CRA

LAGOON CLOSURE PLAN

GENERAL MOTORS
HARRISON RADIATOR DIVISION FACILITY
MORAINE, OHIO

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

This document presents a Closure Plan for the North and South Settling Lagoons (North and South Lagoons) at the former General Motors (GM) Harrison Radiator Division (Harrison Facility) in Moraine, Ohio. Figure 1.1 presents the Site Location Plan; Figure 1.2 presents the Site Plan.

The Harrison Facility originally submitted closure plans for the North and South Lagoons on November 8, 1985. The Ohio Environmental Protection Agency (EPA) disapproved these closure plans on November 14 and 15, 1988. The Harrison Facility filed a request for an adjudication hearing on December 13, 1988. Over the next several months, the Harrison Facility and Ohio EPA commenced negotiations to discuss settlement of the filed appeal and approval of closure plans for the units. As part of ongoing settlement discussions, General Motors submitted revised closure plans in November 1989. The negotiations continued into 1992, when the United States Environmental Protection Agency (USEPA) issued a RCRA corrective action order for the Harrison Facility. At this point, the Harrison Facility and Ohio EPA agreed to further negotiate the closure of the lagoons after resolution of other General Motor closure plans and the implementation of the corrective action order at the site. The Harrison Facility then focused its attention to the implementation of the corrective action order. In the summer of 1999, Ohio EPA and GM resumed negotiations concerning the development of the closure plan for the lagoons.

The RCRA Facility Investigation (RFI) as part of the USEPA Corrective Action Program for the Harrison Facility, which included an evaluation of the lagoons, was completed in 1996 and a Supplemental RFI for the adjacent GM Powertrain Group, Moraine Engine Plant (Moraine Engine) and the GM Truck Group, Moraine Assembly Plant (Moraine Assembly) was completed in 1999. The 1996 RFI baseline risk assessment evaluated both groundwater and non-groundwater exposure pathways and the 1999 Supplemental RFI baseline risk assessment re-evaluated the groundwater pathway for the lagoons in combination with potential effects from the Areas of Interest (AOI) investigated in the Supplemental RFI (ENVIRON 1999).

On June 3, and August 11, 1999 GM met with Ohio EPA to present and discuss a revised approach for closure of the lagoons. The agreed upon approach was summarized in GM's letter to Ohio Attorney General dated February 8, 2000. A copy of this letter is presented in Appendix A. GM is prepared to move forward and complete the closure in accordance with the approach outlined in this Closure Plan as soon as the Closure Plan is approved by Ohio EPA.

1.2 REPORT PURPOSE

The following sections of this Closure Plan present a closure approach for the North and South Lagoons.

The purpose of this Closure Plan is to:

1. provide the detailed closure approach; and
2. provide the justification for following the specified closure approach for the lagoons.

The closure activities outlined in this plan include solidifying sludge in situ, backfilling the lagoons with material from existing on-site soil stockpiles and/or imported material, and constructing a soil cover on the South Lagoon and an asphalt cover on the North Lagoon. All closure activities will be conducted in accordance with Ohio Administrative Code (OAC) 3745-66-11. Groundwater monitoring during closure will be conducted in accordance with the groundwater monitoring plans contained in Appendix B, until such time that a site-wide groundwater monitoring work plan is approved by Ohio EPA for use at the Site. A post closure groundwater monitoring plan will be submitted with the lagoon closure certification.

1.3 REPORT ORGANIZATION

This Closure Plan is organized as follows:

Section 2.0 - Description of North and South Lagoons
Section 3.0 - Closure Activities
Section 4.0 - Other Factors Considered for Closure Approach
Section 5.0 - Schedule for Closure Activities
Section 6.0 - Long-Term Monitoring and Post-Closure Care
Section 7.0 - Closure and Post-Closure Cost Estimates
Section 8.0 - References

2.0 DESCRIPTION OF NORTH AND SOUTH LAGOONS

2.1 NORTH LAGOON

2.1.1 GENERAL

The existing conditions in the North Lagoon are presented on Figure 2.1 and Plans #1 (existing conditions) and #3 (cross-sections). The lagoon area is approximately 4.6 acres in size and consists of a primary and secondary basin separated by an earthen berm. The secondary basin is also partially divided by an earthen berm, which was used to increase residence time in the basin. During the active life of the lagoon, flow entered the system through the primary basin, was diverted to the secondary basin after initial settling of solids, discharged under a National Pollutant Discharge Elimination System (NPDES) permit to a ditch, which crosses the site, and eventually discharged to the Great Miami River.

The North Lagoon operated between 1972 and October 1989, when the lagoon was taken out of service. Between 1972 and 1979, the lagoon received industrial wastewater including metal plating wastes (zinc, nickel, and chrome), cutting fluids, pickling wastes, oils, porcelain sludges, and electrodeposition paint rinse waters. Between May 1980 and September 1984, the lagoon received only dilute process rinse wastewater, non-contact cooling water, and stormwater runoff. Beginning in September 1984, all process wastewaters were diverted to the on-site pretreatment facility. All stormwater and non-contact cooling water was diverted into a new concrete stormwater retention facility when the lagoon was taken out of service in October 1989.

Historic construction drawings for the North Lagoon are included in Appendix C.

2.1.2 HYDROGEOLOGY

The local hydrogeology in the area of the North Lagoon consists of sand and gravel glacial outwash deposits that make up the Great Miami River Buried Valley Aquifer. A clay-rich till zone is located below the sand and gravel deposits ranging in depth from 40 to 60 feet below ground surface. The till zone ranges in thickness up to 15 feet and is underlain by a deep sand and gravel unit. The two sand and gravel units, separated by the till unit, contain groundwater and are referred to as the upper and lower aquifer.

Water-level measurements (during March, June, and September 1999) taken in monitoring wells adjacent to the North Lagoon recorded the water table at elevations ranging from 31.1 to 34.0 feet below ground surface for monitoring well W-1-N and 26.6 to 29.6 feet below ground surface for monitoring well W-3-N with a groundwater flow direction of north to south.

The upper aquifer has not historically been used as a municipal or industrial water supply due to the upper aquifer's relatively low sustainable yield (estimated at about 0.24 MGD). The upper aquifer in the vicinity of the Site has a saturated thickness of approximately 30 feet. Due to the limited sustainable yield, future development of the upper aquifer as an industrial or municipal water supply is not expected.

Future development of the upper aquifer as an industrial or municipal water supply is unlikely also because the area around the facility has a dependable, high quality water supply from the Dayton Water System, and emergency capacity from the Greater Moraine Water System well fields, which use groundwater from the lower aquifer. Additionally, the development of public water systems using groundwater as a source is governed by Ohio EPA regulations and guidance (OAC Chapters 3745-1 through 3745-82). Likewise, the installation of private water wells is governed by Ohio Department of Health regulations (OAC Chapter 3701-28). These regulations control the development of private wells (particularly where a public water system is available) and require Ohio EPA and Ohio Department of Health determinations that any such development would be protective of human health.

The lower aquifer in the vicinity of the site has historically been used as a municipal drinking water supply until late 1986. However, future re-use of the lower aquifer as a municipal drinking water supply in the vicinity of the site remains a possibility. Currently the GM Moraine Engine and Moraine Assembly facilities use groundwater extracted from several on-site lower aquifer wells for non-potable industrial use.

2.1.3 GROUNDWATER QUALITY

Groundwater monitoring at the North Lagoon, in accordance with the work plans contained in Appendix B and summarized in Section 4.5, for monitoring of RCRA surface impoundments, began in 1981. Groundwater quality upgradient and downgradient of the North Lagoon was monitored under the "detection monitoring" program specified in these regulations from 1981 to 1984. In the spring of 1984, the facility began an "assessment monitoring" program in accordance with the provisions of the groundwater monitoring regulations. Quarterly assessment monitoring of wells upgradient and downgradient of the North Lagoon includes analysis of pH, specific conductance, and volatile organic compounds (VOCs) in the upper and lower aquifers. Groundwater from some of the wells is also analyzed for semivolatile organic compounds (SVOCs), cyanide, and metals. Groundwater assessment monitoring reports have been submitted to the Ohio EPA.

Additional monitoring of groundwater at some of the assessment monitoring wells upgradient and downgradient of the North Lagoon in the upper and lower aquifers was conducted as part of the RFI (January 1993 and October 1994) and the Supplemental RFI (March 1998 and August 1998). The purpose of the 1993 RFI groundwater sampling was to collect groundwater quality data in accordance with the RFI Quality Assurance Project Plan (QAPP) to confirm the general understanding of groundwater quality around the North Lagoon that has been developed through the RCRA assessment monitoring program. The 1993 RFI monitoring included analysis of VOCs, SVOCs, PCBs, pesticides/herbicides, cyanide, and metals at 13 of the 19 wells in the assessment monitoring network. Groundwater from two additional upper aquifer downgradient wells in the network was analyzed for VOCs, metals and cyanide; groundwater from one of these was also analyzed for PCBs.

The results of the 1993 RFI sampling confirmed that certain VOCs were the only hazardous constituents in groundwater that might be associated with sludge in the North Lagoon and are at concentrations of potential health significance. These data showed that SVOCs, PCBs, pesticides/herbicides are not present in groundwater in the assessment monitoring wells sampled, or in any of the other wells located elsewhere at the facility sampled during the RFI. The only exception was bis(2-ethylhexyl)phthalate, which was a SVOC detected at only one well (GM-19D which is not a North Lagoon assessment well) and at a low concentration (0.029 mg/L). The concentrations of cyanide and metals detected in the samples were at concentrations that did not indicate a potential for significant health risk. Accordingly, the groundwater monitoring conducted during the Supplemental RFI in 1998 focused on the analysis of only VOCs. The March 1998 sampling included analysis of only VOCs at six of the assessment monitoring wells, and the August 1998 sampling included analysis of a shorter list of VOCs at only two of the downgradient wells in the upper aquifer.

The potential health significance of concentrations of VOCs detected in monitoring wells directly downgradient of the North Lagoon was evaluated in the RFI baseline risk assessment and again in the Supplemental RFI baseline risk assessment. Maximum concentrations of VOCs in the RFI and Supplemental RFI groundwater data for the

North Lagoon's downgradient wells in the upper aquifer were used in the baseline risk assessments to evaluate the potential health significance of these concentrations. The evaluation assumed the North Lagoon was the source of these constituents; however this assumption is very conservative because these constituents have been detected upgradient of the North Lagoon, upgradient in the lower aquifer, and at upgradient and side-gradient areas at the adjacent GM Moraine Engine Plant. The details of the risk assessments were submitted to the Ohio EPA and USEPA in Volume II of the RFI Report and Supplemental RFI Report (ENVIRON 1996, 1999). The risk assessments for the North Lagoon, which included both groundwater and nongroundwater pathways, and the conclusion of the assessments are summarized in Section 2.4. VOCs detected in the North Lagoon monitoring wells may have migrated from the AOI-7 source area identified in the 1999 Supplemental RFI.

2.1.4 SLUDGE CHARACTERIZATION

The total volume of sludge in the North Lagoon was estimated as 12,800 cubic yards based on the 1988 sludge characterization study, 2,600 cubic yards being located in the primary basin and 10,200 cubic yards being located in the secondary basin ("Draft North Settling Lagoon Revised Closure/Post Closure Plan", Geraghty & Miller, November 3, 1989). In addition, the 1988 study estimated 8.07 million gallons of water were present in the North Lagoon, 0.34 million gallons in the primary lagoon and 7.73 million gallons in the secondary lagoon. Based on a topographic survey completed in April 1999, by Woolpert LLP, ARCADIS Geraghty & Miller, estimated the total volume of sludge in the North Lagoon as 11,700 cubic yards,. As of June 1999 the north end of the secondary basin contained some ponded water.

The RCRA Part A permit application dated June 13, 1988 indicated that sludges in the North Lagoon were generated in part by mixed wastewater streams from the following listed hazardous wastes.

1. F006 - wastewater treatment sludges from electroplating operations;
2. F007 - spent cyanide plating bath solutions from electroplating operations;
3. F009 - spent stripping and cleaning bath solutions from electroplating operations;
4. F012 - quenching wastewater treatment sludges from metal heat treating operations; and
5. F019 - wastewater treatment sludges from the chemical conversion coating of aluminum.

F001 and F005 were identified on the Part A Permit Application. However both F001 and F005 were not included in the mixed wastewater streams for the lagoons. The mixed wastewater stream included non-hazardous process waste, non-contact cooling water and stormwater.

The November 3, 1989, "Draft North Settling Lagoon Revised Closure/Post-Closure Plan" characterized the lagoon sludge and underlying soil. Samples were analyzed for total priority pollutants, VOC priority pollutants, selected metals and cyanide, full RCRA Appendix IX, oil and grease, percent solids and bulk density in 1988. The sample locations are presented on Figure 2.2, and sludge sample results are summarized in Table 2.1. The sludges were found to be not characteristically hazardous. VOCs were not detected in the underlying soils. In addition, levels of metal concentrations in soils do not exceed site-specific background levels developed for the baseline risk assessment.

2.2 SOUTH LAGOON

2.2.1 GENERAL

The existing conditions in the South Lagoon are presented on Figure 2.3 and Plans #2 (existing conditions) and #4 (cross-sections). The lagoon area is approximately 7.9 acres in size and consists of a primary basin, secondary basin, and sludge drying basin separated by earthen berms. During the active life of the lagoon, flow entered the system through the primary basin, was diverted to the secondary basin after initial settling of solids, discharged under a NPDES permit to a ditch, and eventually discharged to the Great Miami River. The sludge drying basin was previously used for the dewatering of sludge removed from the primary and secondary basins.

The South Lagoon originally consisted of a single basin occupying the footprint of the secondary basin, which was constructed in 1965. The sludge-drying basin was added in 1967 and the primary basin was added in 1974. Between 1965 and 1979, the lagoon received industrial wastewater including zinc plating wastes, anodizing wastes, pickling wastes, oils, and porcelain sludges. Between 1980 and November 1985, the lagoon received process wastewater (consisting of dilute acid and alkali rinses from small parts cleaning and non-cyanodic electroplating processes and fly ash dewatering filtrate), water softening sludges, non-contact cooling water, and stormwater runoff. Beginning in November 1985, all process wastewaters were diverted to the on-site pretreatment facility. All stormwater and non-contact cooling water was diverted into a new concrete stormwater retention facility when the lagoon was taken out of service in October 1989.

Historic construction drawings for the South Lagoon are included in Appendix C.

2.2.2 HYDROGEOLOGY

The local hydrogeology in the area of the South Lagoon consists of sand and gravel glacial outwash deposits that make up the Great Miami River Buried Valley Aquifer. A clay-rich till zone is located below the sand and gravel deposits ranging in depth from 50 to 70 feet below ground surface. The till zone ranges in thickness up to 15 feet and is underlain by a deeper sand and gravel unit. The two sand and gravel units, separated by the till unit, contain groundwater and are referred to as the upper and lower aquifer.

Water-level measurements taken (during March, June, and September 1999) in monitoring wells adjacent to the South Lagoon recorded the water table at elevations ranging from 21.0 to 24.5 feet below ground surface for monitoring well HR-17 and 23 to 26.7 feet below ground surface for monitoring well W-4-S, with a groundwater flow direction of north to south.

The upper aquifer has not historically been used as a municipal or industrial water supply due to the upper aquifer's relatively low sustainable yield (estimated at about 0.24 MGD). The upper aquifer in the vicinity of the Site has a saturated thickness of approximately 20 to 45 feet. Due to the limited sustainable yield, future development of the upper aquifer as an industrial or municipal water supply is not expected.

Future development of the upper aquifer as an industrial or municipal water supply is unlikely also because the area around the facility has a dependable, high quality water supply from the Dayton Water System, and emergency capacity from the Greater Moraine Water System well fields, which use groundwater from the lower aquifer. Additionally, the development of public water systems using groundwater as a source is governed by Ohio EPA regulations and guidance (OAC Chapters 3745-1 through 3745-82). Likewise, the installation of private water wells is governed by Ohio Department of Health regulations (OAC Chapter 3701-28). These regulations control the development of private wells (particularly where a public water system is available) and require Ohio EPA and Ohio Department of Health determinations that any such development would be protective of human health.

The lower aquifer in the vicinity of the site has historically been used as a municipal drinking water supply until late 1986. However, future re-use of the lower aquifer as a municipal drinking water supply in the vicinity of the site remains a possibility. Currently the GM Moraine Engine and Moraine Assembly facilities use groundwater extracted from several on-site lower aquifer wells for non-potable industrial use.

2.2.3 GROUNDWATER QUALITY

Groundwater monitoring at the South Lagoon in accordance with the work plans contained in Appendix B and summarized in Section 4.5, for monitoring of RCRA surface impoundments began in 1981. Groundwater quality upgradient and downgradient of the South Lagoon has been monitored under the "detection monitoring" program specified in these regulations since 1981. Semiannual groundwater detection monitoring results have been submitted to the Ohio EPA.

Additional monitoring of groundwater at some of the detection monitoring wells upgradient and downgradient of the South Lagoon in the upper aquifer was conducted as part of the RFI (January 1993 and October 1994) and the Supplemental RFI (March 1998). The purpose of the 1993 RFI groundwater sampling was to collect groundwater quality data in accordance with the RFI QAPP to confirm the general understanding of groundwater quality around the South Lagoon that has been developed through the RCRA detection monitoring program. The 1993 RFI monitoring included analysis of VOCs, SVOCs, PCBs, pesticides/herbicides, cyanide, and metals at 3 of the 5 wells in the detection monitoring network.

Groundwater from three of these wells (one upgradient and two downgradient) was resampled in 1994 and analyzed for only VOCs. The 1994 RFI sampling was conducted to confirm that VOCs detected during the 1993 RFI sampling were in fact present in both upgradient and downgradient monitoring wells, which would be consistent with the belief that the VOCs did not originate from the sludge in the South Lagoon. The 1994 data confirmed that relatively high groundwater concentrations of certain VOCs (e.g., tetrachloroethene as high as 0.166 mg/L and trichloroethene as high as 0.025 mg/L) were present both upgradient and downgradient of the South Lagoon. Because sludge characterization data (totals analysis) collected during development of the Closure Plan for the South Lagoon showed no detection of any target compound list (TCL) VOCs in the sludge, the presence of the VOCs in groundwater upgradient and downgradient of the South Lagoon was attributed to upgradient sources. Accordingly, the March 1998 Supplemental RFI groundwater sampling included only one of the

South Lagoon's upgradient wells (and no downgradient wells), and the groundwater sample was analyzed for only VOCs. The only metals detected in the dissolved-phase groundwater samples from the RFI were barium at 0.176 mg/L (MCL is 2 mg/L) and cobalt at 0.0077 mg/L (risk-based drinking water concentration is 2.19 mg/L based on a hazard quotient of 1). SVOC, PCBs, pesticides/herbicides, and cyanide were not detected in the RFI groundwater samples at the South Lagoon.

VOCs detected in the South Lagoon monitoring wells may have migrated from the AOI-7 source area identified in the 1999 Supplemental RFI.

2.2.4 SLUDGE CHARACTERIZATION

The total volume of sludge in the South Lagoon was estimated as 67,200 cubic yards based on the 1988 sludge characterization study, 7,400 cubic yards being located in the primary basin, 53,800 cubic yards being located in the secondary basin, and 6,000 cubic yards being located in the sludge-drying basin, ("Draft South Settling Lagoon Revised Closure Plan", Geraghty & Miller, Inc., November 3, 1989). In addition, the study estimated 4.99 million gallons of water were present in the South Lagoon, 0.05 million gallons in the primary lagoon and 4.94 million gallons in the secondary lagoon. Based on a topographic survey completed in April 1999 by Woolpert LLP, ARCADIS Geraghty & Miller estimated the total volume of sludge in the South Lagoon as 60,700 cubic yards. In June 1999, there was no standing water in the South Lagoon.

The RCRA Part A permit application dated June 13, 1988 indicated that sludges in the South Lagoon were generated in part by mixed wastewater streams from the following listed hazardous wastes.

1. F006 - wastewater treatment sludges from electroplating operations;
2. F007 - spent cyanide plating bath solutions from electroplating operations;
3. F009 - spent stripping and cleaning bath solutions from electroplating operations;
4. F012 - quenching wastewater treatment sludges from metal heat treating operations; and
5. F019 - wastewater treatment sludges from the chemical conversion coating of aluminum.

F001 and F005 were identified on the Part A Permit Application. However both F001 and F005 were not included in the mixed wastewater streams for the lagoons. In addition, the mixed wastewater stream included non-hazardous process waste, non-contact cooling water, and stormwater.

The November 3, 1989, "Draft North Settling Lagoon Revised Closure/Post-Closure Plan" characterized the lagoon sludge and underlying soil. Samples were analyzed for total priority pollutants, VOC priority pollutants, selected metals and cyanide, full RCRA Appendix IX parameters, oil and grease, percent solids and bulk density. The sample locations are presented on Figure 2.4, and sludge sample results are summarized in Table 2.2. The sludges were found to be not characteristically hazardous. VOCs were not detected in the underlying soils. In addition, levels of metal concentrations in the soil do not exceed site-specific background levels developed for the baseline risk assessment.

2.3 WETLANDS

The South Lagoon secondary basin and the North Lagoon secondary basin contain areas that may be considered wetlands. Since these areas would be lost during the sludge solidification and backfill work proposed in the Closure Plan, a letter was submitted to the Army Corps. of Engineers, dated November 11, 1999, to request a wetlands determination. General Motors received a letter dated January 10, 2000 from the Army Corp. of Engineers, confirming that the lagoons do not contain jurisdictional wetlands. Appendix D contains a copy of the letter from GM to the Army Corp. of Engineers, which further discusses this issue and the response received from the Army Corp. of Engineers.

2.4 RISK ASSESSMENT

As part of the RFI for the Harrison Facility, a site-specific baseline risk assessment was conducted to evaluate the significance of potential exposures to hazardous constituents from SWMUs investigated in the RFI. The RFI baseline risk assessment included an evaluation of potential groundwater and non-groundwater exposures to constituents in the sludge at the North and South Settling Lagoons. The risk assessment results and conclusions were submitted to the USEPA in the Draft RFI Report: Volume II (Baseline Risk Assessment), Delphi Harrison Thermal Systems, General Motors Corporation, Moraine, Ohio (ENVIRON, February 1996), and the Draft Supplemental RFI Report: Volume II (ENVIRON, April 2000). This data has been included for information purposes only. GM is not pursuing a clean closure and will be conducting post-closure groundwater monitoring and care of these units. The following is a brief summary of the risk assessment approach and conclusions.

2.4.1 GROUNDWATER PATHWAY

The baseline risk assessment evaluated potential exposures to hazardous constituents in the sludge at the North Lagoon and South Lagoon via migration to locations of current and reasonably expected future groundwater use. Based on a detailed review of past, current, and potential future groundwater uses in the region, the baseline risk assessment evaluated the following receptor locations for current and reasonably expected future drinking water use:

- West Carrollton: current municipal drinking water supply wells;
- Miami Shores: Greater Moraine Water System's (GMWS) primary emergency drinking water supply; and
- Dryden Road South: GMWS's secondary emergency drinking water supply.

The baseline risk assessment also evaluated current and reasonably expected future non-potable industrial use at the following locations:

- Harrison Facility production wells (currently inactive);
- GM Moraine Assembly production wells (currently active); and
- GM Moraine Engine production wells (currently active).

Additionally, the baseline risk assessment evaluated potential migration of constituents from the Lagoons to the Great Miami River. Further, although the GMWS's Dryden Road north well field is not expected to serve as a drinking water supply, or as an emergency drinking water supply, the potential migration of constituents from the Lagoon to the well field was also evaluated.

The groundwater pathway was assessed using a site-specific numerical groundwater flow and transport model (MODFLOW/MODALL). The groundwater flow model was calibrated and approved by USEPA prior to the risk assessment. The contaminant transport model used conservative assumptions (i.e., continuous source of constituents, no degradation of constituents, and dispersion of constituents) in combination with the maximum groundwater concentrations from the RFI monitoring data for the North and

South Lagoons. To predict the possible migration of constituents from the lagoons under different groundwater pumping patterns in the future, the risk assessment evaluated 10 groundwater pumping scenarios that covered a range of combinations of groundwater pumping rates at the potential receptor wells and interim measures wells. The model estimated the lagoons' contributions to concentrations of constituents at each receptor well in each of these pumping scenarios.

