacial Till. (EDI, 1984)

7.7.3 Hydrogeologic Properties

Surface Sand Unit: A surficial sand layer covers most of the landfill site. This surface sand unit consists of highly stratified fine sand and silt and contains thin layers of clay. The unit is particularly silty and clayey near the bottom where it grades into the more massive clay unit which underlies it.

The 49 borings which were drilled for the landfill site evaluation show the surface sand layer to range from 0 to 13 feet in thickness with an average thickness of approximately 4 feet. The landfill borings were drilled in late October and early November, 1979, following several months of dry weather, so the surface sand was dry. However, a seasonal saturated zone can be expected in this unit when water from rainfall or snowmelt is "perched" on the underlying clay. Figure [7.1-1] is an isopach map showing the occurrence the surface sand unit. Under the Salzburg Landfill, the Surface Sand will be completely removed during excavation and construction of the liner failure detection system.

Lakebed Clay Unit: The Lakebed Clay unit underlies the entire site directly below the surface sand and ranges from 14 to 24 feet thick. The contact between the Lakebed Clay and the Glacial Till is very sharp and distinct in the geophysical logs, particularly the resistivity measurements. The top of the unit lies at elevations between 617 and 622 feet. Bottom elevations are between 594 and 605 feet. For comparison, the bottom of the landfill's liner failure detection system is at an approximate elevation of 600 feet.

The unit is stratified and consists of clay layers mixed with varying fractions of sand and silt. Less than 10 percent of the unit consists of distinct sand, sandy gravel and silt layers. These layers are usually 0.5 feet or less in thickness and are interbedded within the clay. The sandy layers are often wet and are the source of most of the water in site borings. The clay is plastic due to high moisture content. During the excavation of the first 4 landfill cell groups (7 acres total), several saturated sand and gravel layers were encountered. The largest was about 25 feet wide, extending across several cells, and 2 to 3 feet thick on an average. These layers drained readily when first cut into, however the flow was temporary because there is essentially no hydraulic connection between layers.

During the original engineering study, sixty-three silt and clay samples from this unit were collected from the landfill site and analyzed for permeability, Atterberg limits, pH and particle size. Laboratory permeability ranged from 3.1×10^{-6} to 1.4×10^{-8} cm/sec, with 86 percent less than 1.0×10^{-7} cm/sec. Clay particles (less than 5 microns) comprise a significant fraction of all samples ranging from 23.4 to 96.2 percent with an average of 56.3 percent. The liquid limit ranged from 13.0 to 56.5 percent and average 36.2 percent. The plastic index ranged from non-plastic to 35.8 and averaged 16.6. The pH ranged from 7.3 to 8.9. Using the Unified Soil Classification, the unit is predominantly a CL clay with subordinate amounts of CH, SC, SP-SM, ML-CL, and ML soils.

Glacial Till Unit: This unit lies directly below the Lakebed Clay unit and could be identified during drilling by rock fragments (pebbles), hard drilling, and a more uniform, sandy, siltier texture than the overlying Lakebed Clay unit. The unit is typically extremely tight, with local, infrequent saturated interbedded seams of permeable material. The geophysical logs in Appendix [C] show that considerable intervals of the glacial till unit have very uniform characteristics; however, there are also intervals which are clay rich and intervals which are more sandy. These sandy intervals form a sand subunit in the Glacial Till unit.

It is difficult to find an aquifer within the Glacial Till unit. However, evaluation of the boring and well logs drilled to date indicate that there are areas where the sand subunit within the Glacial Till unit is more prevalent. Figure [7.2-6] outlines the area in which sand was found between the 590 and 550 foot elevations. Several residential wells along Waldo Road are screened in this sand subunit. Water chemistry suggests these localized aquifers are recharged from the higher head Regional Aquifer below.

The matrix material of the Glacial Till unit is predominantly sand and silt, with a clay fraction that averages about 30 percent. This is in direct contrast to the Lakebed Clay unit where the clay fraction usually exceeded 50%. Twelve samples were collected from the upper 15 feet of the unit of the site and analyzed for permeability, Atterberg limits, pH, and particle size. Permeability ranged from 1.2×10^{-7} to 2.5×10^{-8} cm/sec, with 82% less than 1.0×10^{-7} cm/sec. The liquid limit and plastic index averaged 20.4 and 8.4, respectively, which are notably lower than for the Lakebed Clay. The pH ranged from 8.0 to 9.0, and the unit is a mix between the SM, SC, SC-SM, CL-ML and CL unified classes.

The deeper rotary borings within the landfill (Dow boring #'s 2708, 3009, 3010, 3011, 3012) and the older coal borings penetrate the entire Glacial Till unit in several places. The borings indicate an average thickness of the unit is approximately 125 feet beneath the Salzburg Landfill.

Regional Aquifer: This unit lies below the Glacial Till unit primarily in the bedrock valleys. The top of the unit lies at elevations between 420 and 460 feet in the area of the Salzburg Landfill. This unit pinches out against the bedrock hill under the landfill so that the Glacial Till rests directly on the bedrock hill. The elevation of the top of the hill under the landfill is approximately 500 feet. The elevations of the tops of the bedrock hills range between 400 and 520 feet. The bottoms of the bedrock valleys are between 150 and 200 feet above sea level. The Regional Aquifer underlies 30-35% of the area within the boundary of the landfill, or approximately the northwestern one-third of the landfill [Figure 7.2-7].

The sand and gravel which compose the regional aquifer were deposited as glacio-fluvial material in the bedrock valleys. The thickness of the aquifer in the center of the valley north of the landfill is on the order of 250 feet. The source area of the sand and gravel in the aquifer is not from the local shale in the bedrock formation except in the deepest parts of the valleys. The sand and rock fragments brought up in drilling are composed of a wide range of rock types. Igneous, metamorphic and sedimentary rocks are all represented in samples from Bedrock Valley Well #1 (26-15) and Dow well #3138 (26-16). The amount of shale in the samples from the Bedrock

Valley Well #1 increased downward. Coal fragments began to be picked up at an elevation of 280 feet. At an elevation of 240 feet, siltstone and sandstone recognizable as being of the Saginaw Formation were found in the sample. At an elevation of 225 feet, twenty percent of the sample was fine grained sandstone of the Saginaw formation. Drilling was terminated at this level in sandstone. In Dow Well #3138 (26-16) shale fragments began to be encountered at an elevation of 200 feet and were mixed with sand and clay down to an elevation of 165 feet where drilling was terminated. The driller indicated that drilling was not consistently slow as would be the case in solid shale. There are two possible explanations for the driller's findings, 1) he was drilling through interbedded shale and sandstone in the bedrock, 2) he was drilling into shale, sand and clay alluvium of the original bedrock valley. Either explanation would place the "bedrock" boundary near an elevation of 200 feet.

The Regional Aquifer is composed dominantly of fine sand to gravel. In most locations the sand or gravel is well sorted and clean. The unit also has thin interbedded clay and silt stringers. These show clearly on the geophysical logs for Dow #3137 (22-3) and #3138. Some of these clays are only 1 to 2 feet thick but they comprise 10 to 15 percent of the unit. The stringers are discontinuous and, therefore, not identifiable over an extended area through either the drilling records or the geophysical logs. (EDI, 1984)

7.7.4 Ground Water Quality

Water quality information can be used in conjunction with the previous data to determine which ground waters are hydraulically connected.

One method for comparison of water quality is to plot the primary constituents in a form that provides a distinct geometric shape for different waters. One type of geometric plots are termed Stiff diagrams after their originator. Stiff diagrams of inorganic parameter concentrations from many ground-water samples are discussed below.

Shallow Ground Water: Diagrams for shallow wells (around 22 to 50 feet deep) at the landfill, Consumers Power, and the residential wells along Waldo Road were prepared. The analyses fall into three distinct groups; 1) Ca^{++}:HCO^{-}_3 rich waters, 2) Na^{+}:HCO^{-}_3 rich waters, and 3) a special situation for the Consumers Power cooling pond shallow wells.

1. The largest group of waters have calcium and bicarbonate (HCO^{-}_3) as the predominant chemical species and exhibit a normal range of concentration for waters in glacial sediments.

2. The second group has a higher concentration of sodium than calcium. This may be is the result of a ground-water process of cation exchange with the glacial clays. Calcium is adsorbed and sodium released by the clays. Because it takes time for this process to occur, it is logical that these waters have been in the ground longer than the waters in the first group.

3. The third group is from three shallow (22 to 28 feet) wells around the Consumers Power cooling pond. Some of the near surface groundwater from the Consumers Power cooling pond show effects of the materials used to build the pond and line the berm. The waters are highest in calcium and sulfate. The levels of magnesium and bicarbonate are high also. A possible source of these ions is dolomitic limestone containing gypsum used as bank protection for the pond.

Regional Aquifer: The waters of the Regional Aquifer show a trend of increasing salinity from the upgradient wells on the southwest corner of the Consumers Power cooling pond to the northeast under the landfill.

Consumers Power Wells 13 (34-2) and 15 (33-1) have unusually high pH values of 9 to 11. The sample from Well 15 is very low in total dissolved solids (TDS) as well as NaCl. The sample from Well 13 appears similar except for higher values of NaCl. Samples from 1979-1980 show both of these wells had higher TDS and Well 15 had a pH range of 7.5 to 8.1. The reason for this recent change in water quality is unkn[illegible] Consumers Power wells 17 (33-2), 20 (33-4), 3 (27-10), 5 (27-1[illegible] and 10 (35-20) show water similar to the shallow ground water.

As water moves east-northeast the total dissolved solids increases primarily by accumulation of sodium and chloride. The exact cause of this increase is not known. Possible explanations are:

1. A permeable sandstone bed in the Saginaw Formation in direct contact with the Regional Aquifer, resulting in a zone where the bedrock brine flows into the Regional Aquifer.

2. Upward leakage of bedrock brine through the many old coal borings. Most of the coal borings were drilled in Section 35, which is also the area where most of the higher sodium and chloride concentrations are found.

"Total dissolved solids (TDS) also increase with depth. Bedrock Valley Test Well #1 (26-15) was sampled at several depths. The TDS increased from 1,000 mg/l at the 200 feet depth to 2,700 mg/l at the 270 feet depth. From 270 to 336 feet the TDS fluctuated around 3,000 mg/l. Below 336 feet the TDS was 4,800 mg/l. The well at building 1803 (22-4) was also sampled at several depths when it was drilled. The stiff diagrams for these samples show a strong salinity increase with depth. The source of this salinity is the bedrock.

Sand Subunit of the Glacial Till Unit: Water from sand layers in the Glacial Till unit in the area of the Salzburg Landfill at depths of 50 to 100 feet shows Stiff diagrams that resemble those of the Regional Aquifer. Around the Consumers Power cooling pond, samples from sand layers in the Glacial Till at depths ranging from 96 to 151 feet show water quality similar to the Regional Aquifer in this area. (EDI, 1984)

7.8 RESOURCES

The proposed site for disposal of the thorium contaminated materials is the Salzburg Landfill, a 152 acre parcel of land owned by the Michigan Division of the Dow Chemical Company. As indicated on Figure 5.3-1, the triangular property is bounded on the north by Salzburg Road, on the southeast by Waldo Road, and on the southwest by C&O Railroad tracks. There are no known mineral resources on or beneath the site.

7.8.1 Local Land Use

As described in Section 5.3.1, most of the surrounding area is heavily industrialized, with some residential housing.

North of the facility is Dow Corning Corporation production facilities. South of the facility are inactive production facilities and vacant land. East of the facility is vacant land and residential housing. West of the Landfill is the Waste Water Treatment Plant of Dow Chemical U.S.A., Michigan Division, Midland locations. To the northwest of the facility are the G&H Development Corp. and Prod Trans, Inc.

7.8.2 Nearby Residences

Nearby residences are described in the Michigan Act 64 Operating License Reapplication:

> The nearest residences to the facility are along the east side of Waldo Road where there are homes that range in distance from 130 to 400 feet from the facility. Since February, 1980, nine of the homes along Waldo Road and Milner Road, adjacent to the facility, have been purchased by Dow Chemical U.S.A., Michigan Division, Midland location. All of the homes purchased were torn down. Two of the homes remaining are owned by private individuals.

7.9 MAPS

The proposed disposal site has previously been reviewed and judged suitable for the location of a waste disposal facility based on topographical, hydrological, and geological criteria.

7.9.1 Topography

As described in the Act 64 Operating License Reapplication:

> The topography of the facility is shown on Figure [7.9-1]. In general, the facility slopes slightly from northeast to southwest with approximately five feet of elevation difference. Most surface elevations range between 620 feet and 625 feet, USGS Datum. However, localized elevations both higher and lower do occur. The highest elevation is 636.8 feet and is located on a small mound near the center of the facility. The lowest elevations are about 617 feet and occur along the western side in localized depressions. (EDI, 1984).

7.9.2 Hydrology & Geology

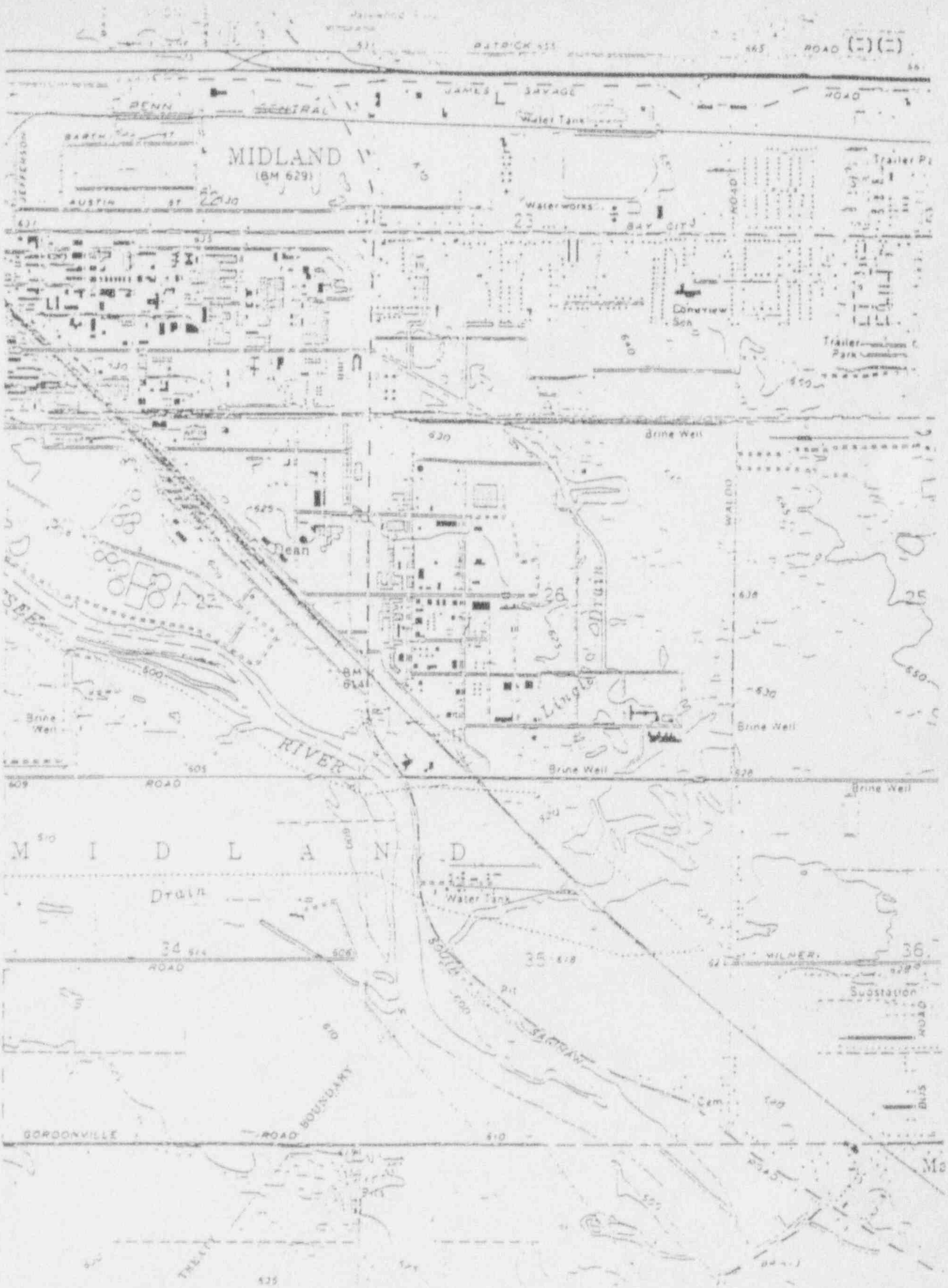
Maps of the hydrologic and geologic characteristics of the site are included in the Figures in Sections 7.1, 7.2, 7.4, and 7.5.

7.10 SITE STABILITY AND PERFORMANCE

The Salzburg Landfill and Cell 36/37 (to be used for the disposal of the thorium contaminated materials) have been sited and designed to minimize the possibility of natural hazards impacting the long-term stability of the facility. No flooding, subsidence or erosion of cover materials at the site have been recorded or are anticipated at the facility.

7.10.1 Flooding

The Salzburg Landfill and Cell 36/37 are designed to be above the 500-year flood plain of the Tittabawassee River and to minimize ponding of surface water on the site during periods of rainfall. The revised preliminary "Flood Insurance Study, City



TOPOGRAPHIC MAP OF MIDLAND AREA

ADAPTED FROM USGS MIDLAND SOUTH QUADRANGLE
7.5 MINUTE TOPOGRAPHIC SERIES, 1973

Dames & Moore

FIGURE 7.9-1

of Midland Michigan" prepared by the Federal Emergency Management Agency (FEMA) includes an evaluation of the 500-year flood plain on the Tittabawassee River adjacent to the Salzburg Landfill. The 500 year flood elevation is only 612.5 feet MSL, compared to natural site elevations of 620 to 625 feet. Final grades on the site are somewhat higher. There is a small Dow dam, approximately 2 miles upstream from the landfill on the Tittabawassee River. Based on the FEMA report, the top of the dam is at elevation 596 ft and the 500 year flood elevation, over the dam, is 612.5 ft. If a dam break were to occur, the site would still not be flooded, even if it is assumed that the water levels did not decrease between the dam and the site.

The site is graded to minimize or eliminate ponding of water on the site during periods of precipitation. The covers of disposal units, including proposed Cell 36/37, are graded with a minimum slope of 1% to promote runoff. Drainage between cells is promoted by drainage swales which are inspected annually for signs of erosion or deposition. No ponding of water or erosion has been noted at the site in graded areas.

7.10.2 Subsidence

Subsidence due to long-term settlement of the thorium contaminated materials or liquefaction of soils beneath or adjacent to the disposal cell are not likely to affect the integrity of the disposal cell or drainage of precipitation from the site. In the event of an earthquake, liquefaction of soils is unlikely to occur due to the dense nature of the subsurface till and the relative absence of sands. Although isolated sand lenses are encountered in the till, the high stanaard penetration resistance values encountered in the borings (see Appendix D) indicate that the sands are too deep and dense to liquify. The soils in the lakebed clay stratigraphic unit are clayey, a soil type not subject to liquefaction.

The thorium contaminated material, as described in Section 3 of this license application, are predominantly soil-like materials (the slag) with limited volumes of construction debris, primarily masonry. These materials will be placed in the disposal cell and compacted as each lift is added. Compaction of the material will minimize void space, and hence settlement, within the cell. This will in turn minimize the effects of settlement (such as changes in site grading) on the disposal cell cover, providing continuation of site drainage in the long term. Thorium bearing construction debris to be disposed of in the cell is generally in small pieces (less than 6" diameter) which will not create large void spaces during compaction. The few isolated pieces of debris as large as 12" will be spread apart from each other.

Organic materials in the construction debris are limited to a few pieces of wood and soil. The wood, like the larger pieces of masonry, will purposely be spread across the disposal cell. The amount of wood is extremely small, and should average much less than 1" in thickness across the cell. Even assuming complete decomposition of the wood, the induced void space and settlement would be minimal.

7.10.3 Drainage and Erosion Control

The following description of drainage and erosion control is from the Salzburg Landfill RCRA Part B Application approved by the U.S. EPA. The entire landfill, and not just Cell 36/37 which contains the thorium materials, has been designed to control erosion. To ensure compatibility of Cell 36/37 and the rest of the Salzburg Landfill's erosion control system, the same controls are proposed. Drainage and erosion are primarily controlled by planting and maintaining a vegetative cover of a type which does not require continuing fertilizers and irrigation to insure viability and by establishing a cover slope between 1% and 2% over the actual cell areas.

The site is not on the flood plain of the Tittabawassee River (See Section 7.10.1). Therefore, flood erosion will be extremely unlikely.

7.11 PAST DISPOSALS

There have been no previous disposals of radioactive material at the proposed site. However, the site is currently operating as an EPA-licensed hazardous waste disposal facility. In operation since 1982, the Salzburg Landfill receives solid waste from operation of Dow Chemical plants. The main types of hazardous wastes placed in the cells include:

(1) incinerator ash
(2) secondary waste water treatment plant solids

Incinerator ash, and secondary waste water treatment plant solids are considered hazardous waste by application of the provisions of 40 CFR 261.3 and 40 CFR 261.4(a)(2). Because the Dow Chemical USA, Michigan Division, Midland location incinerator is a hazardous waste incinerator, ash from the facility is, by definition, a hazardous waste. In addition, because the Dow Chemical USA, Michigan Division, Midland location waste water treatment facility treats waste water that includes listed waste streams, secondary solids from the waste water treatment plant are, by definition, hazardous wastes. None of these wastes would meet the characteristic definition of hazardous waste. The Landfill operators monitor the disposal cells and site groundwater.

There has been no cell leakage or loss of integrity during operation of the facility. There have been several incidents of waste contamination of monitored liquids. Further investigations determined that the liner systems have not failed, and attribute the observed contamination to linkage of the leachate collection system and liner failure detection system. These incidents are summarized in Appendix E.

7.12 PERFORMANCE ASSESSMENT

The performance assessment consists of predictive analyses of the following radiological impacts;

- Doses during remediation from direct exposure and airborne particulate and thoron releases to onsite remediation workers, onsite non-remediation workers, the maximally exposed member of the general public residing in proximity to the Bay City and Midland sites, and an individual along the transport route (section 7.12.1).

- Subsequent to emplacement of the material at Salzburg and capping of the trench, annual doses to an inadvertent human intruder from inhalation, direct exposure and ingestion of food products raised on the site (section 7.12.2).

7.12.1 Impacts During Remediation

The radiological impacts on remediation workers were evaluated for the removal of material from the existing slag piles at Bay City and Midland, movement to an onsite staging area, transport of the material to the Salzburg site, emplacement and cover of the trench, and the health physics and monitoring support provided at each location. Impacts were also assessed to a hypothetical individual residing full time just outside the controlled facility boundary at Bay City and Midland for the duration of the material removal process, and for an "onlooker" who occupies the same position close to the transport route for the passage of all the trucks.

The analytic approach, assumptions employed, input parameters, and calculated exposures for each of these operational steps are detailed in Appendix I. For each operation, total exposure of the population of workers, and to the maximally exposed worker and resident are calculated. In each instance, highly conservative assumptions as to dose levels and exposure times have been made to arrive at worst case assessments of individual dose. The following sequential approach was used to assess the radiological impacts:

- The radiological sources, in terms of airborne concentrations of particulates and thoron, and gamma exposure levels, directly above the slag piles were characterized from the existing data base of material concentrations and gamma survey data at Bay City and Midland.

- The viable dispersion pathways for each step in the operations of material removal through emplacement in the trench at Salzburg were defined. Dispersion to receptors for direct exposure, and inhalation of particulates and thoron gas were assessed for each step.

- Concentration at the receptors (remediation workers, hypothetical resident and onlooker) were evaluated and the doses calculated to exposed individuals.

The calculated doses to the maximally exposed individual are summarized in Table 7.12-1 for both remediation workers and members of the public for the remediation of the Bay City site and in Table 7.12-2 for the remediation of the Midland site. The

TABLE 7.12-1

CALCULATED MAXIMAL INDIVIDUAL RADIOLOGICAL EXPOSURE FOR REMEDIATION OF BAY CITY PILE (MREM/ACTIVITY)

Individual	Whole Body Gamma	Particulate WB	Inhalation L	(1) BM	Thoron Inhalation to Lung
1. On-site Remediation Worker					
Bay City	196	0.37	4.4	17.4	27.8
Salzburg	990	1.9	57	87	139
2. Transport Worker	1980	___(2)	___	___	___
3. On-site Non-nuclear Worker	0.003	___(3)	___	___	0.24
4. Off-site Nearest Resident	.005	0.4	12.4	19.0	0.70
5. Off-site Transport Onlooker/Shipment	0.00007	___(2)	___	___	___

(1) WB = Effective Whole Body
L = Average Lung
BM = Bone Marrow

(2) Dose from particulate and thoron inhalations are negligible

(3) Dose from particulate and thoron inhalation are negligible

TABLE 7.12-2

CALCULATED MAXIMAL INDIVIDUAL RADIOLOGICAL EXPOSURES FOR REMEDIATION OF MIDLAND PILE (MREM/ACTIVITY)

Individual	Whole Body Gamma	Particulate Inhalation(1) WB	L	BM	Thoron Inhalation to Lung
1. On-Site Remediaton Worker					
Midland	2	2.02	0.5	0.8	1.4
Salzburg	10.2	0.1	2.7	4.1	9.1
2. Transport Worker	32.7	__(2)	--	--	--
3. On-site non-nuclear worker	0.0004	__(3)	--	--	0.06
4. Off-Site Nearest Resident	0.0002	0.03	0.9	1.3	0.2
5. Off-Site Transport Onlooker/Shipment	0.000002	__(2)	--	--	--

(1) WB = Effective Whole Body
L = Average
BM = Bone Marrow

(2) Doses from particulate and thoron inhalation are negligible

(3) Doses from particulate inhalation are negligible

maximum projected individual dose to a remediation (transport) worker of 1980 mrem is less than half of the annual exposure level of 5000 mrem for nuclear workers in 10 CFR20, and the 0.003 mrem whole body gamma dose for onsite non-nuclear worker is a negligible fraction of the 500 mrem annual permissible 10 CFR 20 dose. The maximal whole body dose of 0.4 mrem calculated for a hypothetical resident at the site boundary at Bay City is a negligible fraction of the permissible 10 CFR 20 non-nuclear worker annual limit of 500 mrem. Even though the performance objectives of 10 CFR 61 are only applicable to a LLW disposal site, it is instructive to note the 0.4 mrem dose is a small fraction of the 10 CFR 61 whole body limit of 25 mrem, while the 12.4 mrem lung dose and 19.0 mrem bone marrow dose are within the 25 mrem organ limits stated in the 10 CFR 61 performance objectives. Thus, the radiological impacts from the proposed disposal operations are well within regulatory standards.

7.12.2 Intruder Impacts

As mandated by 10 CFR Part 20.302a and the guidance in NUREG-1101, Dames & Moore has assessed the impacts of inadvertent human intrusion by modeling the site and intrusion scenarios using the ONSITE/MAXI1 computer code. These intrusion scenarios include external exposure from the waste mass and internal exposure due to inhalation of airborne particulates and ingestion of potentially contaminated food products raised on the site.

The latest version of the code has been adapted for use on an IBM PC/XT/AT computer. This is the version which was used for the calculation of impacts. This version also permits the user to optionally select data given by the International Commission on Radiological Protection (ICRP) in their Publication No. 30 (ICRP 1979-1982) in place of those given by the ICRP in Publication No. 2 (1959) and supplied with the original ONSITE/MAXI1 computer software. This version of the ON-SITE/MAXI1 computer program uses the same methodology (with the addition of ICRP Publication No. 30 methods) and produces essentially the same results as earlier versions of the computer program documented by Napier et. al. (1984) and Kennedy et. al. (1986). Inhalation doses varied from those in earlier versions, because default inhalation parameter values were changed to be consistent with those used in ICRP Publication No. 30. Six sample problems are presented in the documentation. The inputs of these sample problems were executed by Dames & Moore and compared with the documentation as a quality assurance check.

The ONSITE computer program is the interactive user interface that allows the end-user to create and use the radiation exposure scenarios. The MAXI1 computer program is then used with the scenario information to calculate the maximum annual dose to the exposed individual from selected pathways. Intermediate dose conversion factors for the external exposure pathways, ICRP Publication No. 2 internal dose conversion factors (ICRP, 1959), and ICRP Publication No. 30 effective dose equivalent factors for internal inhalation and ingestion (ICRP, 1979-1982) are stored in data files. These factors can be found in the ICRP publications. The inhalation dose conversion factors are derived from the model in ICRP Publication No. 2 (ICRP, 1959) and are calculated using the Task Group Lung Model (TGLM) (ICRP, 1966) as contained in the DACRIN (Houston, Strenge and Watson 1974) computer program. Additional metabolic data for the inhalation calculations were obtained from ICRP Publication No. 19 (ICRP, 1972). The external dose conversion factors for various waste disposal geometries and densities are calculated using the ISOSHLD (Engel, Greenborg and Hendrickson, 1966) shielding program.

Default data files and input parameters which are provided with the code package have been used except where site-specific information is readily available. Table 7.12-3 shows a list of parameters which were conservatively chosen to model the Salzburg Landfill disposal scheme.

The scenario developed using the ONSITE program begins in 1990 A.D., the year that the thorium trench is anticipated to be capped. The scenario ends 50 years later, the maximum length of time allotted by the code.

The source term assumed for the thorium-bearing material is 2.4E+08 pCi/m^3 buried 1 meter below the ground surface.

The surface inventory dilution factor was set at 1.0 which means that no credit is taken for environmental turnover or dilution of the contaminated material with clean soil.

Continuous exposure (8760 hours/year) is assumed for external and inhalation pathways. A breathing rate of 270 cm^3/sec is the default value used by the code. Mass loading was selected as the model used for the resuspension source term available for inhalation.

Table 7.12-3

INPUT PARAMETERS FOR ONSITE/MAXI
COMPUTER CALCULATIONS

Parameter	Value Input
Scenario Begins	1990 A.D.
Scenario Ends	2040 A.D.
Surface Inventory Dilution Factor	1.0 (unitless)
Size of Disposal Area	1.0 E + 04 m^2
Fraction of Total Diet Grown on Site	1.0 (unitless)
Hours of External Exposure to Contamination	8760 hours/yr
Hours of Inhalation of Airborne Contamination	8760 hours/yr
Breathing Rate	270 cm/sec
Resuspension Model Used	Mass loading
Density of Resuspended Soil	2.0 E + 06 g/m^3
Mass Loading Factor	1.0 E- 04 g/m^3
Fraction of Roots in Upper Soil	1.0 (unitless)
Concentration of Thorium-232 in Deeply Buried Material	2.4 E + 08 pCi/m^3
Minimum Depth of Material	1.0 m

It was assumed that the site is 10,000 m^2 in size, sufficient to generate the entire annual diet for a family of four. The fraction of roots in the upper soil is assumed to be 1.0.

The output file generated by the ONSITE/MAXI1 code is provided as Appendix F. As shown, the maximum annual dose to an inadvertant intruder is 1.5 E-03 Rem per year. This hypothetical impact is much less than the 2.5 E-02 Rem per year which is recommended as a design basis for radioactive waste disposal per 10 CFR Part 61; this impact also meets the guidelines suggested by NRC (Neuder, et al., 1987) for On-Site disposal under 10 CFR Part 20.302. The calculated impacts are also a small fraction of the normal background radiation level in Michigan of approximately 0.07 Rem per year from naturally-occurring sources. (ORNL, 1981) It should also be noted that the dose is entirely from direct radiation exposure through the cover. However, due to a model limit of 3 feet of cover, compared to an actual cover thickness of over 5 feet, this dose is overstated for the Salzburg Landfill. Therefore, the impacts from the proposed disposition scheme are judged to be acceptably low.

7.12.3 Groundwater Impacts

The environmental transport of radionuclides from the Salzburg Landfill through the groundwater is not considered a viable pathway due to the natural site geologic conditions, the solubility of the material, and the design of the disposal cell. Either the natural conditions, or the design, independent of the other, should be fully adequate to minimize or prevent releases through the groundwater. Both in combination provide an even higher margin of safety in protection against the migration of radionuclides through the groundwater pathway. Since groundwater transport of radionuclides is not a viable pathway, MOCMOD has not been used to model transport.

7.12.3.1 Engineered Barriers

The Salzburg Landfill, including Cell 36/37, has been designed to meet state and Federal regulations for the successful operation of a hazardous waste disposal facility. The Federal, EPA and state regulations were written to provide for zero release from disposal facilities through the use of natural (clay) and synthetic materials (PE liner), leak detection systems, and redundancy in the design. Operating experience at the Salzburg Landfill has shown that the cells constructed to date are functioning as designed and no releases to the environment have been detected.

The first design barrier to the generation and release of leachate to the groundwater is the cover system. As described in Section 8.0, the cover system includes from top to bottom: a vegetative cover, two feet of topsoil, a sloping, horizontal drainage layer, a polyethylene (PE) infiltration barrier (liner), and 3 feet of compacted clay. Most precipitation falling on the cell will either be diverted as runoff, or evapotranspire. The water infiltrating through the topsoil (calculated to be a maximum of 8 inches, see Section 7.3) to the drainage layer will be diverted by the impermeable PE liner through the drainage media. Even if the PE liner were to fail locally, the clay layer beneath the PE liner will have a permeability less than 1×10^{-7} cm/sec which would severely limit downward infiltration. Water migrating to the drainage layer will move horizontally through the drain if saturation occurs.

Infiltration through the 3 feet of clay, assuming future failure of the PE liner, will probably be on the order of 0.026 in/yr (0.08 cm/year). This is calculated assuming a permeability in the clay of 1×10^{-7} cm/sec, a hydraulic gradient of 0.1, and water being available for infiltration during 3 months of the year. The permeability is taken directly from the minimum design specification. Availability of water for 3 months of the year is from the water balance contained in Section 7.3. However, it is likely that infiltration would only occur some days during the 3 months, and not every day, further lowering the infiltration estimate. The hydraulic gradient used in the calculation is probably also higher than would be encountered. However, even if higher gradients were present, they should not be higher than 1. Even using this unrealistically higher estimate of hydraulic gradient results in a calculated maximum infiltration of only 0.26 in/year (0.8 cm/year).

If the PE liner fails, and limited quantities of water infiltrate through the thorium bearing materials, a leachate collection system and a clay and additional PE liner are in place to eliminate discharges to the environment. The leachate collection system and PE liner should totally prevent releases. As with the cover, if it is assumed the PE layer fails, a clay layer is present to severely inhibit migration. In the RCRA Part B permit application approved by the EPA it has been calculated that it would take 15,000 years for water to migrate through the 5 foot thick clay liner assuming no chemical retardation (EDI, 1986). Since thorium has been found by numerous research efforts to have high Kd values (>2700 in clays and 40 to 470 in sands), in soil water mixtures with a pH greater than 6 (Teknekron Research, 1982) the time required for the thorium to migrate through the liner would be significantly longer than the 15,000 years for water, and breakthrough of the thorium would take much longer.

The half-lives of the daughter products of thorium-232 total only 8.6 years (see Table 3.1-2). The migration of the daughters would therefore be for a limited distance before they decay, because of the slow transport of water through the liner and chemical retardation of the elements in clay.

It is unrealistic to anticipate any releases of thorium from the disposal facility to the groundwater. The synthetic and clay liners and covers should prevent the generation and/or migration of leachate bearing thorium-232 or its daughters from the facility.

7.12.3.2 Geologic Barriers

As discussed in Section 7.12.2.1, it is not anticipated that any leachate will be produced or released from Cell 36/37 in the long term. However, if such a release should occur, no contamination of an aquifer would occur.

There are two partially connected stratigraphic units which are considered aquifers in the vicinity of the Salzburg Landfill: the regional artesian aquifer, locally found beneath the till; and some local sand lenses of limited areal extent. Neither of these two aquifers, as shown on Figures 7.2-6 and 7.2-7, are located directly beneath Cell 36/37.

The lakebed clay and glacial till (excluding the sand lenses mentioned above) have such low permeabilities that cannot be considered as potentially useable sources of water. Their hydraulic conductivities, as discussed in Section 7.5 are less than 1×10^{-7} cm/sec, far too low to be considered as a potential source of drinking water.

In order for thorium bearing leachate to reach the regional aquifer it would have to migrate downward at least 125 feet and horizontally at least 350 feet. However, as discussed in Sections 7.5 the aquifer is artesian and water migration is actually from the aquifer upward into the till, which will prevent any migration of leachate into the aquifer. Additionally the high clay content of the till (over 30%) and the high pH of groundwater (8.0 to 9.0) would retard thorium migration to extremely low rates. Retardation coefficients for thorium, reported by a number of researchers by Teknekron Research (1982), in clay with high pH in the water are 2,700 or greater. This is essentially equivalent to no migration. Therefore, even if the hydraulic gradient could be reversed, neither thorium-232 nor its short lived daughter products could reach the aquifer.

Migration of thorium-232 and its daughters to the sand lenses used as domestic water supply is unlikely to occur because of the design of the waste disposal cell. However, if a release were to occur, the till should mitigate the likelihood of migration.

The sand lense used as a source of water is approximately 50-75 feet lower than the base of the disposal cell, and 1000 feet to the east. The measured hydraulic gradient in the sand lense east of the till is 0.002 (see Section 7.7.2) and the hydraulic conductivity 1×10^{-7} cm/sec.

The velocity of water in soil can be calculated using the formula

$$V = \frac{Ki}{N_e}$$

Where: K=hydraulic conductivity
i=hydraulic gradient;
N_e=the effective porosity; and
V= the velocity of the water

The effective porosity of a clay is typically in the range of 0.01 to 0.10. Assuming the porosity is 0.01, it would take approximately 50,000 years for water to migrate from the cell to the edge of the sand layer. Thorium, due to its high retardation coefficient, would take much longer.

Another small sand lens, not considered an aquifer in the RCRA Part B permit, is present beneath the northern end of the disposal cell. This lens is restricted to a small area entirely beneath the Salzburg Landfill which will be administratively controlled in the future, preventing its use. The yield from the sand lense is low enough that it isn't considered useable even for domestic use. Additionally, the high retardation of thorium in the 50-75 feet of clayey till above the sand, should prevent the migration the thorium to the sand lens, even if leakage from the cell should occur.

If, in the event of the failure of manmade and natural barriers to migration, some thorium did reach one of the aquifers, concentrations should be extremely low. In 1977, at the request of the State of Michigan, Division of Radiological Health, the solubility of the thorium from the sludge was measured in water of pH 2, 7 and 10. As stated in the analysis of the results, (Dow, 1977): "The solubility at all pH's tested was found to be less than 0.1 micrograms/milliliter or less than 1.1×10^{-8} microcuries/milliliter". This compares to 10 CFR Part 20, Appendix B Table II Column 2 water concentrations of 2×10^{-6} mCi/ml. The Part 20 concentrations are a factor of 182 times higher. It is reasonable to assume that leachate from the thorium slag to be disposed of in Cell 36/37 would contain activities no higher than those measured in the test since the tests spanned a range of pH's greater than those likely to be encountered in natural conditions.

7.12.4 Surface Water and Bathtubbing

Groundwater transport of thorium to surface water in the vicinity of the Salzburg Landfill is unlikely to occur because of a lack of surface water in the immediate vicinity of the site, the protective nature of the design of Cell 36/37, and the naturally low permeability of the lakebed clay and till which surround the burial cell.

The potential for "bathtubbing" of the trench, resulting in surficial release of leachate is also unlikely due to the presence of both institutional and design controls. The EPA approved design, used for the Salzburg Landfill including Cell 36/37, provides controls to minimize or eliminate the generation of leachate, and design features to allow the detection and collection of any leachate which is collected.

The first defense against bathtubbing is the presence of the cover system, described in Sections 8.0 and 7.12.2.1 which should minimize or eliminate infiltration into the disposal cell. The presence of a 40 mil minimum PE cover liner should provide complete protection against infiltration. As discussed in Section 8.0 the PE layer is installed under a strict quality assurance and testing program to ensure the reliability of the installed cover.

If, at some point in the future limited leachate was to be generated, due to an unlikely partial failure of the cover, a leachate monitoring and collection system is in place. This system allows for the complete removal of leachate which has migrated through the thorium bearing materials. Since all leachate produced can be removed, bathtubbing cannot occur as long as the site is maintained in the future.

If, in the long term, the PE liners should fail, and institutional control of the leachate collection system should stop, the clay covers and liners will limit the potential for bathtubbing. The top clay cover will be built to have a permeability of less than 1 x 10^{-7} cm/sec. The overlying topsoil and drainage layers have been designed to provide protection to the clay layer from frost damage (Dow, 1986). Since the thorium bearing material to be buried below the clay will be compacted, subsidence should be minimal, protecting the clay cover from subsidence-induced cracking.

If both the top and bottom PE liners fail, infiltration and leachate loss should be balanced since the top and bottom liners have the same permeabilities. If some build-up of water were to occur in the trench this would merely act as an additional driving force to ensure that water would leave the cell as fast as it enters.

As discussed in Section 7.12.2.1, infiltration through the cover should be limited to 0.026 in/yr, even if the PE liner completely fails. If the cover PE liner completely failed, and the bottom PE liner remained 100 % intact (an unlikely combination) it would still take 100's or 1000's of years for the cell to fill with water.

It is estimated from reference to data on comparable material that the compacted thorium slag will have a porosity of at least 20%. The slag thickness in the cell is planned to be between 13.5 and 17.5 feet. If the infiltration is 0.026 inches of water per year, it would fill the cell at a rate of 0.13 in/year since 80% of the cell will already be occupied with the slag solids. At that rate, it would take over 1000 years to fill the trench. However, it is unrealistic to assume that the top PE liner completely fails while the bottom remains completely intact. Therefore, even if the bottom liner remains relatively intact compared to the top liner, it should take thousands of years for the cell to fill with water.

The Salzburg facility was designed to prevent bathtubbing and overflow to the surface and operating experience has demonstrated that this will not occur at the site. The potential for surface contamination through surface water transport of thorium is extremely low. In addition, the solubility of thorium in water is very low.

8.0 DISPOSAL PROCEDURES

The applicant intends to emplace the thorium-bearing material in a cell of similar design and construction to the cells used for hazardous waste disposal at the Salzburg Landfill. The disposal cell is described in the RCRA Part B Application, and the relevant portions are summarized in this application as Section 8.1. Drawings of the cell and cap construction are included as Appendix G.

The cell will be filled from the bottom of the cell up. The minimum distance to another burial cell used for disposal of non-radioactive materials is ten feet.

The material will be transported to the Salzburg landfill by truck. The material, mostly in soil form, will be covered with tarpaulins to minimize fugitive dust during transport.

8.1 DISPOSAL CELL DESCRIPTION

Introduction and Scope

This section describes the construction plan for Salzburg Landfill, owned and operated by the Dow Chemical U.S.A., Michigan Division, Midland Location, EPA Facility I.D. number MID 980617435.

The plan describes activities related to construction of the liner failure detection system, compacted clay liner, PE liner installation, leachate collection system, and operational activities required during operation of the cell. This plan is intended to satisfy the requirements for construction of Cell [36/37] in accordance with interim status regulations and the Hazardous and Solid Waste Amendments of 1984.