For the lagoons at Delphi Thermal, the maximum groundwater concentration of a constituent measured during the supplemental RFI (or the RFI, if no data were collected during the supplemental RFI) from monitoring wells associated with the lagoons (see Appendix C, Section 1 of the 1996 baseline risk assessment) is considered to be representative of the concentration that leaches from the lagoon waste, and is used as the source term, if the constituent was detected in the lagoon sludge or is a degradation product of constituents detected in the sludge. This approach may tend to overestimate the source concentration since it does not account for potential contributions from upgradient sources.

Based on the results of the groundwater modeling, the RFI baseline and supplemental baseline risk assessments determined that the North Lagoon and South Lagoon would not be expected to contribute constituent concentrations exceeding Safe Drinking Water Act, Maximum Contaminant Levels (MCLs) or similar risk-based drinking water concentrations at the receptor wells in the pumping scenarios evaluated.

2.4.2 NON-GROUNDWATER PATHWAYS

The baseline risk assessment evaluated potential exposures to hazardous constituents in the sludge at the North Lagoon and South Lagoon via non-groundwater exposure pathways under current and reasonably anticipated future land use at and around the Harrison Facility. Based on a detailed review of past, current, and potential future land use at and around the facility, the following potentially exposed populations and exposure pathways were evaluated in the risk assessment:

- potential receptors: on-site groundskeepers and off-site residents; and
- potential exposure pathways: inhalation of vapors; inhalation of particulates.

Estimates of reasonable maximum exposures were derived using the maximum constituent concentrations in the upper stratum of the sludge in each lagoon in combination with "standard" USEPA screening models for emissions of vapors and particulates, and air dispersion. Exposure factors for the groundskeeper scenario were based on site-specific practice and those for off-site exposures were USEPA standard default exposure factors.

Based on these estimates of reasonable maximum exposures, the RFI baseline risk assessment determined that the cumulative excess cancer risk and hazard index (HI) for the potential exposures evaluated are well within levels considered acceptable under RCRA corrective action. The high-end estimates of cumulative cancer and non-cancer risks did not exceed the cumulative cancer risk level of 10^{-5} and non-cancer HI level of 1 specified in the Ohio EPA Guidance for Reviewing Risk Based Closure Plans for RCRA Units (1999) for risk-based demonstrations of RCRA unit decontamination.

3.0 CLOSURE ACTIVITIES

In accordance with OAC 3745-66-12, the Closure Plan considers the following requirements:

- Description of the Facility: Provided in Section 2.1.1 and Section 2.2.1 of the plan.
- Description of Hazardous Waste Management Units to be Closed: Provided in Section 2.1 and Section 2.2 of the plan.
- Map of Facility: Provided on Figure 1.1 and Figure 1.2 contained in the plan.
- Detailed Drawing of Unit(s) to be Closed: Provided on Figure 2.1 and Figure 2.3, and Plan #1 and Plan #2 contained in the plan.
- List of Hazardous Wastes: Provided in Section 2.1.4 and Section 2.2.4 of the plan.
- Removal of Waste: Not applicable since waste material will be solidified in place.
- Schedule for Closure: Provided in Section 5.0 and on Figure 5.1 contained in the plan.
- Air Emissions and Wastewater: Provided in Section 3.6 of the plan.
- Personnel Health and Safety: Provided in Appendix E of the plan.
- Decontamination Efforts: Provided in Section 3.6 of the plan.

The plan also considered site characterization data and the Site Baseline Risk Assessment conducted as part of the RFI and Supplemental RFI.

The closure activities outlined in this plan include solidifying sludge in situ, backfilling the lagoons with material from existing on-site soil stockpiles and/or imported material, and constructing a soil cover on the South Lagoon and an asphalt cover on the North Lagoon. All closure activities will be conducted in accordance with the Health and Safety Plan (HASP) presented in Appendix E. Plans #1 through #12, which detail the proposed closure, are included in the Closure Plan document.

3.1 SITE PREPARATION

Active use of the lagoons ended approximately 11 years ago. Since that time substantial vegetative growth occurred in both the North and South Lagoons. In preparation for lagoon closure activities, most of the area of the North and South Lagoons was cleared and grubbed during August and September 1999. Trees and shrubs removed from the lagoons were chipped and stockpiled on-site. Sections of trees too large to chip (i.e., logs larger than 12-inch diameter) were stockpiled adjacent to the lagoons for future off-site landfilling. Clearing and grubbing activities were conducted in a manner to ensure sludge material in the lagoons was not disturbed. This included leaving tree or plant roots in place where removal would have resulted in potential disturbance of sludge materials.

Lagoon closure site preparation will begin with the setup of the support zone and the contaminant reduction zone located as shown on Plans #5 and #6. Following setup of the support zone and contamination reduction zone, the area (not in contact with sludge) surrounding the lagoon(s) will be graded to minimize runon from adjacent land surfaces. Runoff controls for stormwater in contact with sludge material were not considered since all sludge material is located and will be contained in the base of the lagoons, which are all located below the existing ground surface. Best management practices will be used to control stormwater runoff during construction activities.

Solidification of the lagoon sludge material will not begin until the decontamination facilities, including the decontamination pad, are operational.

3.2 DEMOLISH STRUCTURES

Pipes, inlet sewers, outlet structures, utility poles, vaults, and other structures located within the surface impoundment system (refer to Plans #5 and 6) will be plugged in place, removed, or partially demolished.

Underground pipes left in place will be plugged as shown on Plan #11. Where possible underground pipes left in place will be filled with flowable fill. Tree roots removed, which have been exposed to sludge, will be shaken and/or subjected to high pressure washing prior to off-site landfilling. Demolition debris for off-site disposal, will be stockpiled for decontamination (if exposed to sludge in the past). If the material meets the definition of clean hard fill, it may be size reduced and used as part of the backfill.

3.3 SLUDGE SOLIDIFICATION

The lagoon sludge will undergo physical solidification prior to the lagoons being backfilled. Solidification will be conducted by adding a pozzolanic material (cement kiln dust, CKD) to the sludge. Solidification will be conducted in place by placing the stabilization agent on the sludge surface and mixing it in with an excavator bucket or using an injection system mounted on a trackhoe. Sludge solidification will be conducted to a minimum physical strength criterion of 25 pounds per square inch (psi) (closure criteria). This strength has been selected as it meets the four criteria listed in the Ohio EPA, March 1999 document entitled "Closure Plan Review Guidance for RCRA Facilities". Specifically, the following requirements will be met:

(i) Increasing strength over time: Pozzolanic materials such as CKD, are known to increase the strength of soil or sludge material over time, as the CKD hydrates. Increase strength was also demonstrated during the treatability study packet parameters results.

(ii) Capable of supporting a final cap plus a safety factor of two (2): Calculations provided in Appendix F.

(iii) Capable of supporting a load-bearing capacity plus a safety factor of two (2): Calculations provided in Appendix F.

(iv) Proof of chemical stabilization: TCLP analysis of samples of sludge material from the North and South Lagoon, conducted in 1989 demonstrated that the existing sludge material is not characteristically hazardous. The addition of CKD will further reduce the mobility of any organic or inorganic constituents contained in the sludge material.

Sludge solidification and lagoon backfilling will begin in the South Lagoon. Solidification of all sludges contained in the South Lagoon will be completed prior to sludge solidification in the North Lagoon starting unless this affects the work schedule. The void volume of the North Lagoon was estimated at 142,222 cubic yards and at 185,259 cubic yards in the South Lagoon (Woolpert LLP, June 2, 1999).

3.3.1 GEOTECHNICAL TESTING

Between September and October 1999, samples of undisturbed sludge (shelby tube samples) from the North and South Lagoons were sent off-site for geotechnical testing. The objective of the testing was to verify the sludge in the lagoons requires in situ solidification to support the cover system, to determine the amount of CKD required, and to estimate the potential settlement or consolidation of sludge material following backfilling. Testing of the sludge material included moisture content analysis, sieve and hydrometer analysis, atterberg limits, specific gravity, total organic carbon (TOC), and consolidation testing. Drilling activities and geotechnical testing were conducted by the H.C. Nutting Company in Cincinnati, Ohio. Prior to extracting samples at each location, a pilot boring was drilled, complete with continuous split spoon sampling and logging. The drilling program scope of work, including drill hole locations and drill logs, is presented in Appendix F. The results of the geotechnical testing indicate that the sludge in both the North and South Lagoons require in situ solidification to meet the closure criteria (minimum unconfined compressive strength of 25 psi).

3.3.2 BENCH SCALE STUDY

Additional bench scale testing of the sludge in the North and South Lagoons is currently being conducted. The additional testing will be used to determine the optimum ratio of reagent that is required in each lagoon to achieve the closure criteria (minimum unconfined compressive strength of 25 psi). Testing will consist of adding specified ratios of CKD to sludge material removed from each of the lagoons and testing the unconfined compressive strength of the samples following chemical hydration. Results of the bench scale testing will be provided to the Ohio EPA, once available.

3.3.3 SOLIDIFICATION PROCEDURES

The specifics of the solidification process will be based on the contractor selected and their method of application. In general, the solidifying reagents will be injected pneumatically into the sludge using a "rake-like" attachment in place of a bucket, on the trackhoe, or by direct mixing using the trackhoe bucket. The required mixing will be provided using a raking motion through the sludge, uniformly mixing the reagent. Solidification will be conducted from the edge of the lagoons or from areas already solidified.

3.4 LAGOON BACKFILLING

Following solidification, the lagoons will be backfilled with on-site material from existing soil stockpiles, broken or crushed on-site concrete structures, and/or imported fill material. The imported fill material will include clean soil and/or clean, hard fill. The material will be compacted to a minimum of 95 percent modified proctor density and graded to promote drainage away from the former lagoons. Plans #9 and #10 present cross sections of the backfilled lagoons. A minimum of ten feet of backfill material will be placed over all solidified sludge material. Stormwater drainage from the South Lagoon will be collected in a network of ditches, catchbasins and underground pipes. Collected stormwater will be discharged to the existing underground 84-inch diameter storm sewer, along the north perimeter of the South Lagoon. Stormwater drainage from the North Lagoon will be collected in a network of catchbasins and underground pipes. Collected stormwater will be discharged to the GM stormwater retention ponds located adjacent to the southwest side of the North Lagoon. Maximum stormwater flow calculations for the North and South Lagoons area presented in Appendix G.

3.4.1 SOIL STOCKPILE CHARACTERIZATION STUDY

The existing north soil stockpile was characterized in July 1999 to determine the physical and chemical properties of the material. The report presenting results of the July 1999 testing concludes that the soil stockpile is acceptable for use as backfill for the lagoons (ARCADIS Geraghty & Miller, 1999).

3.4.2 SETTLEMENT ANALYSIS

The geotechnical testing completed in September and October 1999 also evaluated the settlement characteristics of the in situ sludge. The lagoons will be backfilled with up to 25 feet of compacted soil on top of the solidified sludge. The solidification of the sludges to 25 psi before backfilling is expected to reduce the actual amount of settlement that will take place. The predicted settlement of the solidified sludge is estimated at several inches with the majority of the settlement occurring within 90 days.

The final grading and covers will only be installed after at least 90 days following backfilling, to minimize the possibility of differential settlement of the final cover.

3.5 COVER

The cover for the North Lagoon area will consist of a minimum of 5 inches of coarse compacted aggregate followed by two 1.5-inch lifts of asphalt. The cover for the South Lagoon will consist of a minimum of 12 inches of compacted clay (1.0×10^{-7} cm/sec permeability) and 6 inches of topsoil material that will be seeded. Details of the North Lagoon cover and the South Lagoon cover are presented on Plan #11.

Maintenance and repair activities will be completed as soon as possible after problems are identified. Routine maintenance and repair activities will be completed no later than 6 weeks after problem identification. If significant repairs are required which will take longer than 6 weeks to complete, a schedule will be forwarded to Ohio EPA indicating when repairs will be completed.

The following maintenance activities will be completed for the asphalt cover over the North Lagoon:

1. erosion damage will be repaired through replacing asphalt, and minor regrading if necessary;
2. regrading in response to subsidence or settlement will be completed as necessary to maintain adequate surface water drainage. Damaged asphalt will be repaired or replaced; and
3. damage to the asphalt by pests is not anticipated due the resistant nature of the asphalt cover. However, if evidence of pest damage is discovered, the pests will be exterminated and the cover will be repaired.

The following maintenance activities will be completed for the vegetated cover over the South Lagoon:

1. erosion damage will be repaired through revegetation, and minor regrading if necessary;
2. regrading in response to subsidence or settlement will be completed as necessary to maintain adequate surface water drainage. Disturbed areas will be revegetated;
3. the grass will be mowed at least monthly during the growing season of April to October. At these times, bare areas or erosion damage will be repaired and deep-rooted vegetation will be removed; and
4. regular grass mowing will tend to discourage pests. If evidence of pest damage is discovered, the pests will be exterminated and the cover will be repaired.

3.5.1 AREA COVERED AND SLOPE

The cover will be installed to the limits shown on Plans #7 and #8. The design contours for the North Lagoon area provide final surface sloping towards the storm water collection system. The design contours for the South Lagoon area provide final surface sloping outwards towards the perimeters. The final contour plan for the cover provides for slope stability and minimal erosion. Prior to completion of the cover, existing monitoring wells in the South Lagoon area may have to be extended to accommodate cover contours.

3.6 CONSTRUCTION PROCEDURES AND CONTROLS

3.6.1 FUGITIVE DUST EMISSIONS CONTROL

Appropriate fugitive dust prevention measures will be taken during construction activities. This may include inspection, watering and cleaning of haul roads, covering material stockpiles when not in use, and conducting solidification activities in a manner to minimize dust emissions.

The primary and secondary ambient air quality standard for suspended particulates is a 24-hour average concentration of 150 microgram per cubic meter ($\mu g/m^3$), as defined in OAC 3745-17-02. In addition, in accordance with OAC-17-07, the 3-minute average fugitive dust emissions are not to exceed 20 percent opacity, and fugitive dust emissions from material stockpiles are not to be visible greater than 13 minutes per hour.

Dust monitoring will be conducted to ensure compliance with these standards. Dust monitoring will consist of time average particulate sampling using a total suspended particulate (tsp) high volume air sampler and regular visual observation of work areas, material stockpiles, and haul roads.

3.6.2 VOLATILE EMISSIONS CONTROL

VOCs were reported in certain samples of sludge from the North Lagoon collected during the 1988 characterization study. It is not anticipated that these levels will result in unacceptable volatile emissions. However, total VOC monitoring will be conducted using a photo ionization detector (PID) during the first 5 days of solidification activities in the North Lagoon.

If required based on the total VOC monitoring results, appropriate volatile emission prevention measures will be taken during construction activities. An action level of 5 parts per million in the breathing zone is to be used as a trigger for VOC emission prevention. This may include covering sludge and solidified sludge surfaces, conducting solidification activities in an alternate manner to minimize volatile emissions, and continuous VOC monitoring during the solidification process.

3.6.3 DECONTAMINATION PROCEDURE FOR EQUIPMENT AND STRUCTURES

Equipment and structures that come in contact with sludge materials during closure activities will be decontaminated prior to leaving the closure area or before its use with non-contaminated materials. It is anticipated that equipment that contacts sludge materials will be limited to the equipment which applies and mixes the solidification materials.

Equipment that is used to haul materials or to construct the final cover is not expected to become contaminated. It is not anticipated that trucks hauling clean backfill material will come in contact with sludge and therefore will not require decontamination prior to leaving the Site. Procedures will be followed during backfilling that specify clean material to be pushed over solidified material to eliminate contact of this equipment with sludge material. However, if for some reason this equipment does come in contact with sludge material, it will be decontaminated.

Equipment decontamination will consist of removal of heavily caked material from the equipment using wire brushes or shovels followed by three separate rinses using a high pressure, low volume water wash. Solids collected from the decontamination pad(s) will be transferred to the lagoons for solidification. Wastewater collected from the decontamination process will be used in the sludge solidification process. A decontamination area will be constructed at both the South and North Lagoon areas as shown on Plan 5 and Plan 6. All decontaminated equipment will be visually inspected prior to being allowed to leave the Site or to work on Site with clean materials.

3.6.4 PERSONNEL DECONTAMINATION

Personnel expected to come in contact with sludge material will be required to don personnel protective equipment. That equipment will be specified in the health and safety plan contained in Appendix E. It will include, at a minimum, overboots, gloves, disposable coveralls, glasses, and hard hats. Dust masks or respirators will also likely be required for personnel applying solidification materials.

Personnel decontamination will also be conducted in the established decontamination area. The procedures will include:

- removing and disposing dust masks and/or respirators in plastic garbage bags;
- brushing off heavily caked-on material from overboots and gloves, if necessary;
- washing overboots, gloves and hard hats and goggles, if necessary, with high pressure, high temperature, low volume water wash;
- placing overboots and gloves, if reusable, on plastic sheeting to dry; disposing in garbage bags if unusable; and
- disposing of disposable coveralls in garbage bags.

These procedures will be repeated each time an individual leaves the closure area or before conducting a non-contaminated closure activity. All collected used PPE will be containerized, managed, and disposed of off-site as a non-hazardous material.

The site-specific Health and Safety Plan is presented in Appendix E.

3.6.5 WATER TREATMENT

Water from personnel and equipment decontamination will be directed back to the lagoons and utilized in the solidification process.

3.6.6 DECONTAMINATION AREA CLOSURE

At the completion of closure activities requiring contact with sludge materials, the decontamination pads will be dismantled. Sand material from the decontamination pads will be used as backfill in the lagoon area. Other materials of construction such as liners, will be sampled to determine appropriate off-site disposal. The decontamination area will be regraded in accordance with the final Closure Plan grading.

3.6.7 OFF-SITE DISPOSAL

Demolished structures (such as steel, and polyethylene piping, etc.) will be pressure washed as specified in Section 3.6.3. Following pressure washing, demolition debris will be sent off-site for recycling (steel), for disposal (wood, fiberglass or polyethylene material), or crushed (concrete) and used in the lagoon as backfill, if appropriate. Crushed concrete will be placed directly above solidified sludge material in the lagoons. All used PPE will be containerized, managed, and disposed of off-site as a non-hazardous material.

3.7 CONSTRUCTION QA/QC ACTIVITIES TO BE CONDUCTED

To enable certification of closure, a construction quality assurance and quality control (QA/QC) program will be implemented throughout closure activities. Inspectors will be present during closure activities to conduct the QA/QC program. The Site Engineer will have the responsibility to ensure the QA/QC program is followed. All observations and determinations of the QA/QC program will be recorded in a daily log of activities, and a final report will be prepared summarizing these activities as well as all results of the QA/QC tests conducted. Construction QA/QC procedures are described below.

3.7.1 SITE PREPARATION

The limits of the final cover are shown on Plans #7 and #8. The areas will be surveyed and staked prior to Site preparation activities to keep waste equipment within the boundaries of the area to be covered. Stakes with colored flagging will be placed around the limit of the cover at a maximum spacing of 50 feet.

3.7.2 SOLIDIFICATION

The solidification process will be monitored to identify the depth to which solidification is completed, the degree of mixing, and the volume of solidification material injected into the sludge.

After solidification, sludge will be sampled and tested to ensure that the minimum unconfined compressive strength at 28 days meets the specified unconfined strength criterion of 25 psi. Representative samples will be collected from the recently solidified sludge and formed into molds. One sample will be collected from every 2,500 cubic yards of solidified sludge or a minimum of one sample each week of solidification, whichever is greater. Sample locations will vary in depth and distance from the trackhoe. These samples will be cured for 28 days and tested for unconfined compressive strength in accordance with American Society for Testing Materials (ASTM) D 2166. The sludge also will be tested for unconfined compressive strength with a pocket penetrometer to monitor the gain in strength required to operate equipment on the solidified sludge.

All sampling and testing will be documented and will be included in the final closure certification report.

3.7.3 COMPACTION TESTING OF BACKFILL

Following sludge solidification (and comprehensive strength testing) the lagoon will be backfilled, using a combination of imported material and material from the soil stockpiles. Backfill material will be placed continuously and in uniform layers not exceeding 12 inches. Backfill material will be placed in lifts and compacted to the modified proctor density specified (95 percent minimum) for the lagoons. Compaction testing of backfill material will be conducted using a radioactive troxler machine operated by an independent geotechnical firm. Compaction testing will be conducted at a minimum frequency of one test per 2,500 cubic yards (loose) of backfill material.

Compaction of granular backfill will be conducted by a vibratory roller while compaction of clay material will be conducted by a sheep's foot roller or similar equipment.

3.7.4 SURVEY OF COVER

Following completion of the lagoon backfilling, the subgrade will be surveyed by the Contractor prior to starting the construction of the cover. A minimum of 90 days will be allowed for settlement (and additional backfilling if necessary) prior to final cover construction. Grades and elevations will be compared by the Contractor to design values shown on the drawings. Grades and elevations will be re-surveyed by a professional land surveyor, licensed in the State of Ohio, following the completion of the cover. The information from the survey will be used to assemble as-built drawings of the cover, which will be required in the Closure Plan.

3.8 POST CONSTRUCTION DOCUMENTATION

3.8.1 INSTITUTIONAL CONTROLS

3.8.1.1 NOTICE IN DEED

A record (to be noticed in the deed) of the type, location and quantity of waste contained within the closed lagoons will be submitted to Montgomery County and Director of OEPA within 60 days of final cover completions of both lagoons. The deed notice will include a record of the type, location and quantity of waste. The deed notice will also document future uses of the property that are consistent with the assumptions included in the risk assessment.

3.8.1.2 SURVEY PLAT

Within 60 days of the final cover completion of both lagoons, a survey plat indicating the location and dimensions of the closed lagoons with respect to permanently surveyed benchmarks will be submitted to Montgomery County, and the Director of OEPA. This plat (part of the deed recording), will be prepared and certified by a professional land surveyor and will contain a note, prominently displayed, that states the owner's and operator's obligations to restrict disturbance of the Site.

3.8.2 CERTIFICATION OF CLOSURE

Certification of closure will be conducted at its completion by an independent, registered, professional engineer and the owner/operator. It will be incorporated into a final closure report. The report will summarize all closure activities and present documentation to show that closure was conducted in accordance with the approved Closure Plan and that the closure criteria (minimum unconfined compressive strength of 25 psi) was achieved. Certification of closure will be made within 60 days of the final cover completion of both lagoons, to the Director of OEPA by registered mail. Documentation supporting the independent, registered, professional engineer's certificate will be furnished to the Director of OEPA as follows:

1. the following certification statement, as worded in OAC 3745-50-42(d): "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the

information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.";

2. the approved Closure Plan, or reference to the approved Closure Plan;
3. the volume of waste closed in place;
4. all correspondence regarding closure activity after Ohio EPA approval of the Closure Plan;
5. details of sampling and analysis methods;
6. laboratory records;
7. a narrative describing all activities during closure;
8. details, including as-built drawings;
9. post-closure activities; and
10. the signature of the owner/operator and of a qualified, independent, registered, professional engineer licensed to practice in the State of Ohio.

4.0 OTHER FACTORS CONSIDERED FOR CLOSURE APPROACH

4.1 GENERAL

The approach to closure presented in Section 3.0 of this Closure Plan is consistent with Ohio EPA's March 1999 Closure Plan Review Guidance which states that "hazardous waste can be consolidated or treated in situ within an area of contamination without triggering land disposal restrictions or minimum technology requirements" (page 82).

The approach to closure is technically sound based on the following information.

4.2 RISK ASSESSMENT

As indicated in Section 2.3, the Baseline Risk Assessment conducted as part of the RFI and Supplemental RFI evaluated several SWMUs including the lagoons. The RFI concluded that the lagoons, as they are currently configured, do not pose an unacceptable risk to human health or the environment. This data has been included for information purposes only. GM is not pursuing a clean closure and will be conducting post-closure groundwater monitoring and care of these units.

4.3 TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) RESULTS

The TCLP results for sludge samples collected in 1988 as part of the November 3, 1989 Draft North and South Settling Lagoon Revised Closure Plans indicate that the sludge material does not exhibit any of the characteristics of a hazardous waste. It should be noted that these results date back to 1988 and some constituent levels in the sludge will have decreased over the past 11 years since these samples were collected. Tables 4.1 and 4.2 present the results of the TCLP analysis of samples of sludge material from the North and South Lagoons.

4.4 PCB RESULTS

In September 1988 Geraghty & Miller Consulting Engineers, Inc. completed sampling of the South Lagoon sludge material. Analysis of the samples of the sludge material recorded concentrations of Polychlorinated Biphenol (PCB) 1254 ranging from 1.6 to 206 milligram per kilogram (mg/kg) (dry weight), with a median concentration of

10.4 mg/kg. Only two samples from the South Lagoon (lower strata of the north side of the secondary basin) recorded PCB 1254 concentrations above the 50 mg/kg threshold limit for regulation under the Toxic Substances Control Act (TSCA). Concentrations of PCB 1260 ranged from 1.5 to 4.6 mg/kg with a median concentration of 3.0 mg/kg ("Draft South Settling Lagoon Revised Closure/Post-Closure Plan", Geraghty & Miller Consulting Engineers, Inc., November 3, 1989.)

Sampling of the North Lagoon sludge material was also conducted during the fall of 1988 by Geraghty & Miller Consulting Engineers, Inc. Analysis of the samples of the sludge material recorded one concentration of PCB 1242 of 3.1 mg/kg. Concentration of PCB 1260 ranged from 5.1 to 27.4 mg/kg with a median concentration of 7.7 mg/kg ("Draft North Settling Lagoon Revised Closure Plan", Geraghty & Miller Engineers, Inc., November 3, 1989.)

No PCBs were detected above the 50 mg/kg threshold limit for regulation under TSCA, in the sludge contained in the North Lagoon.

The finding of the baseline risk assessment revealed that PCB levels that are present in the sludge do not pose an unacceptable risk to human health or the environment. In addition, PCBs found within the sludge contained in the South Lagoon secondary basin will be solidified using CKD. Solidification of the sludge will significantly reduce the mobility of the PCBs contained in the South Lagoon secondary basin.

4.5 GROUNDWATER RESULTS

Assessment groundwater monitoring has been conducted at the North Lagoon since 1984. Detection groundwater monitoring has been conducted at the South Lagoon since 1981. The groundwater quality results indicate that the impacts, if any, attributable to the lagoons are minimal and that the source area in the vicinity of the Former Oil House (AOI-7) is the most significant contributor to groundwater contamination across the Site. The Former Oil House Area is currently being addressed under an approved Interim Measures Work Plan (ARCADIS Geraghty & Miller, Inc. June 1999).

Quarterly assessment monitoring of wells that are upgradient and downgradient of the North Settling Lagoon has been ongoing since 1984, as outlined in the Revised Groundwater Quality Assessment Plan for the Harrison Radiator North Lagoon (ARCADIS Geraghty & Miller, Inc., May 2000, contained in Appendix B). Groundwater samples are collected from the 14 upper aquifer wells and 5 lower aquifer wells shown on Figures 4.1 and 4.2, respectively. The upgradient wells include upper aquifer wells HR-4, HR-8, HR-9, HR-11 and W-1-N, and lower aquifer wells HR-10 and HR-12. The downgradient wells include upper aquifer wells W-2-N, W-3-N, W-4-N, HR-1, HR-2, HR-3, HR-5, HR-6 and HR-7, and lower aquifer wells HR-13, HR-14 and HR-15. The parameter list for North Settling Lagoon assessment monitoring was developed based on a review of the results of sludge samples collected from the lagoon during the fall of 1988. All samples are analyzed for the Appendix IX list of volatile organic compounds, pH, and specific conductance. In addition, samples from selected wells (HR-9 through HR-12, HR-14, HR-15, W-3-N, W-4-N) are analyzed for semi-volatile organic compounds, cyanide, and the 15 Appendix IX metals that were detected in the 1988 sludge samples from the lagoon. These metals include antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, tin, vanadium, and zinc. Groundwater flow conditions and contaminant migration rates are also determined on a quarterly basis.

Semi-annual detection monitoring of wells that are upgradient and downgradient of the South Settling Lagoon has been ongoing since 1981, as outlined in the Revised Groundwater Monitoring Detection Program for the Harrison Radiator South Lagoon (ARCADIS Geraghty & Miller, Inc., May 2000, contained in Appendix B). Groundwater samples are collected from five upper aquifer wells shown on Figure 4.3. The upgradient wells include upper aquifer wells HR-16 and HR-17, and the downgradient wells include upper aquifer wells W-2-S, W-3-S, and W-4-S. The parameter list for South Settling Lagoon detection monitoring was developed based on a review of the results of sludge samples collected from the lagoon during the fall of 1988. All samples are analyzed semi-annually for indicator parameters (pH, specific conductance, total organic carbon, total organic halide) and annually for groundwater quality parameters (chloride, iron, manganese, phenols, sodium, sulfate).

5.0 SCHEDULE FOR CLOSURE ACTIVITIES

The closure schedule is presented on Figure 5.1. It is anticipated that closure activities will require approximately 15 months to complete. A monthly progress report will be submitted to Ohio EPA during the time period between Ohio EPA's approval of the Closure Plan and submittal of the Closure Report and Certification. Ohio EPA will be notified a minimum of 5 days prior to the start of any critical activities.

6.0 CLOSURE AND POST-CLOSURE COST ESTIMATES

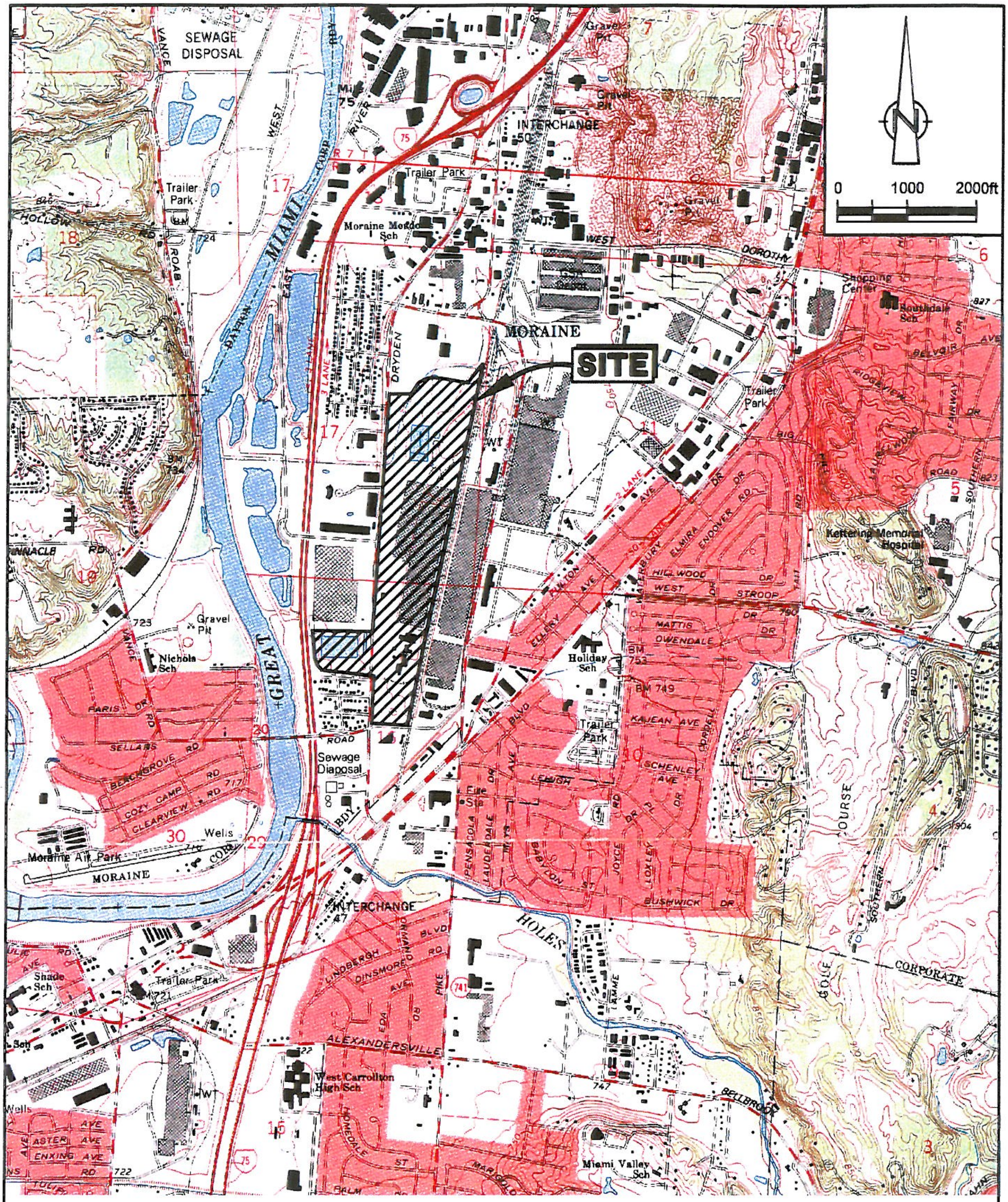
6.1 CLOSURE COST ESTIMATE

The total cost of closure is estimated as $6,152,400. A breakdown of the closure cost estimate is presented in Table 6.1. The cost of closure may vary depending on the time of year, but it has been assumed that closure activities will be completed during the appropriate construction season to minimize cost and ensure quality.

7.0 REFERENCES

1. "Description of Current Conditions", ARCADIS Geraghty & Miller, January 1991.
2. "Draft Supplemental Resource Conservation and Recovery Act Facility Investigation Report", Volume I ARCADIS Geraghty & Miller, June 1999 and Volume II ENVIRON Corporation, June 1999.
3. "Closure Plan Review Guidance for RCRA Facilities", Ohio EPA, March 1999.
4. "Draft South Settling Lagoon Revised Closure/Post-Closure Plan", Geraghty & Miller Consulting Engineers, Inc., November 3, 1989.
5. "Draft North Settling Lagoon Revised Closure Plan", Geraghty & Miller Consulting Engineers, Inc., November 3, 1989.
6. "Draft RFI Report", Volume I Geraghty & Miller, Inc. February 1996 and Volume II ENVIRON, February 1996.
7. "First Quarter Groundwater Quality Assessment, January through March 1999", ARCADIS Geraghty & Miller, Inc., July 8, 1999.
8. "Second Quarter Groundwater Quality Assessment, April through June 1999", ARCADIS Geraghty & Miller, Inc., September 28, 1999.
9. "Third Quarter Groundwater Quality Assessment, July through September 1999", ARCADIS Geraghty & Miller, Inc., January 10, 2000.
10. "Soil Pile Characterization, General Motors Corporation, Moraine, Ohio", ARCADIS Geraghty & Miller, Inc., September 24, 1999.
11. "Primary Groundwater Source Area (AOI-7), Interim Measures Work Plan", ARCADIS Geraghty & Miller, Inc., June 1999.
12. ARCADIS Geraghty & Miller, Inc. 2000. Revised Groundwater Quality Assessment Plan for the Harrison Radiator North Lagoon, Harrison Radiator Division, General Motors Corporation, Moraine, Ohio. May 2000.
13. ARCADIS Geraghty & Miller, Inc. 2000. Revised Groundwater Monitoring Detection Program for the Harrison Radiator South Lagoon, Harrison Radiator Division, General Motors Corporation, Moraine, Ohio. May 2000.

FIGURES



SOURCE: USGS QUADRANGLE MAP
DAYTON SOUTH, OHIO

figure 1.1

SITE LOCATION PLAN
HARRISON FACILITY
Moraine, Ohio

CRA

12611-00(003)GN-WA001 MAY 26/2000

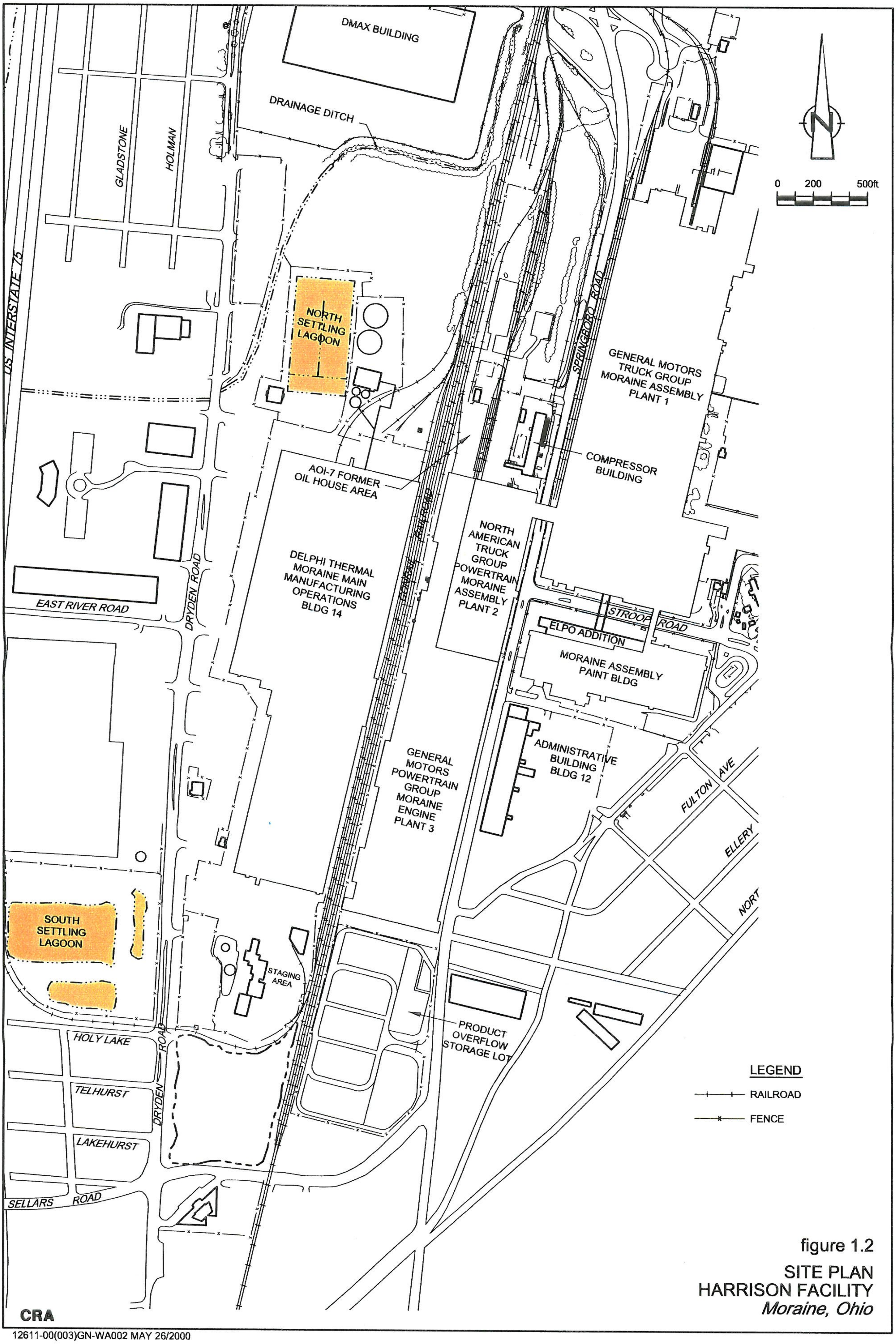
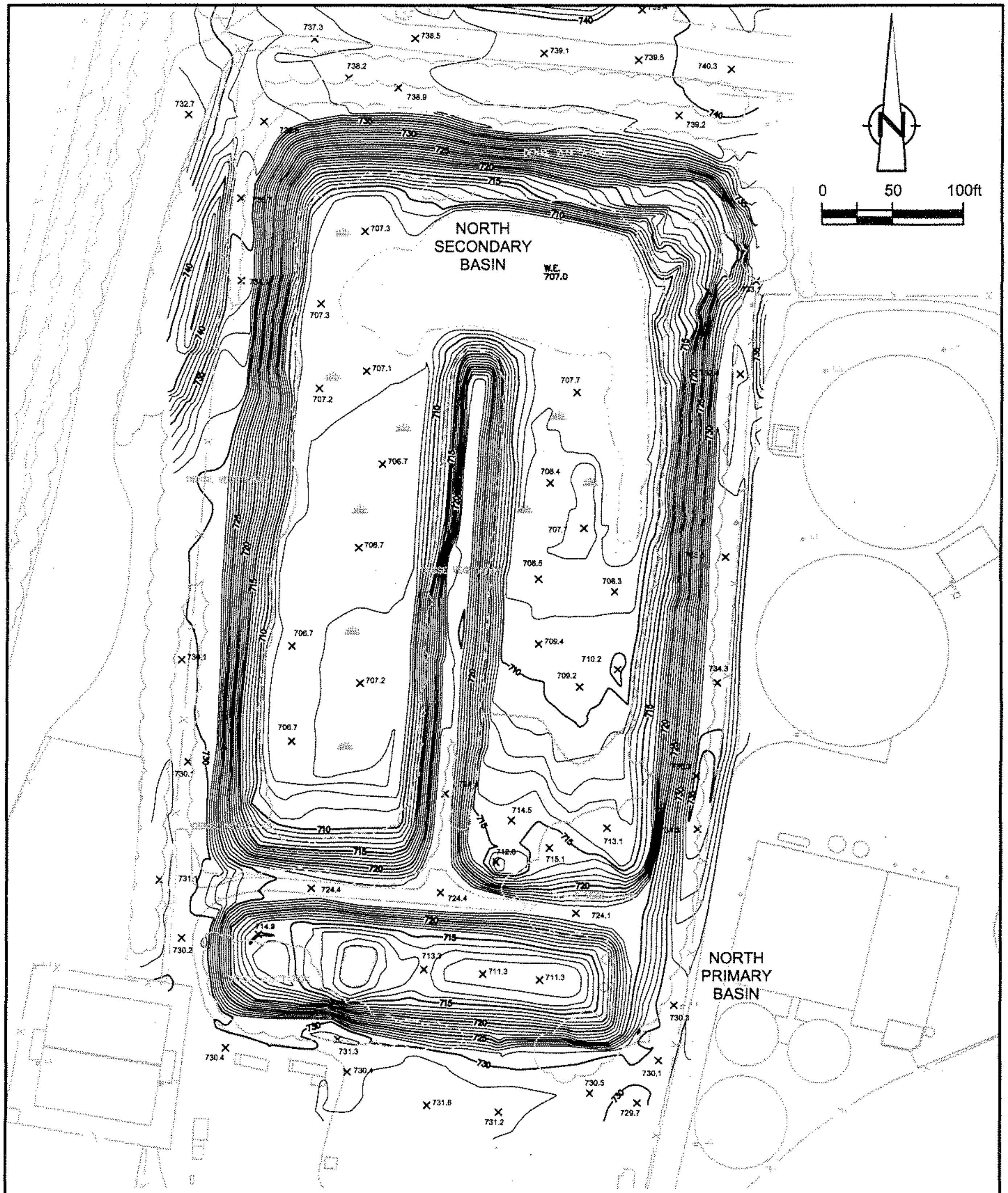