Construction Performance Standard

The construction plan is designed to ensure that after construction is complete and operation of Cell [36/37] has commenced, the threat to human health and the environment is minimized or eliminated by preventing release of [radioactive] waste constituents into the ground, groundwater, surface water, or air. If evidence of leaks or spills is detected, samples will be taken and analyzed to determine the extent, if any, of contamination in the ground, groundwater, surface water, or air.

If contamination is determined to be present, and

1. the contamination is at concentrations sufficient to pose a threat to human health or the environment, and

2. the contamination can be attributed to the operation and/or closure of the facility,

The most suitable alternative to remedy such contamination will be implemented to insure protection of public health and the environment.

Construction Plan Activities

Drawings in Appendix G details the cell construction. The complete liner system consists of a three foot thick (minimum) compacted clay liner which has a permeability of 1×10^{-7} centimeter per second or less.

Above this will be a liner failure detection system consisting of a drainage mat up the walls and drilled collection tubes running horizontally on top of the three foot thick compacted clay liner. The collection tubes will be covered with drainage media to an overall depth of twelve inches. This drainage media will also cover the entire surface of the bottom compacted clay liner to a depth of twelve inches. The liquid collected by the liner failure detection system will gravity drain to a collection sump. Accumulated liquid will be sampled and analyzed when liquid is withdrawn from this collection sump.

Above the liner failure detection system, a five foot thick (minimum) compacted clay liner which has a permeability of 1×10^{-7} centimeter per second or less will be constructed.

On top of the five foot thick compacted clay liner, a 100 mil PE liner will be installed over the entire active surface of the cell.

The leachate collection system, consisting of perforated pipe covered by a twelve inch thick drainage layer, will be installed above the PE liner on the base of the cell.

Liner Characteristics

The material used for the three foot and five foot clay liners meets the following specifications:

1. Permeability coefficient of 1×10^{-7} cm/sec or less.
2. Greater than 25 percent of the particles are less than five microns in diameter.
3. Unified soil classification of CL or CH.

Soil testing methods, location and frequency have been reviewed by the EPA in the RCRA Part B Application.

The PE liner is 100 mil thick.

Equipment Decontamination Steps

All activities for the construction of Cell [36/37] are being conducted outside of the active portion of the current waste hauling area. No equipment decontamination before, during, or after construction is necessary.

Erosion Prevention

Erosion of the clay liner is eliminated by the installation of the synthetic liner on top of it. Run-on from adjacent land areas into the cells is eliminated by having the top of liner five feet above adjacent grade.

Site Preparation

The cells to be constructed will be prepared by excavating to the desired subgrade profile, per drawings. Topsoil material excavated will be stockpiled for future use in capping. Sandy and off-grade clay soils excavated will be stockpiled separately for use as daily cover in landfill operations.

Clay soils excavated, suitable for liner construction, will be stockpiled at a location adjacent to the site. This stockpile will be shaped and graded to facilitate precipitation run-off and ease of access for reuse in construction.

A soil sampling program will be undertaken to confirm the quality of the sub grade material. [This sampling program will be consistent with that approved by the EPA for the remainder of the Landfill.]

Sufficient soil test data will be generated to ensure that 6 meters of soil with a maximum permeability of 1.0×10^{-6} cm/sec is available at all points below and lateral to the bottom of the landfill.

Techniques to be utilized in obtaining the required soil data may include soil borings and/or resistivity and EM surveys to replace or supplement borings.

Benchmark Protection

> Inspection of the facility benchmark is performed every three years by cross-checking the benchmark elevation to the elevation readings of the nearest Dow Chemical U.S.A, Michigan Division, Midland location benchmark. The Dow benchmarks are checked at least every three years against the USGS benchmark located west of the Tittabawassee River along Poseyville Road, near the Dow facility. (Dow, 1986)

8.2 WATER TABLE

The extent of the water table under the Salzburg Landfill is described in the RCRA Part B Application as follows:

> The Regional Aquifer is found under about one-third of the Landfill approximately 120 feet below the ground surface [but not below Cell 36/37]. The piezometer head in this aquifer is in the 623-624 (USGS datum) range but this Aquifer is confined by the Glacial Till found everywhere under the facility. The localized water bearing sand units are depleted during construction and the landfill cells are constructed above any geological units which could be considered aquifers. (Dow, 1986)

8.3 MATERIAL EMPLACEMENT PROCEDURES

The thorium-bearing material is placed in the disposal cell in the same manner as hazardous waste is buried in other cells. This procedure is described in the RCRA Part B Application as follows:

> When the facility is operating, waste is brought to the open cell area via trucks. The trucks transfer the waste to the face of the current cell lift and a compactor is used to compact the waste and to maintain the lift height. Each lift is fifty feet wide, eight feet high and is the length of the Landfill cell. The lifts are placed using two feet deep compacted layers, in parallel with the leachate collection system.
>
> At the end of each working day about six inches of cover material is place over the waste to prevent wind dispersal of particulate matter. The cover is inspected each operating day. (Dow, 1986)

8.4 CELL CLOSURE PLAN ACTIVITIES

> The Closure Plan for the cells requires that completed areas be finished with final cover, top soil, and vegetative growth. The Closure Plan minimizes the need for further maintenance. This reduces the potential for contamination, and allows a monitoring record to be established before post-closure monitoring begins.

The plan identifies the steps that will be necessary to close the cells at the facility. (Dow, 1986)

8.4.1 Site Preparation

The cells to be closed will be prepared for clay capping by shaping and grading to meet the desired subgrade profile. The existing PE liner and clay wall will be located before grading and shaping. The liner/wall will serve as the baseline and starting point for constructing the clay cap. Surveyors will place corner stakes to mark the wall initially. All subsequent field stakes will be placed by the capping contractor. The contractor will shape and grade an area capable of being capped with the first clay lift each day. Threatening weather may alter the schedule.

All equipment used for transporting waste material in the shaping and grading work will be thoroughly cleaned before it will be allowed to work with clay. (Dow, 1986)

8.4.2 Final Cover

Drawings B2-020-884040 and B2-021-884040 detail the cap construction (see Appendix G). The final cover consists of a three foot thick (minimum) compacted clay layer which has a permeability of 1×10^{-7} centimeters per second or less and a 40 mil polyethylene liner.

Over the top of the PE liner, a drainage layer, consisting of a single layer of Geonet, will be installed.

To prevent plugging of the Geonet layer, a needle punched, non-woven geotextile, six or eight ounces per square yard minimum, will be placed over the top of the Geonet layer.

Soil capable of supporting vegetative growth will be placed to a total depth of 24 inches.

After placement of this soil, the cover will be seeded and fertilized to established vegetative cover as soon as possible to minimize erosion.

The final surface contours were chosen to minimize pooling water on top of the clay cap.

The drainage layer over the clay cap was chosen to drain any water that had percolated through the top vegetated cover so that it would drain away from the capped area.

The cover material over the drainage layer, twenty four inches of soil, was chosen to provide adequate support of the vegetation and to minimize erosion of the cover itself.

The slope of one percent minimum was chosen to reduce the velocity of the run-off from the cover material, yet still allow drainage of run-off from the cover to eliminate ponding.

Also aiding in the removal of water from the cover is the installation of the peak on the area being capped. This reduces the travel time of any run-off thereby reducing the chance for permeation of water into the cover.

Vegetative Cover

Vegetation on the cover material has been chosen for survival in the Midland, Michigan climate and will consist of a mixture of several grass strains, and be seeded in the procedure and mix shown below.

1) Spread 20-26-6 fertilizer at 450 pounds/acre.

2) Seed 400 pounds/acre of the following custom blend:

Perennial Rye	20%
Wintergreen Fescue	15%
Common Kentucky Bluegrass	30%
Ruby Creeping Red Fescue	15%
Scaldis Hard Fescue	20%

3) Cover all slopes steeper than 1 to 4 with ROLL/LITE[R] or equivalent erosion control fabric to hold seed and minimize erosion.

8.5 RADIATION EXPOSURE RATE

The post-emplacement exposure rate, as calculated using ONSITE/MAXI, is 0.15 microrem-per-hour. This calculated exposure rate is conservative due to the under-statement of soil shielding used in the calculation (3.3 ft (1m) versus a reality of at least 5 ft).

8.6 PATHWAY MONITORING

Water Monitoring

Effluent water samples will be collected and analyzed for radiological constituents in the leachate formed in the disposal cell. Samples will initially be collected after the cell has been constructed but before the material is placed in the cell to establish baseline conditions. Cell leachate subsequently generated during filling and after closure will be sampled and analyzed before the leachate is released into the water treatment plant. The drinking water standards (15 pCi per liter total alpha activity and 5 pCi per liter of combined radium 226 and 228) will be used for the release criteria.

In addition, samples from the groundwater monitoring wells emplaced around the Salzburg Landfill, as described in Section 7.4.2, will be routinely analyzed for these radiological constituents in addition to the current list of non-radiological constituents. Baseline levels will be initially established before filling of Cell 36/37 and long-term trends monitored after closure to validate that leachate infiltration is not occurring along environmental pathways.

Air Monitoring

Baseline thoron and thorium concentration in air will be initially established at the Salzburg site prior to construction of Cell 36/37. During truck unloading and filling of the disposal cell, air samples will be collected downwind of the cell and analyzed to determine thoron concentration and thorium dust liberation. The data obtained will be used to evaluate onsite work conditions to assure that worker's and public exposure are maintained ALARA. After Cell 36/37 is closed, a survey to measure thoron levels will be performed at a height of 1 meter above the release ducts from the cell and at the closest disposal site perimeter fence downwind of the cell. A release standard of 0.5 pCi per liter of thoron (above background) in air will be adhered to. Thermoluminescent dosimeters (TLDs) will also be used to establish gamma levels at the same locations to provide an early indication of any airborne movement of radiological constituents during emplacement and after closure.

Thoron concentrations will be analyzed using the Kusnetz method, and the filter samples from the air pumps will be analyzed for thorium concentration on the dust (particulates) using neutron activation techniques.

The occupational health and safety program to be conducted at the Midland, Bay City and Salzburg sites is described in Section 9.0.

9.0 RADIATION SAFETY PROCEDURES

An Environmental Health and Safety Plan (EHSP) will be implemented to establish safety criteria and procedures for workers involved in the removal and transfer of thorium material from the Bay City and Midland sites and disposal at the Salzburg landfill.

Applicable health and safety standards are specified in the EHSP, and responsibilities for carrying out the plan are delineated. The Project Radiation Safety Officer (RSO) will have prime responsibility for implementing the EHSP and will thus be responsible for onsite worker health and safety and for ensuring that environmental releases do not adversely affect public health. The RSO and supporting DOW staff will perform the combined health physics and industrial hygiene functions.

9.1 HEALTH AND SAFETY PLAN HIGHLIGHTS

9.1.1 Worker Training

A formal training program will be conducted by the Project RSO for all remediation workers before they begin their on-site activities. In addition to conventional industrial hygiene training, the sessions will also emphasize radiological safety procedures for the material removal, transfer, and disposal phases including those covering self-monitoring and personal decontamination.

The RSO will conduct physical walk through inspections of the thorium storage sites prior to the initiation of activities connected with material removed. The inspections will concentrate on the necessary safety precautions to be taken. In addition, the RSO will provide follow-up training sessions to workers prior to beginning work at a new location or when working conditions change. These sessions will cover the specific nature of the hazards, the extent of contamination exposure that day, and an explanation of the safety equipment to be used.

9.1.2 Controlled Areas

Controlled Areas shall be established onsite by the RSO to protect workers from unnecessary exposure to radiation or toxic materials, and to prevent the spread of contamination.

Each of the sites shall be divided into three well delineated zones, as follows:

Contamination Zone

This zone includes the actual areas of contamination (uncovered thorium under excavation). This zone has the highest inhalation exposure potential and/or presents a high probability of skin contact.

Contamination Reduction Zone

This zone includes the areas immediately surrounding the Contamination Zone, and includes the vehicle and equipment decontamination stations. This zone has the next highest inhalation hazard but does not have a high probability of skin contact.

Clean Zone

This zone covers all areas outside of the Contamination Reduction Zone inside the site boundary Adverse exposure is unlikely.

Access to these areas shall be controlled for people, vehicles, and equipment by fencing and posting the area or by using other methods to prevent inadvertent exposure to contaminated material.

ok

Smoking, drinking, eating, or other activities that would enhance the transfer of radionuclides into the human body shall be prohibited in contamination zones. See Section 9.2.5 for elaboration on those protective measures.

Controlled areas will be conspicuously marked at points of potential access with signs satisfying applicable posting and labeling requirements as set forth in 10 CFR 20 and 29 CFR 1910.1200.

At times when it is necessary to barricade or 'rope off" an area, all barricades, ropes, and warning signs, whether used in roadway or not, shall be in accordance with ANSI Standards D-6.1-1971.

9.2 RADIOLOGICAL HEALTH PRECAUTIONS/OCCUPATIONAL MONITORING

9.2.1 Dosimetry

All remediation workers at the Bay City and Midland thorium sites will be required to wear appropriate dosimetry. These will be worn in an area of the body where they are not subject to contamination from airborne dust, generally under protective clothing. When not in use these dosimeters will be stored in a place that avoids contamination and away from the thorium pile where additional exposure could occur (low background area). These forms of dosimetry will be turned in to be read and thus determine the exposure levels monthly.

A pressurized ion chamber (PIC) will be operated on a continual basis onsite during removal and transfer operations to monitor area concentrations and exposure levels and thus assure worker safety in the zone of excavation.

9.2.2 Air Monitoring

An air sampling program will be conducted for any material movement operations that have the potential for radionuclides to become airborne above applicable guidelines and will continue until all site excavation work is completed at Bay City and Midland. High volume air samplers will be used for area monitoring downwind of the work area. These monitors will be used to assess releases due to excavation operations. Air filters will be analyzed for thorium concentrations and to determine thoron concentrations using the Kusnetz method. Thoron & thorium concentrations will be established over the thorium piles at Bay City and Midland prior to initiating remedial activities to provide a basis for comparison during operations. Baseline concentrations will be established in areas in proximity to the piles but not influenced by them.

At the Salzburg landfill, baseline thoron and thorium concentrations will be established prior to emplacement of the material, and downwind air samples will be collected to assess operational concentrations as the trucks unload material into the disposal cell.

The results of the air monitoring program will be used to evaluate work conditions and permit the application of procedures to maintain the potential for worker validation at ALARA levels.

9.2.3 Respiratory Protection

Any remedial excavation or emplacement operations in which there exists the possibility of inhaling radioactive Thorium in the form of dust will warrant that all workers in the immediate area wear air purifying respirators. Workers will be required to have medical approval and be fit tested if respirator protection is necessary. The need for continual use of respiratory protection will be evaluated on a ongoing basis during the remedial operation, and the determination will be made based on job analyses and possible air monitoring results obtained during the work.

9.2.4 Contamination Monitoring/Decontamination Procedures

To minimize the spread of low level contamination and potential for ingestion, coveralls, boots, and gloves will be worn by the workers in the restricted area (contamination zone). These will be removed before these individuals leave the site and will be placed back on when they reenter the site. This protective clothing will be considered as contaminated and will not leave the site until released or disposed of, if required, by the RSO.

All personnel leaving the controlled areas will then be monitored for contamination by the RSO staff using portable beta-gamma monitors . Any additional contamination will be removed to within regulatory limits with the objective of achieving ALARA levels. Procedures will be followed to avoid workers ingesting dust particles containing Thorium.

The material in the trucks will be wetted and covered with a tarpaulin after loading on to the truck. Before leaving the controlled areas at Bay City and Midland each vehicle will be subjected to an exterior high pressure wash covering the undercarriage and frame and then visually inspected in its entirety for dust and potential transfer points (i.e. wheels, undercarriage) will be monitored with portable survey instruments. The process will be repeated after unloading at Salzburg.

Any equipment leaving the site will be evaluated to determine the contamination level, and decontaminated if necessary to achieve release criteria to unrestricted areas.

10.0 RECORD KEEPING

10.1 PERIOD OF STORAGE

Records of disposals made under the requested license will be maintained by the licensee until the commission authorizes disposal of such records.

10.2 RECORD CONTENTS

The requirements for records are simplified by the nature of the waste. All of the contaminated waste will be disposed of in one disposal cell, and transported in bulk from the storage sites. Records of the disposal activities will be maintained in conjunction with those of the hazardous waste facility.

The movement of all materials to Cell 36/37 will be tracked using a waste disposal manifest. The following information is contained on each record:

1. Originating site
2. Shipment destination (Salzburg Landfill)
3. Material description
4. Material quantity - yd3
5. Shipment number
6. Shipment date
7. Receiving date

The record also provides the data base for:

1. Reporting to governmental agencies the material received by the facility
2. Facility operating log

A daily operating log is maintained at the facility. The log is used to record facility activities and other requirements of the RCRA, MI Act 64, and the facility operating license.

10.3 DISPOSAL SITE IDENTIFICATION

The cell used for disposal of the thorium-bearing material will be specially identified on the Salzburg site through use of the radiation symbols as specified in 10 CFR 20.

The records of the Salzburg Landfill will contain a complete description of the disposal cell used for the thorium material, including a map of the site, to scale, indicating the location of the burial cell and the site boundaries.

11.0 STATE AND LOCAL REQUIREMENTS

11.1 OTHER RELEVANT ENVIRONMENTAL PERMITS

There is no intention to comingle hazardous wastes with the thorium-bearing material discussed in this license application. The Salzburg Landfill is, however, operated by Dow Chemical USA, Michigan Division, as a hazardous waste disposal facility. The following permits and licenses are relevant to such operations:

A. Michigan Act 64 Construction Permit
   1. Issued: 09/15/81
   2. No expiration date

B. Michigan Act 64 Operating License/RCRA Part B Permit
   1. Issued: 01/87
   2. Expires: 01/92

C. Michigan Act 641 Operating License

D. National Pollution Discharge Elimination System Permit
   1. Issued: 10/3/88
   2. Expires: 10/1/93

11.2 RESTRICTIVE COVENANTS

Restrictive covenants have been placed on the use of the Salzburg Landfill in recognition of the hazardous waste disposal activities conducted there. The covenants were recorded on July 3, 1984 by the Register of Deeds, Midland County, Michigan.

A copy of the covenants is included as Appendix B.

Prior to burial of radioactive waste under this license application, further covenants shall be included on the Landfill deed to the effect that radioactive material has been disposed of on the site.

12.0 CERTIFICATE

The applicant and any official executing this application on behalf of the applicant certifies that this application and all information contained herein, including any supplements attached is true and correct to the best of our knowledge and belief.

R M Croyle
Signature

Randy Croyle
Environmental Manager
Michigan Division
Dow Chemical U.S.A.

13.0 REFERENCES

Dow, 1977; Dow Chemical U.S.A., Letter from E.O Gooding, Dow to Mr. D.E. Van Farowe, Michigan Department of Health; Reference: Magnesium-Thorium Sludge Pile in Bay City; December 14, 1977.

Dow, 1986; Dow Chemical U.S.A. "Salzburg Landfill RCRA Part B Application, Vol. IIB", Revised, 1986

EDI, 1983; EDI Engineering & Science, "Salzburg Landfill RCRA Part B Application, Volumes II A, B, and D", Prepared for Dow Chemical U.S.A., Michigan Division, 1983

EDI, 1984; EDI Engineering & Science, "Salzburg Landfill RCRA Part B Application, Volume IIE", Prepared for Dow Chemical U.S.A., Michigan Division, 1984

EDI, 1984a; EDI Engineering & Science "Salzburg Landfill Michigan Act 64 Operating License Reapplication" Prepared for Dow Chemical U.S.A., Michigan Division, 1984.

Engel et al., 1966; Engel, R.L., Greenborg, J., and Hendrickson, M.M., ISOSHLD-A Computer Code for General Purpose Isotope Shielding Analysis, BNWL-236, Pacific Northwest Laboratory, Richland, WA.

FEMA, 1983; Federal Emergency Management Agency," Flood Insurance Study, City of Midland, Michigan" Revised Preliminary, 1983

Goode, et al., 1987; Goode, Daniel J., Neuder, Stanley M., Pennifill, Roger A., and Ginn, Timothy, "On-Site Disposal of Radioactive Waste Estimating Potential Groundwater Contamination" U.S. Nuclear Regulatory Commission NUREG-1101, Vol. 3, 1986

Houston, et al., 1974; Houston, J.R., Strege, D.L., and Watson, E.C., DACRIN-A Computer Program for Calculating Organ Dose from Acute or Chronic Radionuclide Inhalation, BNWL-B-389, Pacific Northwest Laboratory, Richland, WA.

ICRP, 1966; "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract"; Health Phys. 12:137-207.

ICRP, 1959; International Commission on Radiological Protection, Publication No. 2, Report of ICRP Committee II on Permissible Dose for Internal Radiation. Pergamon Press, Elmsford, NY.

ICRP, 1979-1982; International Commission on Radiological Protection, Publication No. 30, Limits for Intakes of Radionuclides by Workers, Pergamon Press, Elmsford, NY.

Kennedy, et al., 1987; Kennedy, W.E., Peloquin, R.A., Napier, B.A., and Neuder S.M.,"Intruder Dose Pathway Analysis for the On-Site Disposal of Radioactive Wastes: The ON-SITE/MAXI1 Computer Program" Pacific Northwest Laboratory NUREG/CR-3620, PNL-4054 Supplement No. 2, National Technical Information Service Springfield, VA

Kennedy, et al., 1984; Kennedy, W.E., Jr, Peloquin, R.A., Napier, B.A., and Neuder, S.M., Intruder Dose Pathway Analysis for the ONSITE/MAXI1 Computer Program. NUREG/CR-3620 Supplement 1, National Technical Information Service, Springfield, VA.

ORNL, 1981; Myrick, T.E., Berben, B.A., and Hazelwood, F.F., "State Background Radiation Levels: Results of Measurements Taken During 1975-1979", ORNL/TM-7343,1981.

Napier et al., 1984; Napier, B.A., Peloquin, R.A., Kennedy, W.E. Jr., and Neuder, S.M., Intruder Dose Pathway Analysis for the Onsite Disposal of Radioactive Wastes: The ONSITE/MAXI1 Computer Program. NUREG/CR-3620, NTIS, Springfield, VA.

Neuder, et al., 1986; Neuder, Stanley M., "On-Site Disposal of Radioactive Waste: Guidance for Disposal by Subsurface Burial" U.S. Nuclear Regulatory Commission NUREG 1101, Vol. 1, 1986

Neuder, et al., 1987; Neuder, Stanley M. and Kennedy, W.E. "On-Site Disposal of Radioactive Waste: Methodology for the Radiological Assessment of Disposal by Subsurface Burial" U.S. Nuclear Regulatory Commission, NUREG 1101, Vol. 2, 1987

Teknekron, 1982; Teknekron Research, Inc., "Parameters and Variables Appearing in Repository Siting Models", NUREG/CR-3066, 1982

APPENDIX A
COST ESTIMATE FOR OFFSITE DISPOSAL

Cost Estimate - Removal and Disposal in Commercial Facility

Waste Volumes - Bay City - 40,000 yd^3; Midland - 12,000 yd^3

Cost Item		Estimate ($1,000)	
1.	Preparation of Remediation Plan	25	
2.	Preparation of HP Plan	15	
3.	HP Monitoring Program	250	
4.	Radiation Surveys to Define Removal Requirements	180	
5.	Post Closure Monitoring - One Year	80	
6.	Waste and Soil Excavation	375	
7.	Closure of Remediation Sites/Maintenance	850	
8.	Onsite Movement, Packaging, Loading	24825 (Packaged in 55 gallon drums)	
9.	Transport Costs to Richland or	14063	
	Transport Costs to Beatty		12,915
10.	Disposal Costs - Richland	51,895 (1)	
	Disposal Costs - Beatty		44,180 (2)
	Total	$92.308	$83,445

(1) Based on $37/ft^3$ burial cost (including $10/ft^3$ surcharge)

(2) Based on $31.50/ft^3$ burying costs (including $10/ft^3$ surcharge)

Burial cost quoted in telecon with U.S. Ecology - 9/87

APPENDIX B
RESTRICTIVE COVENANTS

Facility file

February 27, 1981

RECEIVED

OCT 21 1988

Michigan Div. Legal

John M. Alford
Environmental Sanitarian
Department of Natural Resources
Resource Recovery Divs.
P.O. Box 128
Roscommon Mi. 48653

Re: Salzburg Road Sanitary Landfill, Declaration of Restrictive Covenant, City of Midland, Midland County

Dear Mr. Alford:

Enclosed is a copy of the Declaration of Restrictive Covenant for the Dow Chemical Company 7.4 acre sanitary landfill located off Salzburg Road, Midland County.

This covenant was recorded with the Midland County Register of Deeds office on February 11, 1981 in accordance with Act 641, P.A. of 1978.

Should you have any questions, please feel free to contact this office.

Sincerely,

Douglas Dial

Douglas Dial, R.S., Director
Environmental Health Division

DD:pm
CC: Larry Washington, Mgr. of
Dow Environmental Services
W. C. Meagher, Real Estate Dept. of
Dow Chemical Company

FEB 11 11 31 AM 1981 DECLARATION OF RESTRICTIVE COVENANT

RECEIVED
DEC 17 1980
RES. RECOVERY REG. II

REGISTER OF DEEDS
MIDLAND

THIS INDENTURE made the 24th day of November, 19 80, by and between, THE DOW CHEMICAL COMPANY whose address is: 2030 Dow Center, Midland, Michigan 48640 part(y) (ies) of the first part; and Howard A. Tanner, Director of the Michigan Department of Natural Resources for and on behalf of the State of Michigan, whose address is: Steven T. Mason Building, Lansing, Michigan 48913, party of the second part;

WITNESSETH THAT:

WHEREAS, application for licensure under provisions of 1978, PA 641, 1970 CL 299.401 *et seq*, for the purpose of conducting, managing, maintaining or operating a disposal area upon lands situated in the City of Midland, County of Midland, more particularly described as: Commencing at the North Quarter (1/4) corner of Section 35, Township 14 North, Range 2 East; thence South 89°-47'-50" East 433.38 feet along the North line of said Section 35; thence South 0°-12'-10" West 252.08 feet to the point of beginning; thence continue South 0°-12'-10" West 413.65 feet; thence South 42°-55'27" West 476.54 feet; thence North 45°-39'42" West 560.70 feet; thence North 42°-41'-11" East 506.25 feet; thence South 89°-47'-5 East 383.80 feet to the point of beginning; containing 8.15 ± acres. has been properly made; and

WHEREAS, the Director of the Department of Natural Resources, will contemporaneously issue such license; and

WHEREAS, 1978 PA 641, *supra*, Section 16 requires that at the time of licensing of a sanitary landfill, an instrument which imposes a restrictive covenant upon the land involved shall be executed by all the owners of the tract of land upon the landfill is located and the director.

NOW THEREFORE, THE DOW CHEMICAL COMPANY, the part(y) (ies) of the first part, do for themselves, their heirs, successors, lessees, or assigns declare, covenant and agree:

R-5527
Rev 2/80

1. That the lands hereinbefore described have been or will hereafter be used as a sanitary landfill, and that neither they, nor their servants, agents, employees, nor any of the heirs, successors, lessees or assigns shall (or shall by their leave or sufferance permit others to) engage in filling, grading, excavating, drilling or mining of the lands and premises above described until 15 years after completion of all landfill activity upon the same, unless written authorization therefor is obtained from the Director of the Department of Natural Resources; and that the State of Michigan or any municipality may in addition to any other remedy available at law bring an action for an injunction or other process against any person, county, or municipality to restrain or prevent any violation of the restrictive covenant hereby imposed upon the subject premises.

2. That at the time of the ensealing and delivery of these presents the above described premises are free from all encumbrances whatever, (except) a right of way granted to Consumers Power Company for above ground electrical transmission lines.

The director of the department of natural resources does for and on behalf of the State of Michigan covenant and agree to execute, acknowledge, and deliver to the party of the first part, a release of the within restrictive covenant, in suitable form, upon the expiration of the 15 year period provided for herein.

RESTRICTIVE CONVENANTS

THE DOW CHEMICAL COMPANY, a Delaware corporation with executive offices at
Name   Company, Partnership, etc.   Address
2030 Dow Center in Midland County, Michigan,
is the record owner of the following described premises in the Township of

Midland, Midland County, Michigan, to wit:

SEE ATTACHED EXHIBIT-A

The Dow Chemical Company is in the process of constructing a hazardous waste landfill
Name
on a portion of its property above described, pursuant to 1979 PA 64 and the rules promulgated thereunder, the location of the facility being described in Exhibit A, attached hereto, and hereby

NOW, THEREFORE, these Restrictive Covenants are executed by The Dow Chemical Co.
Name
to insure the integrity of said disposal facility for the safety of the people of the State of Michigan, to-wit:

(1) No vehicles, except vehicles needed and actually used for maintenance and inspection, shall be allowed within the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(2) No excavation or construction, except as necessary to maintain the integrity of the facility, shall be allowed after closure of the facility in the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(3) No uses of the property shall be made which may or will impair the integrity of the facility.

RECORDED

JUL 3 4 13 PM '84

RICHARD C DIMENT
REGISTER OF DEEDS
MIDLAND COUNTY, MICH

RECEIVED

OCT 21 1988

Michigan Div. Legal

3/81   R 4906

THE DOW CHEMICAL COMPANY (Name), a Delaware corporation with executive offices at (Company, Partnership, etc. Address) 2030 Dow Center in Midland County, Michigan, is the record owner of the following described premises in the Township of

Midland, Midland County, Michigan, to wit:

SEE ATTACHED EXHIBIT-A

The Dow Chemical Company (Name) is in the process of constructing a hazardous waste landfill on a portion of its property above described, pursuant to 1979 PA 64 and the rules promulgated thereunder, the location of the facility being described in Exhibit A, attached hereto, and hereby

NOW, THEREFORE, these Restrictive Covenants are executed by The Dow Chemical Co. (Name) to insure the integrity of said disposal facility for the safety of the people of the State of Michigan, to-wit:

(1) No vehicles, except vehicles needed and actually used for maintenance and inspection, shall be allowed within the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below. except as indicated in Paragraph (8) below.

(2) No excavation or construction, except as necessary to maintain the integrity of the facility, shall be allowed after closure of the facility in the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(3) No uses of the property shall be made which may or will impair the integrity of the facility.

RECORDED

JUL 3 4 13 PM '84

RICHARD C. DMENT
REGISTER OF DEEDS 3/81
MIDLAND COUNTY, MICH

R 4305

RECEIVED

OCT 21 1988

Michigan Div. Legal

(4) The Dow Chemical Company (Name) shall erect, and it and its successors in interest, shall thereafter continuously maintain until further order of the Department of Natural Resources: (i) a secure and sound fence enclosing the area containing the disposal facility at least FIFTY (50) feet measured from all edges of the disposal facility; and (ii) a sign stating: "Warning, Hazardous Waste Disposal Area, KEEP OUT," inside the fence, visible from each side.

(5) The Dow Chemical Company (Name) shall notify the Director of the Michigan Department of Natural Resources of its intent to convey any interest in land located in City of Midland, Section 35 in Midland Township, Midland County, Michigan. No conveyance of title, easement, or other interest in the property shall be consummated by The Dow Chemical Company (Name) without adequate and complete provision for continued maintenance of the facility and monitoring systems described in the Closure and Post Closure Maintenance and Monitoring Plans described in Exhibit B, attached hereto and hereby made a part hereof. For the purpose of assuring adequate maintenance of the facility's monitoring system(s), no property owned by The Dow Chemical Co. (Name), described in Exhibit A shall be conveyed without prior written approval of the Director of the Michigan Department of Natural Resources. Such approval by the Director is not to be unreasonably withheld.

(6) Until further notice from the Director of the Michigan Department of Natural Resources, set forth above, The Dow Chemical Co. (Name), and its successors in title will maintain and monitor the facility as described in Section 41(1) of 1979 PA 64.

(7) Any governmental agency adversely affected by any violations of these restrictions may enforce them by legal actions in the Circuit Court.

(8) The property described in Exhibit A is subject to an existing easement of record granted to Consumers Power Company for electric transmission lines.

These Restrictive Covenants shall run with the land and be binding upon first party, its successors, and assigns.

DATED: This 6th day of July, 1981.

THE DOW CHEMICAL COMPANY

By [signature]

Its I. F. HARLOW, VICE PRESIDENT

Director, Michigan Department of Natural Resources

WITNESSES:

[signature]
Cheryl A. Johnson

[signature]
Lu Ellen Joslyn

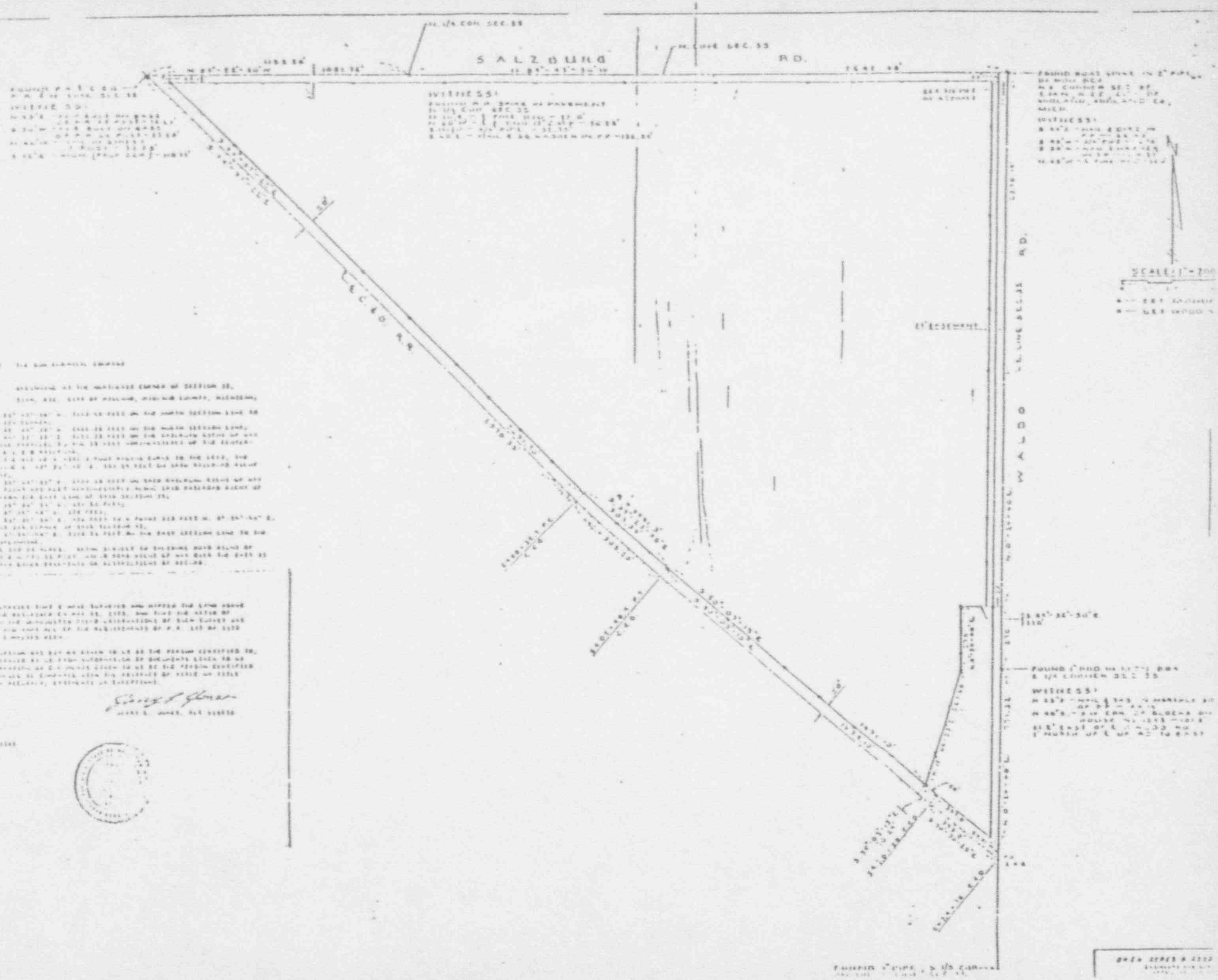
STATE OF MICHIGAN)
) ss.
COUNTY OF MIDLAND)

The foregoing insturment was acknowledged before me this 6th day of July, 1981, by I. F. Harlow, of The Dow Chemical Company ~~corporation~~, on behalf of the Corporation.

The information necessary to complete this instrument was supplied by The Dow Chemical Company, however, the instrument was prepared by the Michigan Department of Natural Resources.

[signature]
NOTARY PUBLIC

CHERYL A. JOHNSON
Notary Public, Midland County, Michigan
My Commission Expires June 1, 1983



SALZBURG RD.
WALDO RD.
C.C.&O. R.R.
WITNESS:
SCALE: 1" = 200'

Certified Copy of

POWER OF ATTORNEY

Know all Men by these Presents, That the FEDERAL INSURANCE COMPANY, 51 John F. Kennedy Parkway, Short Hills, New Jersey, a New Jersey Corporation, has constituted and appointed, and does hereby constitute and appoint Tad N. Coalwell, Harrison T. Plum, Jr., Roberta B. Lukowski and Dick Vlasblom of Midland, Michigan---

each its true and lawful Attorney-in-Fact to execute --- under such designation in its name and to affix its corporate seal to and deliver for and on its behalf as surety thereon or otherwise, bonds or obligations on behalf of THE DOW CHEMICAL COMPANY

of any of the following classes, to-wit:

1. Bonds and Undertakings (other than Fiduciary Bonds) filed in any suit, matter or proceeding in any Court, or filed with any Sheriff or Magistrate, for the doing or not doing of anything specified in such Bond or Undertaking, in which the penalty of the bond or undertaking does not exceed the sum of ONE HUNDRED THOUSAND DOLLARS ($ 100,000.00).
2. Surety Bonds to the United States of America or any agency thereof, including those required or permitted under the laws or regulations relating to Customs or Internal Revenue; License and Permit Bonds or other indemnity bonds under the laws, ordinances or regulations of any State, City, Town, Village, Board or other body or organization, public or private; bonds to Transportation Companies, Lost Instrument bonds, Lease bonds, Worker's Compensation bonds, Miscellaneous Surety bonds and bonds on behalf of Notaries Public, Sheriffs, Deputy Sheriffs and similar public officials.
3. Bonds on behalf of contractors in connection with bids, proposals or contracts to or with the United States of America, any state or political subdivision thereof or any person, firm or Corporation.

In Witness Whereof, the said FEDERAL INSURANCE COMPANY has, pursuant to its By-Laws, caused these presents to be signed by its Assistant Vice-President and Assistant Secretary and its corporate seal to be hereto affixed this 7th day of December 19 82

FEDERAL INSURANCE COMPANY
By

George McClellan
Assistant Vice-President

Richard D. O'Connor
Assistant Secretary

STATE OF NEW JERSEY }
County of Essex } ss:

On this 7th day of December 19 82 before me personally came Richard D. O'Connor to me known and by me known to be Assistant Secretary of the FEDERAL INSURANCE COMPANY, the corporation described in and which executed the foregoing Power of Attorney, and the said Richard D. O'Connor being by me duly sworn, did depose and say that he is Assistant Secretary of the FEDERAL INSURANCE COMPANY and knows the corporate seal thereof; that the seal affixed to the foregoing Power of Attorney is such corporate seal and was thereto affixed by authority of the By-Laws of said Company, and that he signed said Power of Attorney as Assistant Secretary of said Company by like authority; and that he is acquainted with George McClellan and knows him to be the Assistant Vice-President of said Company, and that the signature of said George McClellan subscribed to said Power of Attorney is in the genuine handwriting of said George McClellan and was thereto subscribed by authority of said By-Laws and in deponent's presence.

Acknowledged and Sworn to before me on the date above written.

PATRICIA RYAN NOTARY PUBLIC NEW JERSEY

Notary Public

PATRICIA RYAN
NOTARY PUBLIC OF NEW JERSEY

APPENDIX C
GEOPHYSICAL LOGS

GEOPHYSICAL LOG

Project No. 85553 Well or Boring No. 2366 Date 11-27-79

Client DOW CHEMICAL COMPANY Tested by M.E.B.

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

NE 1/4 NW 1/4 NE 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATES - 62+77 S, 77+66 E

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft Diameter 6 1/4 in.

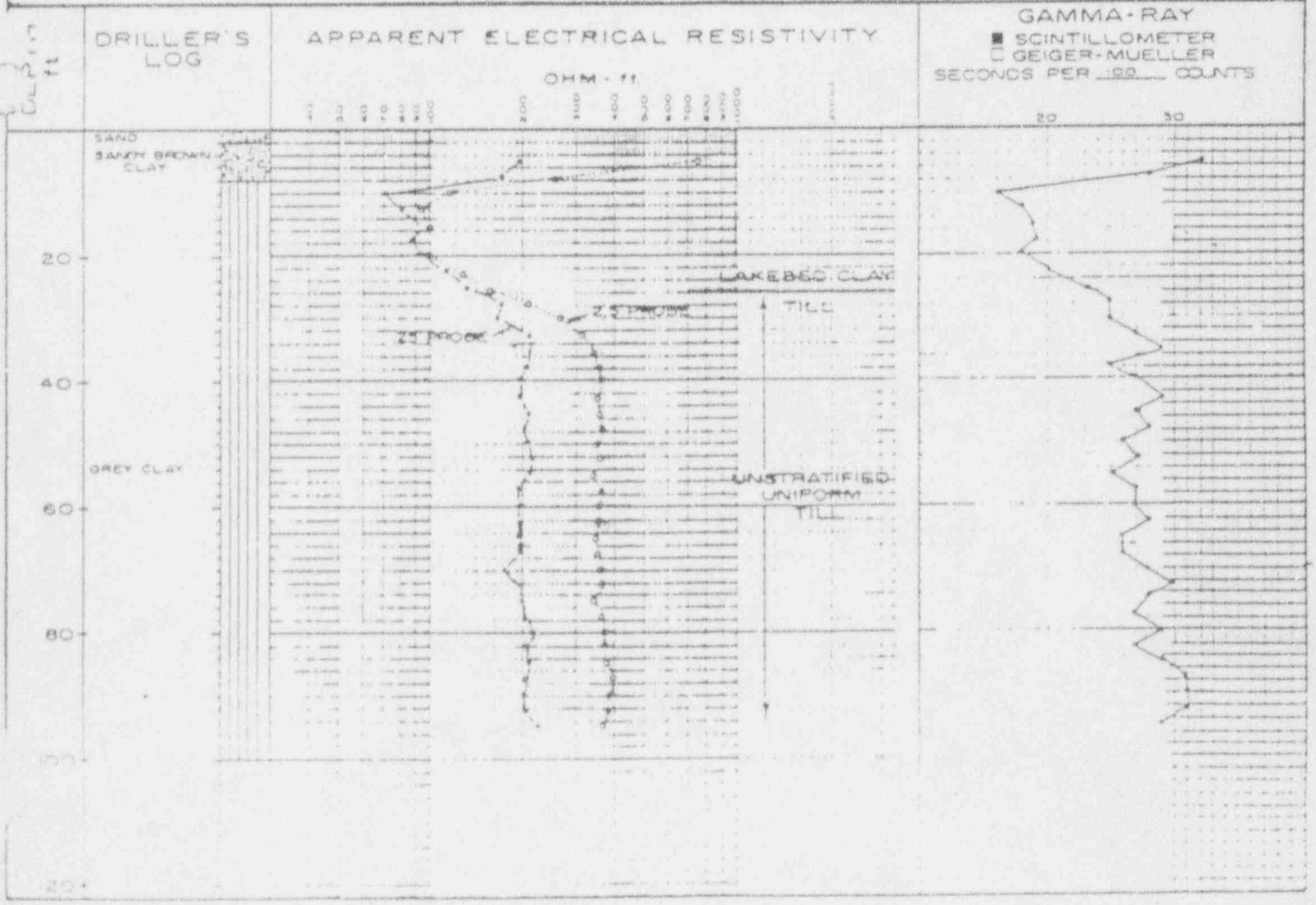
ELEVATIONS

Land Surface 626.2 ft. ABOVE M.S.L. (Meas'd)

Top of Casing ____ ft. ABOVE / BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth 9 FEET



GEOPHYSICAL LOG

Project No 85553 Well or Boring No. 2373 Date 11-28-79

Client DOW CHEMICAL COMPANY Tested by MEB

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

NE 1/4 NE 1/4 NW 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATE: 66+17 S, 63+56 E

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft Diameter 5 1/4 in.

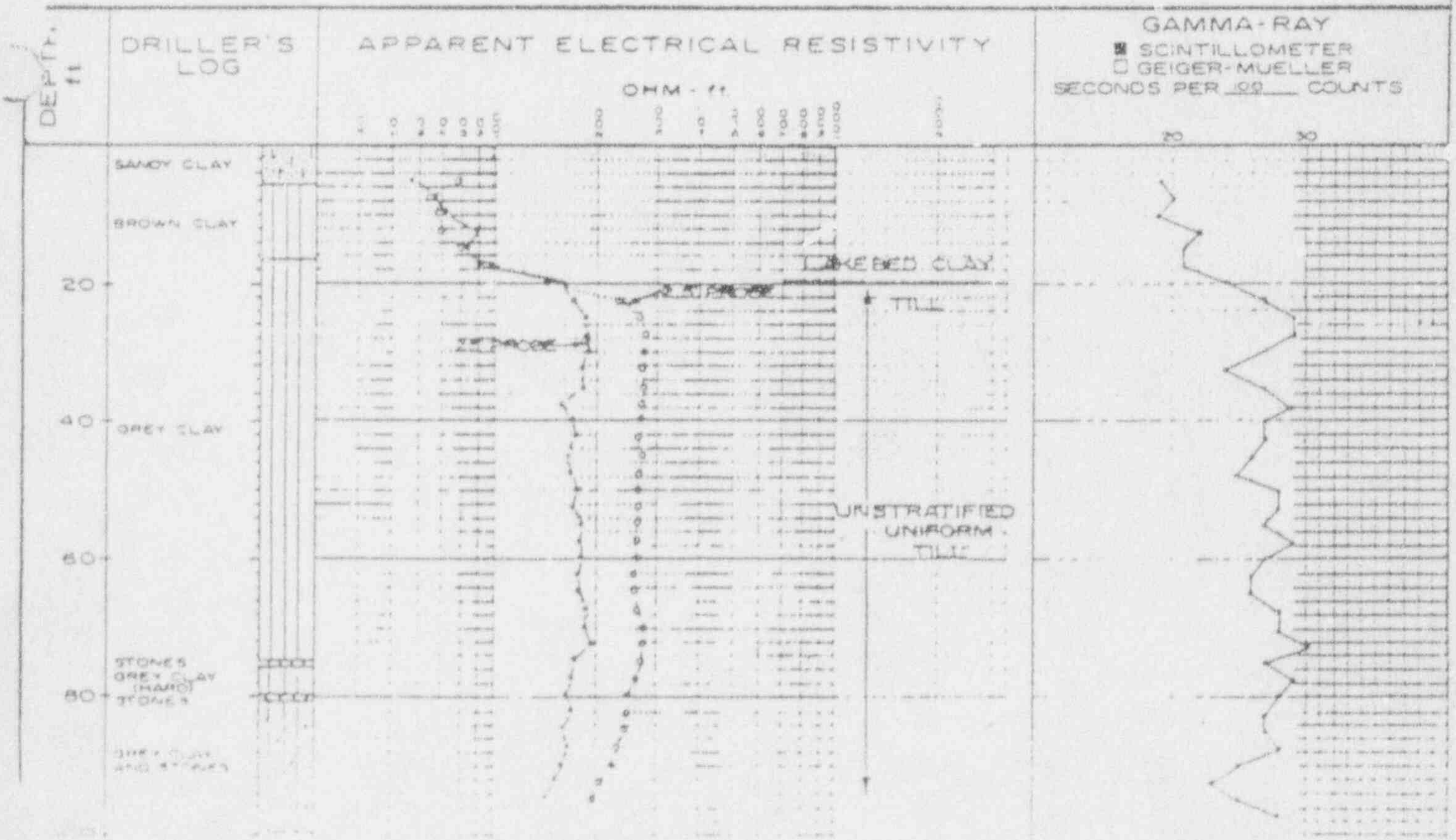
ELEVATIONS

Land Surface 620.9 ft. ABOVE M.S.L. (~~Est'd, Rep'td~~, Meas'd)

Top of Casing ______ ft. ABOVE/BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth < 5 FEET



GEOPHYSICAL LOG

Project No. 85553 Well or Boring No. 2388 Date 11-29-79

Client DOW CHEMICAL COMPANY Tested by MEB

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

SW 1/4 NE 1/4 NE 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATES - 72+17 S, 84+06 E

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft. Diameter 6 1/4 in.

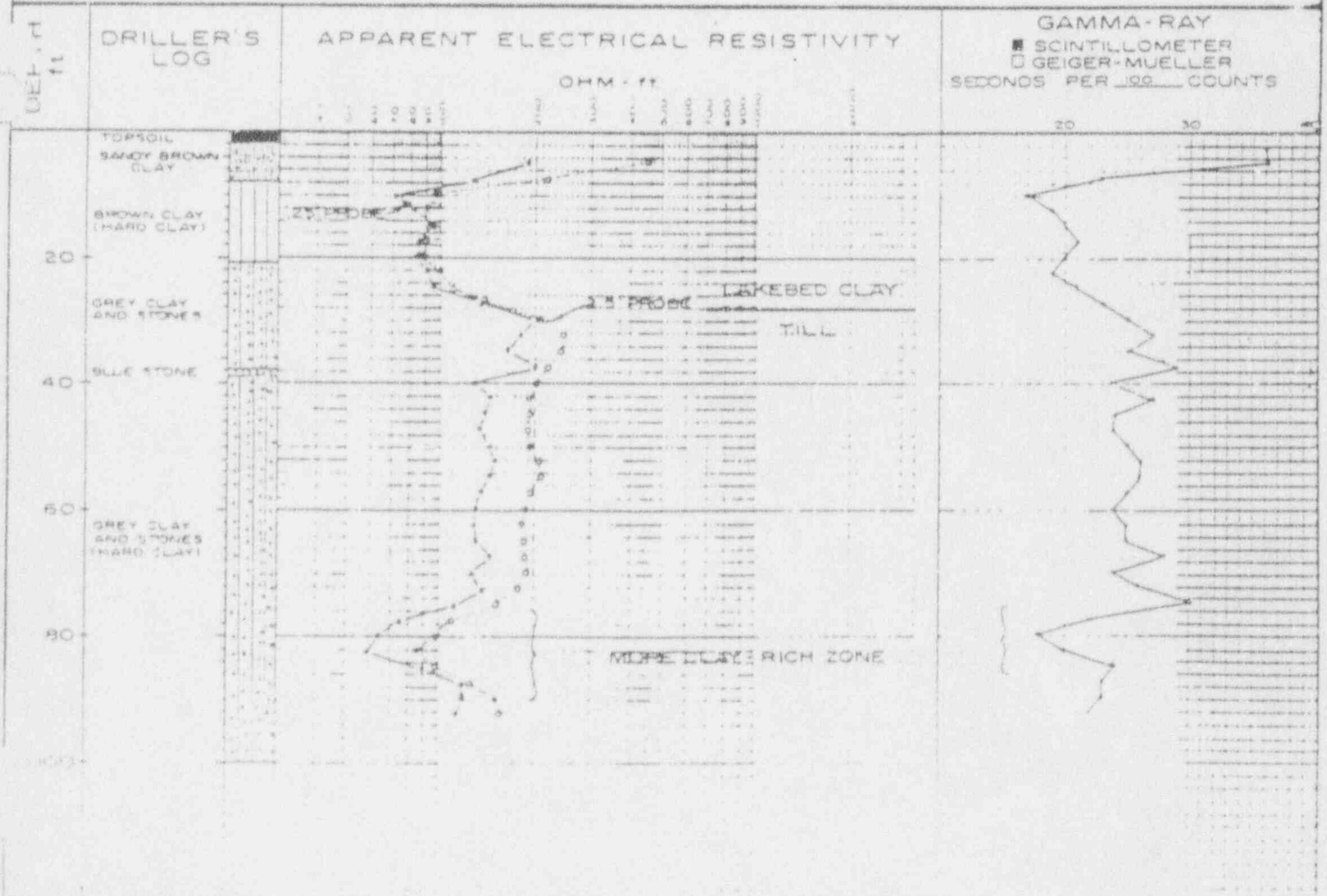
ELEVATIONS

Land Surface 626.8 ft. ABOVE M.S.L. (~~Est'd, Found~~, Meas'd)

Top of Casing ______ ft. ABOVE/BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth APPROX. 9 FT



GEOPHYSICAL LOG

Project No. 85553 Well or Boring No. 2396 Date 11-28-79

Client DOW CHEMICAL COMPANY Tested by MEB

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

NE 1/4 SW 1/4 NE 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATES - 79+14 S, 74+98 E

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft Diameter 5 1/4 in

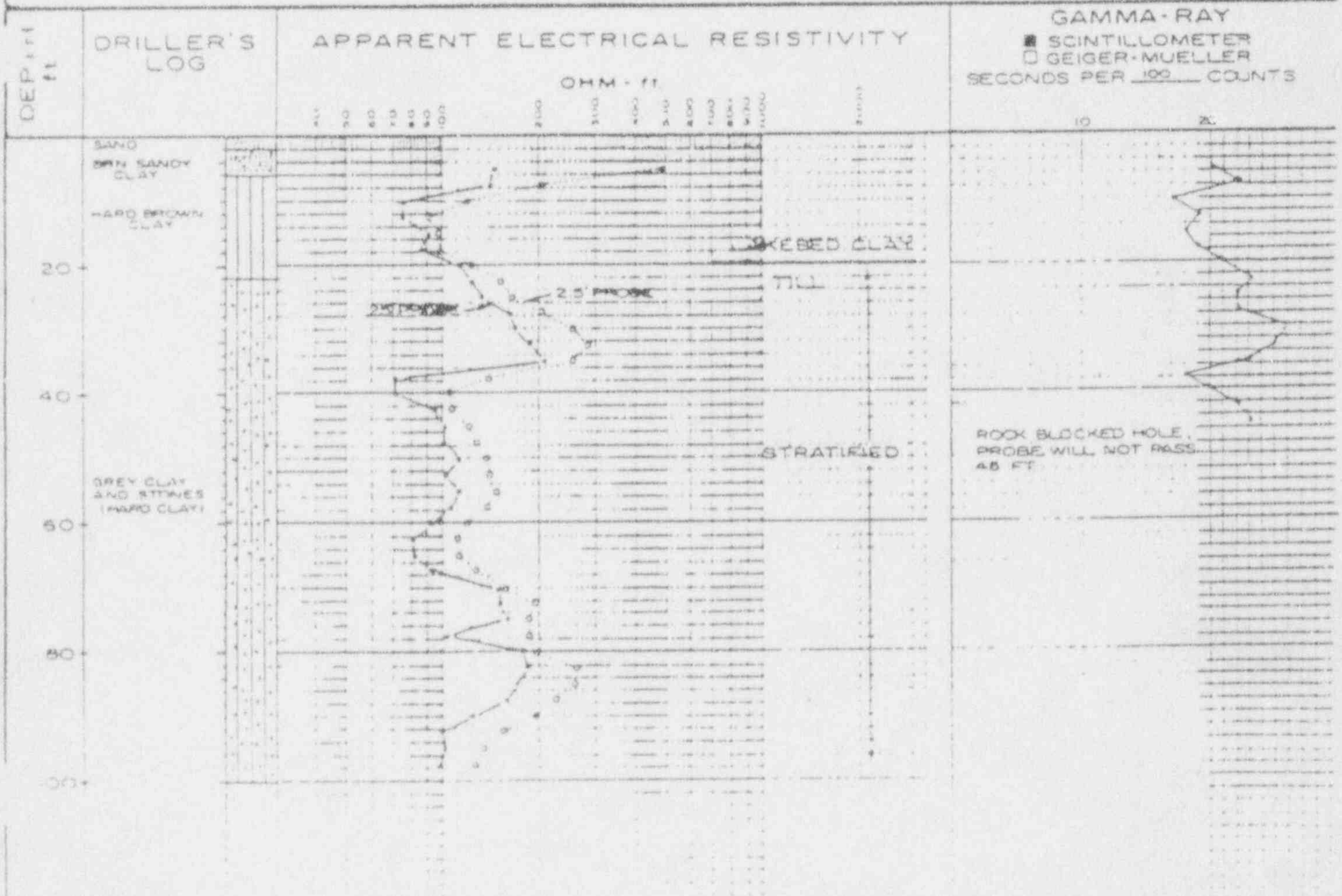
ELEVATIONS

Land Surface 627.7 ft. ABOVE ~~BELOW~~ M.S.L. (~~Est'd, Rep'd,~~ Meas'd)

Top of Casing ______ ft. ABOVE BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth APPROX. 11 FEET



GEOPHYSICAL LOG

Project No. 85553 Well or Boring No. 2396 Date 11-28-79

Client DOW CHEMICAL COMPANY Tested by MEB

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

NE 1/4 SW 1/4 NE 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATES - 79+14 S , 74+98 E

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft. Diameter 5 1/4 in.

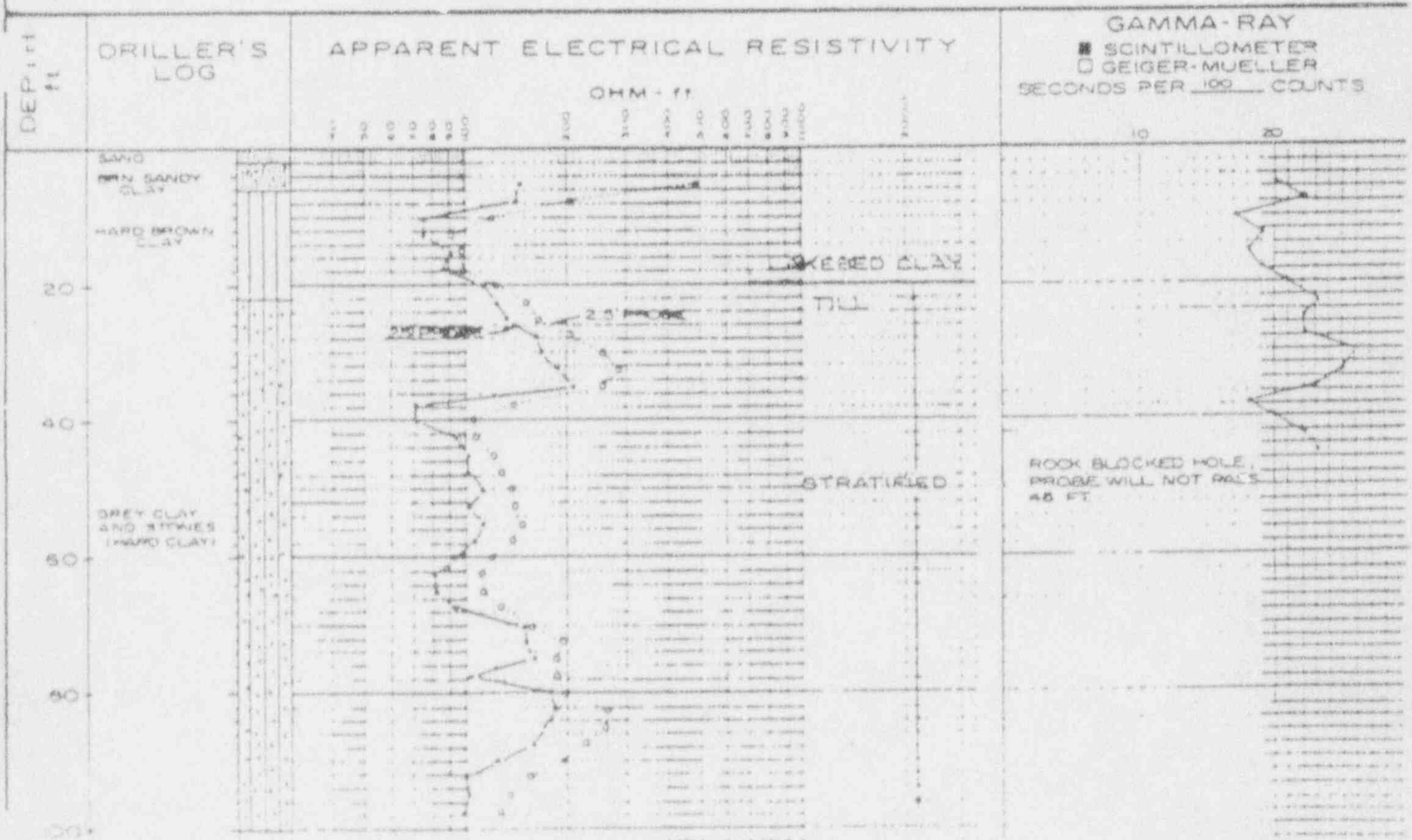
ELEVATIONS

Land Surface 627.7 ft. ABOVE M.S.L. (~~Estd, Rapid,~~ Meas'd)

Top of Casing ______ ft. ABOVE/BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth APPROX. 11 FEET



GEOPHYSICAL LOG

Project No. 85553 Well or Boring No. 2402 Date 11-27-79

Client DOW CHEMICAL COMPANY Tested by MEB

LOCATION

State MICHIGAN County MIDLAND Township MIDLAND

SE 1/4 SE 1/4 NE 1/4 Section 35 T 14 N R 2 E

Distance GRID COORDINATES -

OWNER DOW CHEMICAL COMPANY Address MIDLAND, MICHIGAN

CONTRACTOR KLEINFELT DRILLING CO. Address CHARLOTTE, MICHIGAN

WELL AND LOG DATA

Type of Well EXPLORATORY BORING Depth 100 ft. Diameter 5 1/4 in

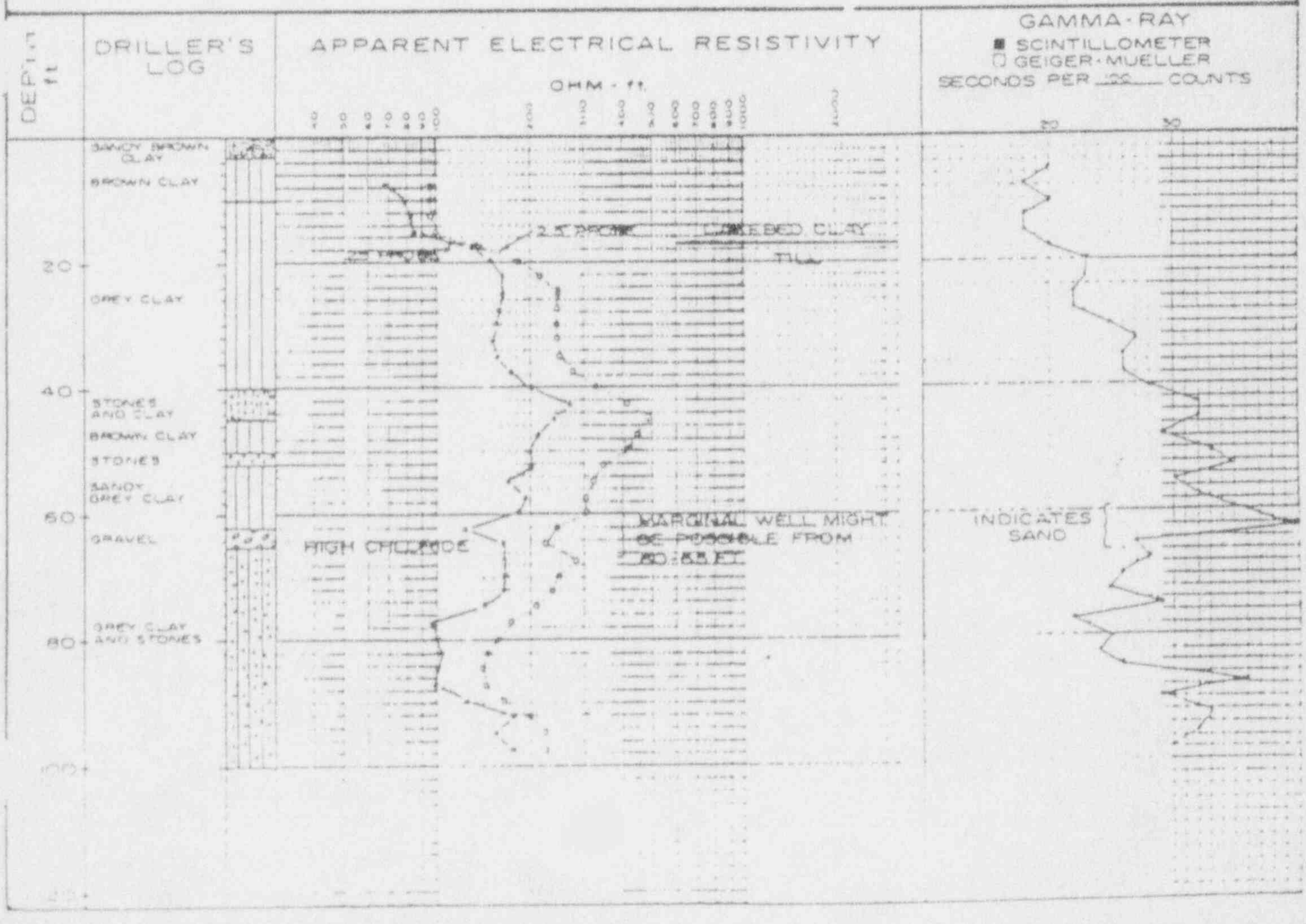
ELEVATIONS

Land Surface 624.9 ft. ABOVE M.S.L. (~~Estd, Repd~~, Meas'd)

Top of Casing ______ ft. ABOVE/BELOW Land Surface

Log Datum LAND SURFACE

Water Table Depth <8 FT



EDI ENGINEERING & SCIENCE
ENGINEERS / GEOLOGISTS / SOLDIERS / CHEMISTS

WILLIAMS & WORKS

PROJECT NO. 20245

OWNERS WELL NO. 3009

CLIENT DOW CHEMICAL CO

DATE 9/27/83

FIELD DATA BY G.S

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

NE 1/4 SE 1/4 NE 1/4 SECTION 22 T 14N R 2E

DISTANCE

OWNER: DOW CHEMICAL CO. ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO. ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL OBSERVATION WELL DEPTH 166 FT. DIA. 4 IN.

ELEVATIONS: LAND SURFACE 625 FT. ABOVE M.S.L. (MEAS'D.)

TOP OF CASING 630.74 FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VB-63 (MODEL) GAMMA LOGGER KECK (MAKE) GR-73 (MODEL)

PROBE:

WATER TABLE DEPTH
UNCONSOLIDATED SOILS
15 FT. BELOW GROUND
CONSOLIDATED SOILS
____ FT. BELOW GROUND

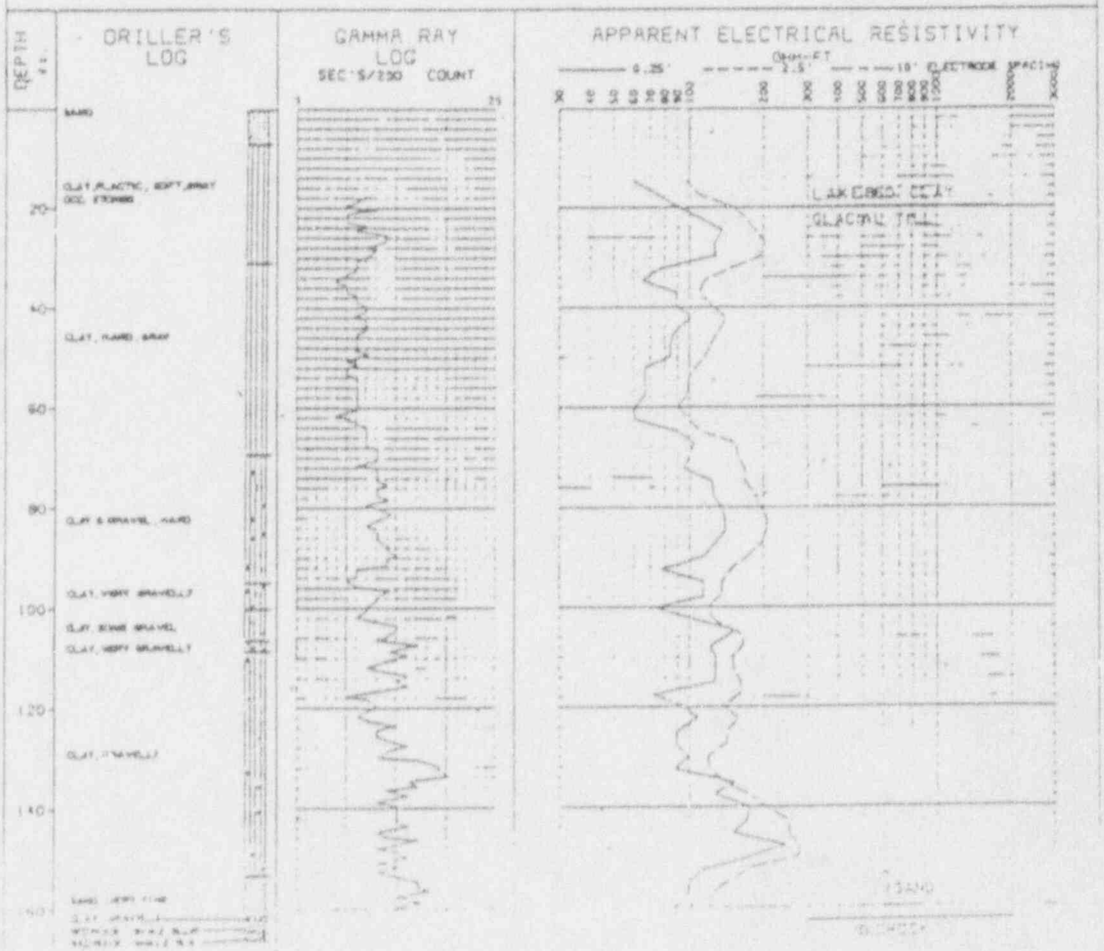
INTERVAL LOGGED: 160 FT. TO 15 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

CONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL

CONSOLIDATED SOILS ____



EDI ENGINEERING & SCIENCE

WILLIAMS & WORKS

PROJECT NO. 20245

OWNERS WELL NO. 3010

CLIENT DOW CHEMICAL

DATE 9/21/83

FIELD DATA BY D.G. J.S.

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

SE 1/4 SE 1/4 NE 1/4 SECTION 36 T 14N R 2E

DISTANCE

OWNER: DOW CHEMICAL CO. ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL OBSERVATION DEPTH 142 FT. DIA. 4 IN.

ELEVATIONS: LAND SURFACE 524.9 FT. ABOVE M.S.L. (MEAS D.)

TOP OF CASING 625.59 FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VB-63 (MODEL) GAMMA LOGGER KECK (MAKE) GR-73 (MODEL)

PROBE:

WATER TABLE DEPTH

UNCONSOLIDATED SOILS

18 FT. BELOW GROUND

CONSOLIDATED SOILS

____ FT. BELOW GROUND

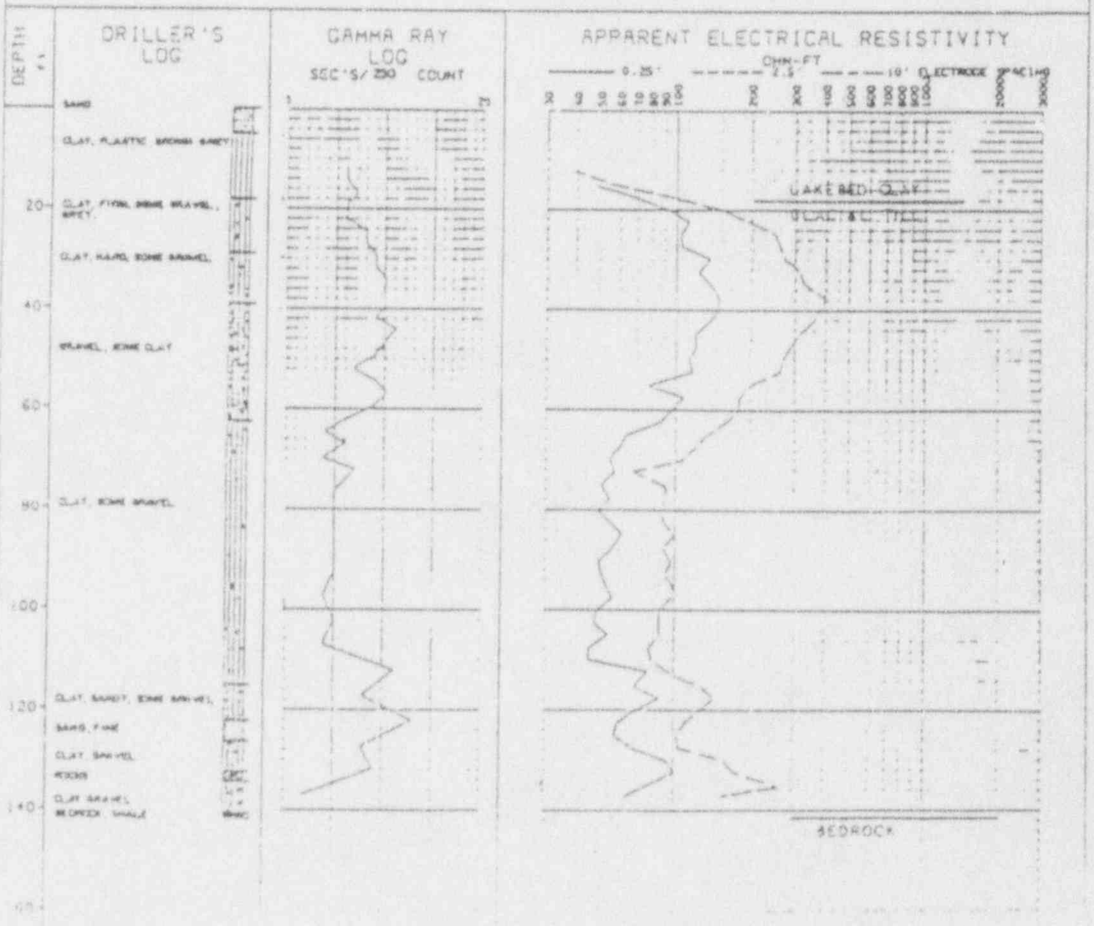
INTERVAL LOGGED: 137 FT. TO 12 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

CONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL

CONSOLIDATED SOILS



Environmental Data Inc.
WILLIAMS & WORKS

PROJECT NO. 20337
OWNERS WELL NO. 3011
CLIENT DOW CHEMICAL
DATE 9/28/84
FIELD DATA BY G.S.

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND
NE 1/4 NE 1/4 NE 1/4 SECTION 35 T 14 N R 2E
DISTANCE ______

OWNER: DOW CHEMICAL ADDRESS MIDLAND, MICHIGAN
CONTRACTOR: RAYMER CO ADDRESS GRAND RAPIDS, MICHIGAN

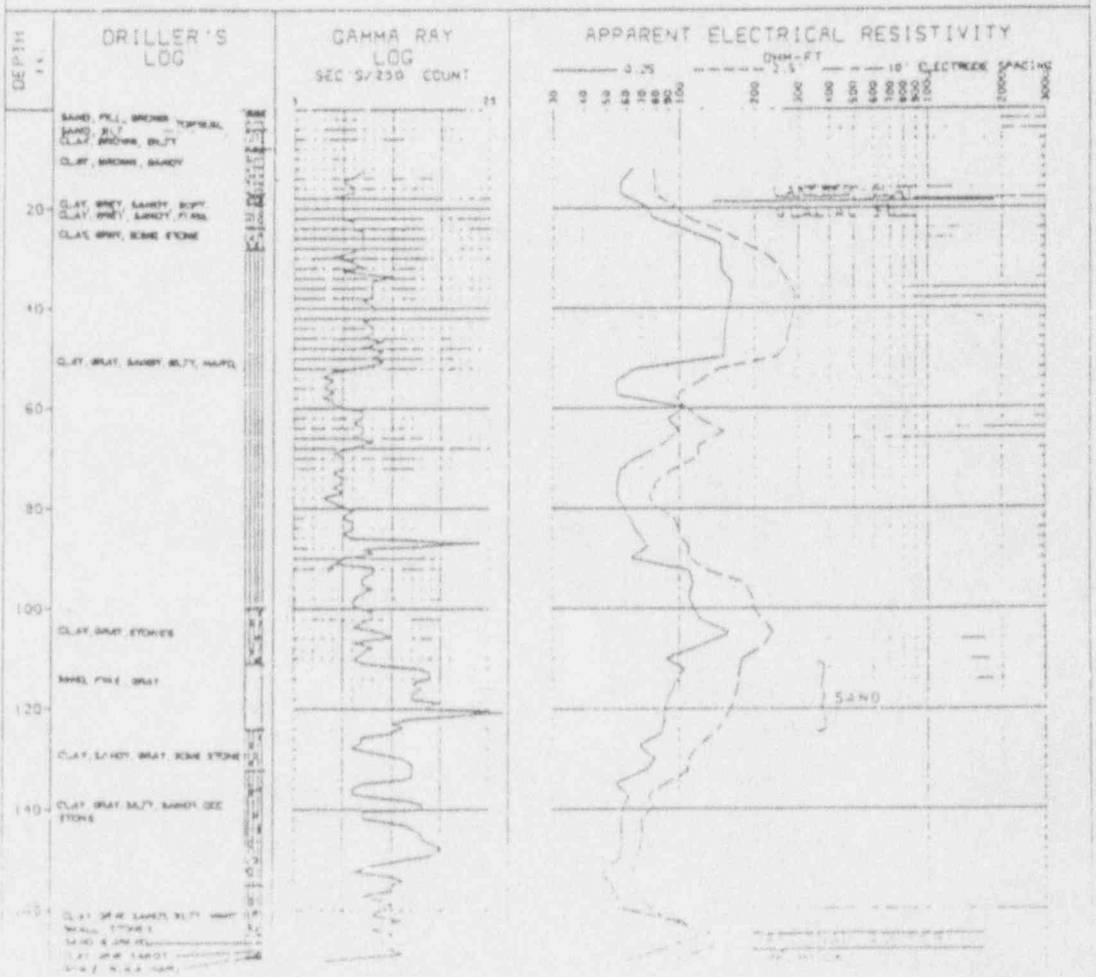
WELL & LOG DATA: TYPE OF WELL OBSERVATION DEPTH 170 FT. DIA. 4 IN.
ELEVATIONS: LAND SURFACE 624.4 FT. ABOVE M.S.L. (MEAS'D)
TOP OF CASING 627.39 FT. ABOVE LAND SURFACE
LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VR-63 (MODEL) GAMMA LOGGER KECK (MAKE) GR-73 (MODEL)

PROBE:

WATER TABLE DEPTH
UNCONSOLIDATED SOILS ______ FT. BELOW GROUND
CONSOLIDATED SOILS ______ FT. BELOW GROUND

INTERVAL LOGGED: 170 FT. TO 12.5 FT. BELOW LAND SURFACE
FLUID LEVEL: UNCONSOLIDATED SOILS ______ FT. BELOW LAND SURFACE
CONSOLIDATED SOILS ______ FT. BELOW LAND SURFACE
TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL
CONSOLIDATED SOILS ______



EDI ENGINEERING & SCIENCE

WILLIAMS & WORKS

PROJECT NO. 20237

OWNERS WELL NO. 3012

CLIENT DOW CHEMICAL

DATE 10/3/83

FIELD DATA BY G.S.

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

SW 1/4 NE 1/4 NE 1/4 SECTION 35 T 14 N R 2E

DISTANCE ______

OWNER: DOW CHEMICAL CO. ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL BORING DEPTH 152 FT. DIA. 6 3/4 IN.

ELEVATIONS: LAND SURFACE 611 FT. ABOVE M.S.L. (MEASD.)

TOP OF CASING ______ FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VB-63 (MODEL) GAMMA LOGGER KECK (MAKE) GR-73 (MODEL)

PROBE:

WATER TABLE DEPTH

UNCONSOLIDATED SOILS ______ FT. BELOW GROUND

CONSOLIDATED SOILS ______ FT. BELOW GROUND

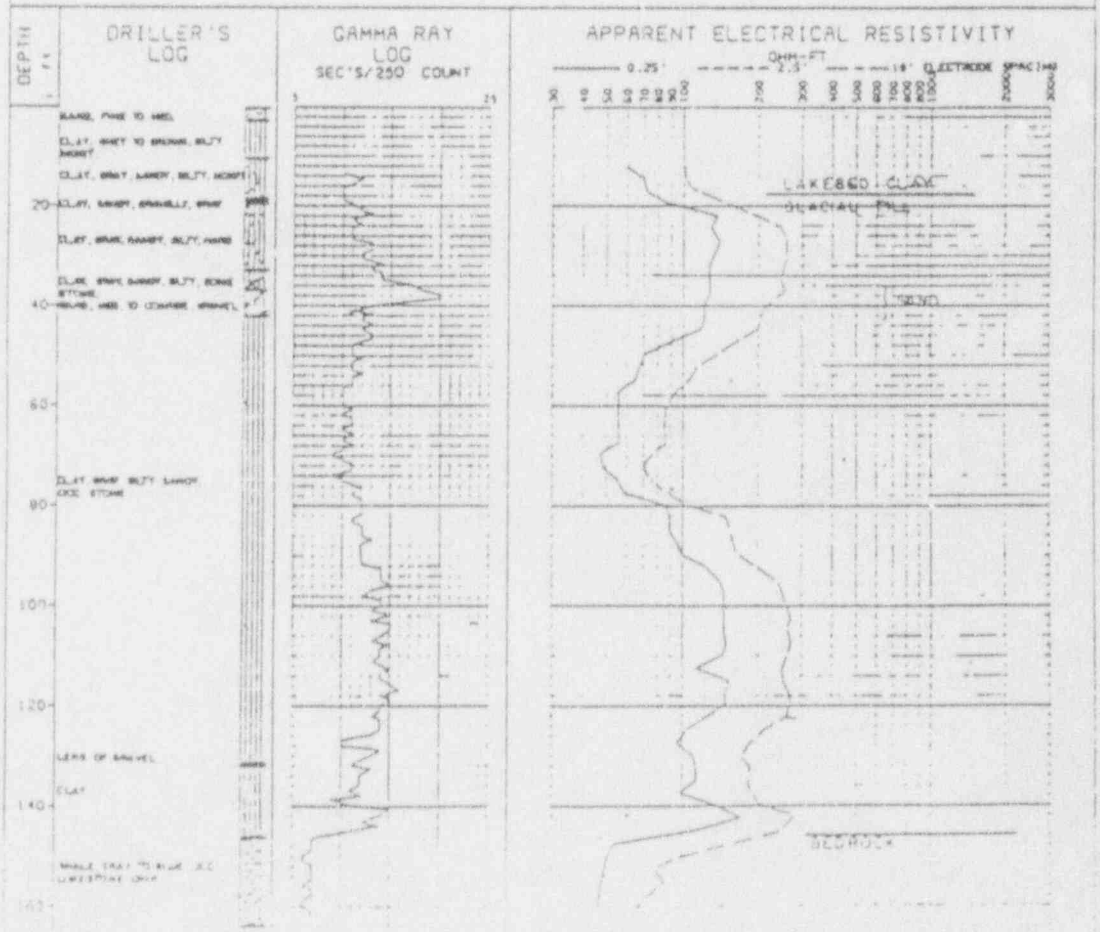
INTERVAL LOGGED: 152 FT. TO 14 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS ______ FT. BELOW LAND SURFACE

CONSOLIDATED SOILS ______ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL

CONSOLIDATED SOILS ______



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WILLIAMS & WORKS

GRAND RAPIDS, MI

PROJECT NO. 20237

OWNERS WELL NO. 3013

CLIENT DOW CHEMICAL CO

DATE 10/6/83

FIELD DATA BY GS

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

NE 1/4 NW 1/4 NW 1/4 SECTION 35 T 14N R 2E

DISTANCE

OWNER: DOW CHEMICAL CO. ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO. ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL OBSERVATION DEPTH 256 FT. DIA. 4 IN.

ELEVATIONS: LAND SURFACE 612.5 FT. ABOVE M.S.L. (MEASD.)