figure 1.2

SITE PLAN
HARRISON FACILITY
Moraine, Ohio

12611-00(003)GN-WA002 MAY 26/2000



LEGEND

- CONTOUR
- FENCE
- TREE LINE
- DITCH
- SWAMP
- SPOT ELEVATION

CRA

figure 2.1

NORTH SETTLING LAGOON
1999 EXISTING CONDITIONS - PLAN VIEW
HARRISON FACILITY
Moraine, Ohio

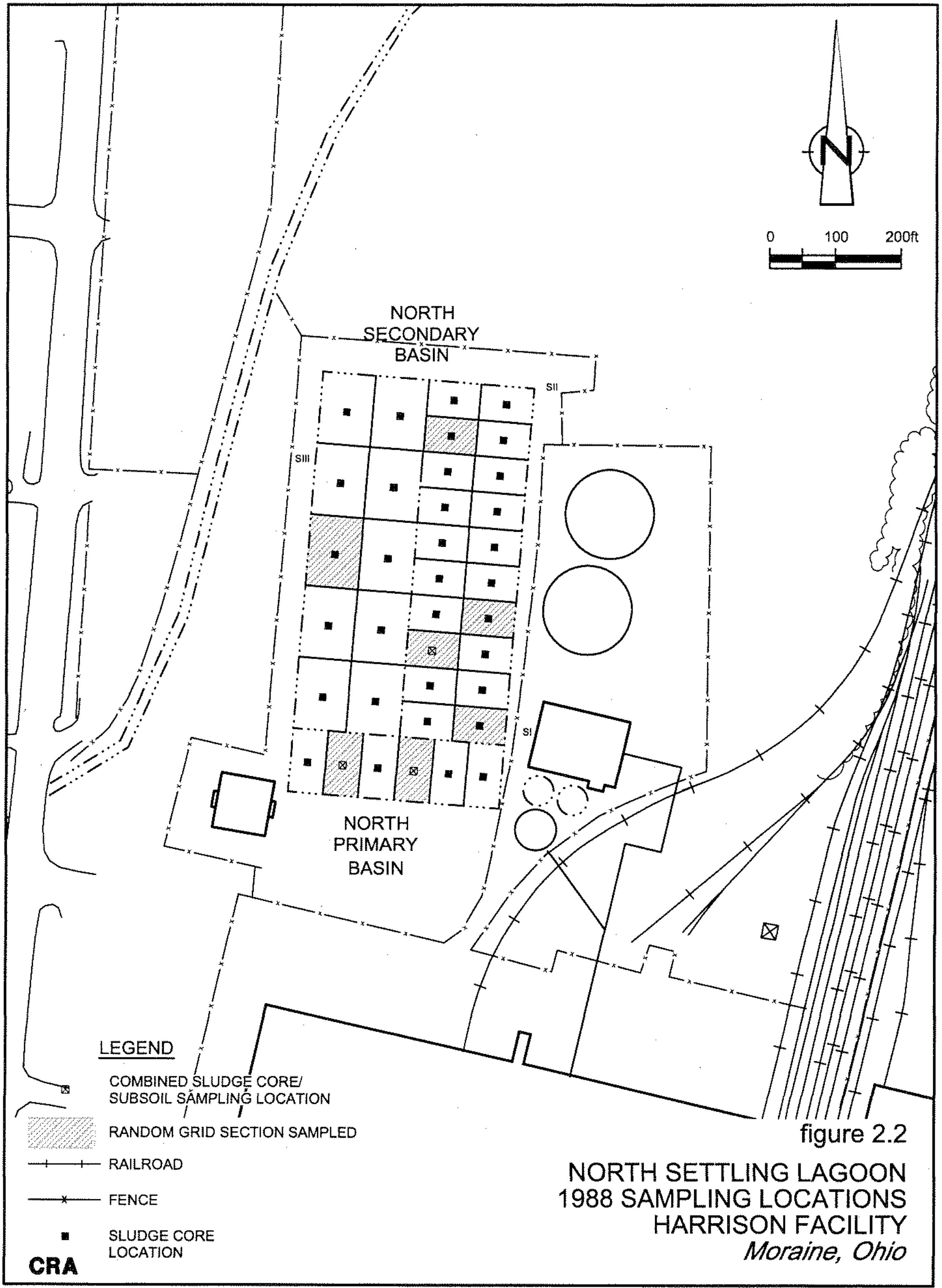


figure 2.2

NORTH SETTLING LAGOON
1988 SAMPLING LOCATIONS
HARRISON FACILITY
Moraine, Ohio

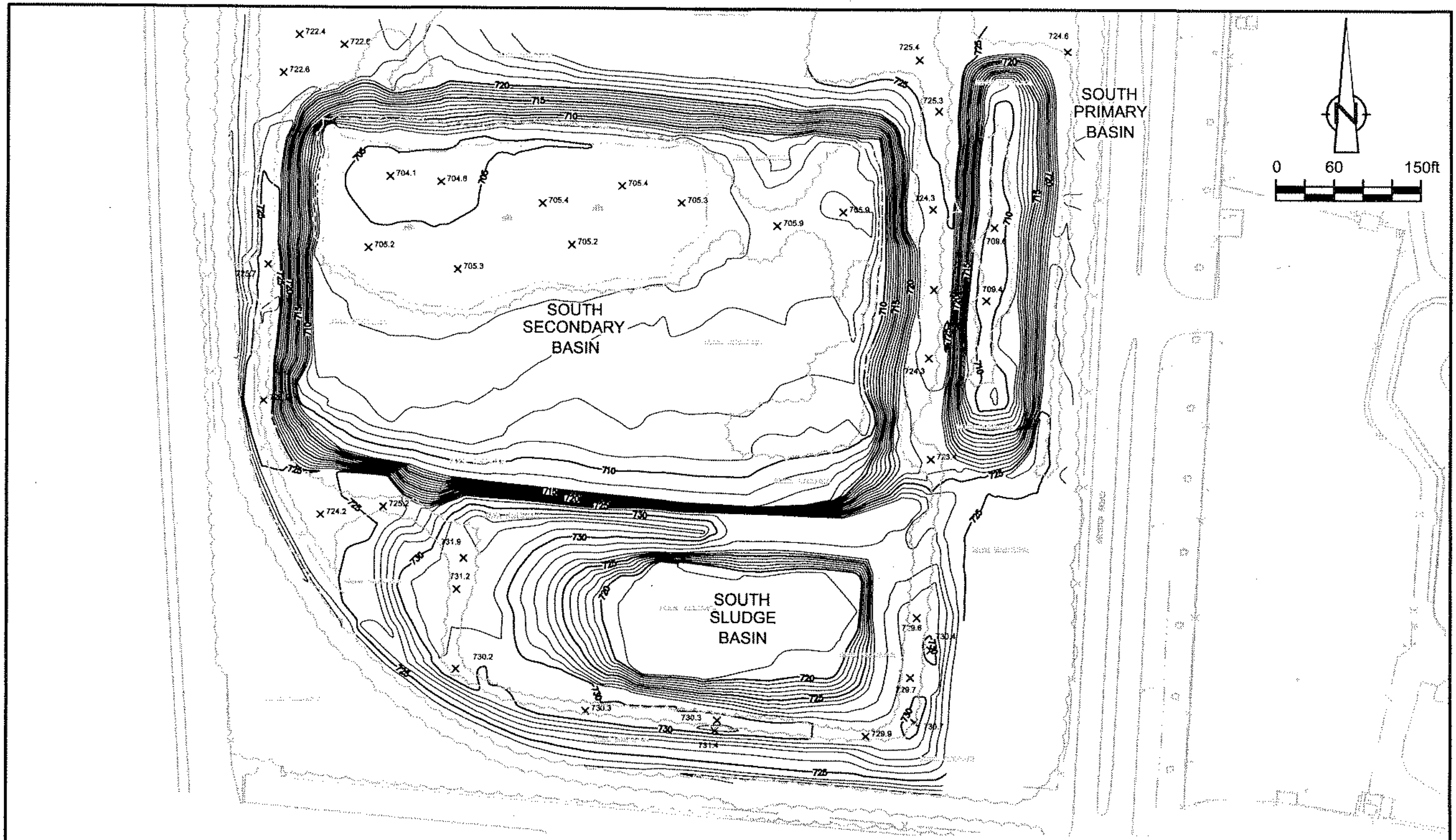
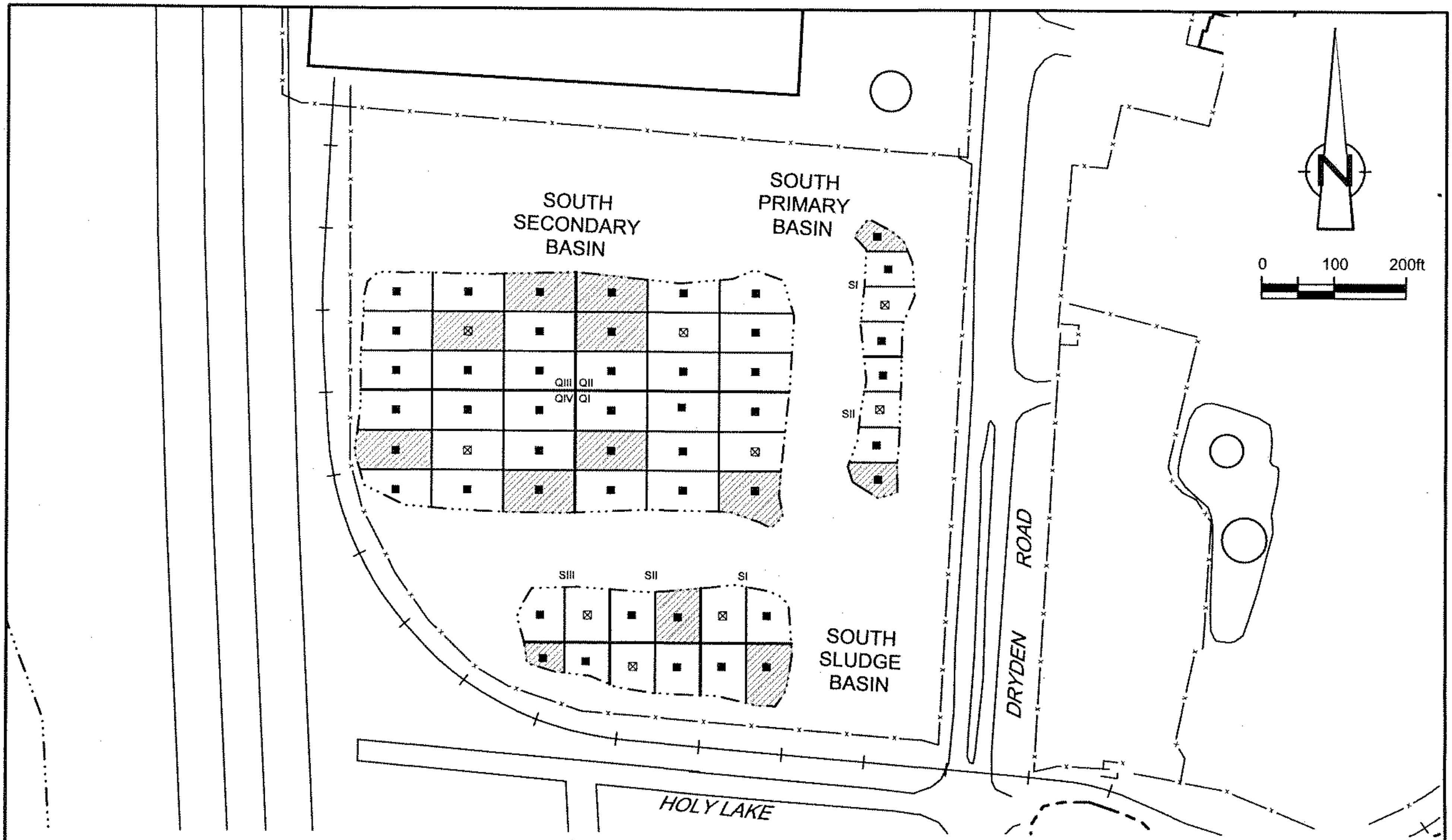


figure 2.3

SOUTH SETTLING LAGOON
1999 EXISTING CONDITIONS - PLAN VIEW
HARRISON FACILITY
Moraine, Ohio

12611-00(003)GN-WA007 MAY 26/2000



LEGEND

RAILROAD

FENCE

■ SLUDGE CORE LOCATION

☒ COMBINED SLUDGE CORE/ SUBSOIL SAMPLING LOCATION

▨ RANDOM GRID SECTION SAMPLED

CRA

figure 2.4

SOUTH SETTLING LAGOON
1988 SAMPLING LOCATIONS
HARRISON FACILITY
Moraine, Ohio

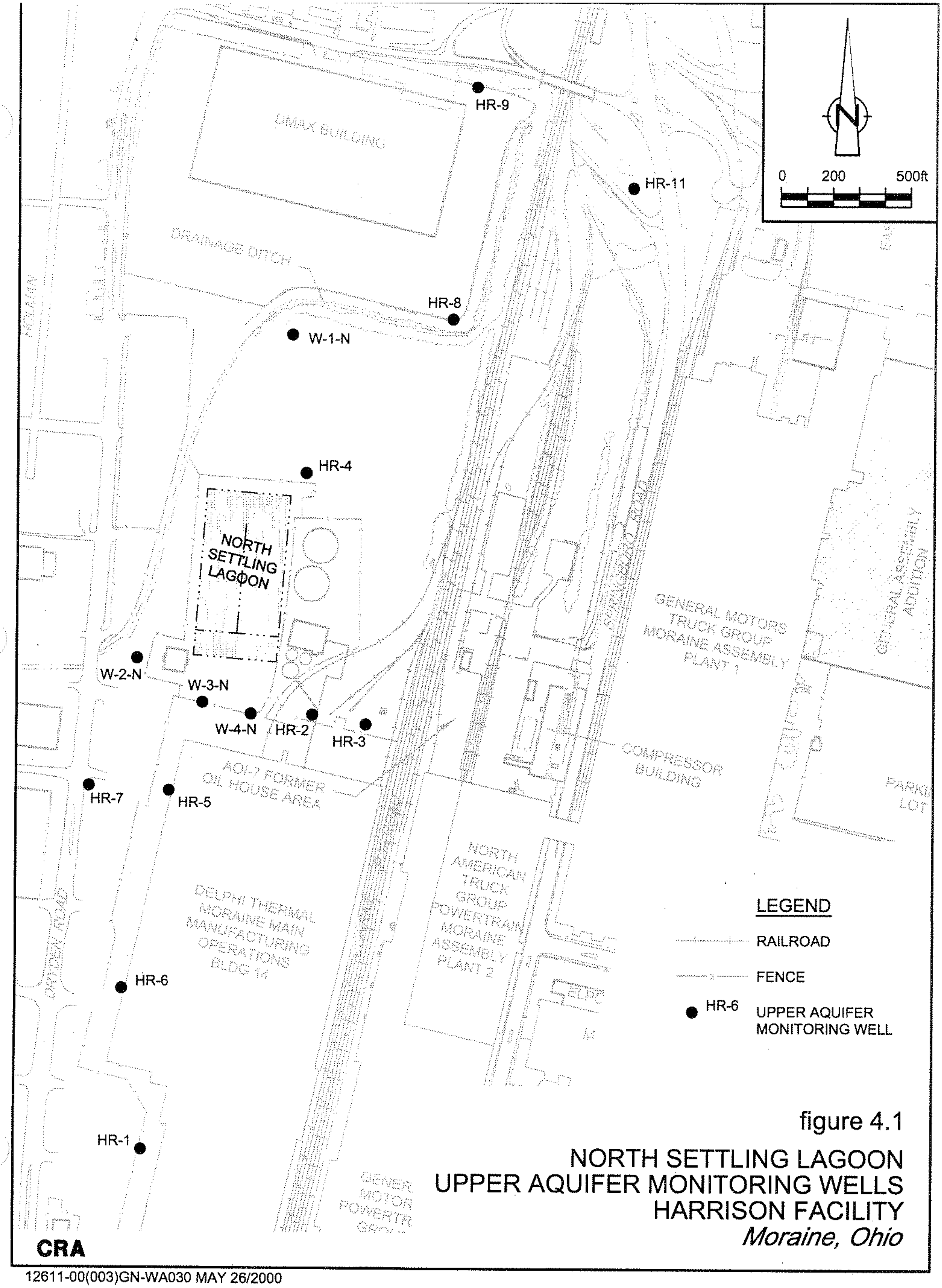


figure 4.1

NORTH SETTLING LAGOON
UPPER AQUIFER MONITORING WELLS
HARRISON FACILITY
Moraine, Ohio

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12611-00(003)GN-WA030 MAY 26/2000

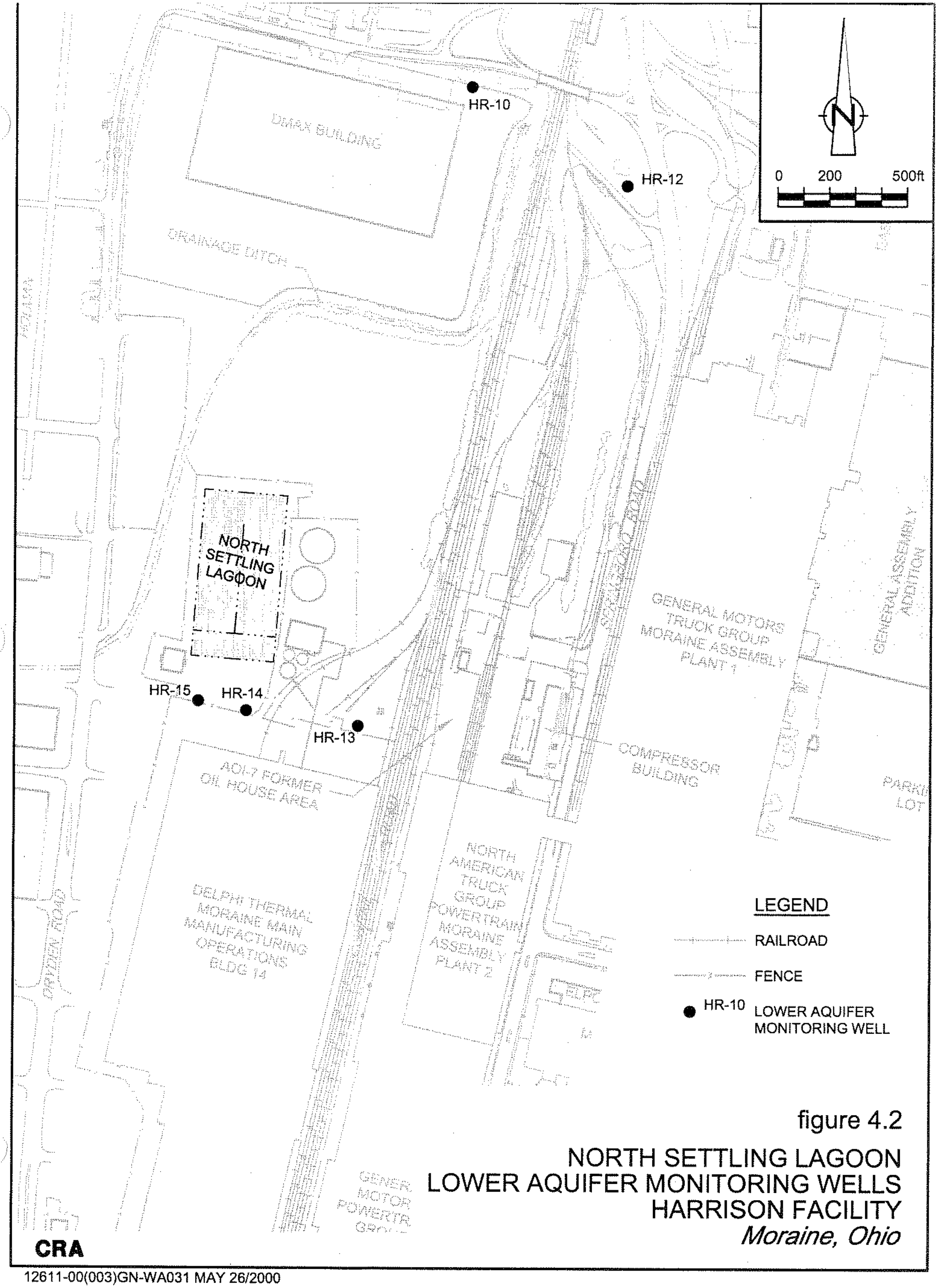


figure 4.2

NORTH SETTLING LAGOON
LOWER AQUIFER MONITORING WELLS
HARRISON FACILITY
Moraine, Ohio

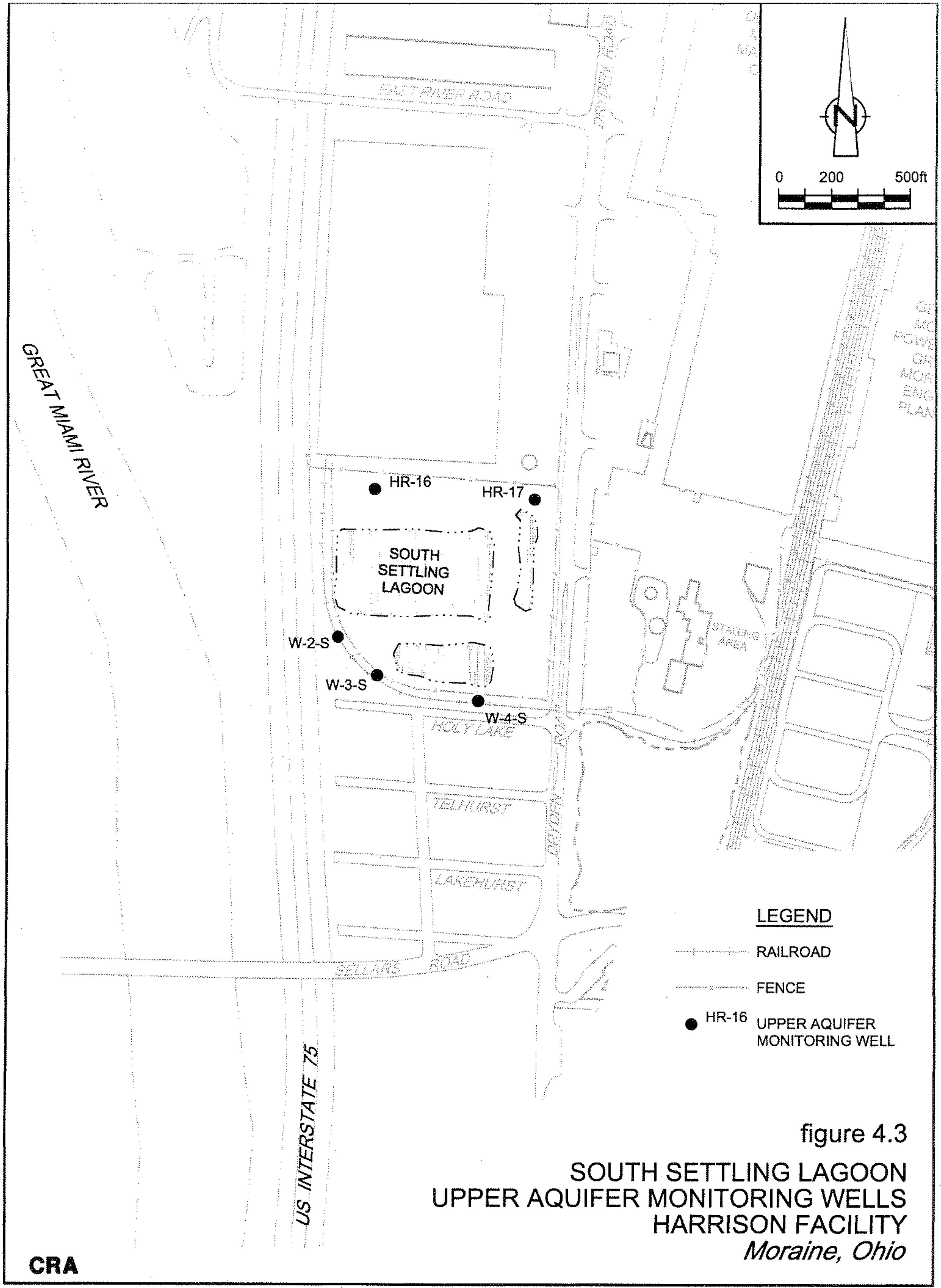
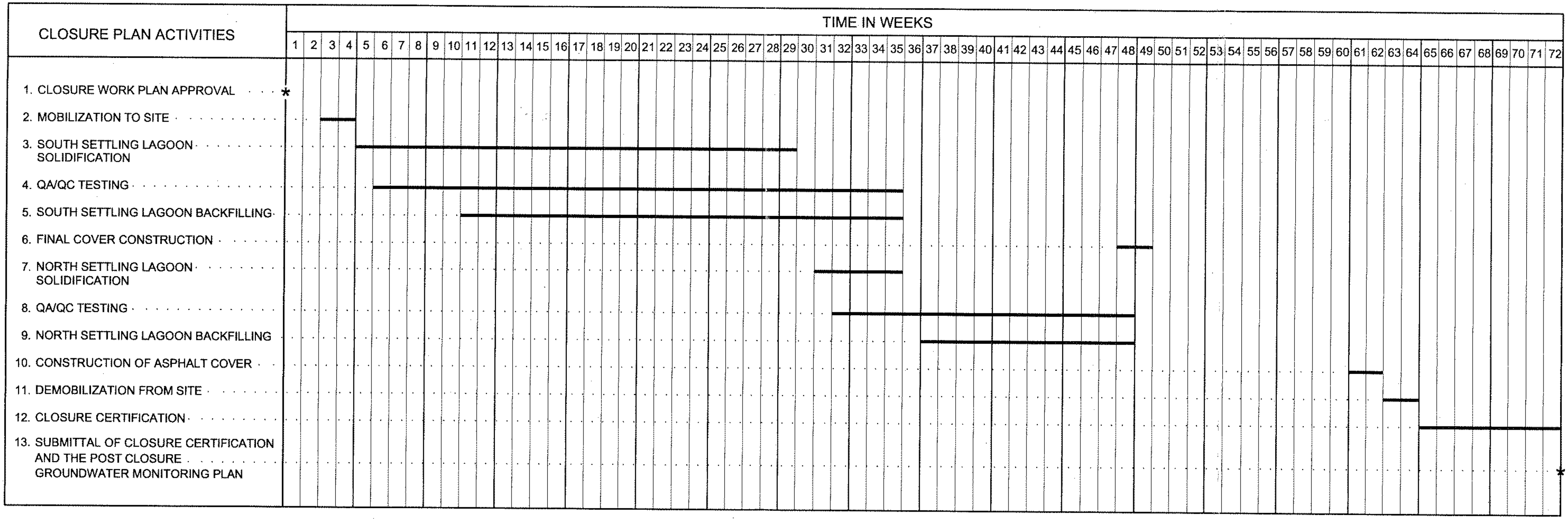


figure 4.3

SOUTH SETTLING LAGOON
UPPER AQUIFER MONITORING WELLS
HARRISON FACILITY
Moraine, Ohio

12611-00(003)GN-WA032 MAY 03/2000



NOTES: 1) SCHEDULE IS SUBJECT TO CHANGE AS CERTAIN CLOSURE ACTIVITIES CAN ONLY BE CONDUCTED DURING THE CONSTRUCTION SEASON.

2) SCHEDULE BASED UPON SOLIDIFICATION OF APPROXIMATELY 75,000 CUBIC YARDS OF SLUDGE.

3) SCHEDULE MAY BE ADJUSTED BASED ON THE TIMING OF OHIO EPA APPROVAL OF THE CLOSURE WORK PLAN (MOBILIZATION TO SITE LIMITED TO AFTER MARCH 2000).