TOP OF CASING 616.45 FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VB-63 (MODEL) GAMMA LOGGER KECK (MAKE) GR-73 (MODEL)

PROBE:

WATER TABLE DEPTH
UNCONSOLIDATED SOILS
FLOWING FT. BELOW GROUND
CONSOLIDATED SOILS
____ FT. BELOW GROUND

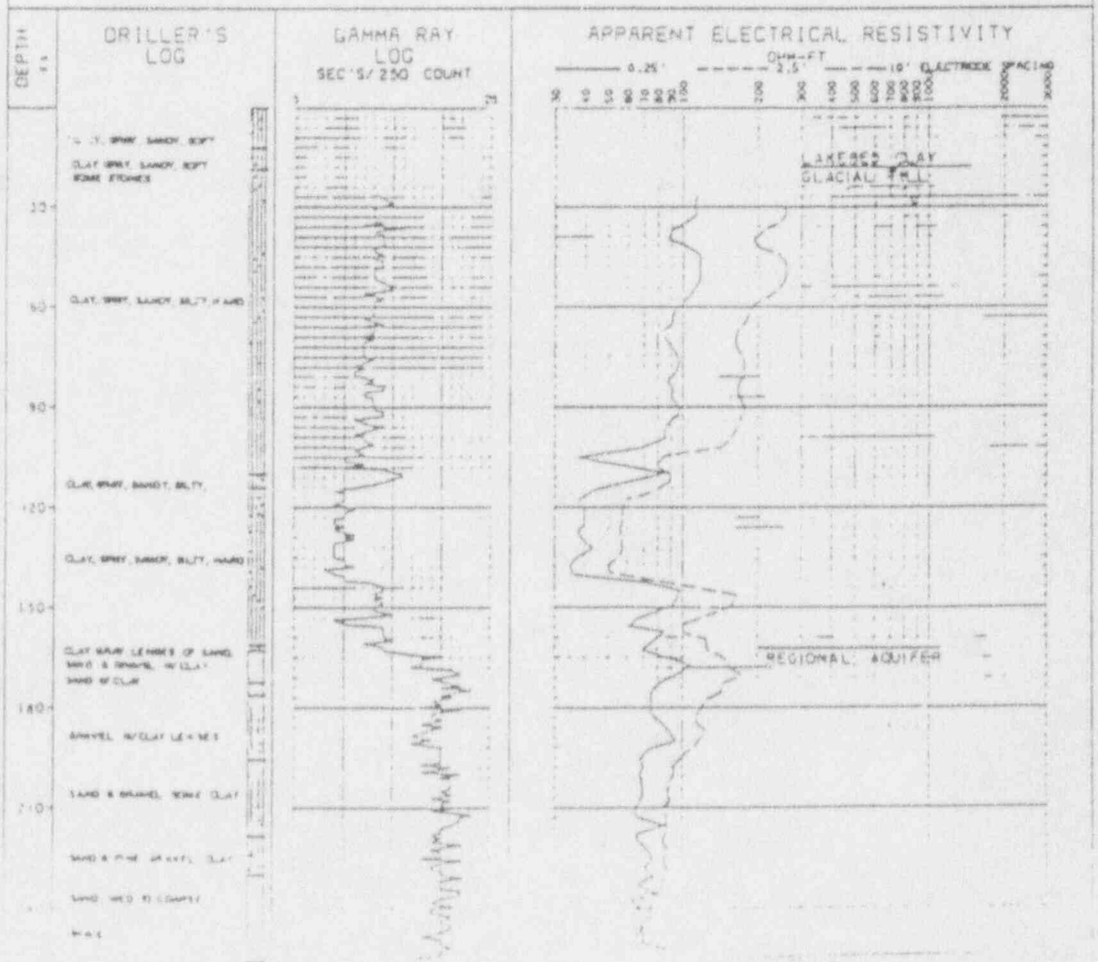
INTERVAL LOGGED: 254 FT. TO 26 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

CONSOLIDATED SOILS ____ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL

CONSOLIDATED SOILS



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WILLIAMS & WORKS

PROJECT NO. 20245

OWNERS WELL NO. 3065

CLIENT DOW CHEMICAL

DATE 11/9/83

FIELD DATA BY G S

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

NW 1/4 NW 1/4 SW 1/4 SECTION 27 T 14N R 2E

DISTANCE ______

OWNER: DOW CHEMICAL COMPANY ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO. ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL OBSERVATION DEPTH 310 FT. DIA. 4 IN.

ELEVATIONS: LAND SURFACE 598 FT. ABOVE M.S.L. (MEAS'D)

TOP OF CASING 601.64 FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VR-63 (MODEL) GAMMA LOGGER ______ (MAKE) ______ (MODEL)

PROBE: LATERAL LOG

WATER TABLE DEPTH
UNCONSOLIDATED SOILS
FLOWING FT. BELOW GROUND
CONSOLIDATED SOILS
______ FT. BELOW GROUND

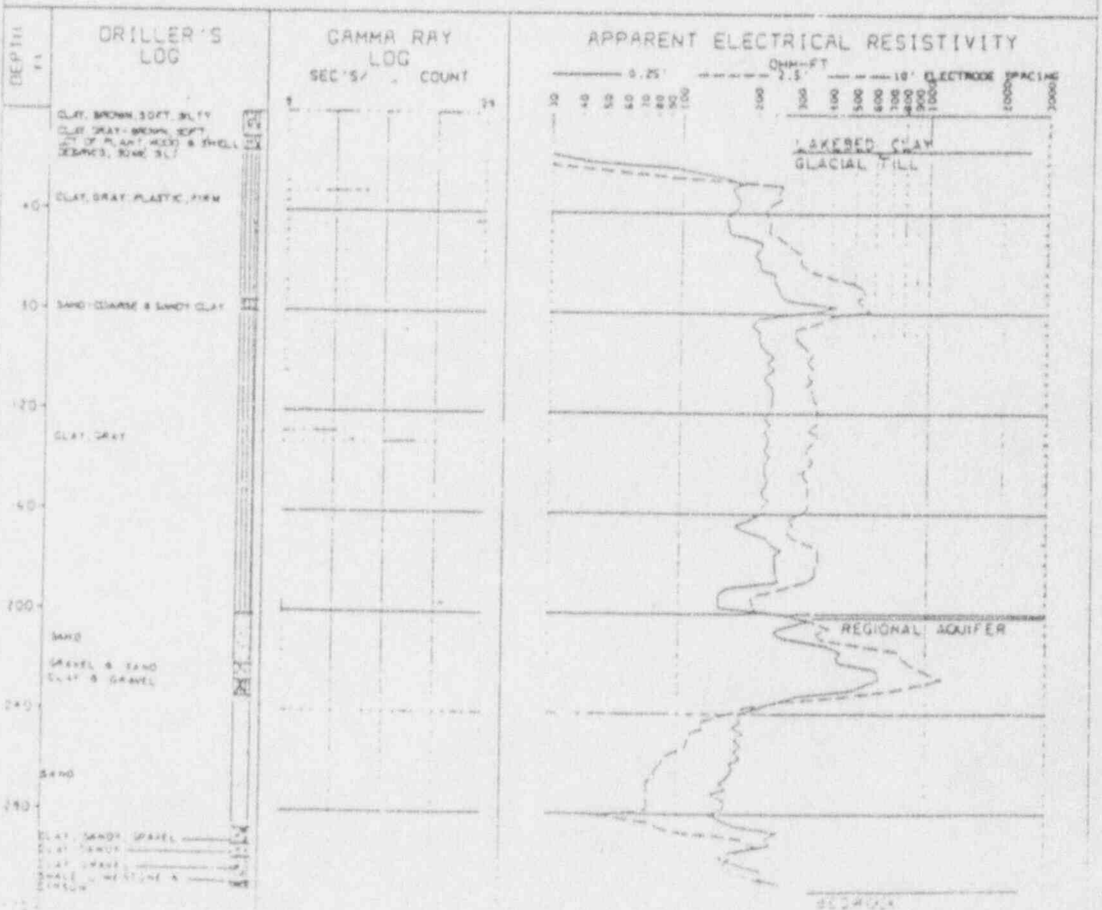
INTERVAL LOGGED: 310.0 FT. TO 1.5 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS 1 FT. BELOW LAND SURFACE

CONSOLIDATED SOILS ______ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA-GEL

CONSOLIDATED SOILS ______



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WILLIAMS & WORKS

PROJECT NO. 20245

OWNERS WELL NO. 3066

CLIENT DOW CHEMICAL

DATE 12/7/83

FIELD DATA BY G.S.

GEOPHYSICAL LOG OF WELL

LOCATION: STATE MICHIGAN COUNTY MIDLAND TOWNSHIP MIDLAND

S.E. 1/4 N.W. 1/4 S.W. 1/4 SECTION 28 T 14N R 2E

DISTANCE _____

OWNER: DOW CHEMICAL CO. ADDRESS MIDLAND, MICHIGAN

CONTRACTOR: RAYMER CO. ADDRESS GRAND RAPIDS, MICHIGAN

WELL & LOG DATA: TYPE OF WELL OBSERVATION DEPTH 230 FT. DIA. 4 IN.

ELEVATIONS: LAND SURFACE 614 FT. ABOVE M.S.L. (EST'D. REPT'D. MEAS'D)

TOP OF CASING 617.05 FT. ABOVE LAND SURFACE

LOG DATUM LAND SURFACE

INSTRUMENT DATA: E-LOGGER KECK (MAKE) VB-63 (MODEL) GAMMA LOGGER _____ (MAKE) _____ (MODEL)

PROBE:

WATER TABLE DEPTH
UNCONSOLIDATED SOILS
FLOWING FT. BELOW GROUND
CONSOLIDATED SOILS
_____ FT. BELOW GROUND

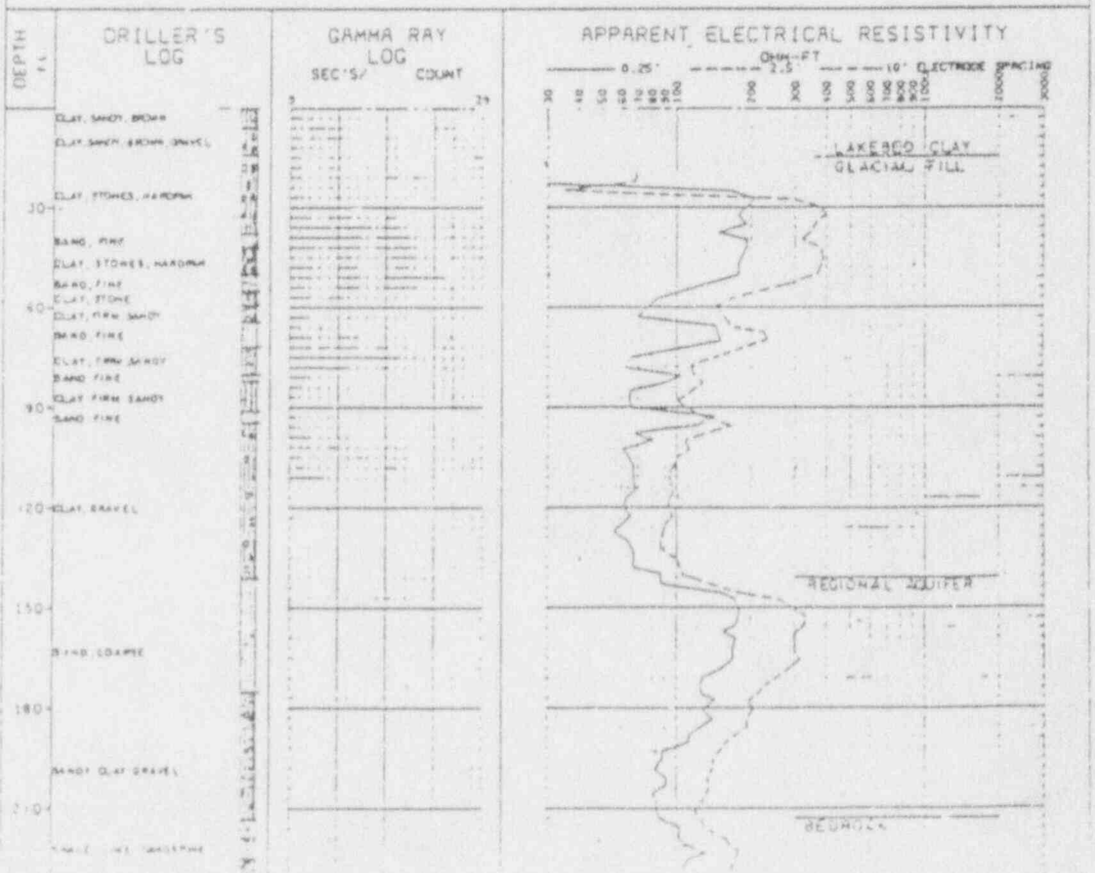
INTERVAL LOGGED: 230 FT. TO 20 FT. BELOW LAND SURFACE

FLUID LEVEL: UNCONSOLIDATED SOILS _____ FT. BELOW LAND SURFACE

CONSOLIDATED SOILS _____ FT. BELOW LAND SURFACE

TYPE OF FLUID: UNCONSOLIDATED SOILS AQUA - GEL

CONSOLIDATED SOILS _____



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Project No. 20245
Date 3/27/84

Geophysical Log of Well

Location
Midland, Michigan
Midland Township
SE 1/4, NE 1/4, NE 1/4, Section 35,
T 14N, R 2E

Owner
Dow Chemical Co.,
Midland, Midland Township

Contractor
Raymer Co.,
Grand Rapids, Michigan

Well No. 3138

Type: Observation

Depth: 475 Feet

Diameter: 4 inches

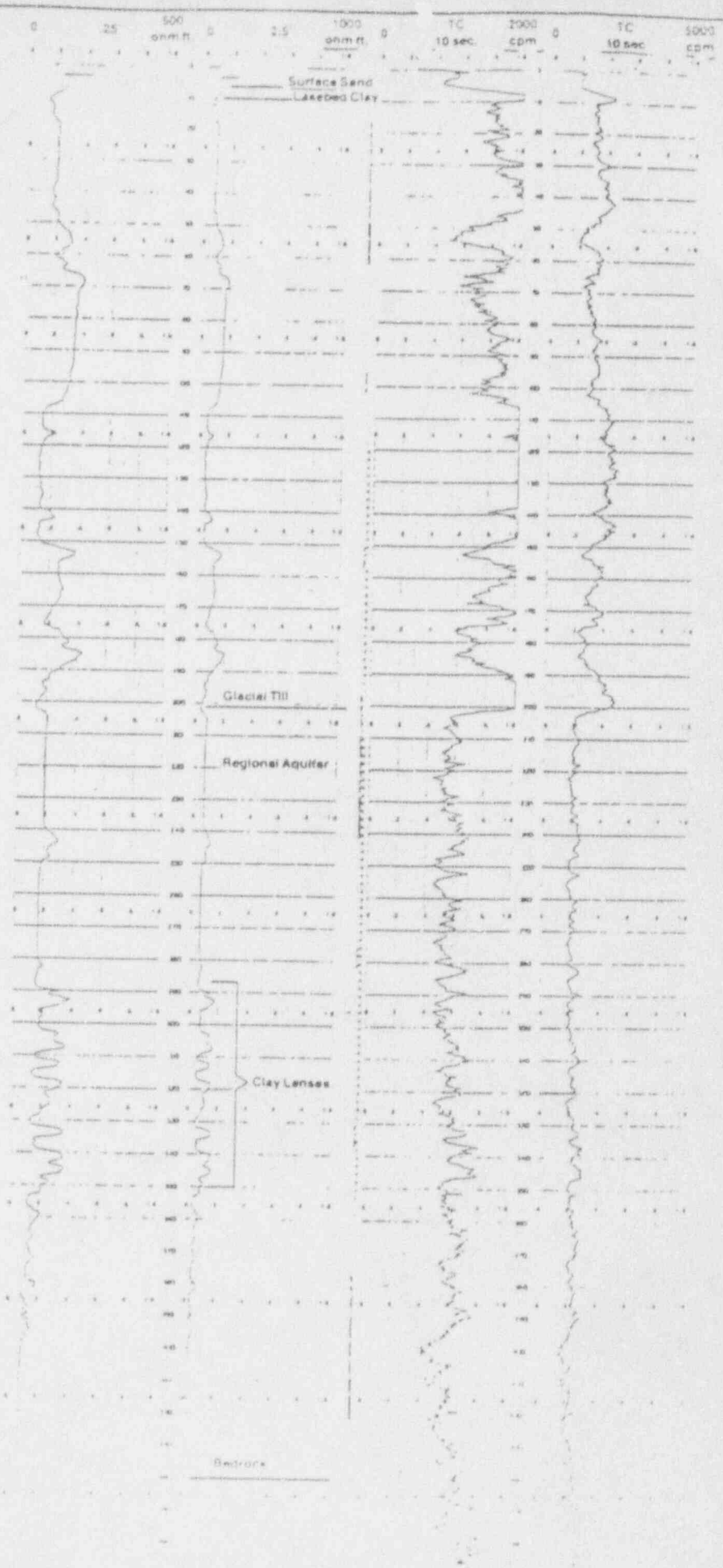
Elevations
Land Surface 639
Top of Casing 641.92

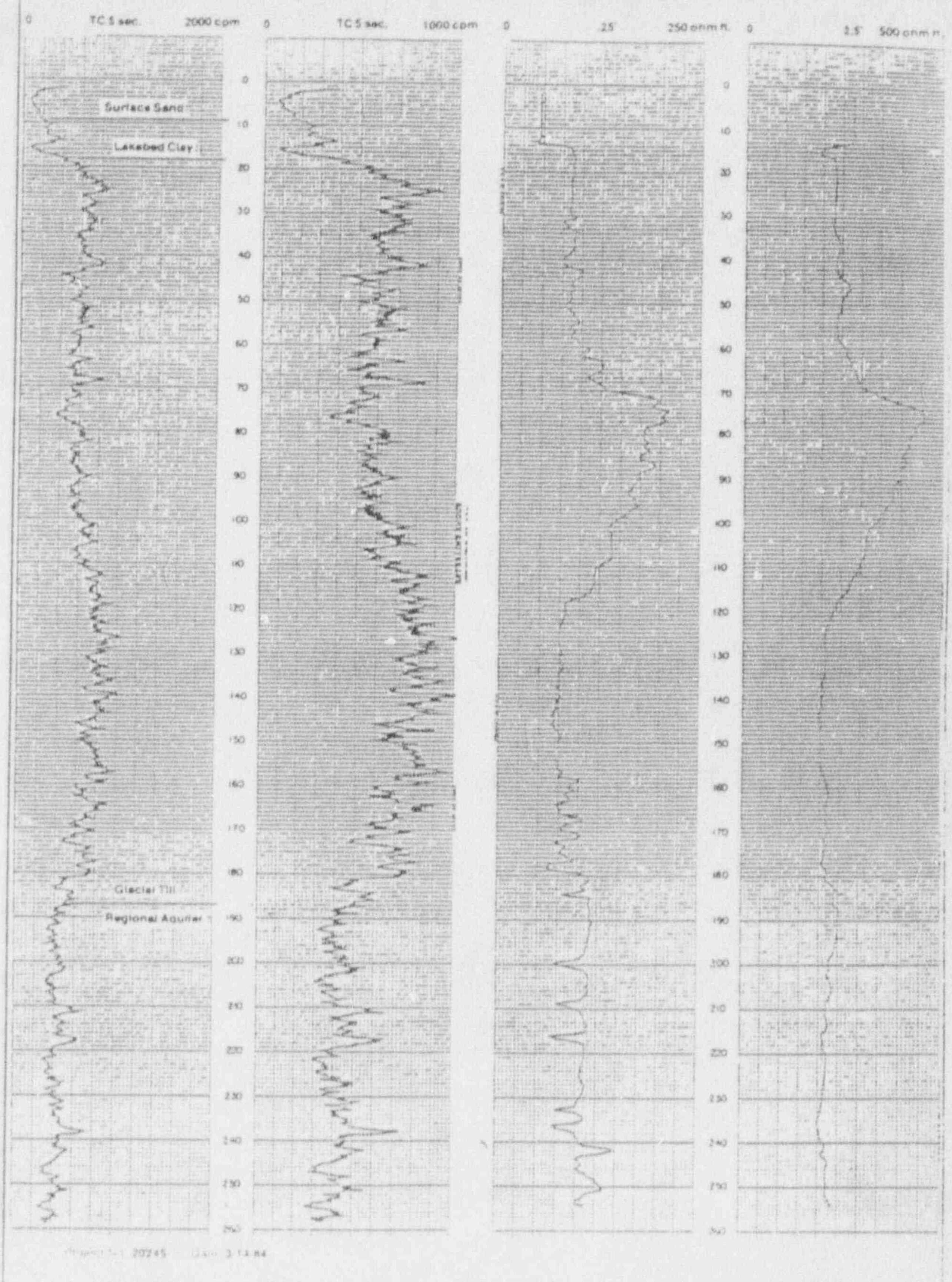
Log Datum:
Land Surface, Field Data by JN

Water Table Depth
16 Feet Below Ground

Interval Logged
470 Feet to 8 Feet

Fluid: Aqua-Gel





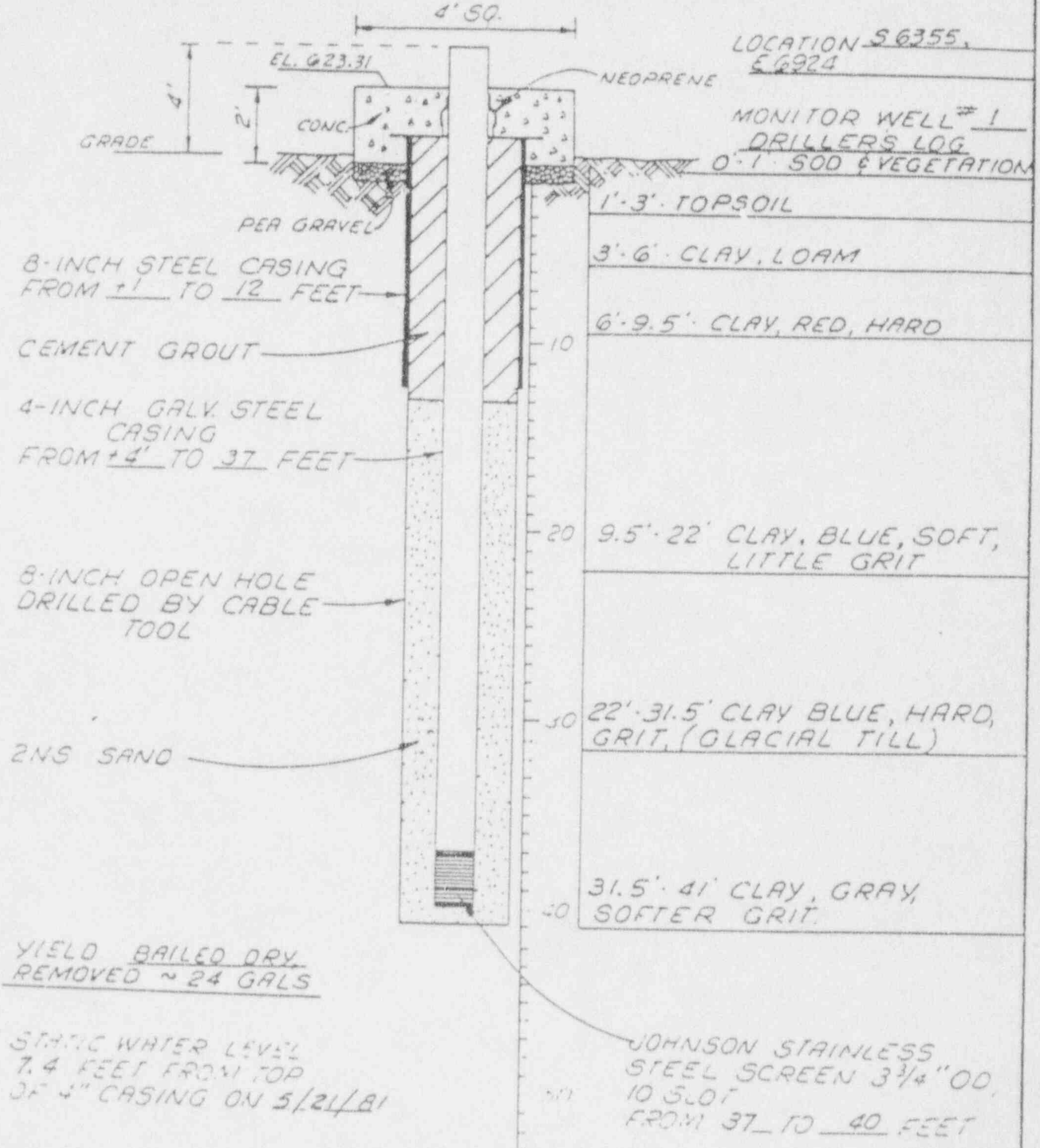
Project No. 20245 Date 3-14-84

Geophysical Log of Well

Midland, Michigan, Midland Township SE¼, SW¼, NE¼, Section 22, T.14N, R.2E
Dow Chemical Co., Midland, Midland Township — Raymer Co., Grand Rapids, Michigan
3137 Observation 225 Feet 4 inches Land Surface 624, Top of Casing 630.95
Land Surface, Field Datum — Feet Below Ground — Feet to Datum — Aqua Gel

APPENDIX D
ACT 64 WELL LOGS

AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)



YIELD BAILED DRY, REMOVED ~ 24 GALS

STATIC WATER LEVEL 7.4 FEET FROM TOP OF 4" CASING ON 5/21/81

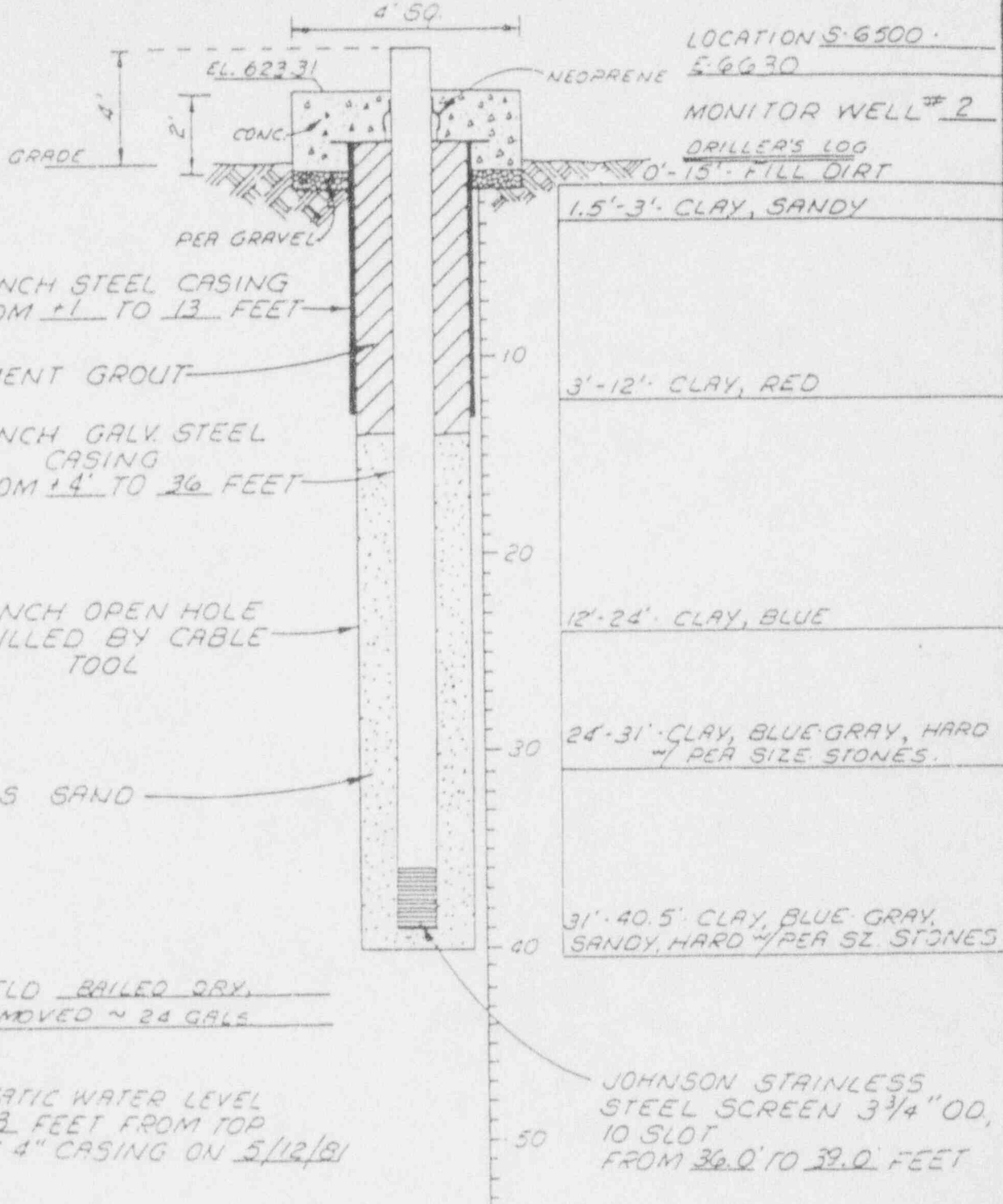
DRILLER DALE FRAZINE

DATE COMPLETED 2/27/81

ELEVATION 625.74 (TOP OF 4" PIPE THREADS)

WILLIAMS WORKS

AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)



YIELD BAILED DRY, REMOVED ~ 24 GALS.

STATIC WATER LEVEL 5.3 FEET FROM TOP OF 4" CASING ON 5/12/81

DRILLER DALE FRAZINE

DATE COMPLETED 3/6/81

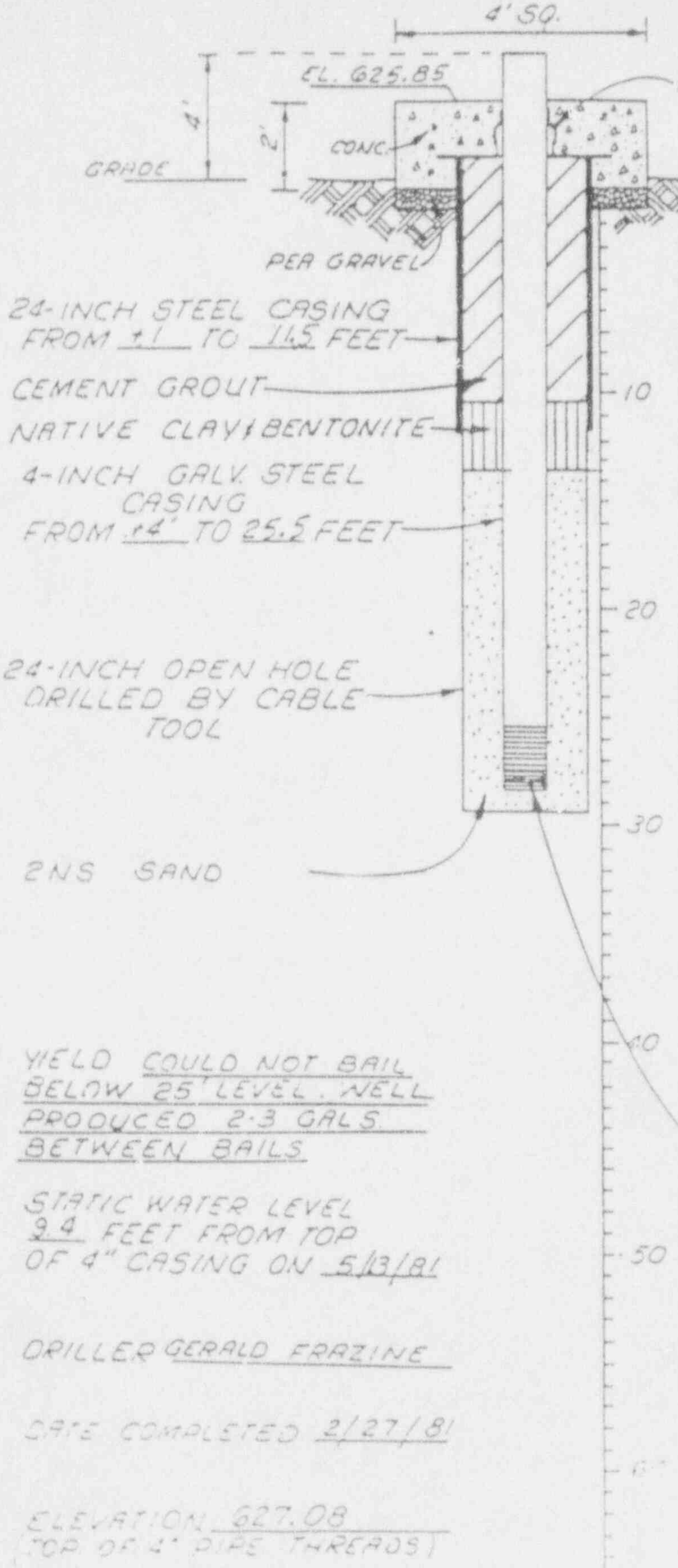
ELEVATION 625.17 (TOP OF 4" PIPE THREADS)

WILLIAMS & WORKS

AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)

LOCATION S 7125, E 6744

MONITOR WELL # 3



DRILLER'S LOG

0'-3'	CLAY
3'-5'	SAND DRY
5'-22'	CLAY, RED TO BLUISH SOFT
22'-29.5'	CLAY, BLUE, VERY HARD, GRAVELLY

YIELD COULD NOT BAIL BELOW 25' LEVEL. WELL PRODUCED 2-3 GALS. BETWEEN BAILS

STATIC WATER LEVEL 9.4 FEET FROM TOP OF 4" CASING ON 5/13/81

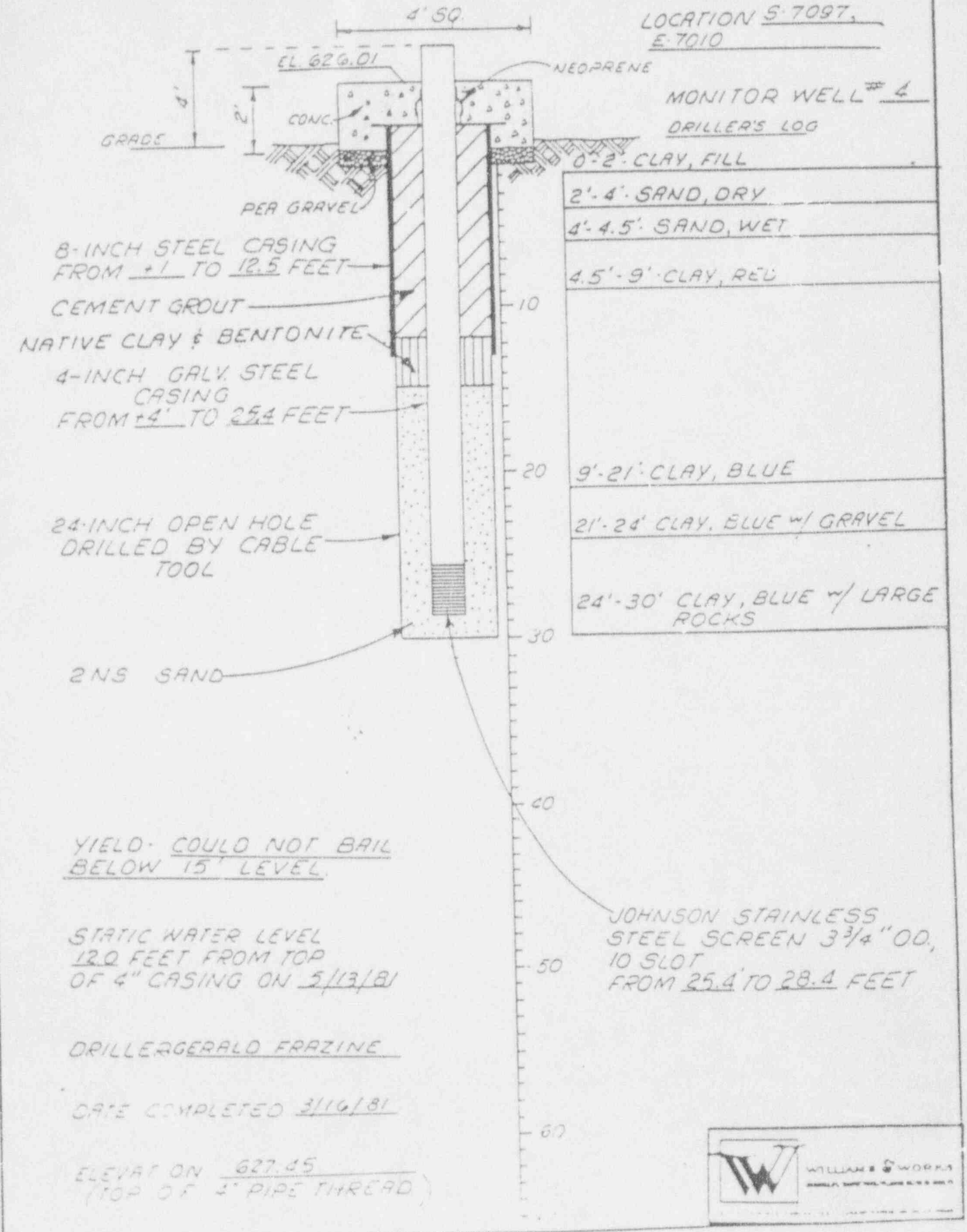
DRILLER GERALD FRAZINE

DATE COMPLETED 2/27/81

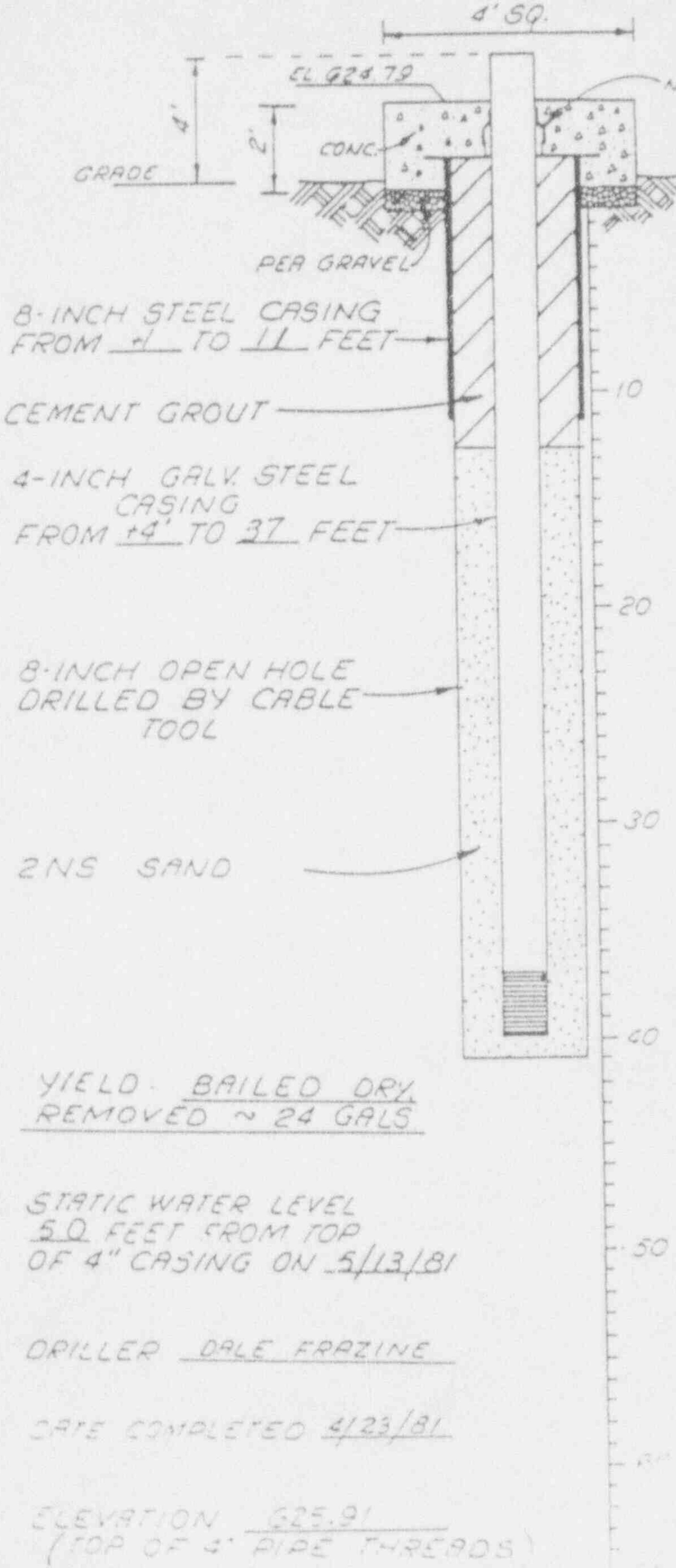
ELEVATION 627.08 (TOP OF 4" PIPE THREADS)

WILLIAMS & WORKS

AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)



AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)



LOCATION S 9145, E 7738

MONITOR WELL # 5

DRILLER'S LOG

0'-1.5' SAND & GRAVEL, FILL
1.5'-2' TOPSOIL
2'-4' CLAY & MUCK
4'-10' CLAY, RED
10'-18' CLAY GRAY, SOFT
18'-22.7' CLAY, GRAY, SOME GRIT
22.7'-26' CLAY, GRAY, GRITTY, HARD
26'-33' CLAY, GRAY, SANDY W/ LARGE STONES, HARD
33-41' CLAY, REDDISH, PEA SIZE GRAVEL & LARGE STONES

YIELD BAILED DRY, REMOVED ~ 24 GALS

STATIC WATER LEVEL 5.0 FEET FROM TOP OF 4" CASING ON 5/13/81

JOHNSON STAINLESS STEEL SCREEN 3 3/4" OD, 10 SLOT FROM 37' TO 40 FEET

DRILLER DALE FRAZINE

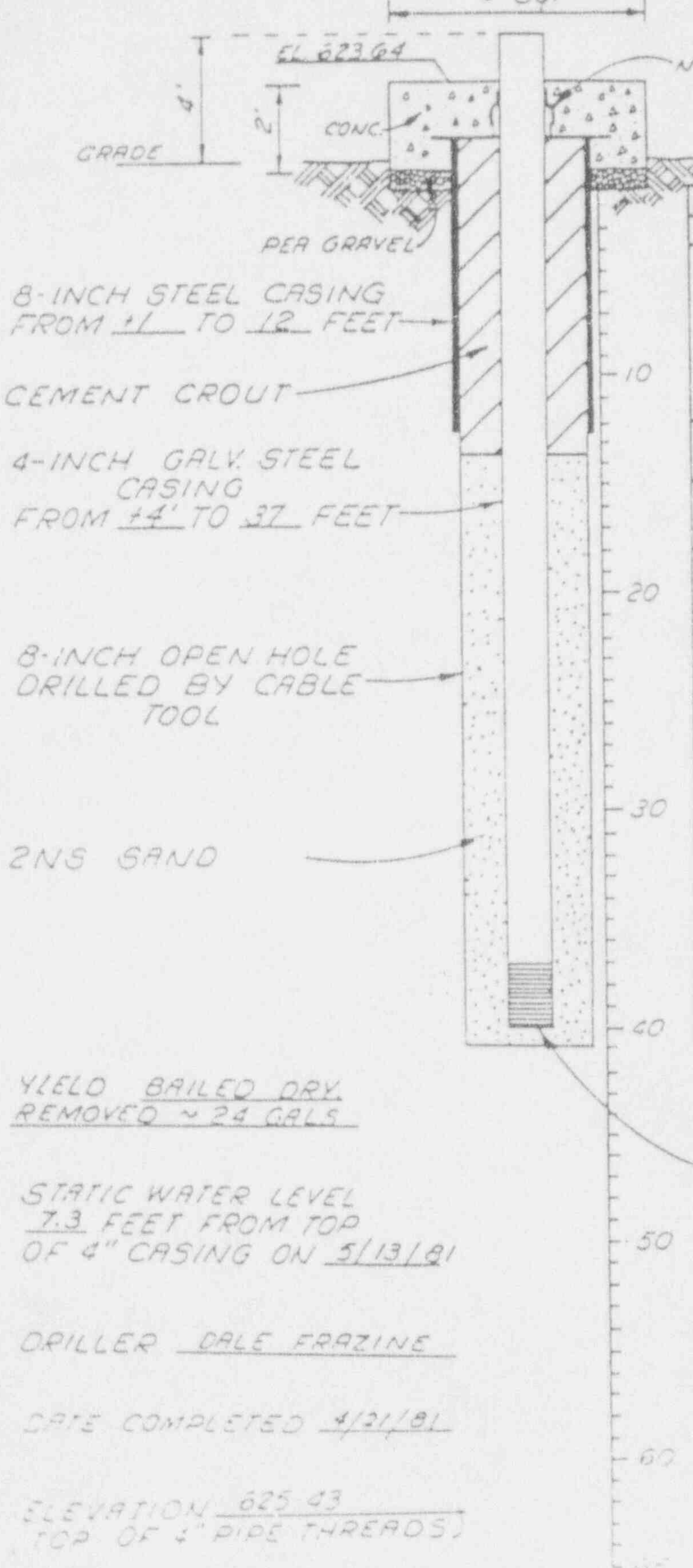
DATE COMPLETED 4/23/81

ELEVATION 625.91 (TOP OF 4" PIPE THREADS)

AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)

LOCATION S 8673, E 8347

MONITOR WELL # 6



DRILLER'S LOG

0'-1.5' SAND & GRAVEL, FILL
1.5'-2'-TOPSOIL
2'-4' -CLAY, LOAM
4'-12' -CLAY, RED
12'-15'-CLAY, BLUE-GRAY, SOFT, GRAVELLY
15'-18'-CLAY, BROWNISH-GRAY
18'-21'-CLAY, GRAY, HARD, TRACE OF OIL
21'-23'-CLAY, GRAY, HARD GRITTY
23'-33'-CLAY, GRAY, HARD, GRITTY, SAND
33'-41' CLAY, GRAY, HARD, GRITTY SANDY, w/ PEA SIZE STONES

YIELD BAILED DRY. REMOVED ~ 24 GALS

STATIC WATER LEVEL 7.3 FEET FROM TOP OF 4" CASING ON 5/13/81

DRILLER DALE FRAZINE

DATE COMPLETED 4/21/81

ELEVATION 625.43 (TOP OF 4" PIPE THREADS)

WILLIAMS & WORKS

EDI ENGINEERING & SCIENCE
ENGINEERS / GEOLOGISTS / BIOLOGISTS / CHEMISTS
611 CASCADE W. PKWY. S.E., GRAND RAPIDS, MI 49506, (616) 943-0870

Page: ____ of ____
Well/Boring No.: MW #7A
Client: Dow
Project No.: 20245
Permit No.:
Date Started 1/22 Finished 1/24

Well / Boring Log Sheet

County	Township	Fraction	Section	T	R
		¼ ¼ ¼			

Contractor: Raymer
Address: Grand Rapids

Equipment:

Supervisor: Ed Culver

Drilling Method(s)	Depth
6½" rotary	133.0'

Grouting/Seal

Depth	To	Material
0	77.5'	cement/bentonite
77.5	79.0'	bentonite pellets
79.0	133'	#7 sand-pak

Development: purged with air

Water Level: ____ Ft. Below: ____
Measured On:

Screen:
Manufacturer: Johnson
Material: stainless steel
Model: Water Mark
Slot/Gauze: 10 slot Dia.: 4"
Length: 60"
Depth Set: 118.0' To: 123.0'

Casing

Dia.	Type	Depth Set
4"	galv.	+4.0' To 118.0'
		To

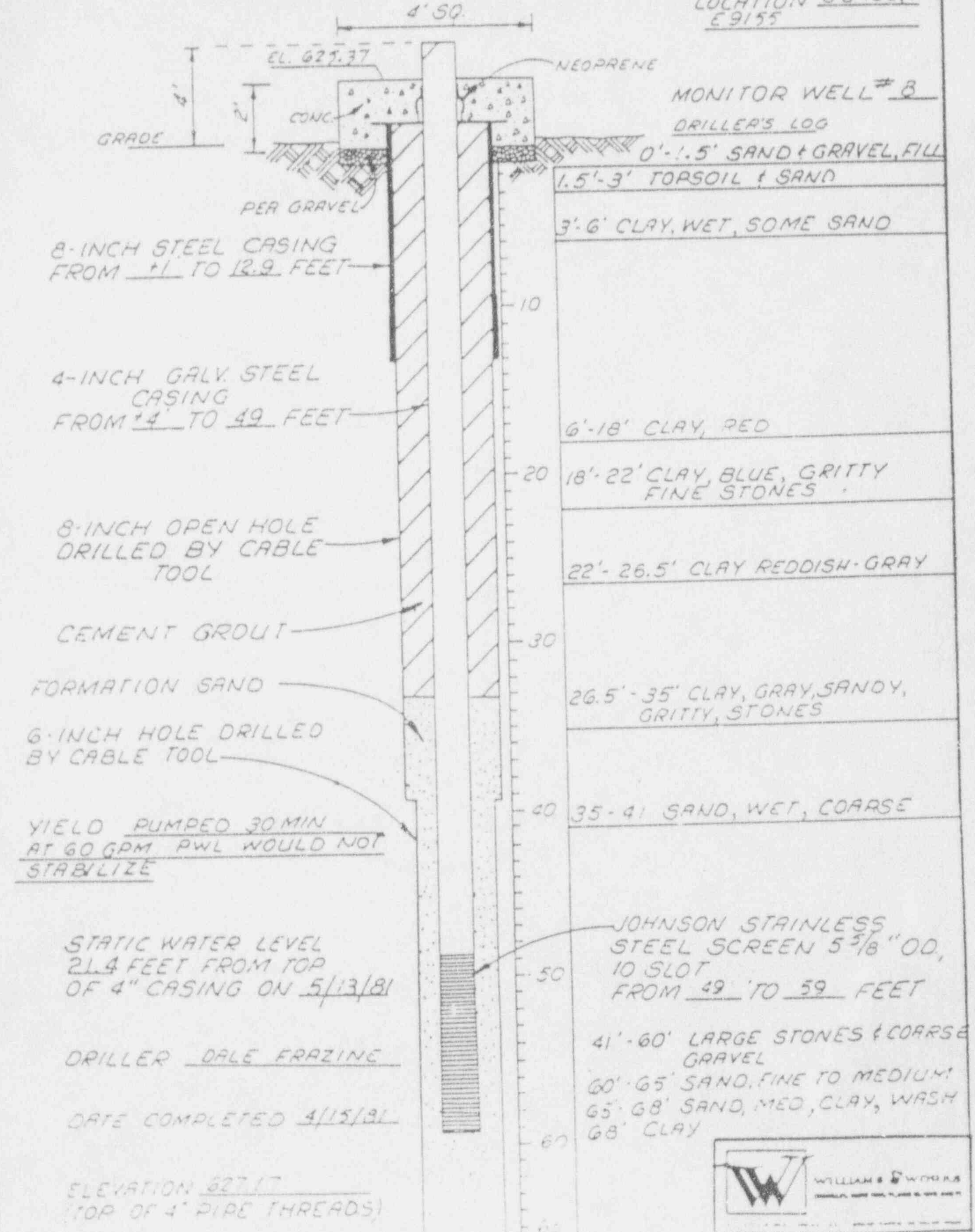
Elevation
Casing:
Ground:
Ref. Pt.:

Remarks (include here, other data applicable)

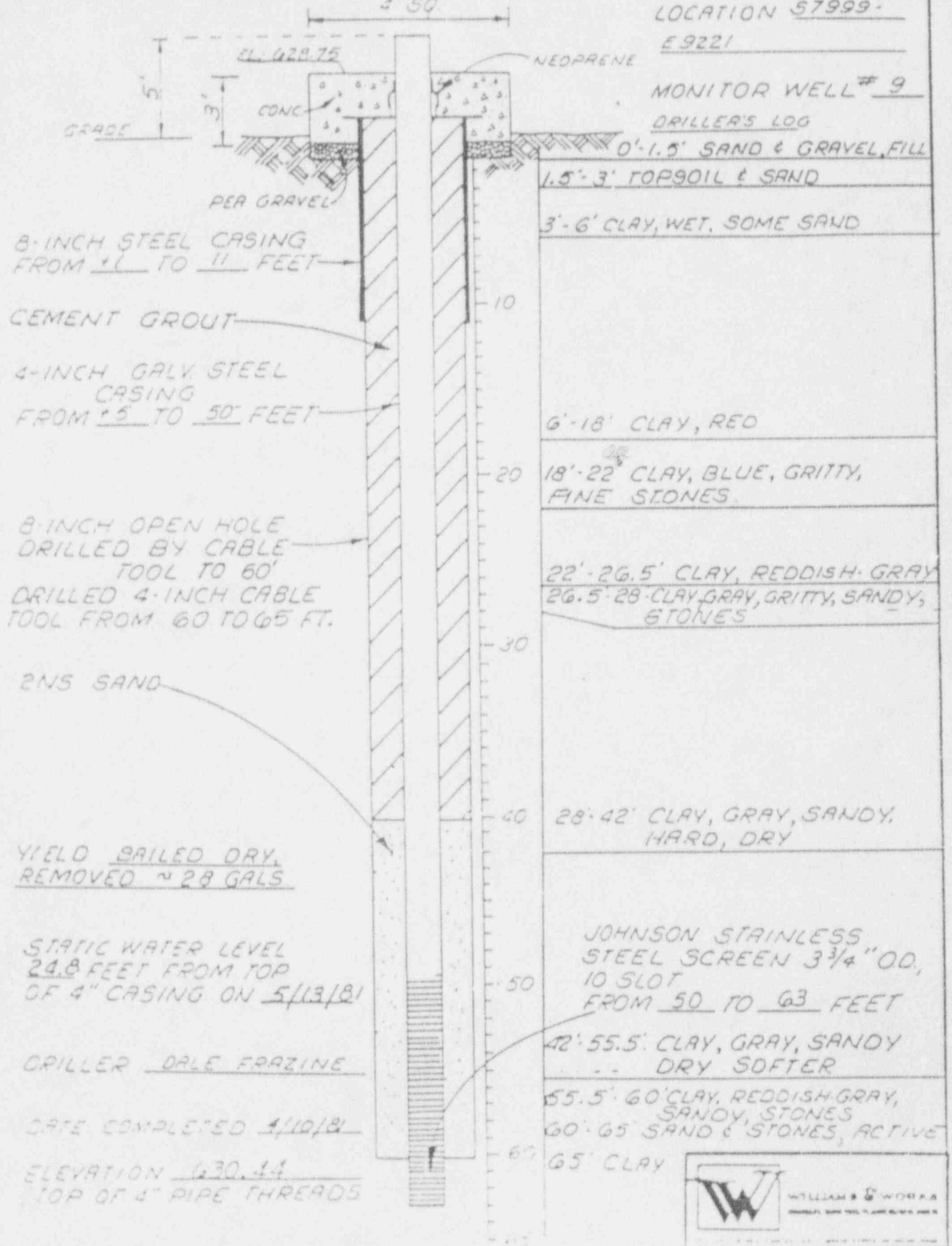
Location Sketch

Thickness	Depth To Base	Description	Remarks			
2.0	2.0	Sand				
1.0	3.0	Topsoil				
10.0	13.0	Clay - brown, sandy				
4.5	17.5	Clay - gray, sandy, silty, soft				
0.5	18.0	Clay - gray, sandy, silty, lenses of fine wet sand				
23.5	41.5	Clay - gray, very sandy, pebbles, firm (occasional lenses of fine wet sand)				
23.5+	65.0+	Clay - gray, silty				
15.0	80.0	Clay - gray, silty, trace of sand				
15.0	95.0	Clay - gray				
28.0	123.0	Clay - grayish brown, very hard				
10.0	133.0	Clay - reddish brown, silty, layers of gray, silty clay				

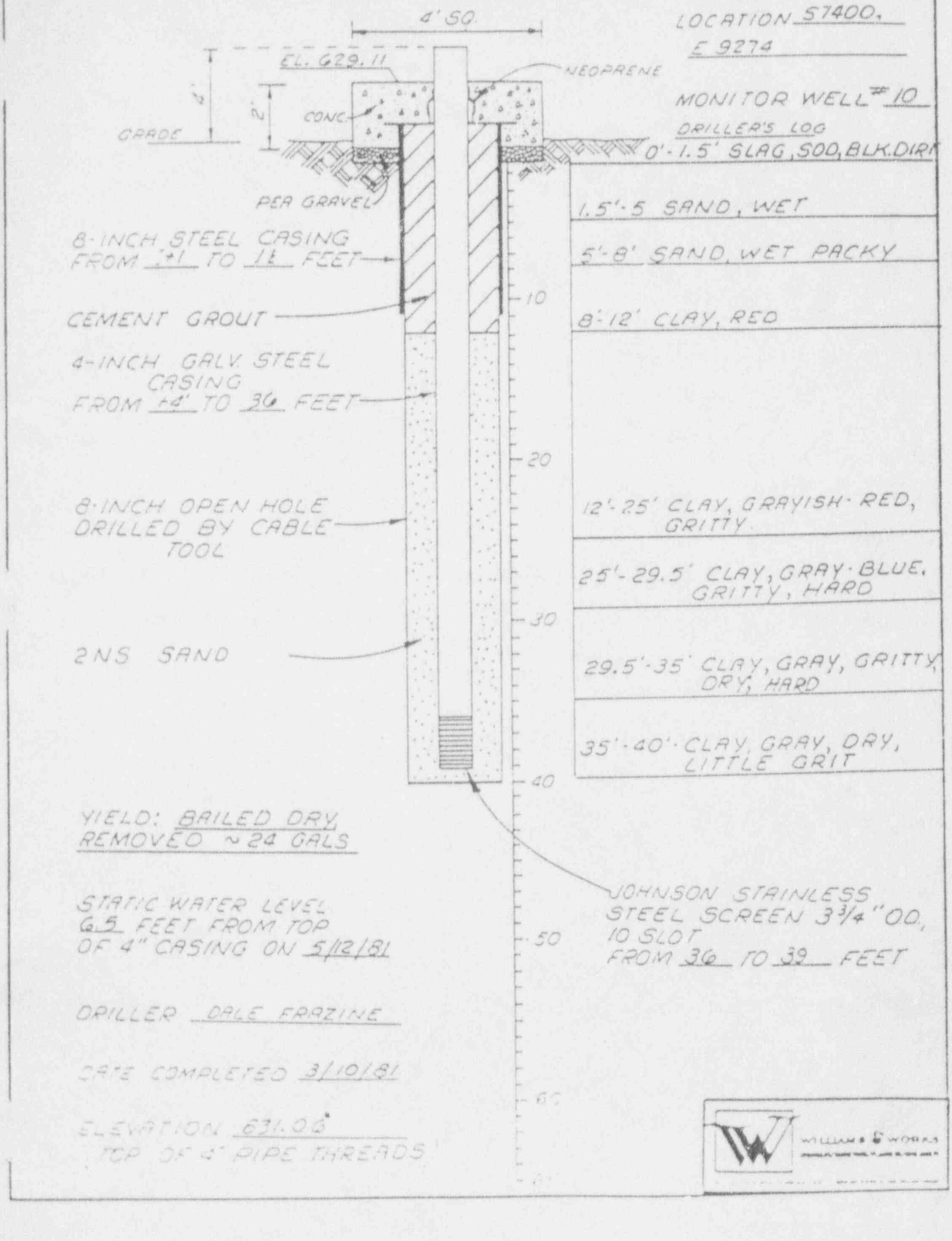
AS-BUILT RECORD OF MONITOR WELL
(SALZBURG LANDFILL)



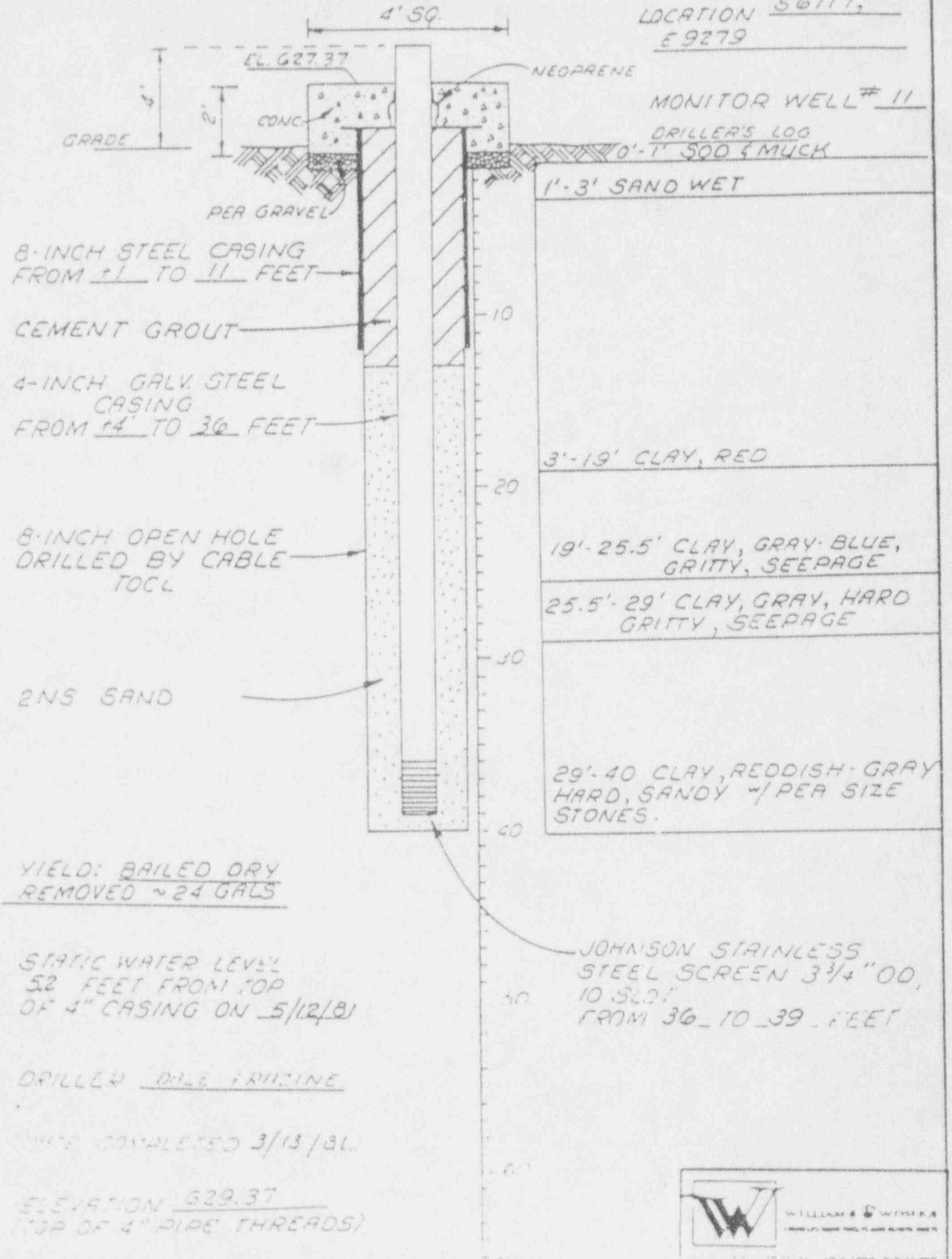
AS-BUILT RECORD OF MONITOR WELL (SALZBURG LANDFILL)



AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)



AS-BUILT RECORD OF MONITOR WELL
(SALZBURG RD. LANDFILL)

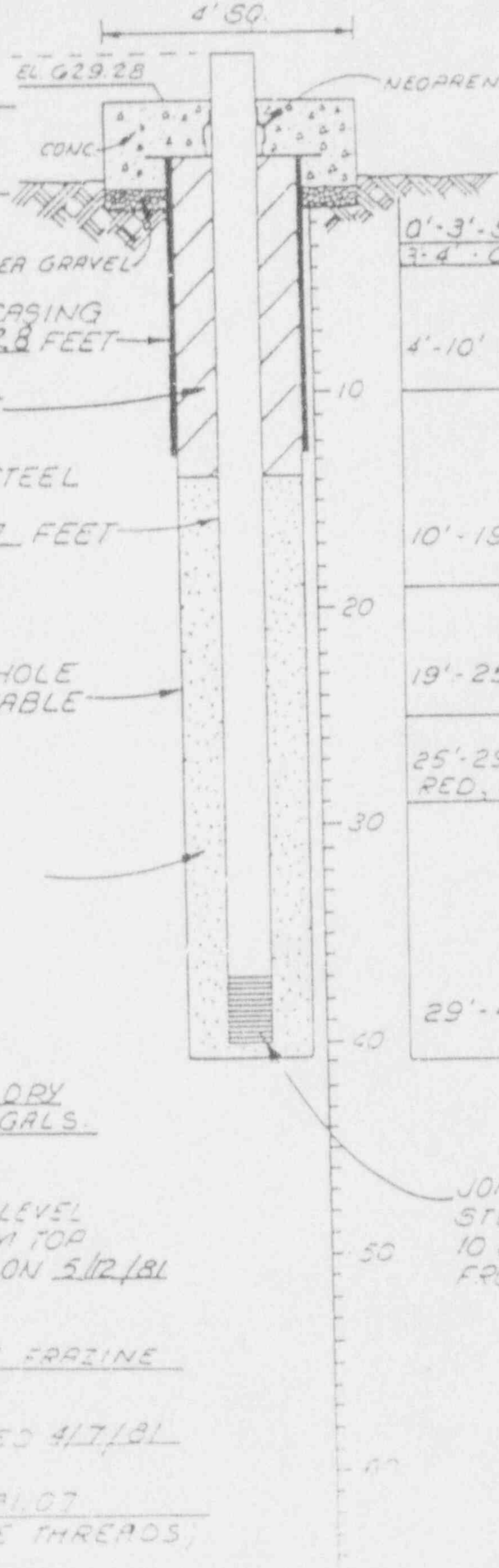


AS-BUILT RECORD OF MONITOR WELL (SALZBURG RD. LANDFILL)

LOCATION S6290, E 8279

MONITOR WELL # 12

DRILLER'S LOG



Driller's Log
0'-3' SAND & GRAVEL, FILL
3'-4' CLAY & MUCK
4'-10' SANDY, MARSH SOILS
10'-19' CLAY, RED, SOLID, SMALL STONES
19'-25' CLAY BROWNISH-RED, SOFT
25'-29' CLAY, BROWNISH RED, SOFT SOME GRIT
29'-41' CLAY, GRAY, HARD GRITTY

JOHNSON STAINLESS STEEL SCREEN 3 3/4" OD, 10 SLOT FROM 37 TO 40 FEET

YIELD: BAILED DRY REMOVED ~24 GALS.

STATIC WATER LEVEL 7.2 FEET FROM TOP OF 4" CASING ON 5/12/81

DRILLER DALE FRAZINE

DATE COMPLETED 4/7/81

ELEVATION 631.07 (TOP OF 4" PIPE THREADS)

APPENDIX E
LANDFILL CONTAMINATION INCIDENTS

APPENDIX E LANDFILL CONTAMINATION INCIDENTS

E.1 Contamination Incident #1

Late in March, 1983, routine monthly monitoring of the Salzburg Landfill indicated that certain waste constituents had entered the liner failure detection system (underliner system). Upon further investigation, it was determined that the landfill liner had not failed but rather that leachate had been siphoned into the liner failure detection sump from the leachate collection system sump. The sequence of events surrounding this incident is given below.

On March 16, a sample was taken from the sump which collects liquid from the liner failure detection system of the Salzburg Landfill. Ground water slowly seeps into this system from the saturated Lakebed Clay unit in which the landfill is built. This liquid is sampled monthly as required by the Michigan Act 64 operating permit for the landfill. Gas chromatographic analysis must show the liquid to be free of certain specified contaminants. The total volume of accumulated liquid in the sump is transferred to Dow's waste treatment plant for treatment.

The sample was prepared for analysis on March 22. After opening the sample bottle, the laboratory analyst discerned an odor similar to that of samples taken from the landfill's leachate collection system. It was assumed that the wrong sample had been obtained and the liner failure detection sump was resampled. Subsequent analysis of this sample, which occurred on March 23, confirmed the presence of constituents normally found in the leachate.

This sudden occurrence of essentially full strength leachate in the liner failure detection system when the landfill had been receiving wastes for less than one year suggested a problem other than liner failure. Further review of sample data, together with drawings and site inspection, led to the conclusion that leachate had been siphoned from the leachate collection system sump to the liner failure detection sump.

The liner failure detection sump was emptied on February 28 by pumping the liquid through a downcomer line which extends into the leachate collection sump. The forwarding pump impeller, as well as the system check valves on the main pump in the leachate collection sump, were in need of replacement; therefore, the leachate level in the sump was higher than normal, resulting in the submergence of the downcomer line from the liner failure detection sump. A hydraulic connection was established between the two sumps. When the liner failure detection sump pump was turned off on the morning of March 1, 1983, a syphon back action developed, resulting in the flow of leachate from the leachate collection system to the liner failure detection sump.

The situation was relieved when the faulty leachate pump was replaced during the afternoon of March 1. As the liquid from the leachate sump was pumped to the waste treatment plant, the liner failure detection sump was also pumped down due to the siphon connection. When the level of liquid in the leachate sump dropped below the point to which the downcomer from the liner failure detection sump was extended, the syphon was broken. Leachate remained undetected in the liner failure detection sump until the March monthly sampling procedures were completed.

As required by the Michigan Act 64 permit, the Michigan Department of Natural Resources (MDNR) was informed of the liner failure detection contamination incident as soon as the contamination of the liner failure detection system was substantiated. Transportation of hazardous wastes to the landfill was also discontinued. Cleanup operations began on March 25 and consisted primarily of flushing the liner failure detection system and sump with city water. The MDNR also approved the resumption of landfill operations, although no wastes were taken to the landfill until March 28. The flushing attempts resulted in very rapid reduction (approximately 90%) of the concentration of the parameters being tested; however, on the afternoon of March 28, the MDNR requested that disposal operations at the landfill again be stopped.

An Order to Cease and Desist was issued to Dow on April 12, 1983. In summary, the order required Dow to do the following:

1. Cease all disposal activities.
2. Sample all monitoring wells at the facility and report the results to the MDNR.
3. Determine the cause of contamination of the liner failure detection system as soon as possible.
4. Provide daily oral and bi-weekly written reports to MDNR.
5. Submit to the MDNR a program to test the integrity of the landfill liner, leachate collection system, and liner failure detection system.
6. Take all steps necessary to identify any ground-water contamination which may have resulted or is likely to result from the contamination incident.
7. After review of all pertinent engineering plans, submit plans, specifications, and an implementation schedule for correction of all design failures identified.

The information requested by the Order was supplied to the MDNR on April 19, 1984. On May 25, 1983, Dow received a modification of Order to Cease and Desist and Consent Agreement which allowed the reopening of cells 3, 4 and 5 for receipt of hazardous wastes at the landfill but requested that an investigation be performed to demonstrate the following:

1. The liner under Cells 3 through 8 had not failed.
2. The liner failure detection system would insure that leaks in the landfill liner could be detected.
3. There was no contamination in the soils below the liner failure detection system.
4. The ground water had not been contaminated under the Salzburg Landfill.

Corrective actions taken to eliminate a similar contamination incident from occurring again included drilling a "syphon break" vent in the downcomer pipe. A leachate flow meter and audible alarms for the leachate sump high level and liner failure detection sump high level were also installed.

Bi-weekly reports were sent to the MDNR regarding the concentrations of specific compounds which were being tested in the waters used to flush the liner failure detection system. The wash waters were sampled daily. The landfill's internal leachate collection system was also flooded with city water and fluorescent tracer dye. Samples from the liner failure detection sump were then analyzed for the presence of the dye and demonstrated that no detectable levels could be found in the liner failure detection system. It was also determined at this point that a more accurate parameter to be used to monitor for liner failure would be fluorescent dye, since analysis of the liner failure detection water continued to show the presence of trace amounts of the leachate constituents which had initially contaminated the liner failure detection system.

The investigation of the integrity of the landfill also included a separate testing of each individual segment of the landfill. Excavation, soil testing, and sediment chemical analysis demonstrated that no contamination existed in the soils below the liner failure detection system. An additional monitoring well was also installed. Samples from this well and existing wells 1, 2, 3 and 4 were collected monthly and analyzed for specific leachate constituents. The soil samples and the ground water showed no contamination.

On December 23, 1983, Dow received notification from the MDNR that the requirements of the May 17, 1983 Consent Agreement had been satisfied and were authorized to begin full use of Cells 3, 4, 5, 6, 7, and

8 for permanent disposal of hazardous waste in accordance with the provisions of the original operating license.

E.2 CONTAMINATION INCIDENT #2

On August 23, 1983, dilute leachate was detected outside of the landfill cells, resulting in the implementation of the Salzburg Landfill groundwater monitoring contingency procedure. Excavation was underway for new Cells #9 and #10 at the landfill. It was necessary to open the trench containing the collection header lines which convey leachate and liner failure detection drainage from Cells #6, #7 and #8. When this was done, liquid drained from the gravel surrounding the drainage piping. This water was sampled and found to contain 80 ppb of tracer dye and also low ppb levels of some of the organic constituents of the landfill leachate. The liner failure detection sump at the landfill was immediately sampled and showed no detectable dye, indicating that the liner failure detection layer had not been affected. In compliance with the Michigan Act 64 Landfill Operating Permit, operation of the landfill was stopped and the MDNR was notified.

The leachate and liner failure detection collection sewer lines from Cells #6, #7, and #8 had been terminated and capped during their original installation in 1982 and lay in a gravel bed. The initial investigation into the cause of the contamination involved examination of these pipes. It was determined that the liquid was coming from the gravel bed and not from the pipes. Because the gravel bed was surrounded by natural clay, no immediate danger to human health or the environment existed.

When the investigation was resumed on the following day, the excavated area was found to contain a pool of liquid which had accumulated overnight. The level of the pool was estimated to be approximately the same as that inside Cells #6, #7, and #8 which indicated that the gravel bed was being fed by liquid from inside the cells. Further investigation showed that one of the manholes of the leachate collection piping system was headed up with liquid. The elevation of the liquid level in the manhole was taken and found to be comparable to the liquid level inside Cells #6 through #8. The liquid level inside an associated manhole was observed to be low, suggesting that a restriction existed between the two manholes. A short piece of polyethylene pipe was discovered crossways in the line between the manholes blocking the flow. When this pipe was removed, the flow rate increased immediately from approximately 10 gpm to 118 gpm through the leachate collection sump. The leachate levels inside Cells #6 through #8 also began to change.

A detailed engineering analysis followed the investigation and concluded that the leakage had occurred from the manhole connections. Typically, manholes and their piping connections are not designed to withstand pressure such as occurred when the manhole was blocked. The manholes were therefore eliminated from the system and replaced with short runs of pipe.

On September 6, 1983, Dow received a letter from the MDNR, indicating that the MDNR concurred with the results fo the investigation and the actions taken at the Salzburg Landfill. The reopening of the landfill was thereby authorized.

Several dewatering wells were installed into the gravel bed and the contaminated gravel bed and surrounding areas are being flushed with City water. The water is pumped into the leachate collection sump. Flushing operations will continue until the monthly analysis for leachate constituents and fluorescent dye show nonquantifiable levels.

Analyses of samples from the ground-water monitoring wells were analyzed for volatile organics. The results were all nondetectable.

E.3 CONTAMINATION INCIDENT #3

On September 26, 1983, perchloroethylene was detected in the liner failure detection system of the Salzburg Landfill. The contamination was discovered during the analysis of samples collected from the liner failure detection sump prior to the monthly discharge of collected liquids to the leachate sump.

The landfill was not receiving wastes at the time the contamination was discovered due to inclement weather; hazardous waste activity did not resume at the landfill until approval was received from the MDNR on October 17, 1983.

Activities to determine the source of the contamination were initiated immediately. The liquid in the liner failure detection sump was again sampled and analyzed to confirm the presence of perchloroethylene. All of the liner failure detection sample ports closest to the sump pump showed dirt or clay deposits which, upon analysis, contained concentration of perchloroethylene higher than that of the initial sump sample.

On September 30, the liner failure detection sump was drained and hydroblasted. A system of flushing individual liner failure detection lines and sampling ports was then devised and implemented. The resulting analytical data showed decreasing levels of contamination as the flushing progressed and perchloroethylene levels were eventually reduced to nondetectable levels.

At no time did analysis of samples from the liner failure detection system show detectable levels of methylene chloride, a major constituent of the landfill leachate. If the liner system had failed, this contaminant, as well as other major leachate constituents, would have been found. A liner integrity test had also been recently completed. Since samples from the liner failure detection sump as well as carbon packs did not show any fluorescence, failure of the landfill liner system was proven unlikely.

It was concluded that the problem which resulted in perchloroethylene contamination of the liner failure detection sump was a single, isolated event in which the contamination began in the sump and traveled back through the liner failure detection piping. However, while it is evident from the data that contamination of the sump occurred from an external source, the exact means of contamination has not been determined.

On October 17, 1983, the MDNR approved resumption of disposal operations at the landfill under conditions of the March 17, 1983 Consent Agreement which was still in effect. An additional requirement included the continued monitoring of perchloroethylene levels in the liner failure detection system. Perchloroethylene was not detected in any samples taken from the ground-water monitoring wells located around the landfill.

E.4 CONTAMINATION INCIDENT #4

In the second quarter of 1985, phenol was detected in the original monitoring well 7 at a concentration of 1.4 ppm. Monitoring well 7 was screened at a depth of 65 feet in the Glacial Till unit. The original intent of screening monitoring well 7 at this depth was to sample groundwater from the sand subunit in the Glacial Till. As detailed in the discussion on groundwater movement in Section 7, monitoring wells 8 and 9 are screened in a sand subunit of the Glacial Till and, therefore, yield sufficient amounts of groundwater to supply representative samples of the groundwater and to fully recover between sampling periods. However, the sand subunit of the Glacial Till which extends under monitoring wells 8 and 9 does not extend under monitoring well 7. Thus, monitoring well 7 was screened in the low permeable Glacial Till and did not yield adequate groundwater to fully recover between sampling or to be properly purged to yield representative samples of the groundwater.

Due to the very low yield, and thus insufficient purging prior to sampling, and to the distance of monitoring well 7 from the active portion of the landfill, the phenol in the groundwater sampled from monitoring well 7 was suspected to be from contamination of the well during its construction. A work plan to evaluate the well as the possible source of phenol was drafted and agreed upon by the Hazardous Waste Division of the Michigan Department of Natural Resources. The action described below was taken under this agreement.

On October 14 and 15, 1985, a temporary monitoring well 7A was drilled next to the original monitoring well 7 to analyze for phenol in the groundwater at the same elevation as monitoring well 7. This well was drilled with hollow-stem auger, and a rigid quality assurance-quality control program was followed. This program included steam cleaning the casing, screen, auger and drill rig prior to entering the site and taking wipe samples for phenol analysis of a 100 cm^2 area of the casing, screen, auger, drill pipe, split spoon, and blank. All of the wipe samples taken had no detectable phenol at a detection limit of 10 ug per wipe. Groundwater samples from this well also did not contain any detectable phenol.

After it was determined that the groundwater in the temporary monitoring well 7A did not contain phenol, the original monitoring well 7 was to be pulled, if possible, and groundwater samples taken from the open hole. On November 11, 1985, the 13-foot long outer 8" casing and 20 feet of the inner 4" casing from the original monitoring well 7 were pulled. However, due to the depth of the cement grout around the 4" casing, this casing separated at a coupling 20 feet deep, leaving 46 feet of 4" casing in the ground. Wipe tests for phenol were taken on the inside of the 4" casing and on the threads. The sample taken on the inside of the casing gathered 16 ug of phenol and the wipe test on the popped threads gathered 14 ug of phenol. since much of the casing remained in the hole, a groundwater sample was not collected.

The phenol on the casing from the original monitoring well 7 and the absence of phenol in temporary monitoring well 7A both support the source of phenol being from contamination during construction of monitoring well 7. Based on this conclusion, the hole for the original monitoring well 7 was plugged from the bottom up with a mixture of bentonite and cement and monitoring well 7A was deepened to be screened in sediments which yield sufficient groundwater for the proper purging of the well prior to sampling.

APPENDIX F
ONSITE/MAXI RESULTS

[illegible]

Case title: [illegible]
Executed on: [illegible] Page [illegible]

PATHWAYS/OPTIONS CONSIDERED:

External exposure/root penetration for waste modeled as slab (volume) source
External exposure to surface contamination modeled as a plane source
Inhalation of resuspended material
Farm product ingestion
Committed effective dose equivalent (CEDE) calculation

TITLES OF LIBRARY FILES ACCESSED:

10: RMDLIB - Radionuclide Master Library (21-Nov-86 H3 & C14 [W] RAP)
11: ORGAN DATA LIBRARY UPDATED BY RA FELDQUIN 8-Jul-86
12: FOOD TRANSFER COEFFICIENT LIBRARY (RAP/WTF 04-APR-86 C1 Update)
13: Committed Dose Equivalents (Sv/Bq) ICRP Publication 30 (22-Nov-86 RAP)
22: OVERBURDEN: 0.0M, SOURCE: 0.1 M (DEN: CONCRETE/1.8): MR/HR 8-Jul-86 RAP
23: DACRIN (DIFDOS) DOSE INCREMENT FILE ONSITE/MAXI 20-Apr-87 RAP
27: OVERBURDEN: 1.0m, SOURCE: 1.0M (DEN: CONCRETE/1.8): MR/HR 15-Jul-86 RAP

NUMBER OF YEARS AFTER WASTE IS DISPOSED THAT:

Scenario begins: [illegible]
Scenario ends: [illegible]

INVENTORY:

Release Term Input units: [illegible] [illegible]
Soil source units: [illegible] [illegible]
Number of radionuclides in inventory: [illegible]

Release Term	Soil Source (per m3)	Irrigation Aquatic (per L)	Drinking Water (per L)	Atmospheric Release (per yr)
TH232	1.4E+03	.0E+00	.0E+00	.0E+00
RA228	1.4E+03	.0E+00	.0E+00	.0E+00
AC228	1.4E+03	.0E+00	.0E+00	.0E+00
TH228	1.4E+03	.0E+00	.0E+00	.0E+00
RA224	1.4E+03	.0E+00	.0E+00	.0E+00
PB212	1.4E+03	.0E+00	.0E+00	.0E+00
BI212	1.4E+03	.0E+00	.0E+00	.0E+00

INVENTORY MODIFICATION FACTORS: (multipliers)

Surface inventory dilution factor: 1.
Irrigation/aquatic inventory modification factor: 1.
Size of site (fractional ha): 1.0E+00
Fraction of total diet grown on site: 1.

EXTERNAL/INHALATION EXPOSURE:

Hours of external exposure to contamination (h/yr):	8.8E+03
Hours of inhalation of airborne contamination (h/yr):	8.8E+03
Breathing rate (cm**3/sec):	2.7E+02

RESUSPENSION PARAMETERS:

Model used:	Mass Loading
Soil density (g/m**3):	1.8E+06
Mass loading factor (g/m**3):	1.0E-04

AGRICULTURAL PARAMETERS:

Fraction of roots in upper soil:	1.00
Fraction of roots in deeply buried waste:	.000
Ratio of ext. contamination in surface/subsurface soil:	.000
Months per year irrigated:	6
Irrigation rate (L/m**2/mo):	1.5E+02
Years of irrigation w/ contaminated water prior to the beginning of the dose calculation period:	0
Number of food types:	10

FOOD TYPE INDEX	FOOD TYPE	GROWING PERIOD (days)	YIELD (kg/m**2)	HOLDUP (days)	CONSUMPTION (kg/yr)	TRANS-LOCATION FACTOR
1	LEAFY VEG.	90.	1.50	1.	9.5	1.00
2	O.A.G.VEG.	60.	.70	1.	9.3	.10
4	OT.RT.VEG.	90.	4.00	10.	76.0	.10
7	ORCH.FRUIT	90.	2.00	10.	42.0	.10
9	OT.GRAIN	90.	1.00	1.	51.0	.10
10	EGGS	90.	.84	1.	19.0	.10
11	MILK	30.	1.30	1.	110.0	1.00
12	BEEF	90.	.84	13.	39.0	.10
13	PORK	90.	.84	15.	29.0	.10
14	POULTRY	90.	.84	1.	8.5	.10

Input prepared by: William [illegible] Date: 10/25/88

Input checked by: Robert [illegible] Date: 10/25/88

PLEASE NOTE ANY SPECIAL CONSIDERATIONS IN THIS SPACE

CALCULATED VALUES:

Ingestion area correction factor:	1.0
External/inhalation area correction factor:	1.0
Inhalation exposure modification factor:	1.0
External exposure modification factor:	1.0

SOIL, AIR, AND WATER CONCENTRATION SUMMARY FOR YEAR: 0

Radio-nuclide	Surface Soil pCi/m2	Deep Soil pCi/m3	Air pCi/m3	Irrigation pCi/L	Drink Water pCi/L
TH 232	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
RA 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
AC 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
TH 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
RA 224	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
PB 212	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
BI 212	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00

SOIL, AIR, AND WATER CONCENTRATION SUMMARY FOR YEAR: 50

Radio-nuclide	Surface Soil pCi/m2	Deep Soil pCi/m3	Air pCi/m3	Irrigation pCi/L	Drink Water pCi/L
TH 232	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
RA 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
AC 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
TH 228	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
RA 224	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
PB 212	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00
BI 212	.0E+00	2.4E+03	.0E+00	.0E+00	.0E+00

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[illegible]
[illegible]

Case title:   [illegible] TRENCH [illegible]
Executed on:  [illegible]                                    Page  [illegible]
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Annual Effective Dose Equivalent (AEDE):            1.5E-03


Maximum Annual Dose (ICRP-2):

    To Organ: TOTAL BODY at Year   3              1.5E-03 rem
    To Organ:    BONE    at Year   3              1.5E-03 rem
    To Organ:   LUNGS    at Year   3              1.5E-03 rem
    To Organ:  THYROID   at Year   3              1.5E-03 rem
    To Organ:    LLI     at Year   3              1.5E-03 rem
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DOSES FROM 1 YEAR OF EXPOSURE (REM)

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	.0E+00	2.5E-01	.0E+00
Breast	.0E+00	1.5E-01	.0E+00
R Marrow	.0E+00	1.2E-01	.0E+00
Lungs	.0E+00	1.2E-01	.0E+00
Thyroid	.0E+00	3.0E-02	.0E+00
Bone Surf	.0E+00	3.0E-02	.0E+00
St Wall	.0E+00	6.0E-02	.0E+00
SI Wall	.0E+00	6.0E-02	.0E+00
ULI Wall	.0E+00	6.0E-02	.0E+00
LLI Wall	.0E+00	6.0E-02	.0E+00
Kidneys	.0E+00	6.0E-02	.0E+00
Effective Dose Equivalent			.0E+00
External Dose			1.5E-01
Annual Effective Dose Equivalent			1.5E-01

---------- MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 1 FOR TOTAL BODY ----------

RADIO-NUCLIDE	INGESTION REM	%	INHALATION REM	%	EXTERNAL REM	%	AQUATIC FOOD REM	%	DRINK WATER REM	%
TH232	.0E+00	0	.0E+00	0	1.4E-22	0	.0E+00	0	.0E+00	0
RA228	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0
AC228	.0E+00	0	.0E+00	0	1.3E-05	0	.0E+00	0	.0E+00	0
TH228	.0E+00	0	.0E+00	0	2.6E-13	0	.0E+00	0	.0E+00	0
RA224	.0E+00	0	.0E+00	0	2.4E-10	0	.0E+00	0	.0E+00	0
PB212	.0E+00	0	.0E+00	0	1.5E-10	0	.0E+(	[illegible]	.0E+00	0
BI212	.0E+00	0	.0E+00	0	1.5E-03	99	.0E+00	0	.0E+00	0

TOTAL	INGESTION		INHALATION		EXTERNAL		AQUATIC FOOD		DRINK WATER	
1.5E-03	.0E+00	0	.0E+00	0	1.5E-03	100	.0E+00	0	.0E+00	0

---------- MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 1 FOR BONE ----------

RADIO-NUCLIDE	INGESTION REM	%	INHALATION REM	%	EXTERNAL REM	%	AQUATIC FOOD REM	%	DRINK WATER REM	%
TH232	.0E+00	0	.0E+00	0	1.4E-22	0	.0E+00	0	.0E+00	0
RA228	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0
AC228	.0E+00	0	.0E+00	0	1.7E-05	0	.0E+00	0	.0E+00	0
TH228	.0E+00	0	.0E+00	0	2.6E-13	0	.0E+00	0	.0E+00	[illegible]
RA224	.0E+00	0	.0E+00	0	2.4E-10	0	.0E+00	0	.0E+00	0
PB212	.0E+00	0	.0E+00	0	1.5E-10	0	.0E+00	0	.0E+00	0
BI212	.0E+00	0	.0E+00	0	1.5E-03	99	.0E+00	0	.0E+00	0

TOTAL	INGESTION		INHALATION		EXTERNAL		AQUATIC FOOD		DRINK WATER	
1.5E-03	.0E+00	0	.0E+00	0	1.5E-03	100	.0E+00	0	.0E+00	0

---------- MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 0 FOR LUNGS ----------

RADIO-NUCLIDE	INGESTION REM	%	INHALATION REM	%	EXTERNAL REM	%	AQUATIC FOOD REM	%	DRINK WATER REM	%
TH232	.0E+00	0	.0E+00	0	1.4E-33	0	.0E+00	0	.0E+00	0
RA228	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0
AC228	.0E+00	0	.0E+00	0	1.3E-05	0	.0E+00	0	.0E+00	0
TH228	.0E+00	0	.0E+00	0	2.6E-13	0	.0E+00	0	.0E+00	0
RA224	.0E+00	0	.0E+00	0	2.4E-10	0	.0E+00	0	.0E+00	0
PB212	.0E+00	0	.0E+00	0	1.3E-10	0	.0E+00	0	.0E+00	0
BI212	.0E+00	0	.0E+00	0	1.5E-03	99	.0E+00	0	.0E+00	0

TOTAL	INGESTION	%	INHALATION	%	EXTERNAL	%	AQUATIC FOOD	%	DRINK WATER	%
1.5E-03	.0E+00	0	.0E+00	0	1.5E-03	100	.0E+00	0	.0E+00	0

---------- MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 0 FOR THYROID ----------

RADIO-NUCLIDE	INGESTION REM	%	INHALATION REM	%	EXTERNAL REM	%	AQUATIC FOOD REM	%	DRINK WATER REM	%
TH232	.0E+00	0	.0E+00	0	1.4E-33	0	.0E+00	0	.0E+00	0
RA228	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0
AC228	.0E+00	0	.0E+00	0	1.3E-05	0	.0E+00	0	.0E+00	0
TH228	.0E+00	0	.0E+00	0	2.6E-13	0	.0E+00	0	.0E+00	0
RA224	.0E+00	0	.0E+00	0	2.4E-10	0	.0E+00	0	.0E+00	0
PB212	.0E+00	0	.0E+00	0	1.5E-10	0	.0E+00	0	.0E+00	0
BI212	.0E+00	0	.0E+00	0	1.5E-03	99	.0E+00	0	.0E+00	0

TOTAL	INGESTION	%	INHALATION	%	EXTERNAL	%	AQUATIC FOOD	%	DRINK WATER	%
1.5E-03	.0E+00	0	.0E+00	0	1.5E-03	100	.0E+00	0	.0E+00	0

MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 0 FOR LLI

RADIO-NUCLIDE	INGESTION REM	%	INHALATION REM	%	EXTERNAL REM	%	AQUATIC FOOD REM	%	DRINK WATER REM	%
TH232	.0E+00	0	.0E+00	0	1.4E-03	0	.0E+00	0	.0E+00	0
RA228	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0	.0E+00	0
AC228	.0E+00	0	.0E+00	0	1.3E-05	0	.0E+00	0	.0E+00	0
TH228	.0E+00	0	.0E+00	0	2.6E-13	0	.0E+00	0	.0E+00	0
RA224	.0E+00	0	.0E+00	0	2.4E-10	0	.0E+00	0	.0E+00	0
PB212	.0E+00	0	.0E+00	0	1.5E-10	0	.0E+00	0	.0E+00	0
BI212	.0E+00	0	.0E+00	0	1.5E-03	99	.0E+00	0	.0E+00	0

TOTAL	INGESTION		INHALATION		EXTERNAL		AQUATIC FOOD		DRINK WATER	
1.5E-03	.0E+00	0	.0E+00	0	1.5E-03	100	.0E+00	0	.0E+00	0

APPENDIX G

DISPOSAL CELL CONSTRUCTION AND CAP DETAILS DRAWINGS

DRAWING B2-001

This drawing is the general plan view of Cells 36 and 37 with their relative position to the previously constructed landfill cells.

This drawing also gives the cells coordinates and dimensions and the finished bottom slopes are also shown.

DRAWING B2-002

This drawing highlights the plan view of the south end of Cell 37 and the monitor and leachate piping. The general locations are shown for lift stations 26 and 27.

This drawing shows the coordinates of lift stations 24 and 25.

DRAWING B2-003

This drawing shows the plan view of the north end of cell 37 and all of cell 36 and the monitor and leachate piping.

DRAWING B2-004

This drawing shows typical cross sections and various details associated with the landfill construction.

The monitor drainage mat detail shows the placement sequence between the three foot compacted clay and five foot compacted clay liners.

The liner anchor detail shows how the 100 mil polyethylene liner and the side wall drainage "leachate collection" system are anchored at the top of the slope.

The inside toe of dike detail shows the wall/bottom intersection and the relationship of the 100 mil PE liner, compacted clay liner and drainage media at this intersection.

DRAWING B2-005

This drawing shows various details associated with the landfill construction.

The leachate drain and monitor line details show the relationship between the pea stone around the drain, the drainage media and the clay liners.

The pipe bedding detail shows how pipelines outside the landfill cells are to be placed upon a bedding of fine aggregate and covered with twelve inches of the aggregate.

The water stop detail specifies the precise location for a polyethylene disc around a pipeline that will be penetrating the clay liner. The disc, or water stop, impedes the flow of liquid along the pipeline.

DRAWING B2-006

This drawing shows the plan view of the lift station area and the above ground piping.

An isometric of the piping is also shown at lift stations 24, 26 and 27.

DRAWING B2-007

This drawing includes two sections of the south end of Cells 36 and 37 which details the area around the lift stations inside the landfill cell.

A cleanout riser detail for the monitor and leachate lines are shown on this drawing.

Several notes for the cleanout riser and the 8 mil PE liner for erosion control are shown on this drawing.

DRAWING B2-008

This drawing shows the plan view and section of lift station 24.

The lift station access cover is detailed in plan view and section. The access cover lifting handle detail is also included.

The lift station collar detail shows how the 100 mil liner is connected to the lift station. This detail also shows how the leachate collection line connects to the lift station.

DRAWING B2-009

This drawing shows the plan view and section for monitor lift station 25.

The cover plate is shown in plan view and section.

The below grade ricer and elbow detail is shown. This is the discharge line for lift station 24.

DRAWING B2-010

This drawing shows various details and sections for the piping entering manhole 17. Lift station 24 will forward its contents to manhole 17.

DRAWING B2-010

This drawing shows various details and sections for the piping entering manhole 17. Lift station 24 will forward its contents to manhole 17.

DRAWING B2-011

This drawing shows the plan view and sections for lift stations 26 and 27.

Piping details are shown for each lift station.

DRAWING B2-012

This drawing shows various pipe support details.

The vent for the monitor lift station is detailed.

The flow meter piping is detailed.

The ladder for access to the monitor lift station details are shown.

DRAWING B2-013

This drawing shows the plan view and section for the access ramp to lift stations 24, 26 & 27.

Pipe support locations are shown on the ramp plan view and section.

The support columns for the access ramp are shown in two section views A-A and B-B.

DRAWING B2-014

This drawing details the installation of the sidewall drainage system and the 8 mil liner. The 8 mil liner is installed only to provide erosion protection to the compacted 5 feet clay liner should construction of the 100 mil liner not be done before the winter season.

DRAWING B2-015

This drawing shows the site excavation plan views and sections. These details show the existing surface elevations and the required excavation depths.

DRAWING B2-016

This drawing shows additional excavation sections. The section locations are shown on the plan view on drawing B2-015.

DRAWING B2-017

This drawing shows the plan view and sections A-A and B-B of the 3 foot compacted clay liner. The location of additional sections are shown on the plan view. These sections are shown on drawing B2-018.

The location and slope of the monitor lines are shown on this drawing.

The sections show the stairstep method used to key the 3 foot compacted clay liner into the existing soil.

DRAWING B2-018

This drawing show additional sections, C-C, D-D, E-E, F-F and G-G of the 3 foot compacted clay liner.

These sections show the location and slope of the monitor lines and monitor drainage mat.

These sections show the stairstep method used to key the 3 foot compacted clay liner into the existing soil.

DRAWING B2-019

No drawing B2-019 exists

DRAWING B2-020

This drawing shows the plan view of the capping for Cells 36 & 37 with contour lines and the transition to previously closed and capped Cells 38 & 39.

A typical section is shown of the capped Cells 36 & 37 and the transition to Cells 38 & 39.

DRAWING B2-021

This drawing shows a typical side slope section and various details for capping a landfill cell.

The side slope section shows the detail of the cap and the landfill sidewall.

The drainage trench detail shows how the cap drainage layer above the 40 mil PE liner is tied to the drain tile.

The gas vent detail shows the method of sealing the gas vent to the 40 mil PE liner, the waterstop in the center of the compacted clay liner and the location of the gas vent trough.

The topsoil berm and downspout detail shows the installation of the downspout and berm to control run-off and prevent erosion.

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

1

IMAGE EVALUATION TEST TARGET (MT-3)

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

February 27, 1981

RECEIVED

OCT 21 1988

Michigan Div. Legal

John M. Alford
Environmental Sanitarian
Department of Natural Resources
Resource Recovery Divs.
P.O. Box 128
Roscommon, Mi. 48653

Re: Salzburg Road Sanitary Landfill, Declaration of Restrictive Covenant, City of Midland, Midland County

Dear Mr. Alford:

Enclosed is a copy of the Declaration of Restrictive Covenant for the Dow Chemical Company 7.4 acre sanitary landfill located off Salzburg Road, Midland County.

This covenant was recorded with the Midland County Register of Deeds office on February 11, 1981 in accordance with Act 641, P.A. of 1978.

Should you have any questions, please feel free to contact this office.

Sincerely,

Douglas Dial

Douglas Dial, R.S., Director
Environmental Health Division

DD:pm
CC: Larry Washington, Mgr. of Dow Environmental Services
W. C. Meagher, Real Estate Dept. of Dow Chemical Company

FEB 11 11 31 AM 1981

Richard ... [signature]
REGISTER OF DEEDS
MIDLAND ... MICH.

DECLARATION OF RESTRICTIVE COVENANT

RECEIVED
DEC 17 1980
RES. RECOVERY REG. II

THIS INDENTURE made the 24th day of November, 19 80, by and between, THE DOW CHEMICAL COMPANY whose address is: 2030 Dow Center, Midland, Michigan 48640 part(y) (ies) of the first part; and Howard A. Tanner, Director of the Michigan Department of Natural Resources for and on behalf of the State of Michigan, whose address is: Steven T. Mason Building, Lansing, Michigan 48913, pa ty of the second part;

WITNESSETH THAT:

WHEREAS, application for licensure under provisions of 1978, PA 641, 1970 CL 299.401 et seq, for the purpose of conducting, managing, maintaining or operating a disposal area upon lands situated in the City of Midland, County of Midland, more particularly described as: Commencing at the North Quarter (1/4) corner of Section 35, Township 14 orth, Range 2 East; thence South 89°-47'-50" East 433.38 feet along the North line of said ection 35; thence South 0°-12'-10" West 252.08 feet to the point of beginning; thence continui South 0°-12'-10" West 413.65 feet; thence South 42°-55'27" West 476.54 feet; thence North 45°-39'42" West 560.70 feet; thence North 42°-41'-11" East 506.25 feet; thence South 89°-47'-50 East 383.80 feet to the point of beginning; containing 8.15 ± acres. has been properly made; and

WHEREAS, the Director of the Department of Natural Resources, will contemporaneously issue such license; and

WHEREAS, 1978 PA 641, supra, Section 16 requires that at the time of licensing of a sanitary landfill, an instrument which imposes a restrictive covenant upon the land involved shall be executed by all the owners of the tract of land upon the landfill is located and the director.

NOW THEREFORE, THE DOW CHEMICAL COMPANY, the part(y) (ies) of th first part, do for themselves, their heirs, successors, lessees, or assigns declare, covenant and agree:

R-5527
Rev 2/80

1. That the lands hereinbefore described have been or will hereafter be used as a sanitary landfill, and that neither they, nor their servants, agents, employees, nor any of the heirs, successors, lessees or assigns shall (or shall by their leave or sufferance permit others to) engage in filling, grading, excavating, drilling or mining of the lands and premises above described until 15 years after completion of all landfill activity upon the same, unless written authorization therefor is obtained from the Director of the Department of Natural Resources; and that the State of Michigan or any municipality may in addition to any other remedy available at law bring an action for an injunction or other process against any person, county, or municipality to restrain or prevent any violation of the restrictive covenant hereby imposed upon the subject premises.

2. That at the time of the ensealing and delivery of these presents the above described premises are free from all encumbrances whatever, (except) a right of way granted to Consumers Power Company for above ground electrical transmission lines.

The director of the department of natural resources does for and on behalf of the State of Michigan covenant and agree to execute, acknowledge, and deliver to the party of the first part, a release of the within restrictive covenant, in suitable form, upon the expiration of the 15 year period provided for herein.

R-5527
Rev 2/80

RESTRICTIVE CONVENANTS LIBER 537 PAGE 406

THE DOW CHEMICAL COMPANY, a Delaware corporation with executive offices at
Name   Company, Partnership, etc.   Address
2030 Dow Center in Midland County, Michigan,
is the record owner of the following described premises in the Township of

Midland, Midland County, Michigan, to wit:

SEE ATTACHED EXHIBIT-A

The Dow Chemical Company is in the process of constructing a hazardous waste landfill
Name
on a portion of its property above described, pursuant to 1979 PA 64 and the rules promulgated thereunder, the location of the facility being described in Exhibit A, attached hereto, and hereby

NOW, THEREFORE, these Restrictive Covenants are executed by The Dow Chemical Co.
Name
to insure the integrity of said disposal facility for the safety of the people of the State of Michigan, to-wit:

(1) No vehicles, except vehicles needed and actually used for maintenance and inspection, shall be allowed within the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(2) No excavation or construction, except as necessary to maintain the integrity of the facility, shall be allowed after closure of the facility in the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(3) No uses of the property shall be made which may or will impair the integrity of the facility.

RECORDED

... 3 4 13 PM '84

RICHARD C. SIMEKT
REGISTER OF DEEDS
MIDLAND COUNTY, MICH

3/81

RECEIVED

OCT 21 1988

Michigan Div. Legal

R 4906

3.

RESTRICTIVE COVENANTS

THE DOW CHEMICAL COMPANY (Name), a Delaware corporation with executive offices at (Company, Partnership, etc. Address) 2030 Dow Center in Midland County, Michigan,
is the record owner of the following described premises in the Township of

Midland, Midland County, Michigan, to wit:

SEE ATTACHED EXHIBIT-A

The Dow Chemical Company (Name) is in the process of constructing a hazardous waste landfill on a portion of its property above described, pursuant to 1979 PA 64 and the rules promulgated thereunder, the location of the facility being described in Exhibit A, attached hereto, and hereby

NOW, THEREFORE, these Restrictive Covenants are executed by The Dow Chemical Co. (Name) to insure the integrity of said disposal facility for the safety of the people of the State of Michigan, to-wit:

(1) No vehicles, except vehicles needed and actually used for maintenance and inspection, shall be allowed within the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(2) No excavation or construction, except as necessary to maintain the integrity of the facility, shall be allowed after closure of the facility in the areas which are enclosed by a sound and secure fence, pursuant to Paragraph (4), below, except as indicated in Paragraph (8) below.

(3) No uses of the property shall be made which may or will impair the integrity of the facility.

RECORDED

JUL 3 4 13 PM '84

RICHARD C. CLMENT
REGISTER OF DEEDS
MIDLAND COUNTY, MICH

(4) The Dow Chemical Company shall erect, and it and its successors in
Name
interest, shall thereafter continuously maintain until further order of the Department of Natural Resources: (i) a secure and sound fence enclosing the area containing the disposal facility at least FIFTY (50) feet measured from all edges of the disposal facility; and (ii) a sign stating: "Warning, Hazardous Waste Disposal Area, KEEP OUT," inside the fence, visible from each side.

(5) The Dow Chemical Company shall notify the Director of the Michigan
Name
Department of Natural Resources of its intent to convey any interest in land located in City of Midland, Section 35 in Midland Township, Midland County, Michigan. No conveyance of title, easement, or other interest in the property shall be consummated by The Dow Chemical Company
Name
without adequate and complete provision for continued maintenance of the facility and monitoring systems described in the Closure and Post Closure Maintenance and Monitoring Plans described in Exhibit B, attached hereto and hereby made a part hereof. For the purpose of assuring adequate maintenance of the facility's monitoring system(s), no property owned by The Dow Chemical Co., described in
Name
Exhibit A shall be conveyed without prior written approval of the Director of the Michigan Department of Natural Resources. Such approval by the Director is not to be unreasonably withheld.

(6) Until further notice from the Director of the Michigan Department of Natural Resources, set forth above, The Dow Chemical Co., and its successors in
Name
title will maintain and monitor the facility as described in Section 41(1) of 1979 PA 64.

(7) Any governmental agency adversely affected by any violations of these restrictions may enforce them by legal actions in the Circuit Court.

(8) The property described in Exhibit A is subject to an existing easement of record granted to Consumers Power Company for electric transmission lines.

These Restrictive Covenants shall run with the land and be binding upon first party, its successors, and assigns.

DATED: This 6th day of July, 1981.

THE DOW CHEMICAL COMPANY

By [signature]

Its I. F. HARLOW, VICE PRESIDENT

____

Director, Michigan Department of Natural Resources

WITNESSES:

[signature]
Cheryl A. Johnson

[signature]
Lu Ellen Joslyn

STATE OF MICHIGAN)
) ss.
COUNTY OF MIDLAND)

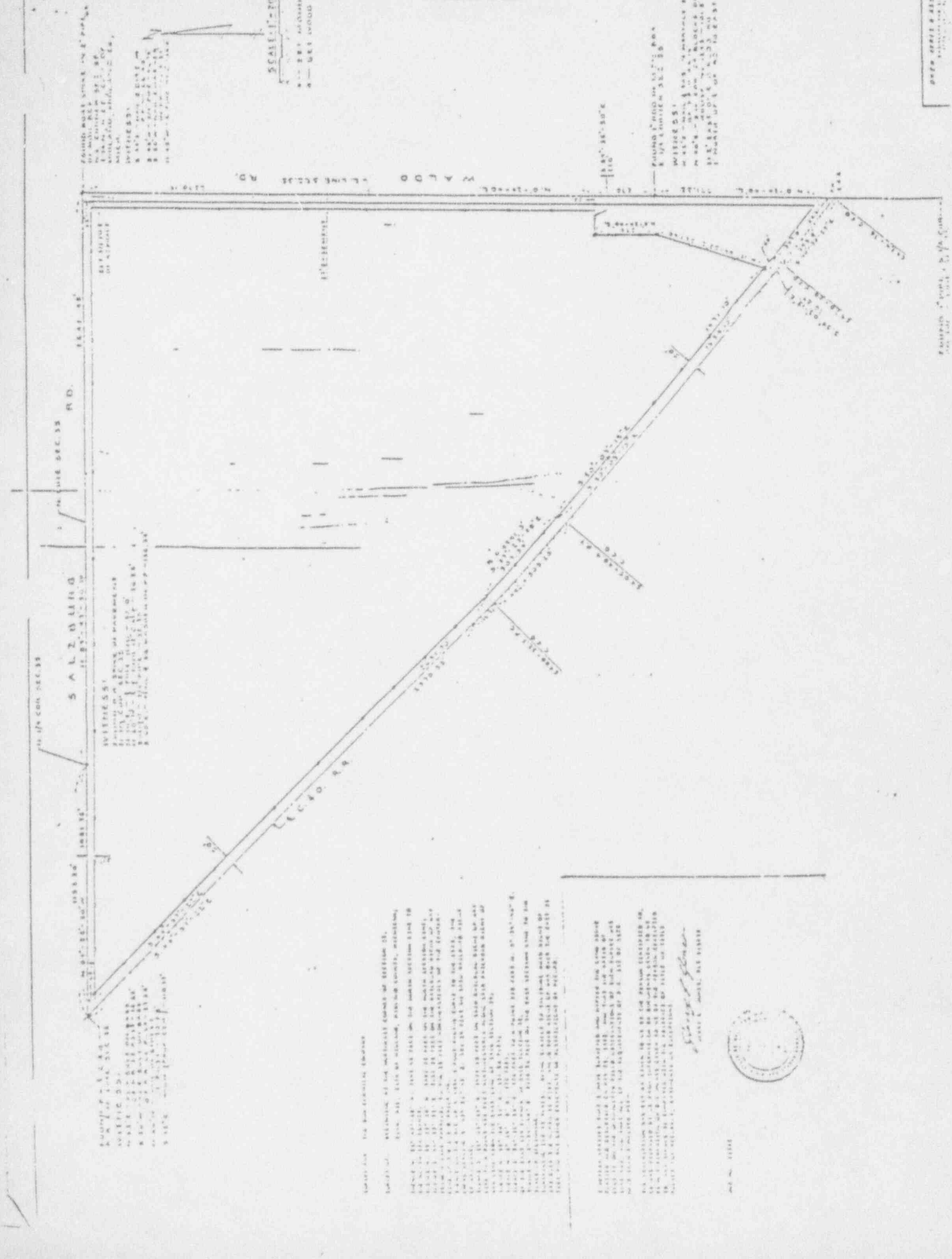
The foregoing insturment was acknowledged before me this 6th day of July, 1981, by I. F. Harlow, of The Dow Chemical Company corporation, on behalf of the Corporation.

The information necessary to complete this instrument was supplied by The Dow Chemical Company, however, the instrument was prepared by the Michigan Department of Natural Resources.

[signature]
NOTARY PUBLIC

CHERYL A. JOHNSON
Notary Public, Midland County, Michigan
My Commission Expires June 1, 1983

EXHIBIT A



Certified Copy of

POWER OF ATTORNEY

Know all Men by these Presents, That the FEDERAL INSURANCE COMPANY, 51 John F. Kennedy Parkway, Short Hills, New Jersey, a New Jersey Corporation, has constituted and appointed, and does hereby constitute and appoint Tad M. Coalwell, Harrison T. Plum, Jr., Roberta B. Lukowski and Dick Vlasblom of Midland, Michigan--

each its true and lawful Attorney-in-Fact to execute -- under such designation in its name and to affix its corporate seal to and deliver for and on its behalf as surety thereon or otherwise, bonds or obligations on behalf of THE DOW CHEMICAL COMPANY

of any of the following classes, to-wit:

1. Bonds and Undertakings (other than Fiduciary Bonds) filed in any suit, matter or proceeding in any Court, or filed with any Sheriff or Magistrate, for the doing or not doing of anything specified in such Bond or Undertaking, in which the penalty of the bond or undertaking does not exceed the sum of ONE HUNDRED THOUSAND DOLLARS ($ 100,000.00).
2. Surety Bonds to the United States of America or any agency thereof, including those required or permitted under the laws or regulations relating to Customs or Internal Revenue; License and Permit Bonds or other indemnity bonds under the laws, ordinances or regulations of any State, City, Town, Village, Board or other body or organization, public or private; bonds to Transportation Companies, Lost Instrument bonds, Lease bonds, Worker's Compensation bonds, Miscellaneous Surety bonds and bonds on behalf of Notaries Public, Sheriffs, Deputy Sheriffs and similar public officials.
3. Bonds on behalf of contractors in connection with bids, proposals or contracts to or with the United States of America, any state or political subdivision thereof or any person, firm or Corporation.

In Witness Whereof, the said FEDERAL INSURANCE COMPANY has, pursuant to its By-Laws, caused these presents to be signed by its Assistant Vice-President and Assistant Secretary and its corporate seal to be hereto affixed this 7th day of December 19 82

FEDERAL INSURANCE COMPANY

By [signature]

George McClellan

Assistant Vice-President

FEDERAL INSURANCE COMPANY NEW JERSEY

[signature]

Richard D. O'Connor

Assistant Secretary

STATE OF NEW JERSEY }
County of Essex } ss:

On this 7th day of December 19 82, before me personally came Richard D. O'Connor to me known and by me known to be Assistant Secretary of the FEDERAL INSURANCE COMPANY, the corporation described in and which executed the foregoing Power of Attorney, and the said Richard D. O'Connor being by me duly sworn, did depose and say that he is Assistant Secretary of the FEDERAL INSURANCE COMPANY and knows the corporate seal thereof; that the seal affixed to the foregoing Power of Attorney is such corporate seal and was thereto affixed by authority of the By-Laws of said Company, and that he signed said Power of Attorney as Assistant Secretary of said Company by like authority; and that he is acquainted with George McClellan and knows him to be the Assistant Vice-President of said Company, and that the signature of said George McClellan subscribed to said Power of Attorney is in the genuine handwriting of said George McClellan and was thereto subscribed by authority of said By-Laws and in deponent's presence.

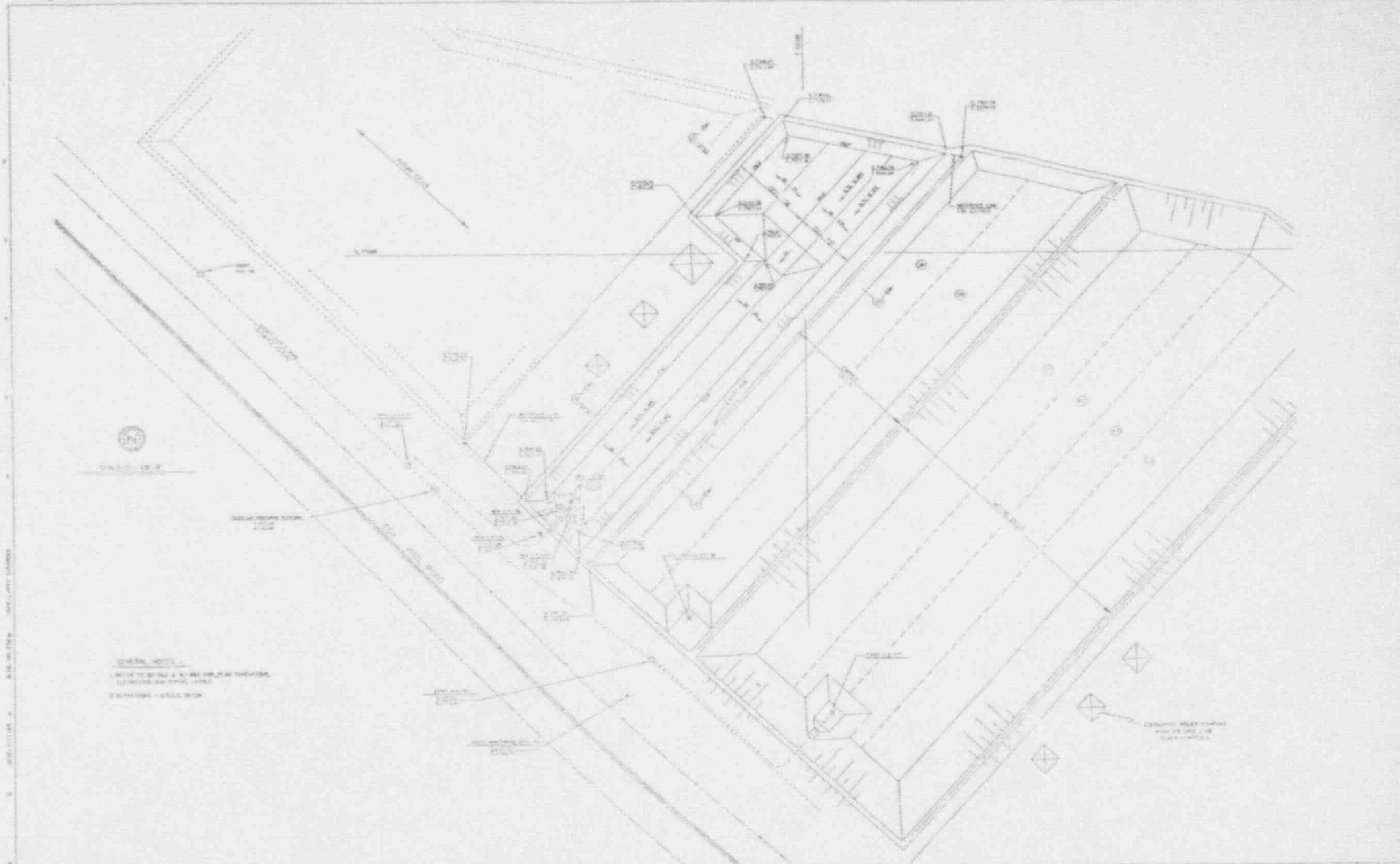
Acknowledged and Sworn to before me on the date above written.

PATRICIA RYAN NOTARY PUBLIC NEW JERSEY

[signature]

Notary Public

PATRICIA RYAN
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires December 11, 19 83

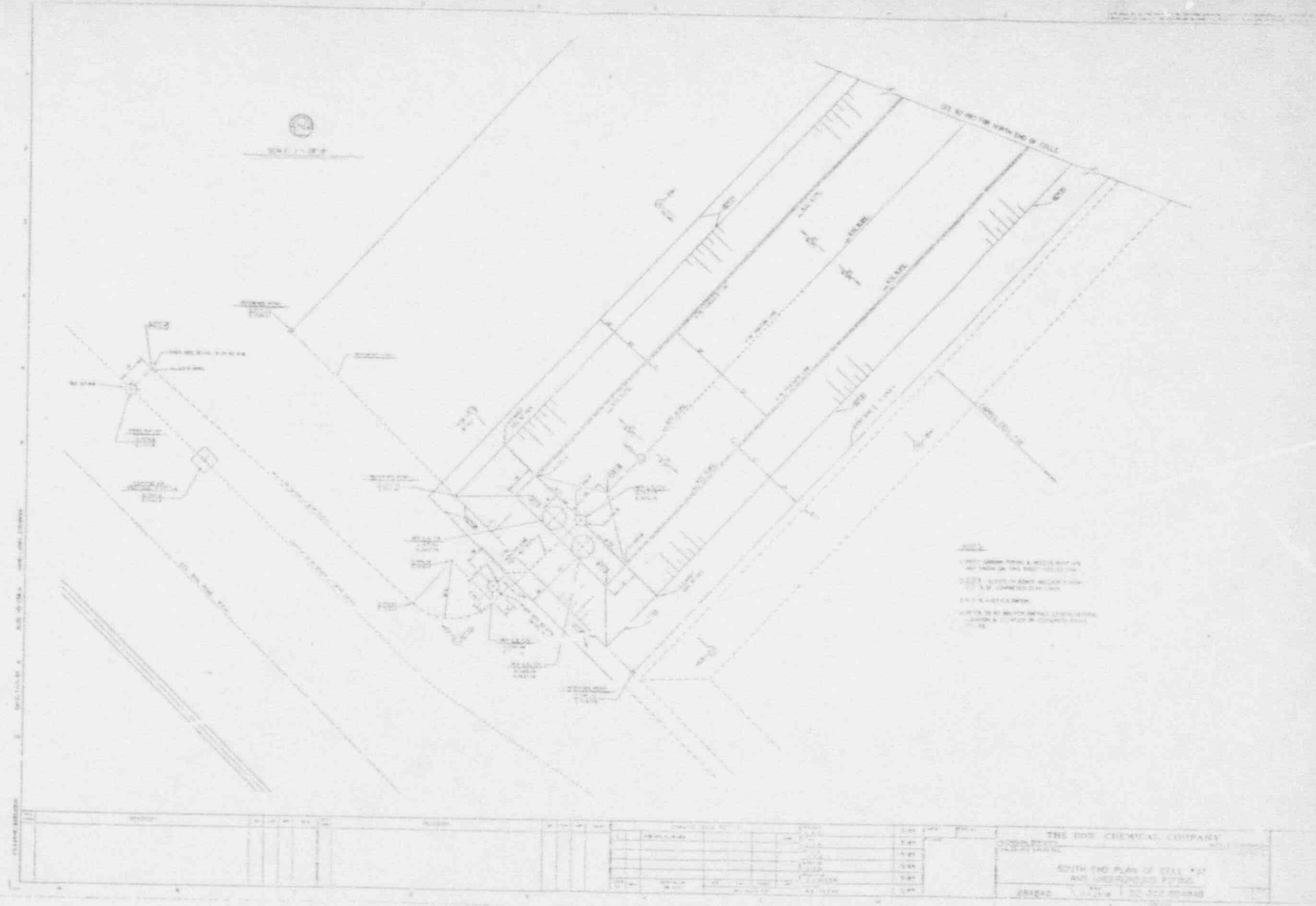


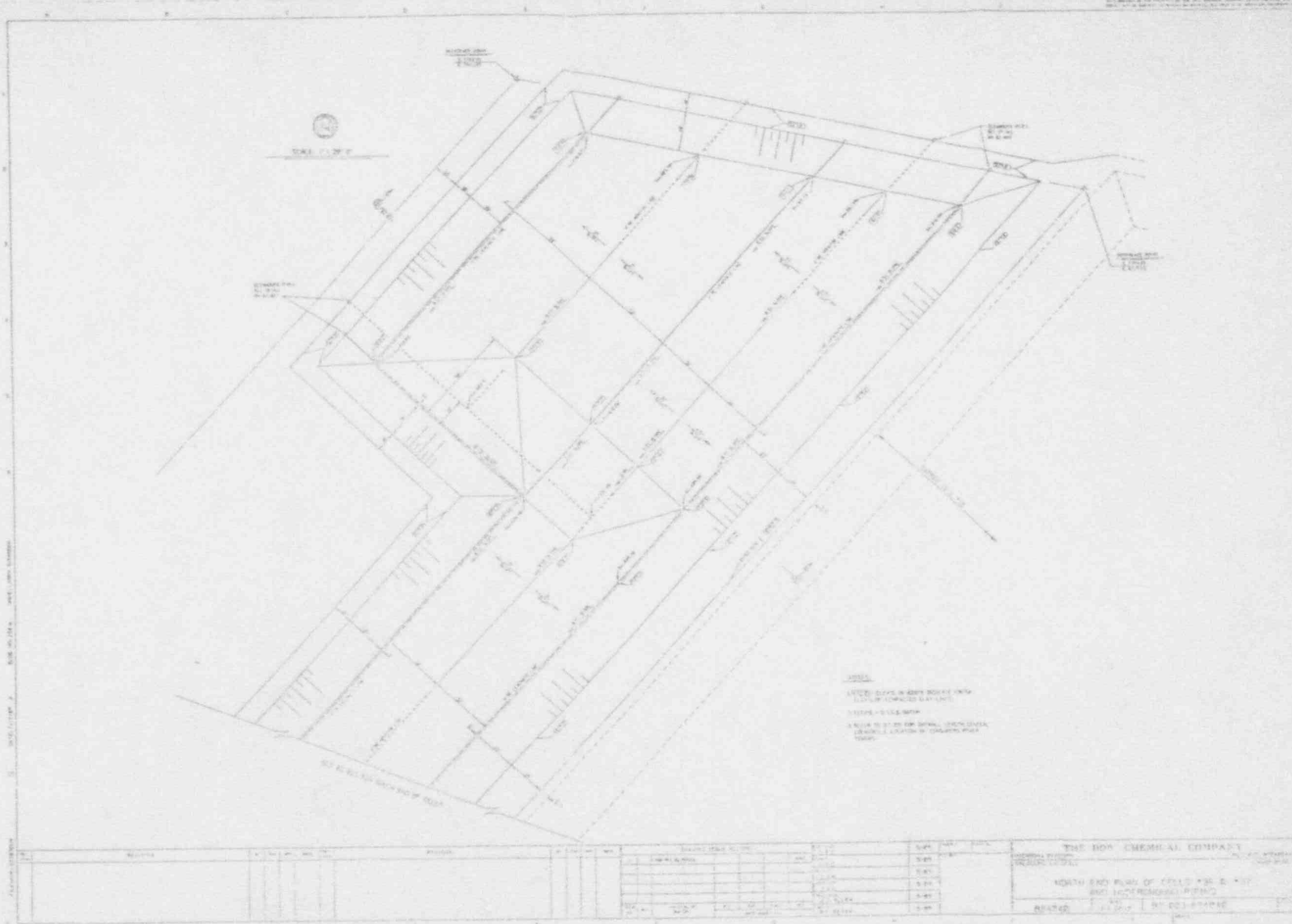
THE DOW CHEMICAL COMPANY

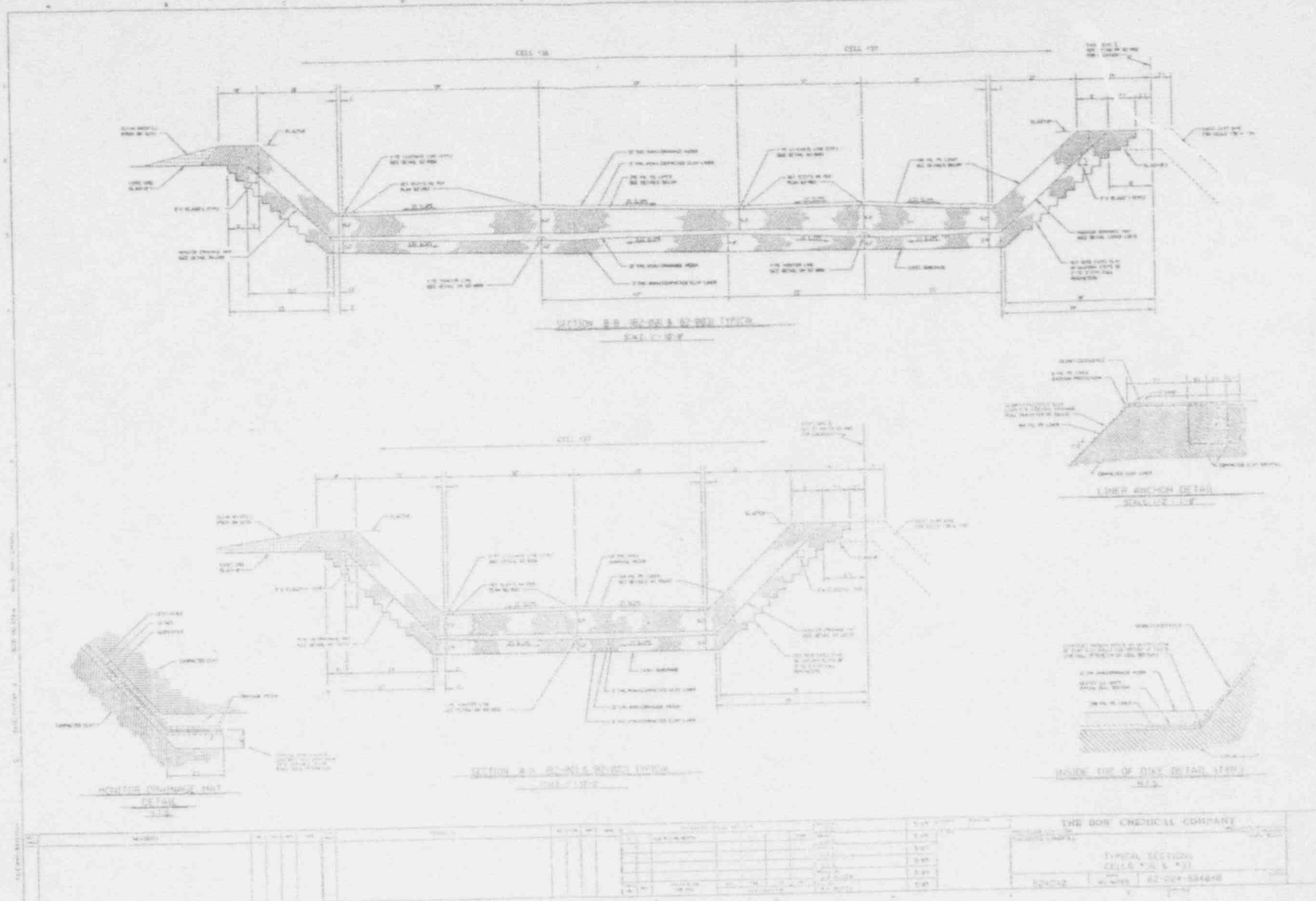
GENERAL PLAN

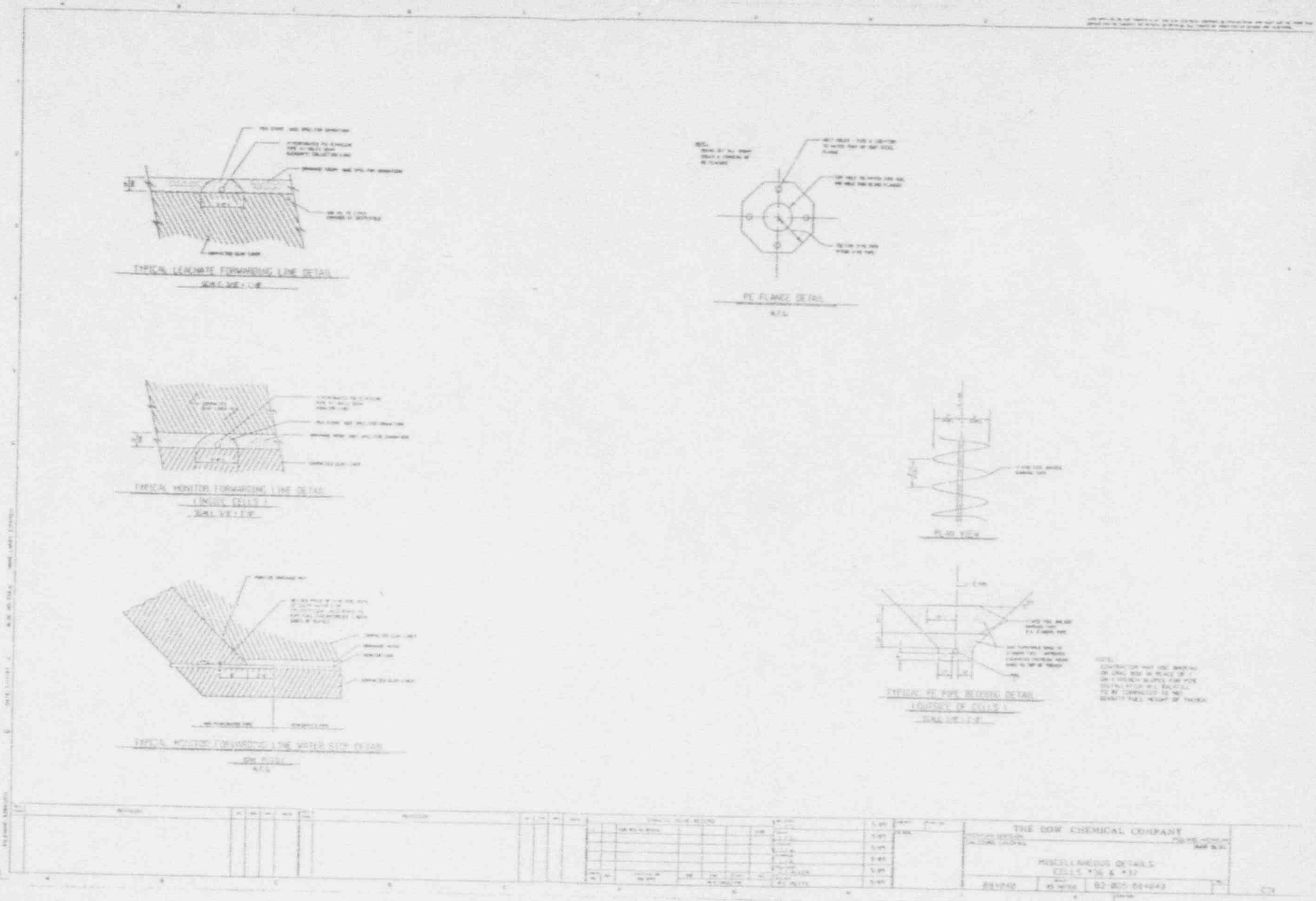
CELLS #36 & #37

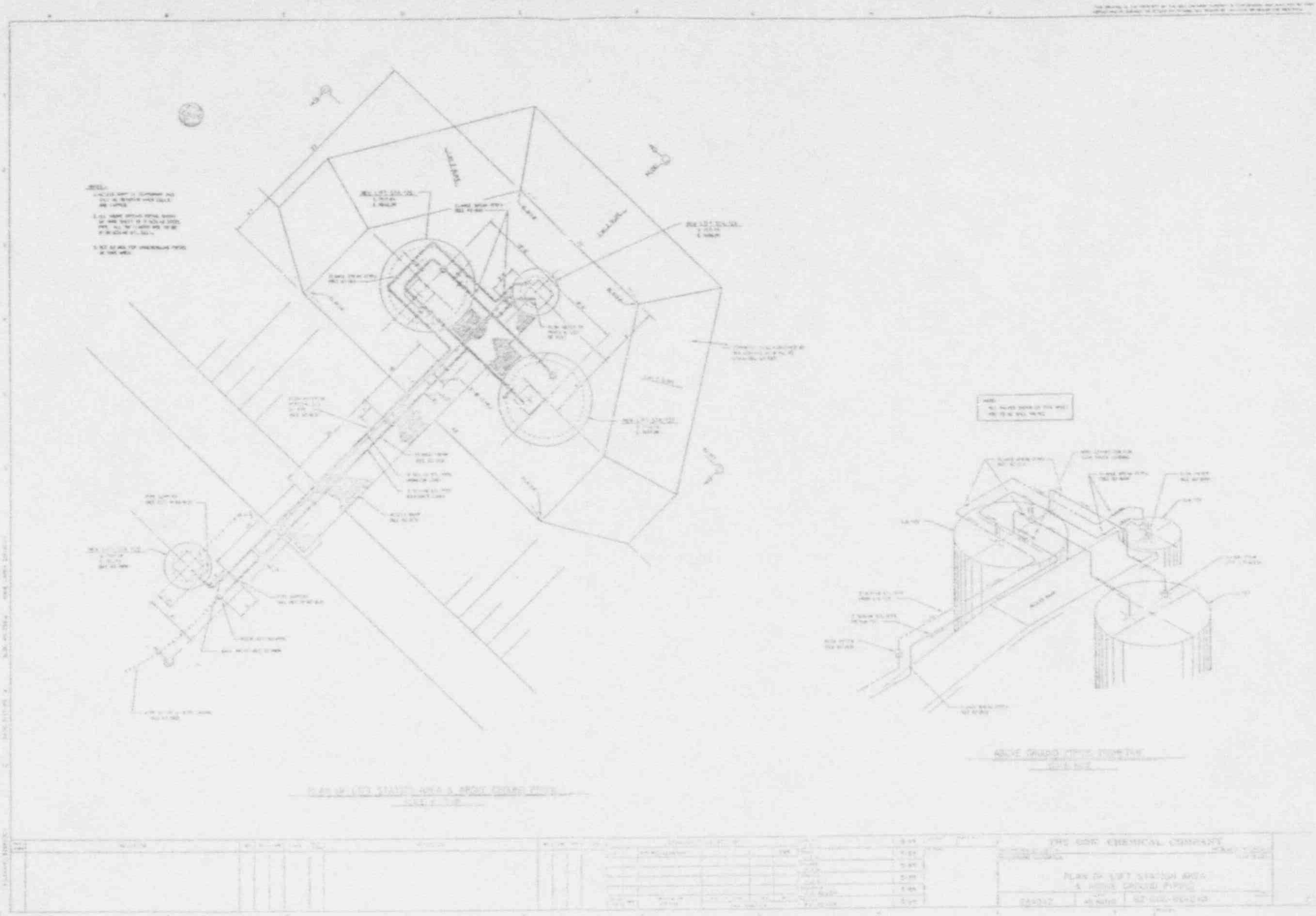
82-??-03:349?