4) LAGOON START LOCATION WILL BE DETERMINED IN THE FIELD

figure 5.1

LAGOON CLOSURE SCHEDULE
HARRISON FACILITY
Moraine, Ohio

CRA

TABLES

TABLE 2.1

SUMMARY OF 1988 SOUTH SETTLING LAGOON SLUDGE ANALYTICAL RESULTS (TOTALS)[5]

Constituent [1]	*CAS No.*	*Frequency of Detection* [2]	*Range of Detected Concentrations* [3]
Metals			
Antimony	7440-36-0	15/18	8.93 - 54.8
Arsenic	7440-38-2	18/18	8.58 - 158.0
Barium	7440-39-3	18/18	330.0 - 2550.0
Cadmium	7440-43-9	18/18	6.57 - 1430.0
Chromium	7440-47-3	18/18	244.0 - 3630.0
Cobalt	--	9/9	72.7 - 1210.0
Copper	--	18/18	54.2 - 969.0
Lead	7439-92-1	18/18	160.0 - 5970.0
Mercury	7439-97-6	18/18	0.207 - 1.87
Nickel	7440-02-0	18/18	218.0 - 3250.0
Selenium	7782-49-2	5/18	2.78 - 76.6
Silver	7440-22-4	17/18	0.492 - 1.33
Tin	--	4/9	213.0 - 741.0
Vanadium	--	5/9	19.1 - 30.7
Zinc	--	18/18	920.0 - 10501.0
Volatile Organics			
1,2-Dichlorobenzene	95-50-1	2/18	0.57 - 1.52
Ethylbenzene	--	7/18	0.153 - 3.4
Tetrachloroethene	127-18-4	2/18	2.05 - 4.7
Toulene	108-88-3	7/18	0.87 - 10.1
Trichloroethylene	79-01-6	3/18	0.55 - 6.66
Xylene	--	6/9	0.150 - 9.25
Extractable Organics			
Bis(2-ethylhexyl)Phthalate	--	4/9	17.4 - 31.2
Fluoranthene	206-44-0	5/9	6.18 - 104.0
Fluorene	--	4/9	1.6 - 18.5
2-Methylnaphthalene	--	6/9	1.2 - 9.54
Phenathrene	--	7/9	2.46 - 41.7
Pyrene	--	5/9	5.58 - 81.5
Miscellaneous			
Cyanide	--	15/18	0.615 - 5.32
PCB 1242	--	1/9	3.1
PCB 1260	--	6/9	5.1 - 27.4
Sulfide	--	9/9	110.0 - 39000.0

AVERAGE DRY WEIGHT AND OIL & GREASE CONTENTS[4]

Basin	*Dry Weight (%)*	*Oil & Grease (%)*
North Primary	43.42	8.37
North Secondary		
SE Segment	31.18	8.04
NE Segment	41.65	13.95
West Segment	29.73	4.33

Notes:

1 - Included only detected constituents from the Primary and Secondary Basins which have been grouped
2 - Calculated by number of times constituent was detected divided by number of times it was tested for
3 - Units in mg/kg (dry weight)
4 - Average values for lagoon sludges calculated from lab data for August/September 1998 sampling
5 - Sludge analytical results contained in "North Settling Lagoon Revised Closure/Post Closure Plan", Geraghty & Miller Engineers, Inc., November 3, 1989.

TABLE 2.2

SUMMARY OF 1988 SOUTH SETTLING LAGOON SLUDGE ANALYTICAL RESULTS (TOTALS)[5]

Constituent[1]	*CAS No.*	*Frequency of Detection*[2]	*Range of Detected Concentrations*[3]
Metals			
Antimony	7440-36-0	14/36	5.03 - 52.8
Arsenic	7440-38-2	36/36	3.4 - 157.0
Barium	7440-39-3	36/36	713.0 - 6740.0
Cadmium	7440-43-9	36/36	0.721 - 26.9
Chromium	7440-47-3	36/36	55.3 - 2020.0
Cobalt	--	5/6	17.8 - 222
Copper	--	36/36	37.2 - 16900.0
Lead	7439-92-1	36/36	87.1 - 398.0
Mercury	7439-97-6	34/36	0.081 - 4.03
Nickel	7440-02-0	36/36	26.3 - 1490.0
Selenium	7782-49-2	1/36	0.78
Silver	7440-22-4	34/36	0.317 - 2.45
Tin	--	1/6	28.3
Zinc	--	36/36	157.0 - 2190.0
Extractable Organics			
Bis(2-ethylhexyl)Phthalate	--	4/13	1.33 - 2.76
Di-n-butyl phthalate	--	1/13	1.99
Miscellaneous			
Cyanide	--	36/36	0.562 - 18.9
PCB 1254	--	8/13	1.6 - 206.0
PCB 1260	--	2/13	1.5 - 4.6

AVERAGE DRY WEIGHT AND OIL & GREASE CONTENTS[4]

Basin	*Dry Weight (%)*	*Oil & Grease (%)*
South Primary	30.03	6.64
South Secondary		
SE Quadrant	27.17	5.8
NE Quadrant	23.23	6.16
NW Quadrant	22.78	4.42
SW Quadrant	24.1	4.84
South Sludge	48.63	5.57

Notes:

1 - Included only detected constituents from the Primary, Secondary, and Sludge Basins which have been grouped.
2 - Calculated by number of times constituent was detected divided by number of times it was tested for.
3 - Units in mg/kg (dry weight).
4 - Average values for lagoon sludges calculated from lab data for August/September 1998 sampling
5 - Sludge analytical results contained in "South Settling Lagoon Revised Closure Plan", Geraghty & Miller Engineers, Inc., November 3, 1989.

Table 4.1
North Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			NPI-COMPL			NPI-COMPU			NSI-COMPL			NSI-COMPM			NSI-COMPU			NSII-COMPL			NSII-COMPU			NSIII-COMPU		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
VOC	1,1,1-Trichloroethane	71-55-6		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	1,1,2,2-Tetrachloroethane	79-34-5																								
VOC	1,1,2-Trichloroethane	79-00-5																								
VOC	1,1-Dichloroethene	75-35-4																								
VOC	1,2-Dichloroethane	107-06-2																								
VOC	1,2-Dichloropropane	78-87-5																								
VOC	1,3,5-Trimethylbenzene	108-67-8	0.009																							
VOC	1,3-Dichloropropene (total)	542-75-6																								
VOC	2-Butanone	78-93-3		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	2-Chloroethylvinyl ether	110-75-8																								
VOC	4-methyl-2-pentanone	108-10-1		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Acetone	67-64-1		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Acrolein	107-02-8																								
VOC	Acrylonitrile	107-13-1																								
VOC	Benzene	71-43-2																								
VOC	Bromodichloromethane	75-27-4																								
VOC	Bromoform	75-25-2																								
VOC	Bromomethane	74-83-9																								
VOC	Butanol	71-36-3		<	0.28		<	0.28		<	0.28		<	280		<	0.28		<	0.28		<	0.28		<	0.28
VOC	Carbon Disulfide	75-15-0		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Carbon Tetrachloride	56-23-5		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Chlorobenzene	108-90-7		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Chloroethane	75-00-3																								
VOC	Chloroform	67-66-3																								
VOC	Chloromethane	74-87-3																								
VOC	cis-1,2-Dichloroethene	156-59-2	0.432						0.093			0.276														
VOC	Cumene	98-82-8																								
VOC	Cyclohexanone	108-94-1		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Dibromochloromethane	124-48-1																								
VOC	Ethyl acetate	141-78-6		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Ethyl Benzene	100-41-4	0.029			0.0199			0.056			0.013				<	0.0063		<	0.0063	0.0078				<	0.0063
VOC	Ethyl ether	60-29-7		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Ethyl methacrylate	97-63-2																								
VOC	Isobutyl alcohol	78-83-1		<	0.24		<	0.24		<	0.24		<	240		<	0.28		<	0.24		<	0.24		<	0.24
VOC	Methanol	67-56-1		<	0.54		<	0.54		<	0.0063		<	540		<	0.54		<	0.54		<	0.54		<	0.54
VOC	Methyl methacrylate	80-62-6																								
VOC	Methylene Chloride	75-09-2		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Mixed alkyl benzenes		0.0623			0.0225			0.366			0.0403			0.0078			0.0084			0.026					
VOC	Styrene	100-42-5										0.01														
VOC	Tetrachloroethene	127-18-4	0.094				<	0.0063		<	0.0063	0.082				<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Toluene	108-88-3	0.334			0.0138			0.085			0.055				<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	trans-1,2-Dichloroethene	156-60-5																								
VOC	Trichloro-1,2,2-trifluoroethane	76-13-1		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Trichloroethene	79-01-6	0.434				<	0.0063		<	0.0063	0.182				<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Trichlorofluoromethane	75-69-4		<	0.0063		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Vinyl Chloride	75-01-4																								
VOC	Xylenes (total)	1330-20-7	0.063			0.0092			0.165			0.02				<	0.0063		<	0.0063		<	0.0063		<	0.0063
SVOC	1,2,4-Trichlorobenzene	120-82-1																								
SVOC	1,2-Dichlorobenzene	95-50-1	0.0043				<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003
SVOC	2,4,6-Trichlorophenol	88-06-2																								
SVOC	2,4-Dichlorophenol	120-83-2																								
SVOC	2,4-Dimethylphenol	105-67-9	0.0046						0.0044																	
SVOC	2,4-Dinitrophenol	51-28-5																								
SVOC	2,4-Dinitrotoluene	121-14-2																								

Table 4.1
North Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			NPI-COMPL			NPI-COMPU			NSI-COMPL			NSI-COMPM			NSI-COMPU			NSII-COMPL			NSII-COMPU			NSIII-COMPU		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
SVOC	2,6-Dinitrotoluene	606-20-2																								
SVOC	2-Chloronaphthalene	91-58-7																								
SVOC	2-Chlorophenol	95-57-8																								
SVOC	2-Methylnaphthalene	91-57-6	0.0038																							
SVOC	3,3'-Dichlorobenzidine	91-94-1																								
SVOC	4,6-Dinitro-2-methylphenol	534-52-1																								
SVOC	4-Bromophenyl-phenylether	101-55-3																								
SVOC	4-Chloro-3-methylphenol	59-50-7																								
SVOC	4-Chlorophenyl-phenyl ether	7005-72-3																								
SVOC	Acenaphthene	83-32-9																								
SVOC	Acenaphthylene	208-96-8																								
SVOC	Anthracene	120-12-7																								
SVOC	Benzaldehyde	100-52-7	0.0114																							
SVOC	Benzo(a)anthracene	56-55-3																								
SVOC	Benzo(a)pyrene	50-32-8																								
SVOC	Benzo(g,h,i)perylene	191-24-2																								
SVOC	Benzo(k)fluoranthene	207-08-9																								
SVOC	bis(2-Chloroethoxy)methane	111-91-1																								
SVOC	bis(2-Chloroethyl) ether	111-44-4																								
SVOC	bis(2-Ethylhexyl)phthalate	117-81-7																								
SVOC	Butylbenzylphthalate	85-68-7																								
SVOC	Chrysene	218-01-9																								
SVOC	Creslic acid		0.0327				<	0.003	0.0116			0.0436				<	0.003		<	0.003		<	0.003		<	0.003
SVOC	Di-n-butylphthalate	84-74-2																								
SVOC	Di-n-octylphthalate	117-84-0																								
SVOC	Dibenz(a,h)anthracene	53-70-3																								
SVOC	Diethylphthalate	84-66-2																								
SVOC	Dimethylphthalate	131-11-3																								
SVOC	Fluoranthene	206-44-0																								
SVOC	Fluorene	86-73-7																								
SVOC	Hexachlorobenzene	118-74-1																								
SVOC	Hexachlorobutadiene	87-68-3																								
SVOC	Hexachlorocyclopentadiene	77-47-4																								
SVOC	Hexachloroethane	67-72-1																								
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5																								
SVOC	Isophorone	78-59-1																								
SVOC	Methylphenol (total)	1319-77-3	0.0327				<	0.003	0.0116			0.0436				<	0.003		<	0.003		<	0.003		<	0.003
SVOC	N-Nitrosodimethylamine	62-75-9																								
SVOC	N-Nitrosodiphenylamine	86-30-6																								
SVOC	Naphthalene	91-20-3																								
SVOC	Nitrobenzene	98-95-3		<	0.003		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003
SVOC	Pentachlorophenol	87-86-5																								
SVOC	Phenanthrene	85-01-8																								
SVOC	Phenol	108-95-2										0.0036														
SVOC	Pyrene	129-00-0																								
SVOC	Pyridine	110-86-1		<	0.003		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003
P/PCB	4,4'-DDD	72-54-8																								
P/PCB	4,4'-DDE	72-55-9																								
P/PCB	4,4'-DDT	50-29-3																								
P/PCB	Aldrin	309-00-2																								
P/PCB	alpha-BHC	319-84-6																								
P/PCB	Aroclor-1016	12674-11-2																								
P/PCB	Aroclor-1221	11104-28-2																								
P/PCB	Aroclor-1232	11141-16-5																								

Table 4.1
North Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			NPI-COMPL			NPI-COMPU			NSI-COMPL			NSI-COMPM			NSI-COMPU			NSII-COMPL			NSII-COMPU			NSIII-COMPU		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
P/PCB	Aroclor-1242	53469-21-9																								
P/PCB	Aroclor-1248	12672-29-6																								
P/PCB	Aroclor-1254	11097-69-1																								
P/PCB	Aroclor-1260	11096-82-5																								
P/PCB	beta-BHC	319-85-7																								
P/PCB	Chlordane	57-74-9																								
P/PCB	delta-BHC	319-86-8																								
P/PCB	Dieldrin	60-57-1																								
P/PCB	Endosulfan sulfate	1031-07-8																								
P/PCB	Endrin	72-20-8																								
P/PCB	Endrin aldehyde	7421-93-4																								
P/PCB	gamma-BHC	58-89-9																								
P/PCB	Heptachlor	76-44-8																								
P/PCB	Heptachlor epoxide	1024-57-3																								
P/PCB	Toxaphene	8001-35-2																								
OTHER	1,4,6-Trimethylnaphthalene																									
OTHER	1-Methylethyl napthalene																									
OTHER	2,6-Bis(1,1dimethylethyl) -4 methyl Phenol																									
OTHER	2-Cyclohexen-1-one												0.07														
OTHER	2-Methylanthracene	613-12-7																								
OTHER	4-Methylphenanthrene																									
OTHER	6-Methyl-2-heptanone		0.0152																							
OTHER	Methyl isoamyl ketone	110-12-3							0.035			0.0263														
OTHER	Mixed aliphatics					0.0327												0.0345			0.0757					
OTHER	Mixed glycols		0.18			0.0288			0.143						0.071			0.119			0.225			0.0967		
OTHER	Oil and Grease	C-007																								
INORG	Antimony	7440-36-0		<	0.25		<	0.25		<	0.25		<	0.25		<	0.25		<	0.25		<	0.25		<	0.25
INORG	Arsenic	7440-38-2	0.024			0.028			0.013			0.022			0.016			0.02			0.008				<	0.005
INORG	Barium	7440-39-3	3.41			2.44			0.77			1.47			2.97			0.67			1.52			1.04		
INORG	Beryllium	7440-41-7																								
INORG	Cadmium	7440-43-9		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02
INORG	Chromium (total)	7440-47-3		<	0.5		<	0.5		<	0.5		<	0.5		<	0.5		<	0.5		<	0.5		<	0.5
INORG	Cobalt	7440-48-4																								
INORG	Copper	7440-50-8	0.03				<	0.025		<	0.025		<	0.025	0.029			0.037			0.055				<	0.025
INORG	Cyanide (total)	57-12-5		<	0.005		<	0.005		<	0.005		<	0.005		<	0.005		<	0.005		<	0.005		<	0.005
INORG	Lead	7439-92-1		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2		<	2		<	2		<	0.2
INORG	Mercury	7439-97-6																								
INORG	Nickel	7440-02-0	11.9			0.655			6.16			4.05			1.47			7.16			5.51			7.63		
INORG	Selenium	7782-49-2		<	0.005		<	0.005		<	0.05		<	0.05		<	0.05		<	0.05		<	0.05		<	0.05
INORG	Silver	7440-22-4		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03
INORG	Sulfide	18496-25-8																								
INORG	Thallium	7440-28-0																								
INORG	Tin	7440-31-5																								
INORG	Vanadium	7440-62-2																								
INORG	Zinc	7440-66-6	0.64			4.32			8.49			5.55			1.27			0.118			0.146			0.504		

Notes:
1. Blank cell indicates compound not analyzed for.
2. "<" indicates compound analyzed for but not detected.
3. "Limit" specifys detection limit.

Table 4.2
South Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			SPI-COMP			SPII-COMP			SSI-COMPL			SSI-COMPU			SSII-COMPL			SSII-COMPU			SSIII-COMPL			SSIII-COMPU			SSIV-COMPL			SSIV-COMPU			SSLI-COMP			SSLII-COMP			SSLIII-COMP		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
VOC	1,1,1-Trichloroethane	71-55-6		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063	0.0068				<	0.0063
VOC	1,1,2,2-Tetrachloroethane	79-34-5																																						
VOC	1,1,2-Trichloroethane	79-00-5																																						
VOC	1,1-Dichloroethene	75-35-4																																						
VOC	1,2-Dichloroethane	107-06-2																																						
VOC	1,2-Dichloropropane	78-87-5																																						
VOC	1,3-Dichloropropene (total)	542-75-6																																						
VOC	2-Butanone	78-93-3		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	2-Chloroethylvinyl ether	110-75-8																																						
VOC	4-methyl-2-pentanone	108-10-1		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Acetone	67-64-1		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063	0.012				<	0.00625		<	0.0063		<	0.0063		<	0.0063	0.0264				<	0.0063
VOC	Acrolein	107-02-8																																						
VOC	Acrylonitrile	107-13-1																																						
VOC	Benzene	71-43-2																																						
VOC	Bromodichloromethane	75-27-4																																						
VOC	Bromoform	75-25-2																																						
VOC	Bromomethane	74-83-9																																						
VOC	Butanol	71-36-3		<	0.28		<	0.28		<	280		<	0.28		<	0.28		<	0.28		<	0.28		<	0.00625		<	0.28		<	0.28		<	0.28		<	0.28		<	0.28
VOC	Carbon Disulfide	75-15-0		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Carbon Tetrachloride	56-23-5		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Chlorobenzene	108-90-7		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Chloroethane	75-00-3																																						
VOC	Chloroform	67-66-3	0.06			0.0819															0.0074			0.0593																
VOC	Chloromethane	74-87-3																																						
VOC	Cyclohexanone	108-94-1		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	6.3
VOC	Dibromochloromethane	124-48-1																																						
VOC	Ethyl acetate	141-78-6		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	6.3
VOC	Ethyl Benzene	100-41-4		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Ethyl ether	60-29-7		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	6.3
VOC	Ethyl methacrylate	97-63-2																																						
VOC	Isobutyl alcohol	78-83-1		<	0.28		<	0.24		<	240		<	0.24		<	0.24		<	0.24		<	0.24		<	0.00625		<	0.24		<	0.24		<	0.24		<	0.24		<	0.24
VOC	Methanol	67-56-1		<	0.54		<	0.54		<	540		<	0.54		<	0.54		<	0.54		<	0.54		<	0.00625		<	0.54		<	0.54		<	0.54		<	0.54		<	0.54
VOC	Methyl methacrylate	80-62-6																																						
VOC	Methylene Chloride	75-09-2		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Mixed Alkyl Benzenes														0.011																									
VOC	Tetrachloroethene	127-18-4		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Toluene	108-88-3		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	trans-1,2-Dichloroethene	156-60-5																																						
VOC	Trichloro-1,2,2-trifluoroethane	76-13-1		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		*<	0.0063		<	0.0063		<	6.3
VOC	Trichloroethene	79-01-6		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Trichlorofluoromethane	75-69-4		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
VOC	Vinyl Chloride	75-01-4																																						
VOC	Xylenes (total)	1330-20-7		<	0.0063		<	0.0063		<	6.3		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.00625		<	0.0063		<	0.0063		<	0.0063		<	0.0063		<	0.0063
SVOC	1,2,4-Trichlorobenzene	120-82-1																																						
SVOC	1,2-Dichlorobenzene	95-50-1		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003		<	0.003		<	0.0295		<	0.003		<	0.003		<	0.003		<	0.003
SVOC	1,2-Diphenylhydrazine	122-66-7																																						
SVOC	1,3-Dichlorobenzene	541-73-1																																						
SVOC	1,4-Dichlorobenzene	106-46-7																																						
SVOC	2,2'-oxybis(1-Chloropropane)	108-60-1																																						
SVOC	2,3,7,8-TCDD (Dioxin)	1745-01-6																																						
SVOC	2,4,6-Trichlorophenol	88-06-2																																						
SVOC	2,4-Dichlorophenol	120-83-2																																						
SVOC	2,4-Dimethylphenol	105-67-9																																						
SVOC	2,4-Dinitrophenol	51-28-5																																						
SVOC	2,4-Dinitrotoluene	121-14-2																																						
SVOC	2,6-Dinitrotoluene	606-20-2																																						
SVOC	2-Chloronaphthalene	91-58-7																																						
SVOC	2-Chlorophenol	95-57-8																																						
SVOC	2-Nitrophenol	88-75-5																																						
SVOC	3,3'-Dichlorobenzidine	91-94-1																																						
SVOC	4,6-Dinitro-2-methylphenol	534-52-1																																						
SVOC	4-Bromophenyl-phenylether	101-55-3																																						
SVOC	4-Chloro-3-methylphenol	59-50-7																																						
SVOC	4-Chlorophenyl-phenyl ether	7005-72-3																																						

Table 4.2
South Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			SPI-COMP			SPII-COMP			SSI-COMPL			SSI-COMPU			SSII-COMPL			SSII-COMPU			SSIII-COMPL			SSIII-COMPU			SSIV-COMPL			SSIV-COMPU			SSLI-COMP			SSLII-COMP			SSLIII-COMP		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
SVOC	4-Nitrophenol	100-02-7																																						
SVOC	Acenaphthene	83-32-9																																						
SVOC	Acenaphthylene	208-96-8																																						
SVOC	Anthracene	120-12-7																																						
SVOC	Benzaldehyde	100-52-7													0.0049																									
SVOC	Benzidine	92-87-5																																						
SVOC	Benzo(a)anthracene	56-55-3																																						
SVOC	Benzo(a)pyrene	50-32-8																																						
SVOC	Benzo(b)fluoranthene	205-99-2																																						
SVOC	Benzo(g,h,i)perylene	191-24-2																																						
SVOC	Benzo(k)fluoranthene	207-08-9																																						
SVOC	bis(2-Chloroethoxy)methane	111-91-1																																						
SVOC	bis(2-Chloroethyl) ether	111-44-4																																						
SVOC	bis(2-Ethylhexyl)phthalate	117-81-7																																						
SVOC	Butylbenzylphthalate	85-68-7																																						
SVOC	Chrysene	218-01-9																																						
SVOC	Creslic acid			<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.0295		<	0.003		<	0.003					<	0.003
SVOC	Di-n-butylphthalate	84-74-2																																						
SVOC	Di-n-octylphthalate	117-84-0																																						
SVOC	Dibenz(a,h)anthracene	53-70-3																																						
SVOC	Diethylphthalate	84-66-2																																						
SVOC	Dimethylphthalate	131-11-3																																						
SVOC	Fluoranthene	206-44-0																																						
SVOC	Fluorene	86-73-7																																						
SVOC	Hexachlorobenzene	118-74-1																																						
SVOC	Hexachlorobutadiene	87-68-3																																						
SVOC	Hexachlorocyclopentadiene	77-47-4																																						
SVOC	Hexachloroethane	67-72-1																																						
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5																																						
SVOC	Isophorone	78-59-1																																						
SVOC	Methylphenol (total)	1319-77-3		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003		<	0.003		<	0.0295		<	0.003		<	0.003		<	0.003		<	0.003
SVOC	N-Nitroso-di-n-propylamine	621-64-7																																						
SVOC	N-Nitrosodimethylamine	62-75-9																																						
SVOC	N-Nitrosodiphenylamine	86-30-6																																						
SVOC	Naphthalene	91-20-3																																						
SVOC	Nitrobenzene	98-95-3		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003		<	0.003		<	0.0295		<	0.003		<	0.003		<	0.003		<	0.003
SVOC	Pentachlorophenol	87-86-5																																						
SVOC	Phenanthrene	85-01-8																																						
SVOC	Phenol	108-95-2																																						
SVOC	Pyrene	129-00-0																																						
SVOC	Pyridine	110-86-1		<	0.003		<	0.003		<	3		<	0.003		<	0.003		<	0.003		<	0.003		<	0.003		<	0.0295		<	0.003		<	0.003		<	0.003		<	0.003
P/PCB	4,4'-DDD	72-54-8																																						
P/PCB	4,4'-DDE	72-55-9																																						
P/PCB	4,4'-DDT	50-29-3																																						
P/PCB	Aldrin	309-00-2																																						
P/PCB	alpha-BHC	319-84-6																																						
P/PCB	Aroclor-1016	12674-11-2																																						
P/PCB	Aroclor-1221	11104-28-2																																						
P/PCB	Aroclor-1232	11141-16-5																																						
P/PCB	Aroclor-1242	53469-21-9																																						
P/PCB	Aroclor-1248	12672-29-6																																						
P/PCB	Aroclor-1254	11097-69-1																																						
P/PCB	Aroclor-1260	11096-82-5																																						
P/PCB	beta-BHC	319-85-7																																						
P/PCB	Chlordane	57-74-9																																						
P/PCB	delta-BHC	319-86-8																																						
P/PCB	Dieldrin	60-57-1																																						
P/PCB	Endosulfan I	959-98-8																																						
P/PCB	Endosulfan II	33213-65-9																																						
P/PCB	Endosulfan sulfate	1031-07-8																																						
P/PCB	Endrin	72-20-8																																						
P/PCB	Endrin aldehyde	7421-93-4																																						
P/PCB	gamma-BHC	58-89-9																																						
P/PCB	Heptachlor	76-44-8																																						

Table 4.2
South Settling Lagoon TCLP (mg/L) Data
Delphi Harrison Thermal Systems, Moraine, Ohio

			SPI-COMP			SPII-COMP			SSI-COMPL			SSI-COMPU			SSII-COMPL			SSII-COMPU			SSIII-COMPL			SSIII-COMPU			SSIV-COMPL			SSIV-COMPU			SSLI-COMP			SSLII-COMP			SSLIII-COMP		
Chem Group	Chemical Name	CASRN	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit	Result		Limit
P/PCB	Heptachlor epoxide	1024-57-3																																							
P/PCB	Toxaphene	8001-35-2																																							
OTHER	Cresylic acid																																				<	0.003			
OTHER	Mixed Alkanes																																								
OTHER	Oil and Grease	C-007																																							
INORG	Antimony	7440-36-0	0.042			0.032				<	0.25		<	0.25		<	0.25		<	0.25	0.097				<	0.025	0.034			0.063				<	0.25		<	0.25		<	0.25
INORG	Arsenic	7440-38-2	0.009			0.014			0.051			0.029			0.092			0.037			0.07			0.036			0.057				<	0.005	0.006			0.006			0.005		
INORG	Barium	7440-39-3		<	2		<	2	2.18			1.27			2.92			1.22				<	2		<	2	1.16			0.829			0.694			0.657			0.813		
INORG	Beryllium	7440-41-7																																							
INORG	Cadmium	7440-43-9		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02		<	0.02
INORG	Chromium (total)	7440-47-3		<	0.5		<	0.5		<	0.05		<	0.05		<	0.5		<	0.5		<	0.5		<	0.05		<	0.5		<	0.5		<	0.5		<	0.5		<	0.5
INORG	Cobalt	7440-48-4																																							
INORG	Copper	7440-50-8	0.044			0.087			0.029			0.067			0.034			0.05			0.04			0.088			0.203			0.109			0.091			0.105			0.136		
INORG	Cyanide (total)	57-12-5		<	0.005		<	0.005		<	0.005		<	0.005	0.007				<	0.005		<	0.005	0.009				<	0.005		<	0.005		<	0.005		<	0.005		<	0.005
INORG	Lead	7439-92-1		<	0.2		<	0.2		<	0.2		<	2		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2		<	0.2
INORG	Mercury	7439-97-6																																							
INORG	Nickel	7440-02-0	0.238				<	0.05	2.05			1.29			2.03			1.67			2.04			1.72			2.46			3.16			0.166			0.097			0.233		
INORG	Selenium	7782-49-2		<	0.005		<	0.005		<	0.0025		<	0.0025		<	0.0025		<	0.0025		<	0.005		<	0.005		<	0.0025		<	0.0025		<	0.005	0.005				<	0.005
INORG	Silver	7440-22-4		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03		<	0.03
INORG	Sulfide	18496-25-8																																							
INORG	Thallium	7440-28-0																																							
INORG	Tin	7440-31-5																																							
INORG	Vanadium	7440-62-2																																							
INORG	Zinc	7440-66-6	0.398			0.711			0.334			0.665			0.454			0.378			0.428			0.303			0.837			0.233			0.157			0.531			0.521		

Notes:
1. Blank cell indicates compound not analyzed for.
2. "<" indicates compound analyzed for but not detected.
3. "Limit" specifys detection limit.

TABLE 6.1

CLOSURE COST ESTIMATE
HARRISON FACILITY, MORAINE, OHIO

Activity	*Unit*	*Estimated Quantity*	*Unit Cost*	*Total Cost*
Direct Capital Costs				
Off-Site Disposal of Debris	L.S.	--	--	$ 25,000
Removal and demolition of structures, grouting of pipes	L.S.	--	--	$ 75,000
Solidification of lagoons with existing soil pile	cubic yard	72,400	$35	$ 2,534,000
Backfilling lagoons with existing soil pile	cubic yard	330,000	$5	$ 1,650,000
Vegetated soil cover (South Lagoon)	acre	9	$27,000	$ 243,000
Asphalt pavement (North Lagoon)	acre	6	$100,000	$ 600,000
Subtotal - Direct Capital Costs				$ 5,127,000
Indirect Capital Costs				
Oversight (5%)				$ 256,350
Contingency (15%)				$ 769,050
Subtotal - Indirect Capital Costs				$ 1,025,400
Total Capital Costs				**$ 6,152,400**

APPENDIX A

GM LETTER TO OHIO ATTORNEY GENERAL, DATED FEBRUARY 8, 2000

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February 8, 2000

Bryan F. Zima, Esq.
Lauren Angell, Esq.
Ohio Attorney General
Environmental Enforcement
30 East Broad Street, 25th Floor
Columbus, OH 43215-3428

Re: Settlement Discussions in the Matter of General Motors Corporation
Harrison Radiator Division, Applicant; Case No. 88-HW-030
Correction to Letter of February 1, 2000
Our File No. 43450

Dear Bryan and Lauren:

On February 1, 2000, I mailed you an outline which, as stated in my letter, was developed jointly between the technical representatives of General Motors and Ohio EPA in order to reach a resolution of the closure plan issues surrounding the Harrison Radiator lagoons. I regret to inform you that the enclosure to my February 1, 2000, letter was incorrect. Accordingly, I am enclosing a new, slightly modified version outlining what General Motors believes to be the agreed upon approach to closure of these lagoons. I apologize in advance for the confusion, but I do not believe the enclosed outline materially changes things.

As indicated in my February 1 letter, I believe we should arrange a final meeting with technical and legal representatives to further refine the details of any closure activities and a final approach to resolution of the current cases, as well as the closure issues. Please contact me at your convenience to arrange such a meeting. In the meantime, thank you in advance for your attention to this matter.

Very truly yours,

Louis E. Tosi

LET:rlb
Enclosure

cc: L. Romeo
J. Caufield
P. Lewis

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General Technical Approach for Closure
North and South Lagoons
General Motors Facilities
Moraine, Ohio

On August 11, 1999, a meeting was held between Ohio Environmental Protection Agency (EPA) and General Motors Corporation (GMC) to facilitate the closure process of the North and South Lagoons at the GMC facilities located in Moraine, Ohio. The following presents the technical approach for closure which was agreed to by both Ohio EPA and GMC during this meeting.

GMC will begin clearing activities on the lagoons to begin pre-closure sampling. This sampling will include sample collection for various physical analyses to determine the current geotechnical properties of the sludge. Upon completion of the initial phase of sampling, a Closure Work Plan will be assembled to document the lagoon closure approach under Ohio Administrative Code (OAC) on closures and other Ohio EPA authorities and to provide supportive background information on how this approach will be protective of human health and the environment. This background information will include data generated from both the Supplemental Baseline Risk Assessment from the recently completed Supplemental RCRA Facility Investigation (RFI) Report for the Corrective Action Program and ongoing activities related to the preparation of the De-listing Petition for the sludge. It is anticipated that this Closure Work Plan will be available for submittal to Ohio EPA prior to March 1, 2000.

The closure approach will involve the in-situ solidification of the sludge remaining in the lagoons. Performance criteria will be based on physical strength parameters. The degree of solidification will be based on the strength required to ensure that future potential industrial development over the former lagoons would be possible. Bench scale testing will be performed on sludge from those areas of the lagoons that are determined to require solidification as well as to determine the appropriate mixture agents and amounts.

After in-situ solidification of the sludge, the remaining depression will be filled with appropriate compacted backfill that will include soils from both on-site and off-site sources. Soils used for backfill will be physically and chemically characterized prior to use.

Upon completion of backfilling activities, a vegatative cover will be constructed over the lagoons. The cover may include up to 12" of clay with 6" of overlying topsoil or asphalt cover and will be graded in such manner as to reduce infiltration of rain water and encourage run-off.

Post-closure activities will be addressed under the Corrective Action Program. After closure of the lagoons, GMC will enact certain deed restrictions that will ensure that the lagoons are only used in a manner consistent with the assumptions in the baseline risk assessment. Additionally, a site-wide groundwater monitoring program will be implemented under the Corrective Action Program to more appropriately monitor site-wide groundwater conditions. This site-wide program will replace the existing RCRA groundwater monitoring that is currently being conducted at the lagoons.

APPENDIX B

REVISED GROUNDWATER MONITORING DETECTION PROGRAM FOR THE HARRISON RADIATOR SOUTH LAGOON AND REVISED GROUNDWATER QUALITY ASSESSMENT PLAN FOR THE HARRISON RADIATOR NORTH LAGOON

ARCADIS GERAGHTY & MILLER

Revised Groundwater Quality Assessment Plan for the North Settling Lagoon

General Motors Corporation
Moraine, Ohio
June 1989
April 1996 CME Modifications
Compiled May 2000

PREPARED FOR

REALM

Introduction

In response to a Consent Decree between Ohio EPA and the Harrison Radiator Division of General Motors, Harrison is submitting this revised groundwater quality assessment plan for the North Lagoon of its Moraine, Ohio facility. The first draft was submitted on December 20, 1988, which was within the required 60 days after the effective date of the decree, October 26, 1988. Written comments on the plan were received from the agency on March 3, 1989. Subsequent discussions with the agency in early May 1989 resulted in several revisions to the Ohio EPA comments. These comments were incorporated into the plan and a final version was submitted to the Ohio EPA in June 1989. In addition, the June 1989 plan met the information requirements contained in O.A.C. 3745-65-93 (D) (2) and (3). The Ohio EPA conducted a Comprehensive Groundwater Monitoring Evaluation (CME) on August 28 and 30, 1995 to evaluate the lagoon monitoring program. As a result of the CME, Ohio EPA had additional comments on the June 1989 version of this sampling plan. Harrison responded to these comments in correspondence dated April 1, 1996. Correspondence submitted to Ohio EPA from ARCADIS Geraghty & Miller, dated March 17, 1999, requested an update to the volatile organic compound analytical method for the assessment monitoring program. The May 2000 version of this plan represents a compilation of the June 1989 plan, the April 1996 responses to CME comments CME, and the updated groundwater analytical methods.

As specified by the state regulations, this groundwater quality assessment plan is to be certified by a qualified geologist or geological engineer, and specify the following: 1) the number, location, and depth of wells; 2) sampling and analytical methods for those hazardous wastes or hazardous waste constituents in the facility; 3) evaluation procedures, including any use of previously gathered groundwater information; and 4) a schedule of implementation. Specific requirements of the Consent Decree for the North Lagoon assessment include the installation of two groundwater monitor wells directly down gradient of the North Lagoon at a depth that will allow for sampling of the lower aquifer groundwater.

General Site Conditions

The North Lagoon is located at the north end of the Harrison plant, and is bounded to the south by plant buildings, to the east by Penn Central railroad tracks, to the west by Dryden Road, and to the north and northeast by an inactive waste disposal site. The North Lagoon was constructed in 1972 and is actually comprised of two lagoons separated by earthen dikes. The total area of the North Lagoon is approximately three acres.

The following sections provide a summary of the site hydrogeology, based on data collected over the past 10 years, as presented in the Description of Current Conditions (DOCC) (Geraghty & Miller, Inc. 1991) and the Draft Resource Conservation and Recovery Act Facility Investigation (RFI) Final Report (Geraghty & Miller, Inc. 1996).

Hydrogeologic Units

The Delphi Thermal site lies over the Great Miami River buried valley aquifer, which consists of valley fill deposits composed of sand and gravel outwash separated by locally discontinuous silt and clay units, frequently referred to as till zones. Beneath the facility, these glacial deposits have been divided into the following hydrogeologic units: the upper sand and gravel unit, the till zone, and the lower sand and gravel unit. Plates 2 and 3 in the DOCC (Geraghty & Miller, Inc. 1991) illustrate generalized cross sections of these three geologic units. Boring logs indicated a large amount of variability in the lithology within each of the three units; however, this lithologic variability within units was generalized in the cross sections. Ordovician shales and limestones of the Richmond Group comprise the dominant bedrock units forming the valleys in the Dayton area. The Richmond Group is overlain by the Silurian Brassfield Limestone in upland areas. The bedrock units are not considered important sources of groundwater because their transmissivity values are lower than those of the buried valley aquifer.

The upper sand and gravel unit is generally 30 to 70 feet thick and contains minor till lenses. This unit is considered a water-table aquifer with saturated thicknesses ranging from 10 to 40 feet. Based on a review of water well logs at the Ohio Department of Natural Resources, there are no known users of groundwater from this upper water-table aquifer in the immediate vicinity of the Delphi Thermal site.

The till zone has a varied thickness and continuity, but appears to be discernable throughout the region; it ranges from being absent to in excess of 50 feet thick beneath the Delphi Thermal site. An isopach map of the till is presented in the Draft RFI Final Report. The thickest portion of the till is centered to the east of the Delphi Thermal facility.

Although the till deposit constitutes a relatively small portion of the valley fill deposits, it is a major hydrologic factor because it can retard recharge to the lower sand and gravel unit. These glacial till deposits are, therefore, referred to as an aquitard. Clay and silt tills have a very low permeability (10^{-7} centimeters per second [cm/sec] or less), a very high unit weight (on the order of 140 pounds per cubic feet [pcf]), and a very low void ratio, yielding a porosity of less than 20 percent (Norris and Spieker 1966). Low porosities result in the transmission of very little water through such a unit. Therefore, the till layers divide the sand and gravel deposits into two or more aquifers. Recharge from the upper aquifer to the lower aquifer can be relatively rapid where the till layer is absent, but regionally the till layer provides an effective barrier causing the lower aquifer to be semi-confined.

The till zone overlies at least 50 to 100 feet of sand and gravel that comprise the lower unit. The lower unit is a fully saturated semi-confined aquifer throughout most of the Dayton area; however, there are locations where the till is thin or discontinuous. In areas where the till is absent, the upper and lower aquifers respond as one hydrogeologic unit. Consequently, aquifer parameters vary with the thickness and distribution of the till layer.

Water Levels and Hydraulic Gradient

Water level measurements indicate that the direction of groundwater flow in both aquifers at the site is generally from north to south, with a westerly bend at the southern portion of the site. This bend in the flow pattern corresponds to the trend of the buried bedrock valley.

Historically, pumping water from the lower aquifer has also influenced the flow regime substantially. When supply wells were active in the lower aquifer, as they were prior to 1986, potentiometric elevations were lowered and a vertical gradient from the upper to lower aquifer was created. Sustained pumping had the effect of lowering water levels in both aquifers because the upper aquifer recharges the lower aquifer through the semi-confining till zone. As municipal and industrial pumping slowed in 1986, water levels began to rise in both aquifers. In response to this termination of pumping in the county well field and at the Delphi Thermal site, water levels in both the upper and lower aquifers have risen. Hydrograph records for shallow wells at Delphi Thermal indicate a rise in the shallow aquifer of approximately 10 feet between 1986 and late 1989 when water levels stabilized. Historic water-level data from the deep aquifer (limited to post September 1988 water levels) for Monitor Wells HR-10, HR-12, HR-13, HR-14, and HR-15 indicate a 5-foot rise in the water levels in the deep aquifer between September 1988 and late 1989. Because of the higher water levels in the last few years, there is very little difference between the water-level elevations in the upper aquifer and the potentiometric surface in the lower aquifer. Additionally, the decrease in groundwater pumping at and near the facility has resulted in a decrease in the hydraulic gradient.

Horizontal hydraulic gradients were approximately 0.0017 feet per foot (ft/ft) in both aquifers in 1986 (Geraghty & Miller, Inc. 1991), 0.0005 ft/ft in both aquifers in 1989, and 0.0008 ft/ft in the shallow aquifer and 0.001 ft/ft in the deep aquifer by October 1994. The 1986 hydraulic gradients show the significant influence that industrial and municipal pumping had on the shallow and deep aquifers. In 1989, when pumping at the Delphi Thermal facility and the Dryden Road North Well Field had been curtailed, it can be seen that the natural hydraulic gradient for both aquifers was much lower than under pumping conditions. Finally, the increase in hydraulic gradients in 1994 represents the influence of Montgomery County pumping one well in the Dryden North Well Field (DN-13) as part of their Pump-to-Waste Program.

The gradients, in each instance, vary across the site to reflect local variations in hydraulic characteristics and hydraulic stresses. The thinning of the shallow aquifer in the central portion of the Delphi Thermal facility, beneath the main manufacturing building, causes a decrease in the hydraulic transmissivity resulting in a local steepening of the hydraulic gradient. The gradient flattens out south of the building, then increases again close to DN-13, which is in operation. Using the 1994 quarterly monitoring data from the Eleventh Annual Groundwater Quality Assessment Report (Geraghty & Miller, Inc. 1995), the annual average site-wide gradient for the shallow aquifer was reported as 0.0008 ft/ft. The gradient from HR-9, near Northlawn Avenue, to the north of the Delphi Thermal manufacturing building was 0.0006 ft/ft. The gradients increased to approximately 0.0008 ft/ft at the central area of the site and decreased to approximately 0.0007 ft/ft at the south end of the site. Gradients varied locally, ranging from 0.0009 ft/ft to 0.009 ft/ft.

The hydraulic gradients in the deep aquifer displayed less variability over the site, except near DN-13 where gradients were influenced by pumping. Gradients observed were approximately 0.0007 ft/ft at the northern portion of the site, 0.0008 ft/ft in the central to southern portion of the site, and approximately 0.002 ft/ft near DN-13 in the deep aquifer.

Hydraulic Conductivities

To determine the hydraulic characteristics of the water-table (upper) aquifer, the lower aquifer, and the till zone in the vicinity of the Delphi Thermal site, Geraghty & Miller analyzed time-drawdown data collected during three pumping tests (Geraghty & Miller, Inc. 1990). The data were analyzed using AQTESOLV, an aquifer-test analysis software package (Duffield and Rumbaugh 1989). Upper aquifer tests were performed in June 1985 and August 1989, at the southern end of the North Settling Lagoon (Test Well 1), and south of Landfill L-1 (Test Well 2), respectively. The deep aquifer test was performed just north of Landfill L-1 (Production Well 45) in November 1989.

The median-hydraulic conductivity determined from the upper aquifer tests is 1,756 feet per day (ft/day), which is greater than published values for the upper aquifer in the Great Miami River Valley (Geraghty & Miller, Inc. 1990). This hydraulic conductivity value suggests the presence of a highly localized permeable feature, such as a river point-bar deposit. Point-bar deposits consist of river-washed sediments that generally have high hydraulic conductivities.

The median specific yield determined from the upper aquifer tests is 7.0 x 10^{-2}. Water-table aquifers typically have specific yields of 0.10 to 0.20 (Kruseman and de Ridder 1983). The drawdown response recorded in Well W-3-N may suggest a localized, semi-confined aquifer setting in the upper aquifer. However, the median value for storage determined from the upper aquifer test of 1.1 x 10^{-2} is well above the range for semi-confined aquifers of 1 x 10^{-4} to 1 x 10^{-6} given by Kruseman and de Ridder (1983), suggesting that the upper aquifer in the vicinity of the Delphi Thermal site responds as a water-table aquifer with localized semi-confined characteristics.

The lower aquifer test data were analyzed both for the pumping period and the recovery period after pumping. Therefore, in addition to a spatial comparison, hydraulic parameters were estimated by different methods of analyses and compared again. The median hydraulic conductivity calculated from all of the lower aquifer test analyses is 349 ft/day. This value is within the 125 to 400 ft/day range reported by Norris and Spieker (1966) for the Dayton area. The minimum and maximum estimated hydraulic conductivity values of 262 ft/day and 463 ft/day were estimated at Well GM-19D and Well 45, respectively. The values of the hydraulic parameters estimated by the drawdown data correlate very well with those estimated from the recovery data, and both sets of parameter values are consistent with published values for the Great Miami River Valley.

The aquifer storage values determined from the lower aquifer test indicate a semi-confined aquifer. The median value of storage is 6.65 x 10^{-4}. Kruseman and de Ridder (1983) describe confined aquifers as having a storage coefficient of 1 x 10^{-4} to 1 x 10^{-6} and unconfined aquifer storage (specific yield) values of 0.10 to 0.20. Therefore, the median value estimated from the lower aquifer test data is at the upper limits of the range of values for a confined aquifer and is consistent with the values expected for a semi-confined aquifer. The storage values determined from the lower aquifer test are consistent with values listed in studies conducted in the Dayton area (Norris and Spieker 1966; Fidler 1975; Dover 1961). In addition, the median storage values are characteristic of those values obtained for a semi-confined aquifer.

Previous Quarterly Assessments

Water-level measurements and groundwater samples have been collected on a quarterly basis from thirteen shallow monitor wells near the North Lagoon since July 1983. Beginning in December 1987, water levels have also been collected quarterly from eleven additional shallow monitor wells on or near the Harrison plant in order to refine the direction of shallow groundwater flow across the entire Harrison property. To assess groundwater flow direction in the lower aquifer, water-level measurements have been collected quarterly since December 1987 from numerous monitor and production wells completed in the lower aquifer.

During August and September of 1988, G&M installed five (two shallow, three deep) additional monitor wells at the Harrison facility. These wells will provide information on up gradient flow conditions and water quality which will be used to assess background contamination not associated with Harrison activities, as well as data regarding flow and quality of the lower aquifer. Beginning in September 1988, these wells are monitored on a quarterly basis. In addition, a modified analytical plan was implemented during the third quarter of 1988. Details of the field program and revised analytical plan are provided in the third quarter 1988 groundwater quality assessment report for the Harrison Radiator North Lagoon.

Assessment Plan

Number and Location of New Wells, O.A.C. 3745-65-93 (D) (3) (a)

As specified in the Consent Decree between Ohio EPA and Harrison Radiator, two groundwater monitor wells were installed directly down gradient of the North Lagoon, at the locations shown on Figure 1. These new wells were screened in the lower aquifer and provide information on flow and quality of the lower aquifer directly downgradient of the North Lagoon.

Each deep borehole was drilled using the cable-tool method under the direct supervision of a G&M hydrogeologist. The deep boreholes were drilled adjacent to existing shallow monitor wells (W-3-N, W-4-N) to form shallow/deep clusters. Each deep borehole was advanced by driving sections of 10-inch ID steel casing into the ground and seating it into the clay-confining unit, where present. The sediments inside the casing were removed using a steel bailer fitted with a check valve. Once the 10-inch casing is driven into the clay formation, the borehole was advanced by driving 8-inch ID sections of steel casing through the inside of the 10-inch casing. The borehole was continued until 15 feet of lower aquifer sediments were encountered. The new monitor wells were installed approximately 88 to 98 feet deep.

Upon advancing the 8-inch ID steel casing to the desired depth in the lower aquifer, a string of four-inch diameter casing with a ten-foot long screen was installed through the inside of the 8-inch casing. The 8-inch casing was then partially removed, allowing the formation sands to collapse around and above the well screen. Bentonite pellets were subsequently installed on top of the sand, hydraulically sealing the screened portion of the well. A thick bentonite slurry was installed above the pellets using the tremie method, thus ensuring an impervious seal above the well screen. The location of this seal, across the confining unit above the lower aquifer, is critical to prevent groundwater flow between the lower and upper units.

To reinforce the integrity of the seal, a thick bentonite amended cement grout was installed above the bentonite seal using the tremie method. The 8-inch casing was progressively removed as additional grout was emplaced. Once grouting was completed inside the 10-inch casing, all of the 8-inch casing was removed and the remaining annulus grouted to the surface. The 10-inch steel casing will remain in the ground permanently, extending above the ground surface to provide a protective casing for the exposed monitor well casing. The monitor well riser pipe was capped with a vented cap to allow equilibration of the water inside the well with atmospheric pressure. Upon completion, a hinged locking lid was welded to the 10-inch outer casing to further protect the well. A typical deep monitor well construction is illustrated on Figure 2.