THE DOW CHEMICAL COMPANY
SOUTH END PLAN OF CELL
AND UNDERGROUND PIPING

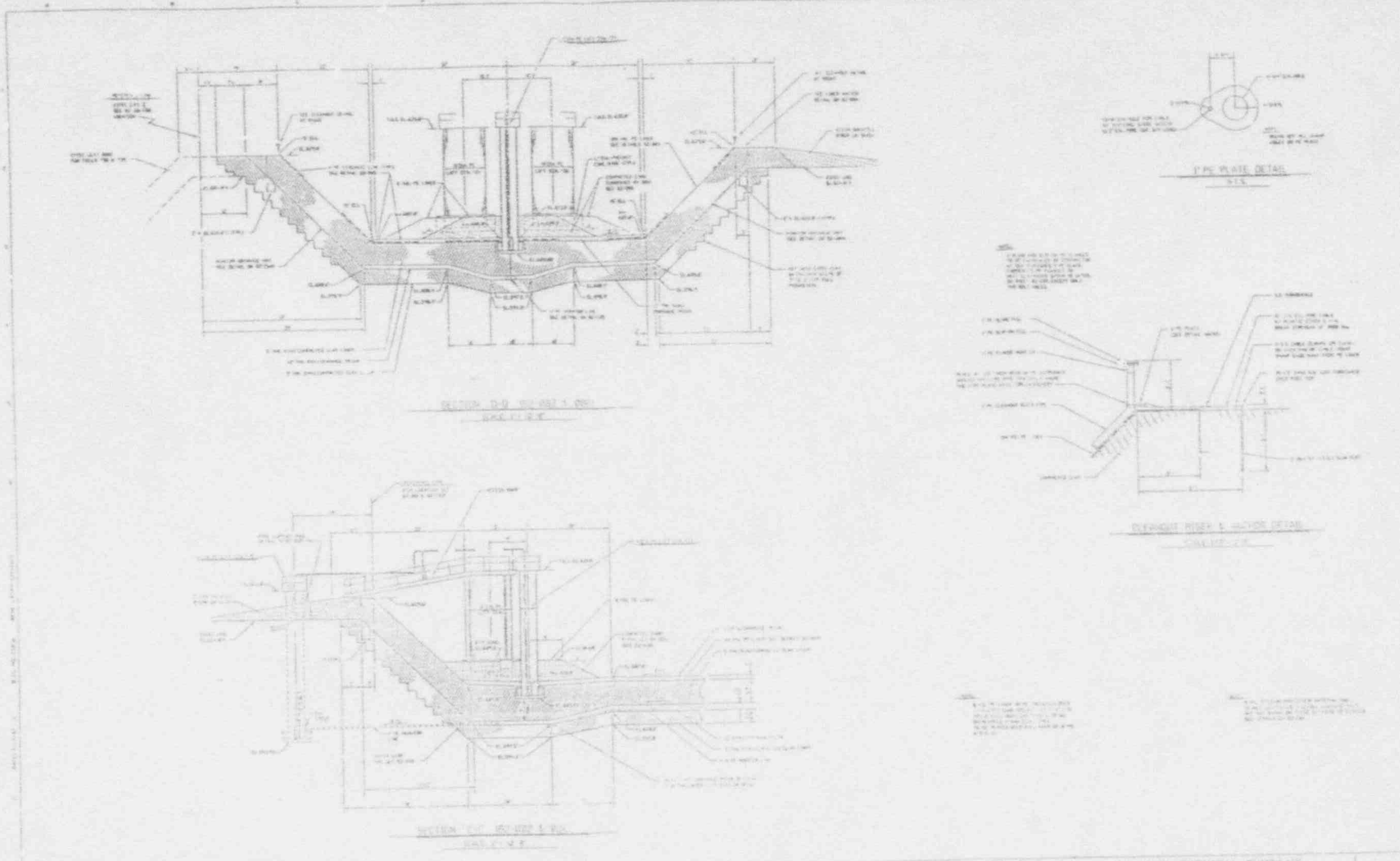

THE DOW CHEMICAL COMPANY
NORTH END PLAN OF CELLS
AND INDEPENDENT PIPING


CELL #36
CELL #37
SECTION B-B TYPICAL
LINER ANCHOR DETAIL
SECTION A-A TYPICAL
MONITOR DRAINAGE MAT DETAIL
INSIDE TOE OF DIKE DETAIL (TYP.)
N.T.S.
THE DOW CHEMICAL COMPANY
TYPICAL SECTIONS
CELLS #36 & #37


TYPICAL LEACHATE FORWARDING LINE DETAIL
PE FLANGE DETAIL
N.T.S.
TYPICAL MONITOR FORWARDING LINE DETAIL
(INSIDE CELLS)
PLAN VIEW
TYPICAL PE PIPE BEDDING DETAIL
(OUTSIDE OF CELLS)
TYPICAL MONITOR FORWARDING LINE WATER STOP DETAIL
N.T.S.
THE DOW CHEMICAL COMPANY
MISCELLANEOUS DETAILS
CELLS #36 & #37

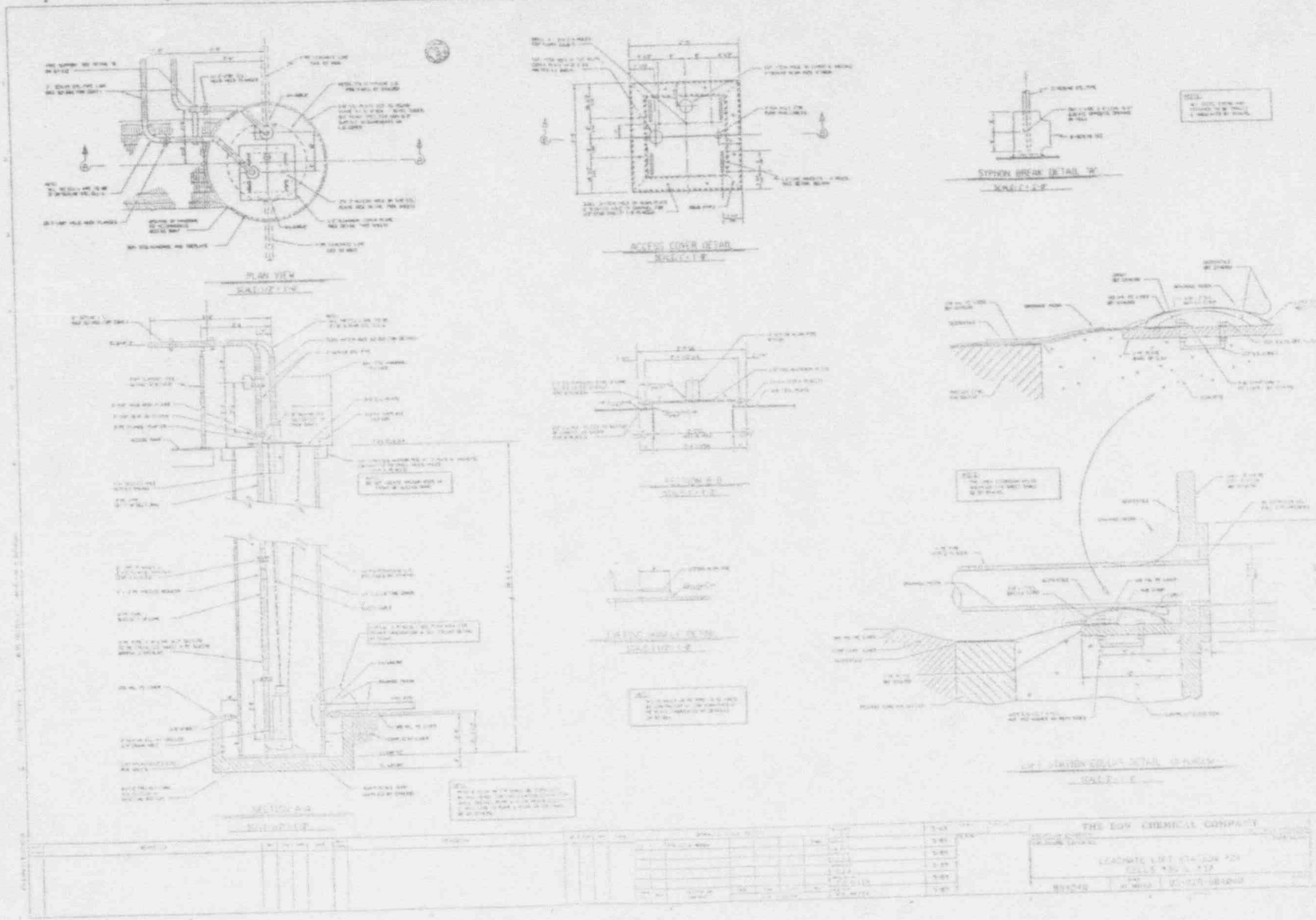


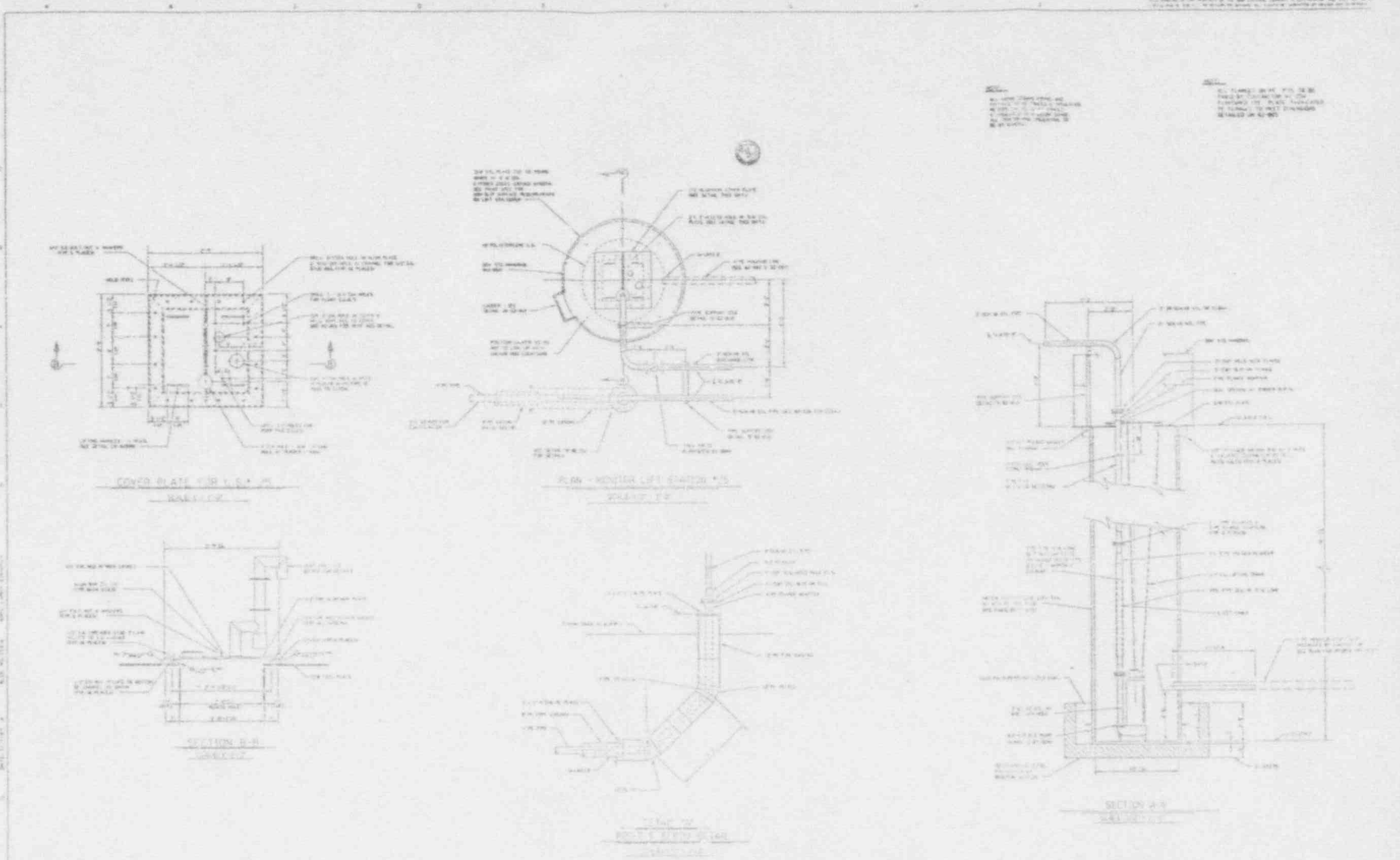
PLAN OF LIFT STATION AREA & ABOVE GROUND PIPING
ABOVE GROUND PIPING ISOMETRIC
THE DOW CHEMICAL COMPANY
PLAN OF LIFT STATION AREA
& ABOVE GROUND PIPING



THE DOW CHEMICAL COMPANY

SECTIONS AT SOUTH END

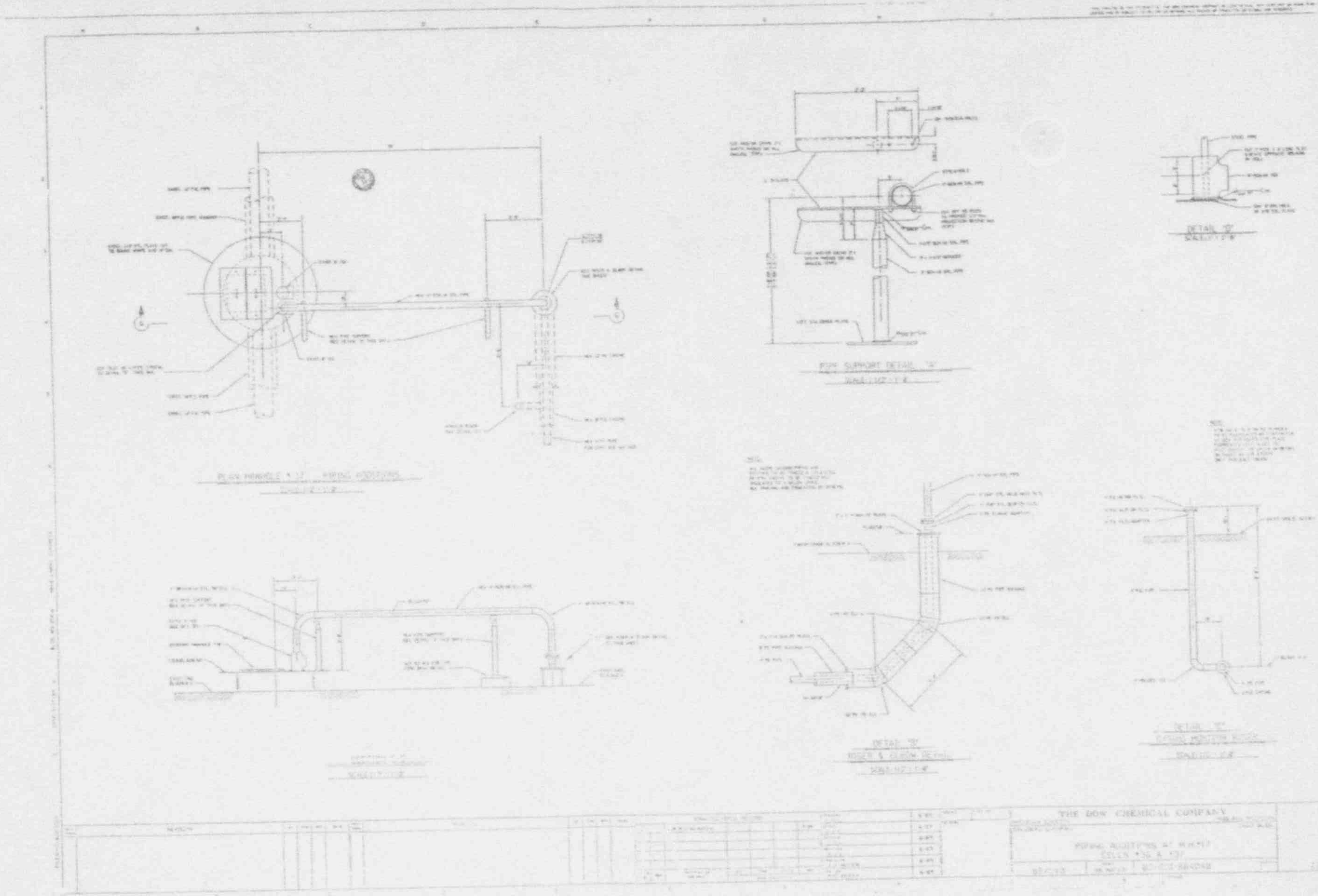

PLAN VIEW
ACCESS COVER DETAIL
SYPHON BREAK DETAIL 'W'
SECTION A-A
SECTION B-B
THE DOW CHEMICAL COMPANY

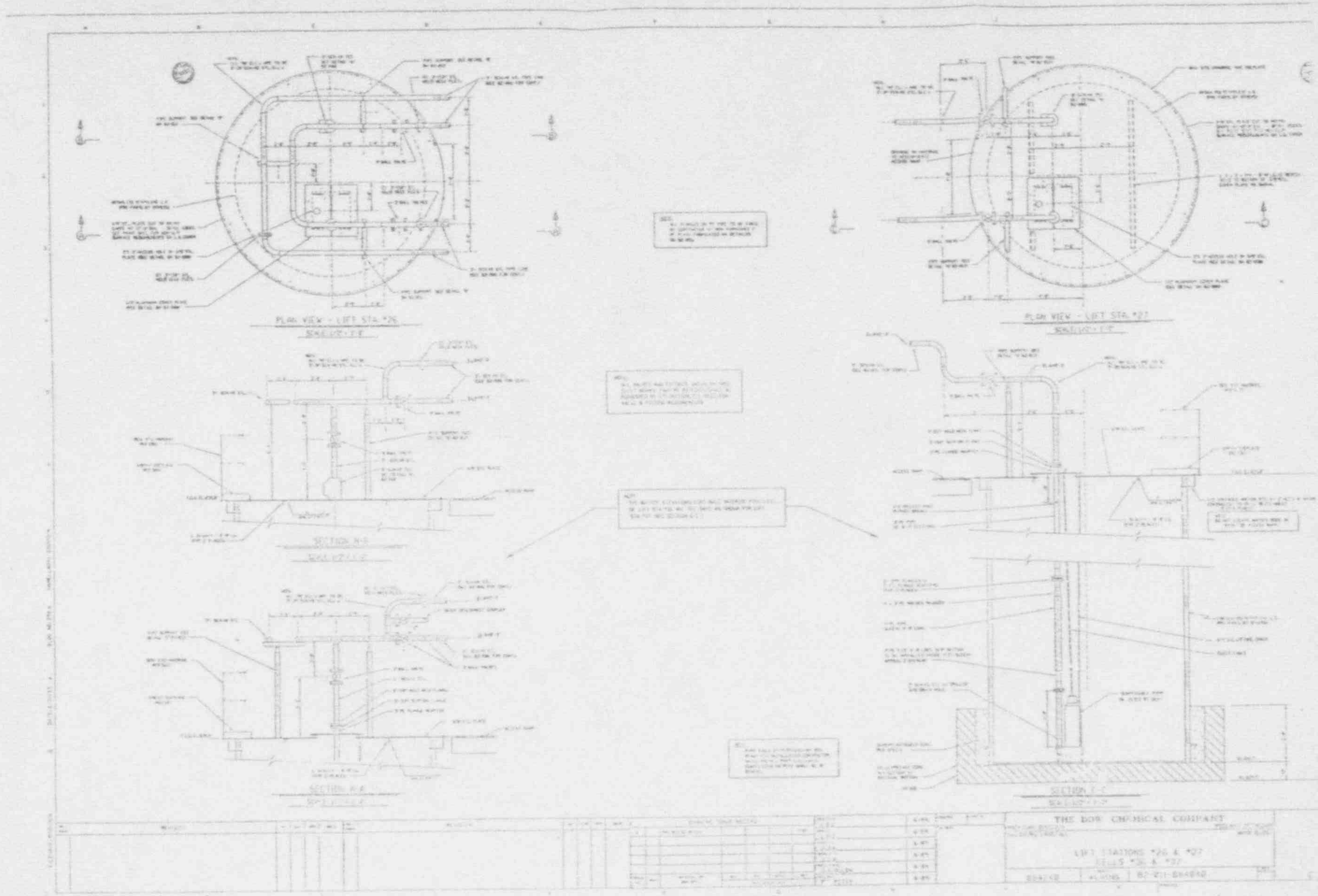


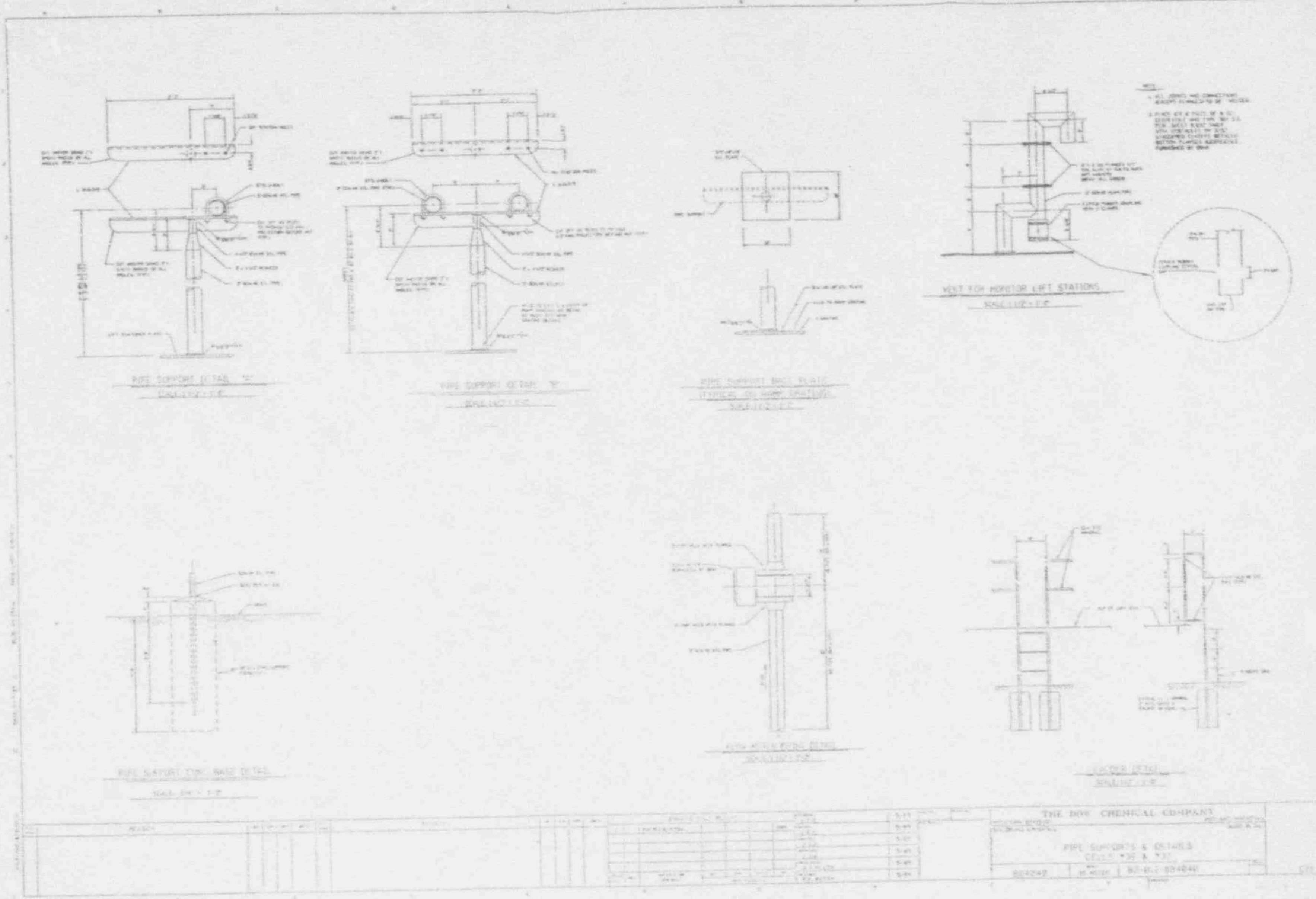
THE DOW CHEMICAL COMPANY

MONITOR LIFT STATION #25
CELLS #36 & #37

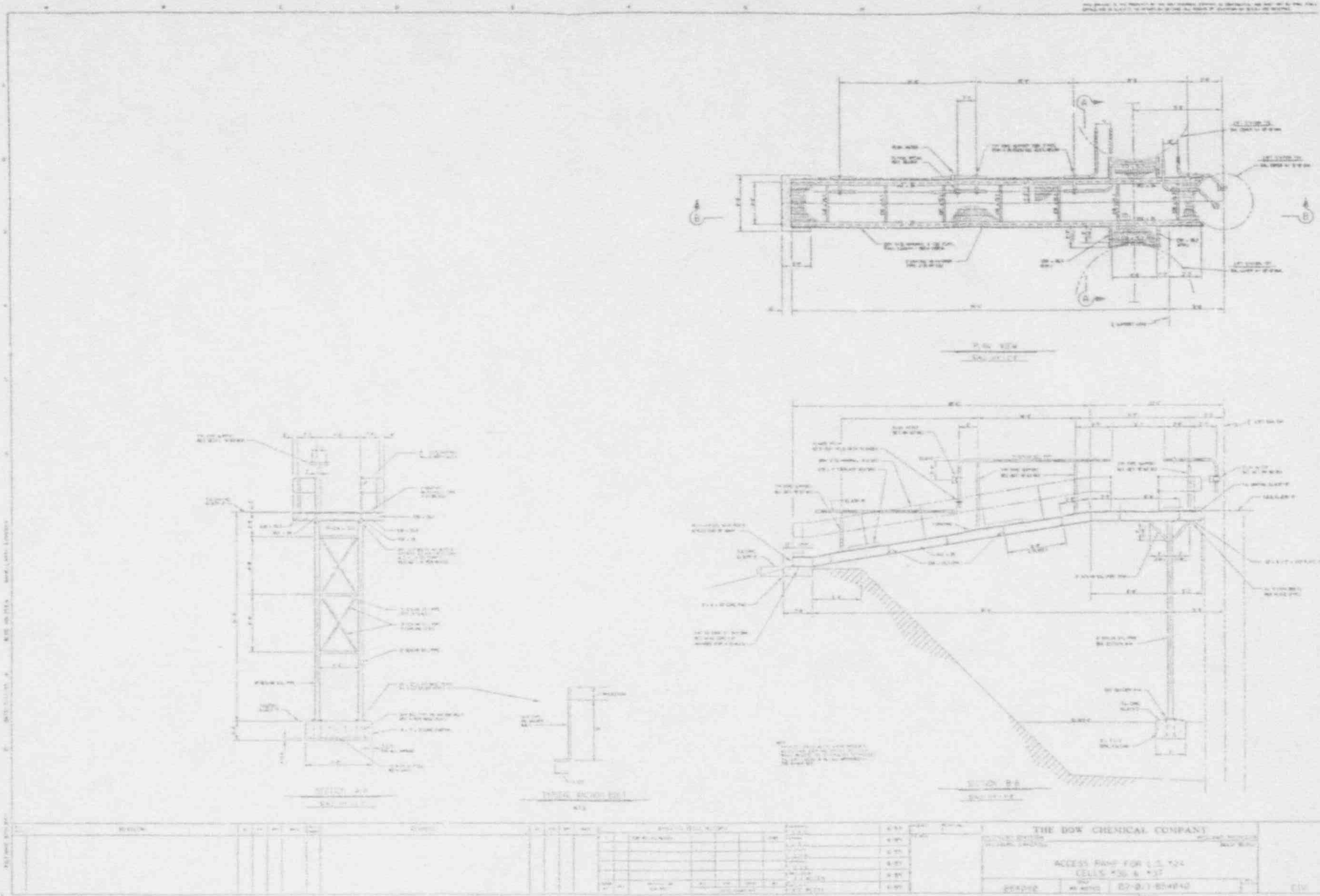
[illegible]

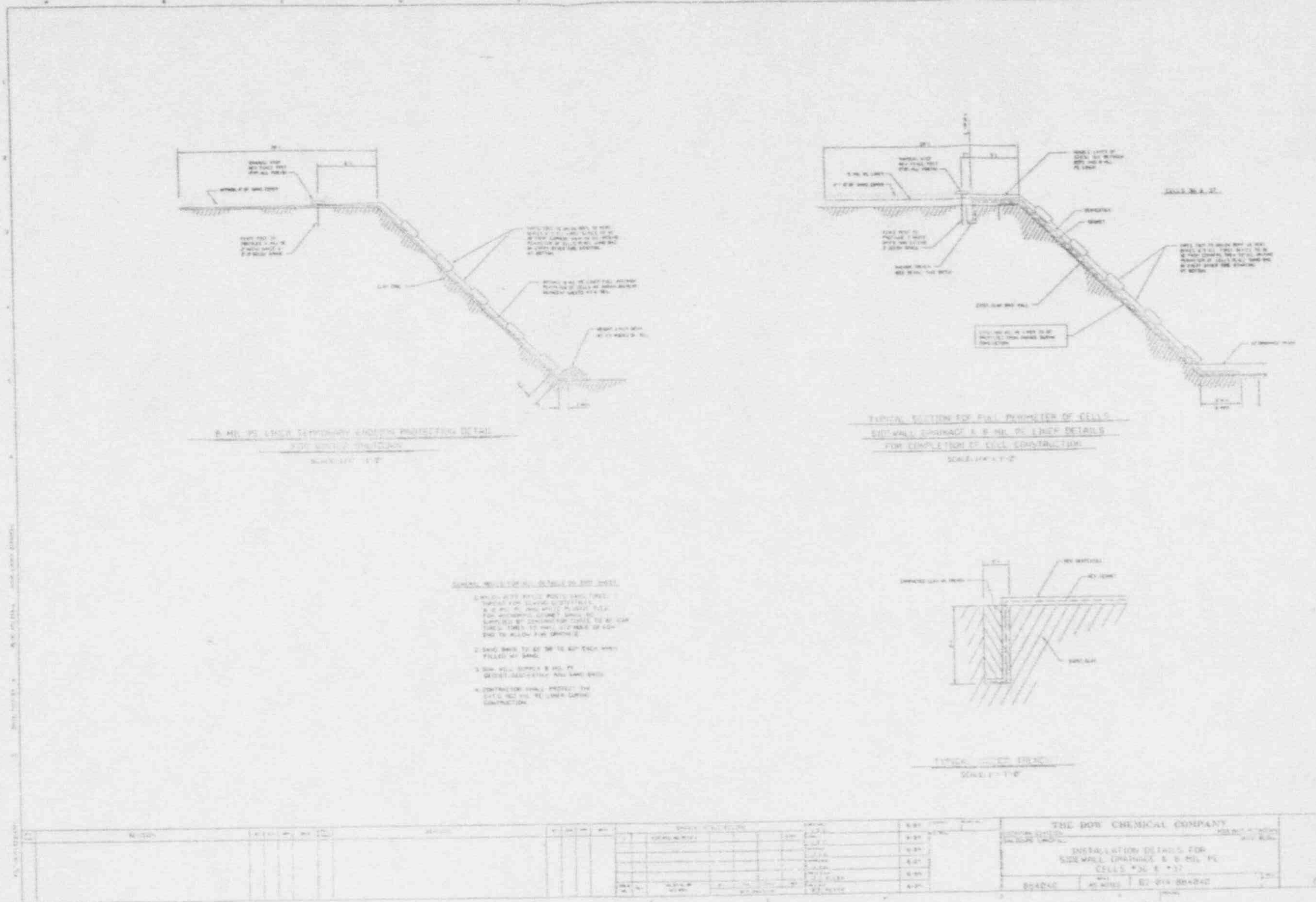

PLAN MANHOLE #17 PIPING ADDITIONS
PIPE SUPPORT DETAIL "A"
DETAIL "D"
DETAIL "B"
RISER & ELBOW DETAIL
DETAIL "C"
THE DOW CHEMICAL COMPANY


PLAN VIEW - LIFT STA. #26
PLAN VIEW - LIFT STA. #27
SECTION A-A
SECTION B-B
SECTION C-C
THE DOW CHEMICAL COMPANY
LIFT STATIONS #26 & #27

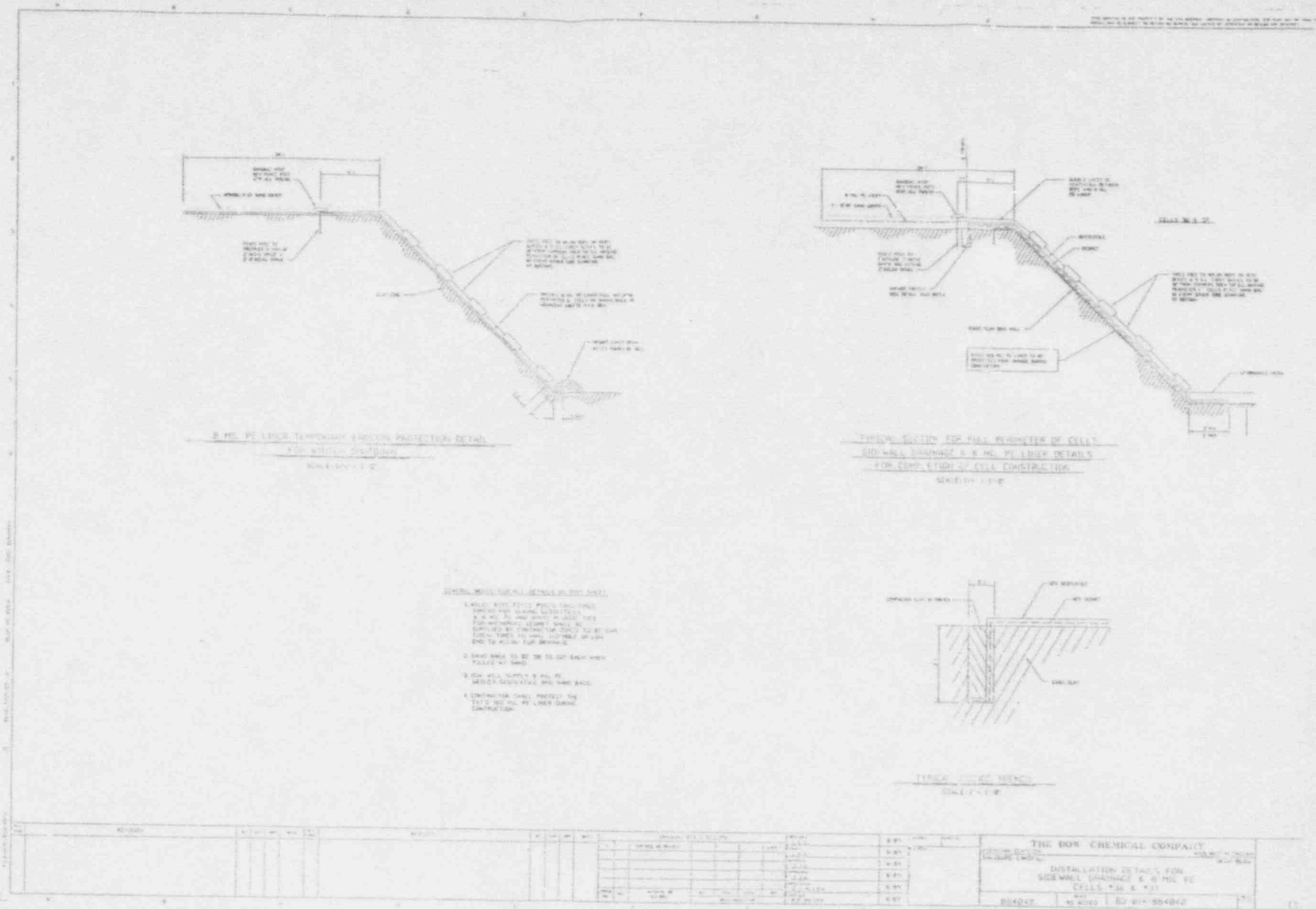


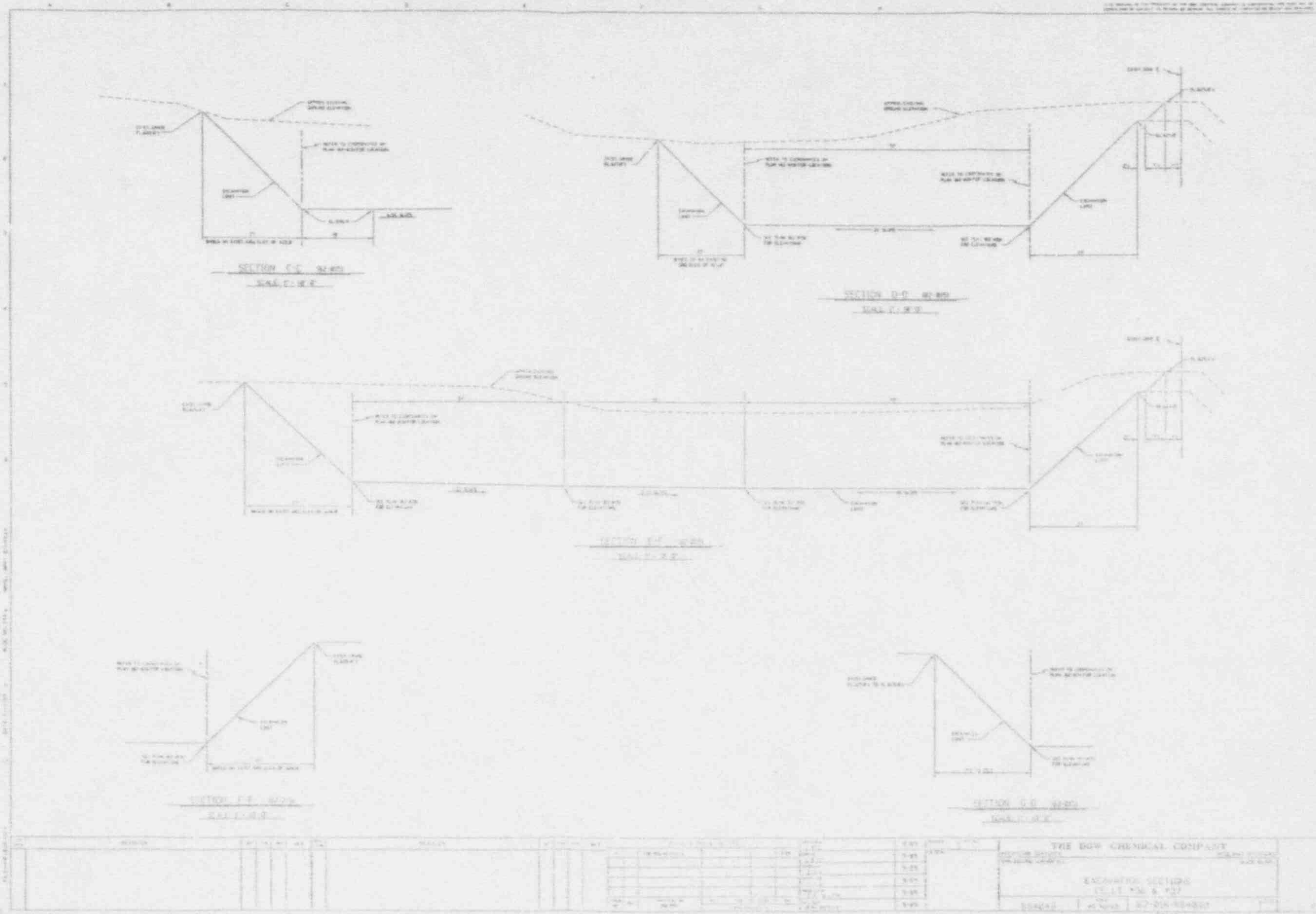
VENT FOR MONITOR LIFT STATIONS
PIPE SUPPORT CONC. BASE DETAIL
LADDER DETAIL
THE DOW CHEMICAL COMPANY
PIPE SUPPORTS & DETAILS