Upon completion, each monitor well was developed to remove fine-grained sediments within the well and in the formation adjacent to the screen. Proper development will help to ensure that the information obtained during future monitoring is representative of actual subsurface conditions. Each newly installed monitor well has a permanent, easily identified reference point from which its water-level measurement will be taken. The reference points were surveyed by a licensed surveyor relative to a common datum.

Sampling and Analysis, O.A.C. 3745-65-93 (D) (3) (b)

After the two deep monitor wells were installed and developed, they were incorporated into the ongoing quarterly groundwater quality assessments of the North Lagoon. The quarterly assessments consist of the following: 1) measurement of water levels from the shallow and deep wells listed on Table 1, and 2) collection of the groundwater samples from the wells listed on Table 2 and illustrated on Figure 3. The samples collected from each well listed on Table 2 will be analyzed for pH, specific conductance, and volatile organic compounds (VOCs). In addition, samples from selected wells (HR-9, HR-10, HR-11, HR-12, HR-14, HR-15, W-3-N, W-4-N) will also be analyzed for semi-volatile (base-neutral and acid extractable) compounds, cyanide, and for the Appendix IX metals that have been detected in sludge samples from the North Lagoon. The rationale for this analysis plan is based on contaminant mobility rates. Data obtained from the two newly installed wells, as well as the three deep wells installed during September 1988, will be used to assess water quality and flow in the lower aquifer, both upgradient and directly downgradient of the North Lagoon.

The water quality sampling will be performed by G&M. The following protocols have been developed to obtain representative groundwater samples from the monitor wells:

1. water-level measurements will be taken from the surveyed measuring point (top of the steel or PVC casing) using an M-scope;

2. three times the volume of standing water will be evacuated from each well using a Teflon bailer (2-inch diameter wells) or submersible pump (4-inch diameter wells);

3. samples will be collected using a bottom-filling Teflon bailer. Samples will be gently poured directly into sample containers. Samples for soluble metals analysis will be field filtered immediately after sample collection. The bailer cord will be replaced for each sample collected and the bailer will be decontaminated immediately prior to use with a distilled water and Micro soap wash, followed by a triple rinse with deionized water;

4. measurements of specific conductance, pH, and temperature will be taken in the field immediately following sampling. Four replicate measurements of pH will be taken; and,

5. all samples will be preserved according to EPA protocols, stored on ice, and transported daily to Test America (formerly NET and Howard Laboratories) for analysis. Chain-of-Custody forms will accompany each sample package.

The groundwater samples collected will be analyzed by Test America for the following parameters:

1. indicator parameters – pH and specific conductance. Four replicate measurements will be reported for each indicator parameter;

2. volatile organic compounds (VOCs);

3. semi-volatile (base-neutral and acid extractable) organic compounds (HR-9, HR-10, HR-11, HR-12, HR-14, HR-15, W-3-N, W-4-N only);

4. selected metals (HR-9, HR-10, HR-11, HR-12, HR-14, HR-15, W-3-N, W-4-N only) – antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, tin, vanadium, and zinc; and,

5. cyanide (HR-9, HR-10, HR-11, HR-12, HR-14, HR-15, W-3-N, W-4-N only).

Each of the metals listed above will be analyzed for total metal concentration first. Soluble metal concentrations will then be analyzed only for those samples, which contain detectable concentrations of total metals. The specific soluble metals to analyze, therefore, will be selected individually for each well.

Complete details of the groundwater sampling protocols and analysis plan to be followed, including analytical methods, for the North Lagoon quarterly assessments are provided in Appendix A.

Evaluation Procedures, O.A.C. 3745-65-93 (D) (3) (c)

Water-level measurements collected from the monitor and production wells will be converted to elevations and plotted on maps for construction of water table and potentiometric contours. Average hydraulic gradients across the site will be calculated using the water-level data, conservative estimates of effective porosity, and an estimate of hydraulic conductivity (1100 ft/day) determined from aquifer tests conducted by G&M in June 1985. The rate of migration of hazardous constituents will be estimated using retardation factors representative of the dominant contaminants detected. The concentration of hazardous waste constituents in the groundwater will be determined by review of the water quality analyses of both inorganic and organic chemicals. In addition, water quality results will be organized and tabulated. Water level and water quality data from each quarter will also be compared to data obtained during previous monitoring periods and evaluated for trends.

At the completion of each quarterly monitoring period, G&M will prepare a groundwater quality assessment report addressing the Harrison Radiator North Lagoon, which will be submitted to the Ohio EPA for review. Each quarterly report will contain water table and potentiometric maps, and tables of analytical results. Each report will also include a narration supporting determinations regarding the extent of contamination, the rate of contaminant movement, and the concentrations of hazardous waste constituents in the groundwater, to the extent possible given the site conditions and the limitations of available investigative techniques. G&M will also prepare annual reports summarizing the results of each quarterly assessment.

Schedule of Implementation, O.A.C. 3745-65-93 (D) (3) (d)

G&M anticipates that drilling for the two new deep monitor wells will commence as soon as possible after receiving written approval from the Ohio EPA regarding the location and depths of the wells. Duration of the drilling will be approximately three to four weeks. In accordance with the Consent Decree, the new wells must be installed within 90 days after receiving notice-to-proceed from Ohio EPA. The two new deep wells will be incorporated into the quarterly monitoring program during the first quarter following their installation and development.

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Table 1. Wells Near the Harrison Facility Used to Assess Water Levels in the Upper and Lower Aquifers During the Quarterly Assessments of the Harrison Radiator North Lagoon.

Shallow Wells	Deep Wells
HR-1	HR-10
HR-2	HR-12
HR-3	HR-13
HR-4	HR-14
HR-5	HR-15
HR-6	GM-1
HR-7	GM-3
HR-8	GM-4
HR-9	GM-5
HR-11	GM-7
W-1-N	GM-9
W-2-N	GM-11
W-3-N	GM-13
W-4-N	GM-14
W-1-S	GM-15
W-2-S	32
W-3-S	35
W-4-S	37
GM-2	42
4S	44
GM-6	45
GM-8	46
GM-10	"A"
GM-16	FW-1
GM-17	FW-2
GM-18	FW-3
	FW-4

Table 2. Wells Sampled During the Quarterly Groundwater Quality Assessments of the Harrison Radiator North Lagoon.

Shallow Wells	Deep Wells
HR-1	HR-10
HR-2	HR-12
HR-3	HR-13
HR-4	HR-14
HR-5	HR-15
HR-6	
HR-7	
HR-8	
HR-9	
HR-11	
W-1-N	
W-2-N	
W-3-N	
W-4-N	

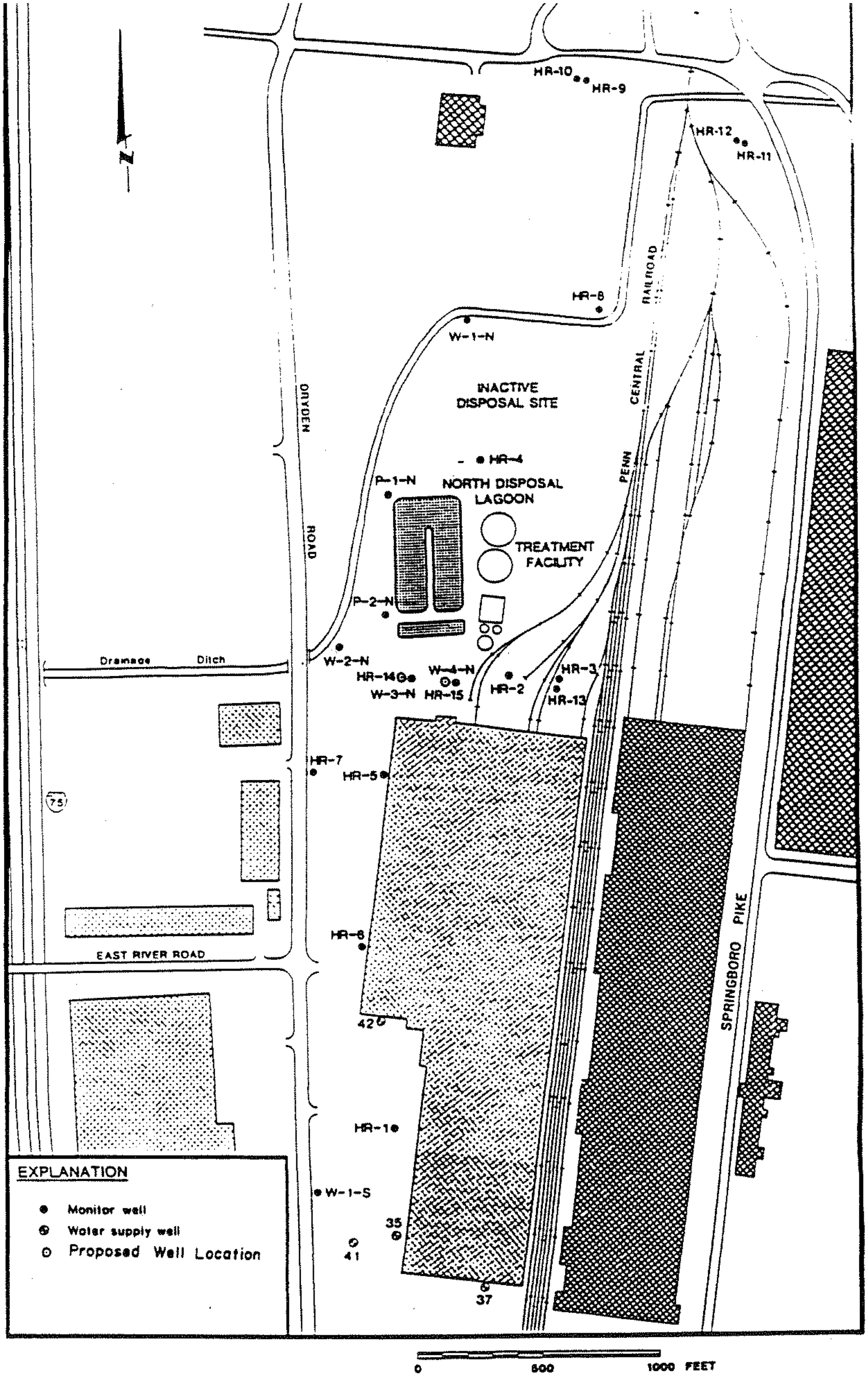

Figure 1. Proposed Deep Well Locations at Harrison Radiator.

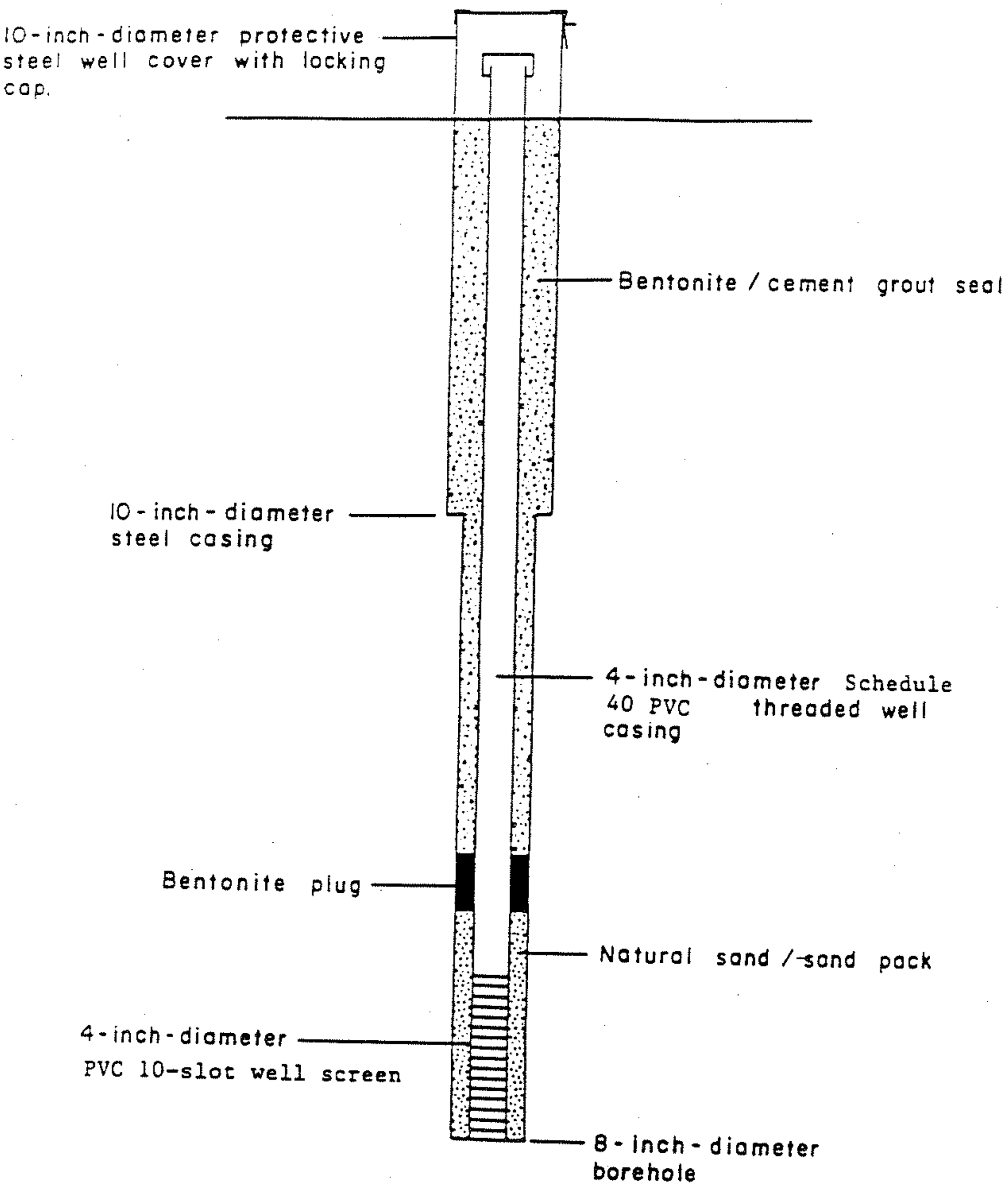

Figure 2. Typical Deep Well Construction.

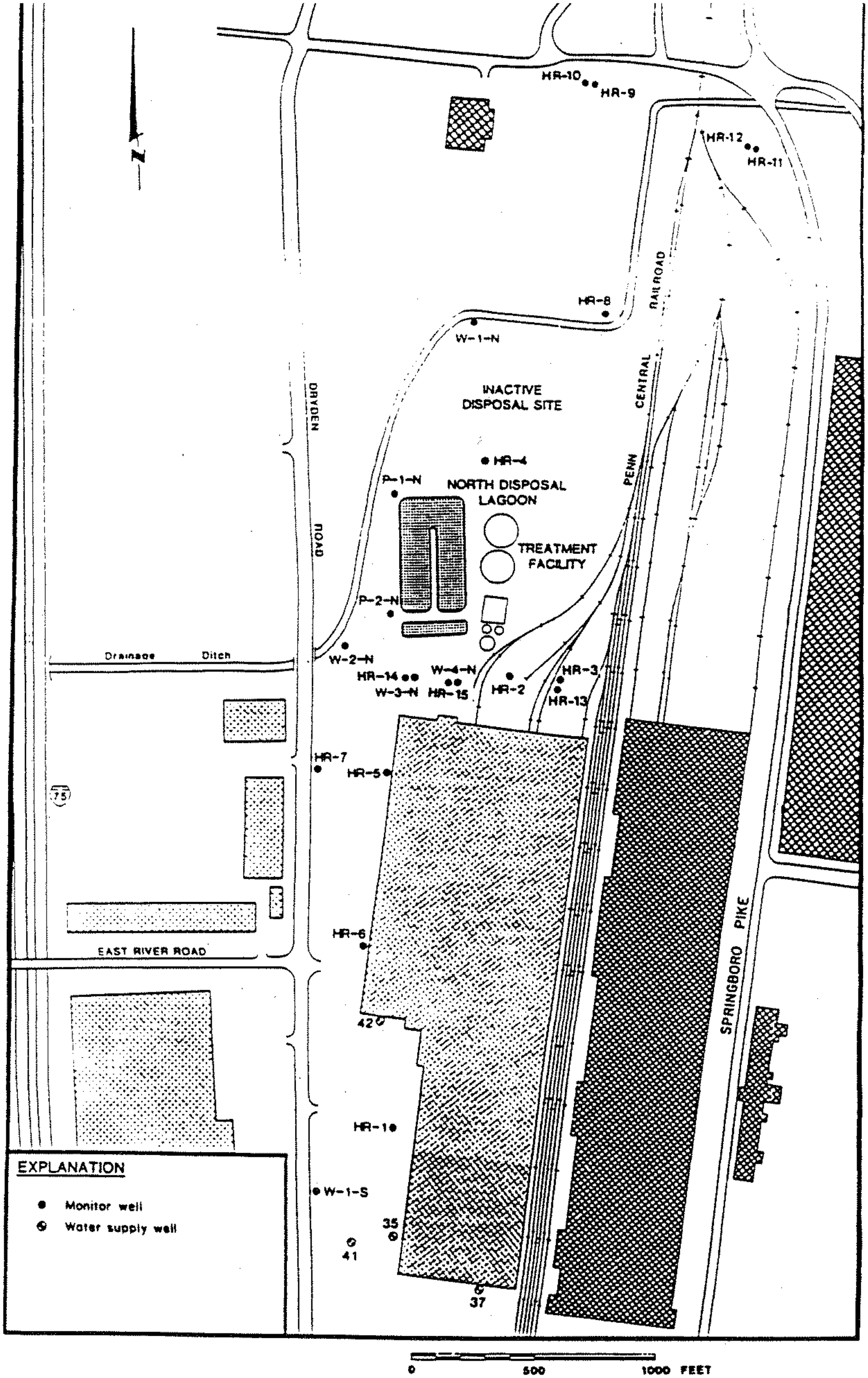

Figure 3. Location of Wells Used in the Quarterly Assessments of the Harrison Radiator North Lagoon.

Appendix A

Groundwater Sampling and Analysis Plan for the North Settling Lagoon

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GROUNDWATER SAMPLING AND ANALYSIS PLAN FOR THE HARRISON RADIATOR NORTH SETTLING LAGOON

1.0 Introduction

Section 265.92 of the U.S. Environmental Protection Agency Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, requires owners and operators to obtain and analyze samples from their installed groundwater monitoring system. The requirement includes the development of a groundwater sampling plan, which must contain procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain-of-custody control. The following information describes the groundwater sampling and analytical protocols for monitoring at the Harrison Radiator North Lagoon.

2.0 Frequency of Sample Collection

Table A-1 presents the groundwater sampling frequency for wells in the vicinity of the Harrison Radiator plant. Twenty wells near the North Lagoon are sampled quarterly.

3.0 Equipment

Sampling equipment needed for collecting representative samples of groundwater are presented below:

1. 100-ft steel measuring tape with weighted bottom (or) water-level indictor ("m-scope") consisting of ammeter, electrode, and 150-ft cable;
2. Several gallons of potable water, distilled water, and deionized water;
3. Wash bottle;
4. Clean rags;
5. Plastic sheeting or large size garbage bags;
6. Bottom-filling Teflon bailer and polypropylene rope;
7. Submersible pump, discharge tubing, and generator;
8. Bucket;
9. Sample bottles;
10. Waterproof marking pen;
11. pH meter;
12. Thermometer;
13. Specific conductivity meter;
14. Water Sampling Logs, Chain of Custody forms, clipboard, pen;
15. Ice chest and ice or freezer packs.

TABLE A-1

List of Wells Sampled Quarterly at the Harrison Radiator North Lagoon

WELL
HR-1
HR-2
HR-3
HR-4
HR-5
HR-6
HR-7
HR-8
HR-9
HR-10
HR-11
HR-12
HR-13
HR-14*
HR-15*
W-1-N
W-2-N
W-3-N
W-4-N
W-1-S**

* Well installed during early 1989.

** W-1-S is no longer sampled as part of North Lagoon Assessment Monitoring.

4.0 Laboratory Arrangements

An initial step in sampling is to notify the contract lab (TestAmerica, Inc. of Dayton, Ohio) of the intention to sample. TestAmerica is informed of the number of wells to be sampled, the analysis to be performed, and the date sampling will begin. The lab then prepares the necessary sample containers with the required preservatives (Table A-2). Each sample container, when received by the sampling team, has a label indicating any preservative which has been added, as well as the analyses to be performed on the sample in that bottle.

5.0 Water-Level Measurements

Prior to collection of any water samples, a full round of water-level measurements is taken. The procedure for collecting water-level measurements is as follows:

A. Identify and unlock the well, then remove the well cap.

B. Using an M-scope, drop the probe down the center of the well until contact with the water surface is indicated. Hold the tape at the measuring point, then record the depth to water measurement, the measuring point (top of PVC casing or metal casing), the date and time.

-or-

Using a steel tape, apply blue carpenters chalk to the bottom two feet of the tape. Slowly drop the weighted tape down the center of the casing. After water is encountered, the tape is held at the closest even foot marker at the top of the well casing, and the measurement recorded. The tape is then reeled out of the well and the measurement where the tape became wet is recorded. Depth to water from measuring point is found by subtracting the "wet" measurement from the "held" measurement. Record "held" measurement, "wet" measurement, depth to water, identify the measuring point (top of PVC casing or metal casing), and note the date and time.

C. Clean the M-scope or tape bottom with distilled water to prevent cross-contamination between wells.

TABLE A-2

List of Parameters Analyzed, Container Description, Preservation Methods, and Holding Times
North Settling Lagoon Assessment Monitoring Progam
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Container	Method of Preservation	Holding Times
*pH	P,G	Cool, 4°C	2 days
*Specific Conductance	P,G	Cool, 4°C	28 days
VOCs	G	HCl to pH<2; Cool, 4°C	14 days
Semi-volatiles	G	Cool, 4°C	7 days
Antimony	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Arsenic	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Barium	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Cadmium	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Chromium	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Cobalt	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Copper	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Lead	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Mercury	P,G	HNO_3 to pH<2; Cool, 4°C	28 days
Nickel	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Selenium	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Silver	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Tin	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Vanadium	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Zinc	P,G	HNO_3 to pH<2; Cool, 4°C	6 months
Cyanide	P,G	NaOH to pH>12; 0.6g ascorbic acid; Cool, 4°C	14 days

Notes:
P = Plastic Container
G = Glass Container
* = Field pH and SpC measurements are performed during sample collection.

6.0 Well Evacuation Procedures

Standing water must be removed from the well casing prior to collection of groundwater samples. Well evacuation procedures are as follows:

A. Identify the well and record its designation on the G&M Water Sampling Log (Figure A-1). Also record preliminary information such as project, location, time, date, weather and sampling personnel on the water sampling data sheet.

B. Unlock the well and remove the vented well cap.

C. Compute the standing volume (gallons) of water in the well by subtracting the depth to water from the total depth of the well. Then multiply this figure by a coefficient which related the diameter of the well to gallons per linear foot. Coefficients for commonly encountered well diameters are listed on the bottom of the G&M Water Sampling Log (0.162 gallons/feet for a two-inch diameter well, and 0.652 gallons/feet for a four-inch diameter well).

D. Remove three to five times the volume of standing water in the well using a Teflon bailer or a pump, depending on the diameter of the well and the depth to water. If a pump is used, first place plastic sheeting around the well to protect sampling equipment from potential contamination. The intake opening of the pump is positioned and maintained ± 10 feet below the water. If there is a decrease in a well's water level as a result of pumping, the intake line is lowered as needed. After evacuation is achieved, slowly raise pump until suction is broken to ensure that the well is properly flushed. Prior to sampling, bail an additional 5 gallons from the top of the water column. Collect the sample at the original pump setting. After purging, record the amount of water removed on the Water Sampling Log.

E. As in the past, purge water will continue to be eliminated to the ground surface away from the well head. The North Lagoon's latest Part A permit revision dated June 13, 1988 list it as containing F006, F007, F009, F012, and F019 waste. Review of latest eight quarters of groundwater monitoring data (1994 and 1995) show that groundwater does not contain the hazardous constituents for which the unit was listed. Namely, in no downgradient well was cyanide, dissolved cadmium, dissolved chrome or dissolved nickel detected. Further analysis of this data show that groundwater does not exhibit any of the characteristics identified in Rules 3745-51-20 to 3745-51-24 of the Ohio Administrative Code. Since groundwater from North Lagoon is not considered to be a hazardous waste, continued elimination of this water to the ground surface, away from the well head, is appropriate.