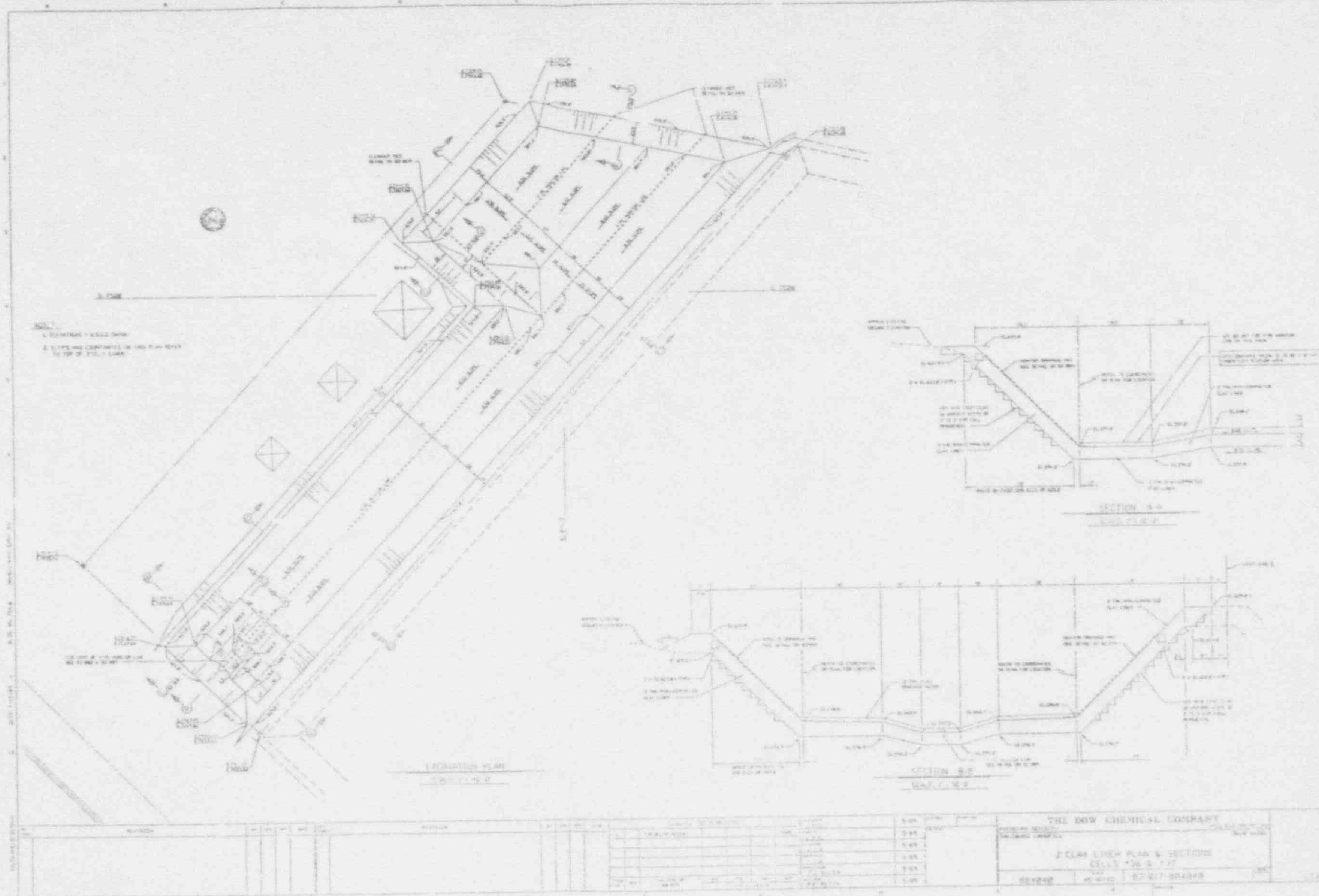

PLAN VIEW
SECTION B-B
THE DOW CHEMICAL COMPANY

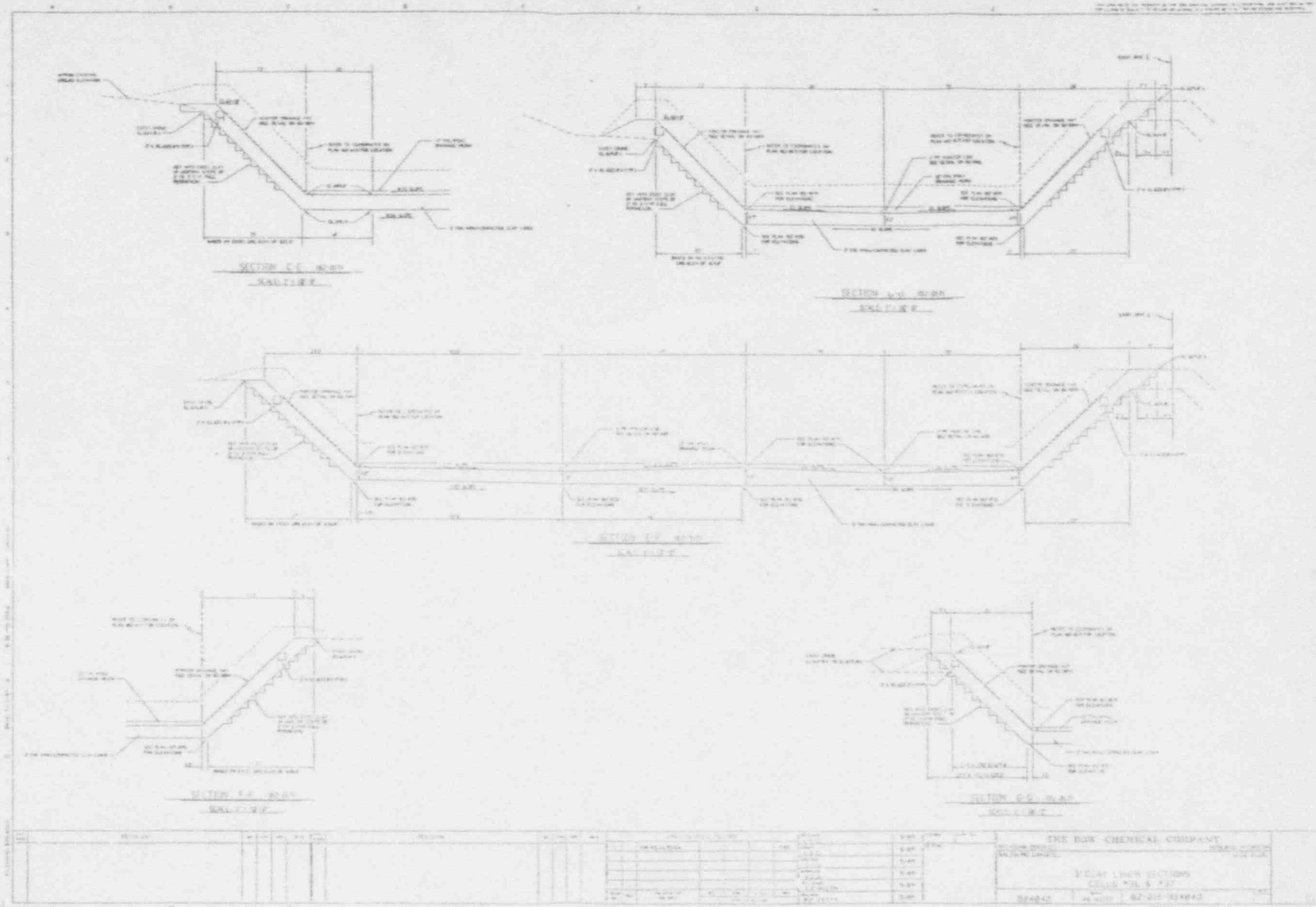


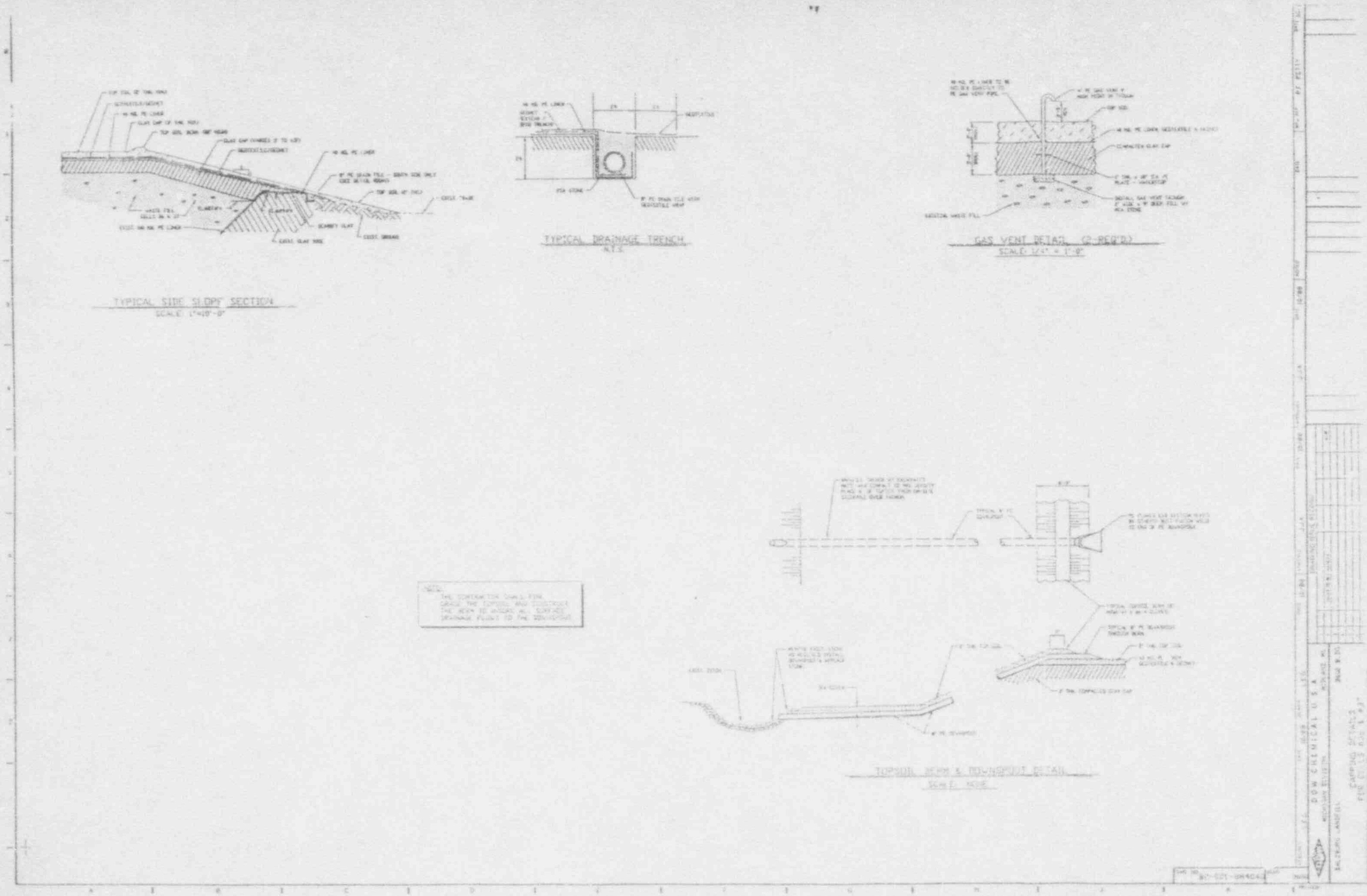
TYPICAL SECTION FOR FULL PERIMETER OF CELLS
SIDEWALL DRAINAGE & 8 MIL PE LINER DETAILS
FOR COMPLETION OF CELL CONSTRUCTION
TYPICAL LINER DETAIL
THE DOW CHEMICAL COMPANY
INSTALLATION DETAILS FOR
SIDEWALL DRAINAGE & 8 MIL PE
CELLS #36 & #37

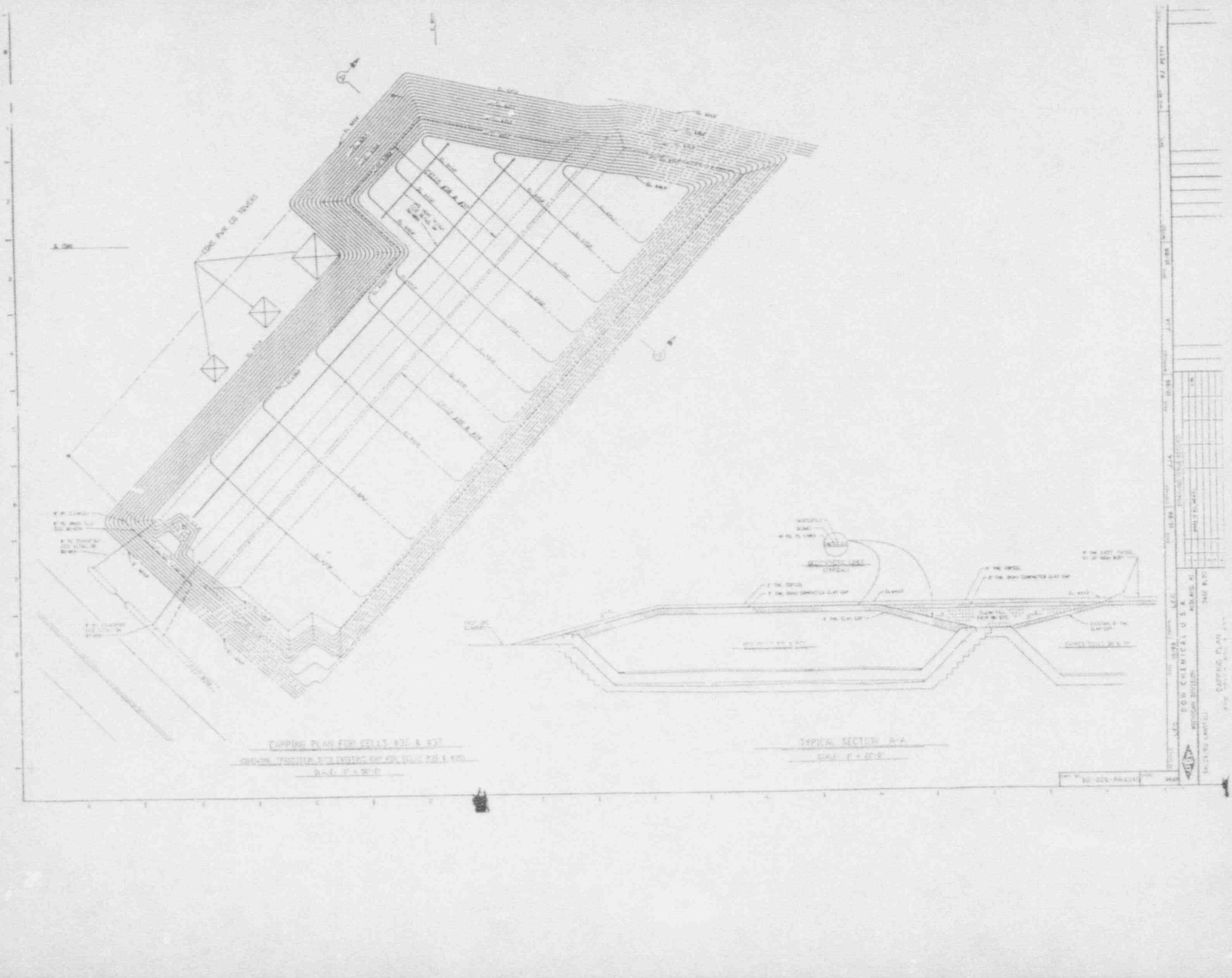

8 MIL PE LINER TEMPORARY EROSION PROTECTION DETAIL
TYPICAL SECTION FOR FULL PERIMETER OF CELLS
SIDEWALL DRAINAGE & 8 MIL PE LINER DETAILS
FOR COMPLETION OF CELL CONSTRUCTION
TYPICAL OUTLET TRENCH
THE DOW CHEMICAL COMPANY
INSTALLATION DETAILS FOR
SIDEWALL DRAINAGE & 8 MIL PE
CELLS *36 & *37


SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
THE DOW CHEMICAL COMPANY
EXCAVATION SECTIONS

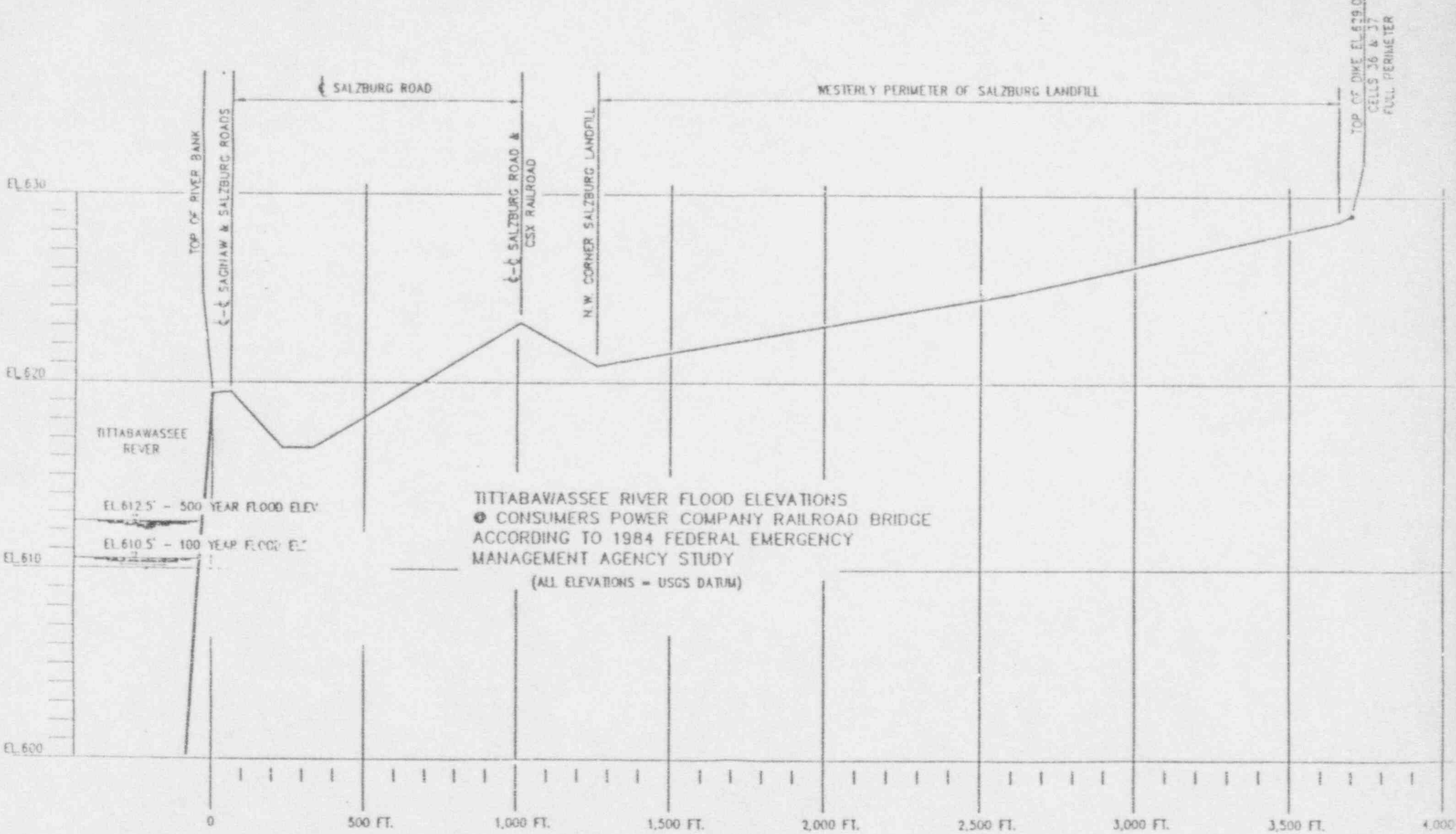

THE DOW CHEMICAL COMPANY
J CLAY LINER PLAN & SECTIONS
EXCAVATION PLAN
SECTION A-A
SECTION B-B


THE DOW CHEMICAL COMPANY
3' CLAY LINER SECTIONS


TYPICAL SIDE SLOPE SECTION
SCALE: 1"=10'-0"
TYPICAL DRAINAGE TRENCH
N.T.S.
GAS VENT DETAIL (2-REQ'D)
NOTE:
THE CONTRACTOR SHALL FINE GRADE THE TOPSOIL AND CONSTRUCT THE BERM TO INSURE ALL SURFACE DRAINAGE FLOWS TO THE DOWNSPOUT
TOPSOIL BERM & DOWNSPOUT DETAIL
SCALE: NONE
DOW CHEMICAL U.S.A.
MICHIGAN DIVISION
SALZBURG LANDFILL
CAPPING DETAILS


TYPICAL SECTION A-A
DOW CHEMICAL U S A
MICHIGAN DIVISION
CAPPING PLAN

APPENDIX H
TITTABAWASSEE RIVER FLOOD ELEVATIONS



CELLS 36 & 37 DIKE ELEVATION
vs.
TITTABAWASSEE RIVER FLOOD ELEVATIONS

Appendix I

Calculations of Radiological Impacts From The Removal, Handling, Transport, and Disposal of Thoriated Material

1.1.0 GAMMA DOSE

The average gamma dose above the thoriated material is taken as:

A) 1.98 mR/hr for the Bay city pile (based on 59 readings taken 1 meter above the surface of the pile in 8/87 by Dow).

B) 0.068 mR/hr for the Midland pile (based on 102 readings taken at a height of 1 meter above the pile in 6/87 by Dow).

1.1.1 Occupational Gamma Dose

The gamma dose (D) to workers performing the material removal, on site handling and loading, transport and disposal of the thoriated material at Salzburg is determined from:

A) $D = 1.98 \frac{\text{mrem}}{\text{hr}} \times \frac{\text{labor-hours}}{\text{activity}}$ at Bay City

B) $D = 0.068 \frac{\text{mrem}}{\text{hr}} \times \frac{\text{labor-hours}}{\text{activity}}$ at Midland

The total and individual maximum exposure of workers for the steps in the material removal through disposal procedure are provided in Table 1.0. For the step of transporting the material from the Bay City and Midland sites to Salzburg, an external gamma dose rate of 1.98 mrem/hr for the Bay City material and 0.068 mrem/hr for the Midland material is used at 1 meter from the exterior of the truck and in the vehicle cab (no reduction in dose is taken for the effect of distance or shielding from the truck body). It is also assumed that the trucks are driven at an average speed of 40 miles per hour by one driver per truck, with 4 drivers being employed at Bay City and 2 drivers being employed at Midland.

The trucks moving the material the 20 miles distance from Bay City to Salzburg would make 4 round trips during a workday (0.5 hrs. to load the truck & 1.0 hr. round trip & 0.5 hrs to unload and decontaminate the truck) during which time the driver would be either in the cab or standing 1 meter from the truck. Using a 20 yd^3 truck to transport the 40,000 yd^3 of material requires 2000 trips at a total exposure (DT) of:

$$DT = \frac{2000 \text{ trips}}{4 \text{ trips/day}} \times \frac{8 \text{ hrs}}{\text{day}} \times 1.98 \frac{\text{mrem}}{\text{hr}} = 7920 \text{ mrem}$$

Each of the 4 drivers would receive a dose of 1980 mrem for the duration of the transport period.

Similarly, for the Midland material, where the distance to Salzburg is 2 miles, 5 round trips a day could be made by each truck, with 600 trips required to transport the 12,000 yd^3 of material. The total exposure of the drivers would be:

$$DT = \frac{600 \text{ trips}}{5 \text{ trips/day}} \times \frac{8 \text{ hrs}}{\text{day}} \times 0.068 \frac{\text{mrem}}{\text{hr}} = 65.3 \text{ mrem}$$

Each of the 2 drivers would receive a dose of 32.7 mrem for the duration of the transport period.

1.1.2 Offsite non-occupational Gamma Dose

This is the predicted gamma dose to an individual residing just outside of the Dow property boundary. The following assumptions are made:

- The resident spends 100 percent of the day on their property; 75 percent inside the home and 25 percent outside.

- The gamma exposure rate inside the home is one-half of that outside the home.

- The gamma exposure rate decreases as a function of $1/r^2$, where r is the distance from the material piles to the site fence; r is 0.5 mile (2640 ft) at Bay City and 0.3 mile (1580 ft) at Midland.

- The dose rates above the piles of 1.98 mrem/hr and 0.068 mrem/hr at Bay City and Midland respectively are at a height of 3 feet.

The dose rate at the site boundary during the excavation, movement and staging of the material is:

$$\frac{(3\ ft)^2}{(2640\ ft)^2} \times 1.98\ \frac{mrem}{hr} = 2.56 \times 10^{-6}\ \frac{mrem}{hr}\ \text{(Bay City)}$$

$$\frac{(3\ ft)^2}{(1580\ ft)^2} \times 0.068\ \frac{mrem}{hr} = 2.45 \times 10^{-7}\ \frac{mrem}{hr}\ \text{(Midland)}$$

The indoor dose (DI) is =

$$Di = 18\ \frac{hr}{day} \times 145\ \frac{days}{activity} \times 2.56 \times 10^{-6}\ \frac{mrem}{hr} \times 0.5 = 0.003\ \text{mrem at Bay City}$$

and correspondingly 0.0001 mrem at Midland.

The outdoor dose (Do) is:

$$Do = 6\ \frac{hr}{day} \times 145\ \frac{days}{activity} \times 2.56 \times 10^{-6}\ \frac{mrem}{hr} = 0.002\ \text{mrem at Bay City and}$$

correspondingly 0.0001 mrem at Midland

The total annual non-occupational dose to an individual residing outside the site boundary is the sum of the indoor an outdoor doses or 0.005 mrem at Bay City and 0.0002 mrem at Midland.

1.1.3 <u>On-Site Non-Occupational Gamma Dose</u>

This is the predicted gamma dose to an individual working in a building on-site. The following assumptions were made:

- The individual is on-site 8 hrs. a day, 5 days a week for the duration of the material removal process.
- The individual works in a building which provides shielding such that the interior exposure rate is one-half of the exterior rate.

- The building is located 2000 ft from the pile at Bay City and 600 ft from the pile at Midland.

Based on these assumptions and the same gamma exposure rates above the piles used in the prior calculation gives an annual gamma dose of 0.003 mrem at Bay City and 0.0004 mrem at Midland to a non-remediation Dow-employee.

1.1.4 Offsite non-occupational Gamma Dose During Material Transport

The non-occupational exposure resulting from transport of the material to Salzburg is assumed to consist of the doses to a portion of the population (onlookers) who are close to the transportation route for a limited period of time. The exposure rate to the onlookers during normal transport conditions is calculated using the following equation:

$D(d) = \frac{2K}{V} I(d)$ where D(d) = total integrated dose at distance d (mrem)

and $I(d) = \int_{d}^{\infty} \frac{\exp(-ur)B(r)dr}{r\,(r^2 - d^2)^{1/2}}$

K = dose rate factor (mrem-ft2) hr

V = Shipment speed (ft/hr)

d = perpendicular distance of an individual from shipment path (ft)

U = linear adsorption coefficient for air = 0.00118 ft^{-1}

B(r) = dimensionless Berger factor = 1 + .0006r

The dose rate (k) calculated as 39.6 and 1.36 $\frac{mrem\text{-}ft^2}{hr}$

for Bay City and Midland materials respectively based on gamma exposure rates of 0.396 and 0.0136 mrem/hr at a distance of 10 meters from the material. The shielding effect of the truck sides is ignored.

The TRANSDOS computer code was then used to evaluate the individual exposures. The dose to an onlooker along the transport route was calculated to be 6.79 X 10^{-5}

mrem and 2.3 X 10^{-6} mrem for each shipment from Bay City and Midland respectively at a distance of 10 meters from the centerline of the shipment route.

1.2.0 AIR PARTICULATE DOSE

The dose from inhalation of particulates during earth moving operations is calculated as follows:

1. Average concentration of thorium in the soil is:

   CS = 188 pCi/g at Bay City (Table 3.1-1)
   CS = 29 pCi g at Midland (Table 3.1-1)

2. Airborne dust burden during earth moving activities = 425 μg/m^3
   (from draft EIS for UMTRA tailings pile in Grand Junction (DOE -86)

3. Specific Activity of dust
   Specific activity of contaminated soil = 2.4
   (from final GEIS (NRC 80)

4. Average air particulate concentration (Ca) is:
   Ca = Cs X 425 μg/m^3 X 2.4 X 10^{-6} g/ug which gives

   $$Ca = .192 \frac{pCi}{m^3} \text{ at Bay City and}$$

   $$Ca = 0.030 \frac{pCi}{m^3} \text{ at Midland}$$

1.2.1 Occupational Air Particulate Dose

The adult in inhalation dose conversion factors (DCFs) for occupational exposure for the thorium decay chain are:

DCF (mrem/year per pCi/m^3) (1)

Organ	Th-232	Ra-228	Th-228	Ra-224	Pb-212	Total (2)
Whole body	6	29	4	--	--	39
Average Lung	363	98	615	5	106	1,187
Bone	1,558	27	122	--	107	1,814

(1) Based on a 2,000 hour work year

(2) Total DCF assumes that the air concentrations of all the isotopes are equal.

The inhalation dose (D) to workers excavating handling, and emplacing the material is:
D = Ca X DCF X fraction of year activity performed (fr)

D = 0.192 $\frac{pCi}{m^3}$ X DCF X fr for Bay City material

D = 0.030 $\frac{pCi}{m^3}$ X DCF X fr for Midland material

The total and individual maximum whole body, lung, and bone exposures of workers in the steps in the material removal and emplacement procedures are provided in Table 2.0. The airborne source term is considered to be negligible during transportation of the material since controls will be imposed to prevent dispersion of the material from the truck. The source term is also considered to be negligible during decontamination of the truck due to the small volume of contaminated material in the truck and the use of water.

1.2.2 Offsite Non-occupational Air Particulate Dose

The predicted dose to a resident of a house located outside of the Dow property line at a distance of 0.5 and 0.3 miles from the thorium contaminated area at Bay City and Midland respectively is based on the following:

- Earth moving activities occur 8 hours a day, 5 days per week. dust is assumed to be in the air less than 10 hours per day.

- The resident is assumed to stand at the property boundary 8 hours per day for the duration of the soil excavation.

- The airborne dust burden at the property boundary is assumed to be less than 5 percent of the dust burden in the breathing zone of the onsite workers (based on data from UMTRA vicinity Properties program in Grand Junction). The dust burden at the property boundary, conservatively taken as 3 percent because of the substantial distances at Bay City and Midland, is 5.8 X 10^{-3} $\frac{\text{pCi}}{\text{m}^3}$ and 0.9 X 10^{-3} $\frac{\text{pCi}}{\text{m}^3}$ at Bay City and Midland respectively.

The inhalation total 50 year committed dose conversion factors (DCF) for non-occupational exposure are:

Organ	Total DCF (mrem/yr per pCi/m^3)
Effective Whole Body (WB)	117
Average Lung (L)	3,561
Bone Marrow (BM)	5,442

The inhalation dose (D) is:

D = Ca X DCF x fraction of year activity performed (fr)

D = 5.8 x 10^{-3} pCi/m^3 x DCF x fr for Bay City material

D = 0.9 x 10^{-3} pCi/m^3 x DCF x fr for Midland material

which gives for nearest resident at Bay City

Whole body dose - 0.4 mrem

Average lung dose - 12.4 mrem

Bone Marrow dose - 19.0 mrem

and for the nearest resident at Midland

Whole body dose - 0.03 mrem

Average lung dose - 0.9 mrem

Bone Marrow dose - 1.3 mrem

The air particulate dose to a person working onsite in a building at a distance from the material will be negligible.

1.3.0 Thoron (Radon-220) Dose to the Lung

The dose from inhalation of thoron gas was estimated using the following approach:

1) Average Ra-228 concentration in soil is assumed to be in equilibrium with the Th-232 and Th-228 concentrations at 188 pCi/g for Bay City material and 29 pCi/g for Midland material.

2) Specific flux of 1 $\frac{\text{pCi-Rn-220}}{m^2\ \text{sec}}$ per $\frac{\text{pCi-Ra-228}}{g}$ was used (from Final Generic EIS (NRC-80)

3) All the thorium-contaminated area is assumed to be exposed at the same time.

4) $\frac{\text{Radon concentration}}{\text{Radon flux}} = \frac{0.03\ \text{pCi/l}}{\text{pCi}/m^2\text{-Sec}}$ (from Grand Junction Project, (DOE-1987)

5) Average thoron concentration (CRN) above thorium-contaminated areas onsite is $CRN = 188\ \text{pCi} \times \frac{1\text{pCi}/m^2\text{-sec}}{\text{pCi/gm}} \times \frac{0.03\ \text{pCi/l}}{\text{pCi}/m^2\cdot\text{Sec}} = 5.64$ pCi/l at Bay City and correspondingly
CRN = 0.87 pCi/l at Midland

It should be noted that this calculated value of CRN is extremely conservative since it is based on parameters derived for Rn-222 in the absence of measured values of thoron concentration or flux. Thoron (Rn-220) concentrations will be considerably less than those calculated based on Rn-222 parameters because of its considerably shorter half life (54 sec vs 3.8 days). As Eisenbud states (EI-1973) "The concentration of radon is reported--to be 50 to 100 times greater than that of thoron---" and "the dose to the lung from thoron and its daughters does not add significantly to the dose received from the radon 222".

1.3.1 Occupational Thoron Dose

The thoron dose to the lung (DRN) from the Bay City material is:

$$DRN = \frac{5.64\ pCi/l \times 0.06/100 \times 0.7\ rad/WLM \times 20 \times man\text{-}hours/activity}{170\ Hrs/WLM \times 10^{-3}\ rem/mrem}$$

Where:

06/100 = daughter equilibrium factor

20 = quality factor to translate from rad to rem for alphas

Thus DRN = 0.278 mrem/hr x man hours/activity for Bay City material and DRN = 0.047 mrem/hr x man hours/activity for Midland material.

The lung dose to workers for the steps in the removal of the material from Bay City and Midland and disposal at Salzburg are provided in Table 3.0.

1.3.2 Offsite Non-Occupational Thoron Dose

The predicted thoron dose rate (D.R.) to a resident just outside the site boundary, at distances of 2640 ft and 1580 ft from the material piles at Bay City and Midland respectively, is:

$$DR = \frac{3\ ft}{2640\ ft} \times 0.278\ \frac{mrem}{hr} = 3.2 \times 10^{-4}\ \frac{mrem}{hr} \text{ at Bay City}$$

$$D.R. = \frac{3\ ft}{1580} \times 0.047\ \frac{mrem}{hr} = 8.9 \times 10^{-5}\ \frac{mrem}{hr} \text{ at Midland}$$

assuming the thoron concentration to vary as a function of 1/r from the source. The assumptions as to resident exposure times and locations are similar to those as in section 1.1.2.

The indoor dose (Di) is =:

$$Di = 18\ \frac{hr}{day} \times 145\ \frac{days}{activity} \times 3.2 \times 10^{-4}\ \frac{mrem}{hr} \times 0.5 = 0.42 \text{ mrem at Bay City and}$$

correspondingly 0.12 mrem at Midland and the outdoor dose (Do) is:

$$Do = 6\,\frac{hr}{day} \times 145\,\frac{days}{activity} \times 3.2 \times 10^{-4}\,\frac{mrem}{hr} = 0.28$$

at Bay City and correspondly 0.08 mrem at Midland

The total thoron dose to the lungs of the closest resident is 0.70 $\frac{mrem}{activity}$ at Bay City for the material excavation and the removal period and 0.20 $\frac{mrem}{activity}$ for the comparable period at Midland.

1.3.3 On-Site Non-Occupational Thoron Dose

The predicted thoron dose to the lung for an individual working in a building on-site not involved in remedial activities is based on the same assumptions as used in section 1.1.3. Using the thoron dose rates above the piles gives a dose at the buildings of:

$$\frac{3\ ft}{2000\ ft} \times 0.278\,\frac{mrem}{hr} \times 8\,\frac{hrs}{day} \times 145\ days \times 0.5 = 0.24\ mrem$$

at Bay City and

$$\frac{3\ ft}{600\ ft} \times 0.047\,\frac{mrem}{hr} \times 8\,\frac{hrs}{day} \times 64\ days \times 0.5 = 0.06\ mrem$$

at Midland.

TABLE I 1.0

Occupational Gamma Doses

Activity	Total Exposure Time (Hrs)		Total Dose (mrem/Activity)		Maximally Exposed Individual (mrem)	
	Bay City	Midland	Bay City	Midland	Bay City	Midland
(1) Excavation of material from thorium-contaminated region and movement to staging area	1000(a)	300(a)	1980	20.4	198 (b)	2(b)
(2) Transport of material to Salzburg (c)	4000	960	7920	65.3	1980	32.7
(3) Emplacement of material and cover at Salzburg	1000	300	1980	20.4	990	10.2
(4) Health Physics and monitoring support						
a) at Source	200	60	396	4.1	198	2.1
b) at Salzburg	1000	300	1980	20.4	990	10.2

(a) Based on operator using a scraper/bulldozer combination.

(b) Based on using 10 persons (1 foreman, 5 laborers, and 4 operators) to perform excavation in 100 hr. period at Bay City and 30 hr period at Midland.

(c) Based on using 6 persons (1 foreman, 3 laborers, 2 operators) to perform emplacement of material and cover, and 1 person to perform vehicle decontamination at Salzburg.

(d) Based on 2 HPs onsite at Bay City full time, Midland and Salzburg performing soil measurements and personal and area monitoring.

TABLE I 1.0

Occupational Gamma Doses

Activity	Total Exposure Time (Hrs)		Total Dose (mrem/Activity)		Maximally Exposed Individual (mrem)	
	Bay City	Midland	Bay City	Midland	Bay City	Midland
(1) Excavation of material from thorium-contaminated region and movement to staging area	1000(a)	300(a)	1980	20.4	198 (b)	2(b)
(2) Transport of material to Salzburg (c)	4000	960	7920	65.3	1980	32.7
(3) Emplacement of material and cover at Salzburg	1000	300	1980	20.4	990	10.2
(4) Health Physics and monitoring support						
a) at Source	200	60	396	4.1	198	2.1
b) at Salzburg	1000	300	1980	20.4	990	10.2

(a) Based on operator using a scraper/bulldozer combination.

(b) Based on using 10 persons (1 foreman, 5 laborers, and 4 operators) to perform excavation in 100 hr. period at Bay City and 30 hr period at Midland.

(c) Based on using 6 persons (1 foreman, 3 laborers, 2 operators) to perform emplacement of material and cover, and 1 person to perform vehicle decontamination at Salzburg.

(d) Based on 2 HPs onsite at Bay City full time, Midland and Salzburg performing soil measurements and personal and area monitoring.

Table I 2.0

Occupational Air Particulate Dose

(A) Bay City Material

Activity	Total Exposure Time (Hrs)		Total Dose (mrem/activity)	Maximally Exposed Individual (mrem)
(1) Excavation of material and movement to staging area.	1000	WB	3.7	0.37
		L	114	11.4
		BM	174	17.4
(2) Emplacement and cover of material at Salzburg.	500	WB	1.9	0.31
		L	57	9.5
		BM	87	14.5
(3) Health Physics Monitoring Support				
(a) at Source	200	WB	0.7	0.4
		L	23	11.5
		BM	35	17.5
(b) at Salzburg	1000	WB	3.7	2.9
		L	114	57
		BM	174	87

(B) Midland Material

Activity	Total Exposure Time (hrs)		Total Dose (mrem/activity)	Maximally Exposed Individual (mrem)
(1) Excavation of material and movement to staging area	300	WB	0.2	0.02
		L	5.3	0.5
		BM	8.2	0.8
(2) Emplacement and cover of material at Salzburg	150	WB	0.1	0.01
		L	2.7	0.5
		BM	4.1	0.7
(3) Health Physics and monitoring support				
(a) at Source	60	WB	0.04	0.02
		L	1.1	0.6
		BM	1.6	0.8
(b) at Salzburg	300	WB	0.2	0.1
		L	5.3	2.7
		BM	8.2	4.1

TABLE I 3.0

Occupational Thoron Dose

Activity	Total Exposure Time (Hrs)		Total Dose (mrem/activity)		Maximally Exposed Individual (mrem)	
	Bay City	Midland	Bay City	Midland	Bay City	Midland
1) Excavation of material and movement to staging area	1000	300	278	14.1	27.8	1.4
2) Emplacement of material and cover at Salzburg	1000	300	278	14.1	139	7.1
3).Health Physics and monitoring support						
a) At source	200	60	56	2.8	28	1.4
b) At Salzburg	1000	300	278	14.1	139	7.1

Footnotes on Table I .0 are applicable to above time durations