Figure A-1

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Water Sampling Log

Project ______ Project No. ______ Page ___ of ___

Site Location ______ Date ______

Site/Well No. ______ Replicate No. ______ Code No. ______

Weather ______ Sampling Time: Begin ______ End ______

Evacuation Data

Measuring Point ______

MP Elevation (ft) ______

Land Surface Elevation (ft) ______

Sounded Well Depth (ft bmp) ______

Depth to Water (ft bmp) ______

Water-Level Elevation (ft) ______

Water Column in Well (ft) ______

Casing Diameter/Type ______

Gallons in Well ______

Gallons Pumped/Bailed Prior to Sampling ______

Sample Pump Intake Setting (ft bmp) ______

Purge Time begin ______ end ______

Pumping Rate (gpm) ______

Evacuation Method ______

Field Parameters

Color ______

Odor ______

Appearance ______

pH (s.u.) ______

Conductivity (mS/cm) ______

(µmhos/cm) ______

Turbidity (NTU) ______

Temperature (°C) ______

Dissolved Oxygen (mg/L) ______

Salinity (%) ______

Sampling Method ______

Remarks ______

Constituents Sampled	Container Description	Number	Preservative

Sampling Personnel ______

Well Casing Volumes

Gal./Ft.	1-¼" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65
	1-½" = 0.09	2-½" = 0.26	3-½" = 0.50	6" = 1.47

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bmp	below measuring point	ml	mililiter	NTU	Nephelometric Turbidity Units
°C	Degrees Celsius	mS/cm	Milisiemens per centimeter	PVC	Polyvinyl chloride
ft	feet	msl	mean sea-level	s.u.	Standard units
gpm	Gallons per minute	N/A	Not Applicable	umhos/cm	Micromhos per centimeter
mg/L	Miligrams per liter	NR	Not Recorded	VOC	Volatile Organic Compounds

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7.0 Procedures for Sample Collection and Field Analyses

A. Inspect the sample containers and choose the right type and number based on the analyses plan. Label the sample containers with the well identification number, date, and time.

B. Allow well to recharge sufficiently to obtain samples. For the wells at Harrison, recharge generally occurs immediately.

C. Measurements of pH, temperature and specific conductance are made in the field at the time of sampling because these parameters change rapidly and a laboratory analysis might not be representative of true groundwater quality. The pH meter is calibrated at the start of each day with pH buffer solutions of 4.0 and 7.0. The conductivity meter is also calibrated at the start of each day with a standard of 1000 umhos/cm. The calibration is checked periodically throughout the day and recalibration performed when necessary. Enough water is removed from the well to determine temperature of the water, specific conductivity, and pH. Four replicate measurements of pH are recorded on the Water Sampling Log; one measurement each of specific conductivity and temperature are also recorded.

D. Water samples are collected using a bottom-filling Teflon bailer. If a pump was used to evacuate the well, bail an additional five gallons of water prior to sample collection.

E. The bailer is lowered into the well in a manner that minimizes disturbances to the water table. The bailer is carefully removed from the well and the water sample gently poured into the sample containers provided by the laboratory; container lids are replaced and sealed. Samples for soluble metals analysis are field filtered.

F. After the samples have been collected, they are placed into coolers with ice to provide thermal preservation until they are delivered to the laboratory.

G. Care is taken to avoid cross-contamination between wells by careful cleaning and rinsing of the bailer and/or pump. The bailer, pump and discharge tubing are decontaminated immediately after sampling with distilled water, Micro soap, and a triple rinse with deionized water. The bailer cord is replaced for each sample collected. Disposable gloves are worn by sampling personnel and are changed prior to collecting each sample.

H. Several quality control samples are also sent to the laboratory to monitor sampling and laboratory performance. One trip blank accompanies each round of samples. The trip blank is a vial filled with organic-free water in the laboratory that travels unopened with the sample bottles and is analyzed for VOCs. Field blanks are made by pouring deionized water into a bailer which has been cleaned, and then pouring from the bailer into the sample bottles; field blanks are analyzed for the entire suite of parameters. In addition, a duplicate sample is collected from one well and analyzed for the entire parameter list.

I. After sample collection is completed each day, the samples are hand-delivered to TestAmerica in the coolers.

8.0 Chain of Custody

The sampling team is responsible for the custody and care of collected samples until the containers have been transferred to the custody of the laboratory. A chain-of-custody form is completed to establish the necessary documentation to track possession from time of collection to analysis. The chain-of-custody form is shown on Figure A-2 and includes the following information:

- Project identification or location,
- Sampling personnel,
- Identity of sample(s),
- Date of sampling, and
- Signatures of persons involved in the chain-of-custody and the dates and times of possession.

9.0 Laboratory Analysis of Samples

During each sampling event, the groundwater samples collected at Harrison Radiator are analyzed by TestAmerica for the parameters listed in Table A-3. This table provides the analytical procedures for each water-quality parameter, as well as appropriate reference sources for detailed information related to laboratory procedures.

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Figure A-2

Laboratory Task Order No./P.O. No. ____________

CHAIN-OF-CUSTODY RECORD

Page ____ of ____

Project Number/Name ____________

Project Location ____________

Laboratory ____________

Project Manager ____________

Sampler(s)/Affiliation ____________

Sample ID/Location	Matrix	Date/Time Sampled	Lab ID	ANALYSIS / METHOD / SIZE						Remarks	Total

Sample Matrix: L = Liquid; S = Solid; A = Air

Total No. of Bottles/ Containers ____

Relinquished by: ____	Organization: ____	Date __/__/__	Time ____	Seal Intact?
Received by: ____	Organization: ____	Date __/__/__	Time ____	Yes No N/A
Relinquished by: ____	Organization: ____	Date __/__/__	Time ____	Seal Intact?
Received by: ____	Organization: ____	Date __/__/__	Time ____	Yes No N/A

Special Instructions/Remarks: ____________

Delivery Method: ☐ In Person ☐ Common Carrier ____ SPECIFY ☐ Lab Courier ☐ Other ____ SPECIFY

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times
for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
pH	9040	SW-846	0.1	S.U.	24 hours*
Specific Conductance	9050	SW-846	1	umhos/cm	28 days
Volatile Organic Compounds					
1,1,1,2-Tetrachloroethane	8260a	SW-846	1	ug/L	14 days
1,1,1-Trichloroethane	8260a	SW-846	1	ug/L	14 days
1,1,2,2-Tetrachloroethane	8260a	SW-846	1	ug/L	14 days
1,1,2-Trichloroethane	8260a	SW-846	1	ug/L	14 days
1,1-Dichloroethane	8260a	SW-846	1	ug/L	14 days
1,1-Dichloroethene	8260a	SW-846	1	ug/L	14 days
1,2,3-Trichloropropane	8260a	SW-846	5	ug/L	14 days
1,2-Dibromo-3-chloropropane	8260a	SW-846	5	ug/L	14 days
1,2-Dibromoethane	8260a	SW-846	5	ug/L	14 days
1,2-Dichloroethane	8260a	SW-846	1	ug/L	14 days
1,2-Dichloropropane	8260a	SW-846	1	ug/L	14 days
2-Butanone (methyl ethyl ketone)	8260a	SW-846	10	ug/L	14 days
2-Chloro-1,3-butadiene (Chloroprene)	8260a	SW-846	5	ug/L	14 days
2-Hexanone	8260a	SW-846	10	ug/L	14 days
4-Methyl-2-pentanone (methyl isobutyl ketone)	8260a	SW-846	10	ug/L	14 days
Acetone	8260a	SW-846	20	ug/L	14 days
Acrolein	8260a	SW-846	50	ug/L	14 days
Acrylonitrile	8260a	SW-846	50	ug/L	14 days
Allyl chloride	8260a	SW-846	5	ug/L	14 days
Benzene	8260a	SW-846	1	ug/L	14 days
Bromodichloromethane	8260a	SW-846	1	ug/L	14 days
Bromoform	8260a	SW-846	1	ug/L	14 days
Bromomethane	8260a	SW-846	5	ug/L	14 days
Carbon disulfide	8260a	SW-846	1	ug/L	14 days
Carbon tetrachloride	8260a	SW-846	1	ug/L	14 days
Chlorobenzene	8260a	SW-846	1	ug/L	14 days
Chloroethane	8260a	SW-846	10	ug/L	14 days
Chlorofrom	8260a	SW-846	1	ug/L	14 days
Chloromethane	8260a	SW-846	10	ug/L	14 days
Dibromochloromethane	8260a	SW-846	1	ug/L	14 days
Dibromomethane	8260a	SW-846	1	ug/L	14 days
Dichlorodifluoromethane	8260a	SW-846	10	ug/L	14 days
Ethyl methacrylate	8260a	SW-846	5	ug/L	14 days
Ethylbenzene	8260a	SW-846	1	ug/L	14 days
Iodomethane	8260a	SW-846	5	ug/L	14 days
Methacrylonitrile	8260a	SW-846	5	ug/L	14 days
Methylene chloride	8260a	SW-846	10	ug/L	14 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Methylmethacrylate	8260a	SW-846	5	ug/L	14 days
Pentachloroethane	8260a	SW-846	5	ug/L	14 days
Propionitrile	8260a	SW-846	50	ug/L	14 days
Styrene	8260a	SW-846	1	ug/L	14 days
Tetrachloroethene	8260a	SW-846	1	ug/L	14 days
Toluene	8260a	SW-846	1	ug/L	14 days
Trichloroethene	8260a	SW-846	1	ug/L	14 days
Trichlorofluoromethane (Fluorotrichloromethane)	8260a	SW-846	1	ug/L	14 days
Vinyl acetate	8260a	SW-846	10	ug/L	14 days
Vinyl chloride	8260a	SW-846	5	ug/L	14 days
Xylenes, Total	8260a	SW-846	1	ug/L	14 days
cis-1,3-Dichloropropene	8260a	SW-846	1	ug/L	14 days
trans-1,2-Dichloroethene	8260a	SW-846	1	ug/L	14 days
trans-1,3-Dichloropropene	8260a	SW-846	1	ug/L	14 days
trans-1,4-Dichloro-2-butene	8260a	SW-846	5	ug/L	14 days
<u>Semi-Volatile Organic Compounds</u>					
Acenaphthene	8270	SW-846	10	ug/L	7 days
Acenaphthylene	8270	SW-846	10	ug/L	7 days
Acetophenone	8270	SW-846	20	ug/L	7 days
2-Acetylaminofluorene (2-AAF)	8270	SW-846	20	ug/L	7 days
4-Aminobiphenyl	8270	SW-846	20	ug/L	7 days
Aniline	8270	SW-846	10	ug/L	7 days
Anthracene	8270	SW-846	10	ug/L	7 days
Aramite	8270	SW-846	15	ug/L	7 days
Benzo(a)anthracene	8270	SW-846	10	ug/L	7 days
Benzo(b)fluoranthene	8270	SW-846	10	ug/L	7 days
Benzo(k)fluoranthene	8270	SW-846	10	ug/L	7 days
Benzo(ghi) perylene	8270	SW-846	10	ug/L	7 days
Benzo(a)pyrene	8270	SW-846	10	ug/L	7 days
Benzy alcohol	8270	SW-846	10	ug/L	7 days
Bis(2-chloroethoxy)methane	8270	SW-846	10	ug/L	7 days
Bis(2-chloroethyl)ether	8270	SW-846	10	ug/L	7 days
Bis(2-ethylhexyl)phthalate	8270	SW-846	10	ug/L	7 days
4-Bromophenyl phenyl ether	8270	SW-846	10	ug/L	7 days
Butyl benzyl phthalate	8270	SW-846	10	ug/L	7 days
p-Chloroaniline	8270	SW-846	10	ug/L	7 days
Chlorobenzilate	8270	SW-846	50	ug/L	7 days
2-Chloronaphthalene	8270	SW-846	10	ug/L	7 days
4-Chlorophenyl phenyl ether	8270	SW-846	10	ug/L	7 days
Chrysene	8270	SW-846	10	ug/L	7 days
Diallate	8270	SW-846	30	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Dibenzo(a,h)anthracene	8270	SW-846	10	ug/L	7 days
Dibenzofuran	8270	SW-846	10	ug/L	7 days
Di-n-butyl phthalate	8270	SW-846	10	ug/L	7 days
o-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
m-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
p-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
3,3'-Dichlorobenzidine	8270	SW-846	20	ug/L	7 days
2,2'-Dichlorodiisopropyl ether	8270	SW-846	10	ug/L	7 days
Diethyl phthalate	8270	SW-846	10	ug/L	7 days
Thionazin	8270	SW-846	20	ug/L	7 days
Dimethoate	8270	SW-846	100	ug/L	7 days
p-(Dimethylamino)azobenzene	8270	SW-846	50	ug/L	7 days
7,12-Dimethylbenz(a)anthracene	8270	SW-846	20	ug/L	7 days
3,3'-Dimethylbenzidine	8270	SW-846	20	ug/L	7 days
a,a-Dimethyl-phenethylamine	8270	SW-846	50	ug/L	7 days
Dimethyl phthalate	8270	SW-846	10	ug/L	7 days
m-Dinitrobenzene	8270	SW-846	20	ug/L	7 days
2,4-Dinitrotoluene	8270	SW-846	10	ug/L	7 days
2,6-Dinitrotoluene	8270	SW-846	10	ug/L	7 days
Di-n-octyl phthalate	8270	SW-846	10	ug/L	7 days
Diphenylamine	8270	SW-846	20	ug/L	7 days
Disulfoton	8270	SW-846	20	ug/L	7 days
Ethyl methanesulfonate	8270	SW-846	20	ug/L	7 days
Famphur	8270	SW-846	10	ug/L	7 days
Fluoranthene	8270	SW-846	10	ug/L	7 days
Fluorene	8270	SW-846	10	ug/L	7 days
Hexachlorobenzene	8270	SW-846	10	ug/L	7 days
Hexachlorobutadiene	8270	SW-846	10	ug/L	7 days
Hexachlorocyclopentadiene	8270	SW-846	10	ug/L	7 days
Hexachloroethane	8270	SW-846	10	ug/L	7 days
Hexachlorophene	8270	SW-846	500	ug/L	7 days
Hexachloroprophene	8270	SW-846	30	ug/L	7 days
Indeno(1,2,3-cd)pyrene	8270	SW-846	10	ug/L	7 days
Isodrin	8270	SW-846	30	ug/L	7 days
Isophorone	8270	SW-846	10	ug/L	7 days
Isosafrole	8270	SW-846	20	ug/L	7 days
Kepone	8270	SW-846	250	ug/L	7 days
Methapyrilene	8270	SW-846	100	ug/L	7 days
3-Methylcholanthrene	8270	SW-846	30	ug/L	7 days
Methyl methanesulfonate	8270	SW-846	20	ug/L	7 days
2-Methylnaphthalene	8270	SW-846	10	ug/L	7 days
Methyl parathion	8270	SW-846	20	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Naphthalene	8270	SW-846	10	ug/L	7 days
1,4-Naphthoquinone	8270	SW-846	100	ug/L	7 days
1-Naphthylamine	8270	SW-846	30	ug/L	7 days
2-Naphthylamine	8270	SW-846	30	ug/L	7 days
o-Nitroaniline	8270	SW-846	15	ug/L	7 days
m-Nitroaniline	8270	SW-846	15	ug/L	7 days
p-Nitroaniline	8270	SW-846	15	ug/L	7 days
Nitrobenzene	8270	SW-846	10	ug/L	7 days
4-Nitroquinoline 1-oxide	8270	SW-846	30	ug/L	7 days
N-Nitrosodi-n-butylamine	8270	SW-846	20	ug/L	7 days
N-Nitrosodiethylamine	8270	SW-846	30	ug/L	7 days
N-Nitrosodimethylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosodiphenylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosodipropylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosomethylethylamine	8270	SW-846	20	ug/L	7 days
N-Nitrosomorpholine	8270	SW-846	20	ug/L	7 days
N-Nitrosopiperidine	8270	SW-846	20	ug/L	7 days
N-Nitrosopyrrolidine	8270	SW-846	20	ug/L	7 days
5-Nitro-o-toluidine	8270	SW-846	20	ug/L	7 days
Parathion	8270	SW-846	20	ug/L	7 days
Pentachlorobenzene	8270	SW-846	20	ug/L	7 days
Pentachloronitrobenzene	8270	SW-846	20	ug/L	7 days
Phenacetin	8270	SW-846	20	ug/L	7 days
Phenanthrene	8270	SW-846	10	ug/L	7 days
p-Phenylenediamine	8270	SW-846	30	ug/L	7 days
Phorate	8270	SW-846	20	ug/L	7 days
2-Picoline	8270	SW-846	20	ug/L	7 days
Pronamide	8270	SW-846	20	ug/L	7 days
Pyrene	8270	SW-846	10	ug/L	7 days
Pyridine	8270	SW-846	10	ug/L	7 days
Safrole	8270	SW-846	20	ug/L	7 days
1,2,4,5-Tetrachlorobenzene	8270	SW-846	20	ug/L	7 days
Sulfotepp	8270	SW-846	20	ug/L	7 days
o-Toluidine	8270	SW-846	20	ug/L	7 days
1,2,4-Trichlorobenzene	8270	SW-846	10	ug/L	7 days
Triethyl phosphorothioate	8270	SW-846	20	ug/L	7 days
1,3,5-Trinitrobenzene	8270	SW-846	30	ug/L	7 days
2-Chlorophenol	8270	SW-846	10	ug/L	7 days
4-Chloro-3-methyl phenol	8270	SW-846	10	ug/L	7 days
ortho-Methylphenol	8270	SW-846	10	ug/L	7 days
meta- & para-Methylphenol	8270	SW-846	10	ug/L	7 days
2,4-Dichlorophenol	8270	SW-846	10	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
2,6-Dichlorophenol	8270	SW-846	10	ug/L	7 days
2,4-Dimethylphenol	8270	SW-846	10	ug/L	7 days
4,6-Dinitro-2-methylphenol	8270	SW-846	10	ug/L	7 days
2,4-Dinitrophenol	8270	SW-846	10	ug/L	7 days
o-Nitrophenol	8270	SW-846	10	ug/L	7 days
p-Nitrophenol	8270	SW-846	10	ug/L	7 days
Pentachlorophenol	8270	SW-846	10	ug/L	7 days
Phenol	8270	SW-846	10	ug/L	7 days
2,3,4,6-Tetrachlorophenol	8270	SW-846	20	ug/L	7 days
2,4,5-Trichlorophenol	8270	SW-846	10	ug/L	7 days
2,4,6-Trichlorophenol	8270	SW-846	10	ug/L	7 days
Inorganic Compounds					
Antimony	7040/6010/7041	SW-846	0.02	mg/L	6 months
Arsenic	7061/7060	SW-846	0.005	mg/L	6 months
Barium	7080/7081/6010	SW-846	0.2	mg/L	6 months
Cadmium	7130/6010/7131	SW-846	0.001	mg/L	6 months
Chromium	7190/6010/7191	SW-846	0.002	mg/L	6 months
Cobalt	7200/6010/7201	SW-846	0.005	mg/L	6 months
Copper	7210/6010	SW-846	0.02	mg/L	6 months
Lead	7420/6010/7421	SW-846	0.005	mg/L	6 months
Mercury	7470	SW-846	0.0002	mg/L	28 days
Nickel	7521/6010	SW-846	0.01	mg/L	6 months
Selenium	7741/7740	SW-846	0.005	mg/L	6 months
Silver	7760/6010/7761	SW-846	0.001	mg/L	6 months
Tin	7870/6010	SW-846	2	mg/L	6 months
Vanadium	7910/7911/6010	SW-846	0.05	mg/L	6 months
Zinc	7950/6010	SW-846	0.05	mg/L	6 months
Cyanide	9010	SW-846	0.005	mg/L	14 days

* Laboratory pH analyzed within 24 hours of sample reciept.

References:
SW-846 = Test Methods for Evaluating Solid Waste, U.S. EPA-SW 846, 1986, Third Edition.

ARCADIS GERAGHTY & MILLER

Revised Groundwater Monitoring Detection Program for the South Settling Lagoon

General Motors Corporation
Moraine, Ohio
June 1989
April 1996 CME Modifications
Compiled May 2000

PREPARED FOR

REALM

Introduction

In response to a Consent Decree between the Ohio EPA and the Harrison Radiator Division of General Motors, Harrison is submitting this revised groundwater monitoring detection program for the South Lagoon of its Moraine, Ohio facility. The first draft was submitted on December 20, 1988, which was within the required 60 days after the effective date of the decree, October 26, 1988. Written comments on the plan were received from the agency on March 3, 1989. Subsequent discussions with the agency in early May 1989 resulted in several revisions to the Ohio EPA comments. These comments were incorporated into the plan and a final version was submitted to the Ohio EPA in June 1989. The Ohio EPA conducted a Comprehensive Groundwater Monitoring Evaluation (CME) on August 28 and 30, 1995 to evaluate the lagoon monitoring program. As a result of the CME, Ohio EPA had additional comments on the June 1989 version of this sampling plan. Harrison responded to these comments in correspondence dated April 1, 1996. The May 2000 version of this plan represents a compilation of the June 1989 plan and the April 1996 responses to comments.

As specified by the Consent Decree, the groundwater monitoring detection program for the South Lagoon includes the installation of two monitor wells directly upgradient of the South Lagoon at a depth that will allow for sampling of the upper aquifer groundwater. These wells will be used for the determination of background water quality for the South Lagoon. Statistical techniques will then be applied during the detection monitoring program to determine whether a statistically significant increase in the concentration of indicator parameters in the groundwater has occurred, or is occurring from the South Lagoon.

General Site Conditions

The South Lagoon is located southwest of the Harrison plant, just east of Interstate 75 and west of Dryden Road. The South Lagoon was constructed in 1966 and is actually comprised of three smaller lagoons bounded by earthen dikes. The total area of the South Lagoon is approximately 5.3 acres.

The following sections provide a summary of the site hydrogeology, based on data collected over the past 10 years, as presented in the Description of Current Conditions (DOCC) (Geraghty & Miller, Inc. 1991) and the Draft Resource Conservation and Recovery Act Facility Investigation (RFI) Final Report (Geraghty & Miller, Inc. 1996).

Hydrogeologic Units

The Delphi Thermal site lies over the Great Miami River buried valley aquifer, which consists of valley fill deposits composed of sand and gravel outwash separated by locally discontinuous silt and clay units, frequently referred to as till zones. Beneath the facility, these glacial deposits have been divided into the following hydrogeologic units: the upper sand and gravel unit, the till zone, and the lower sand and gravel unit. Plates 2 and 3 in the DOCC (Geraghty & Miller, Inc. 1991) illustrate generalized cross sections of these three geologic units. Boring logs indicated a large amount of variability in the lithology within each of the three units; however, this lithologic variability within units was generalized in the cross sections. Ordovician shales and limestones of the Richmond Group comprise the dominant bedrock units forming the valleys in the Dayton area. The Richmond Group is overlain by the Silurian Brassfield Limestone in upland areas. The bedrock units are not considered important sources of groundwater because their transmissivity values are lower than those of the buried valley aquifer.

The upper sand and gravel unit is generally 30 to 70 feet thick and contains minor till lenses. This unit is considered a water-table aquifer with saturated thicknesses ranging from 10 to 40 feet. Based on a review of water well logs at the Ohio Department of Natural Resources, there are no known users of groundwater from this upper water-table aquifer in the immediate vicinity of the Delphi Thermal site.

The till zone has a varied thickness and continuity, but appears to be discernable throughout the region; it ranges from being absent to in excess of 50 feet thick beneath the Delphi Thermal site. An isopach map of the till is presented in the Draft RFI Final Report. The thickest portion of the till is centered to the east of the Delphi Thermal facility.

Although the till deposit constitutes a relatively small portion of the valley fill deposits, it is a major hydrologic factor because it can retard recharge to the lower sand and gravel unit. These glacial till deposits are, therefore, referred to as an aquitard. Clay and silt tills have a very low permeability (10^{-7} centimeters per second [cm/sec] or less), a very high unit weight (on the order of 140 pounds per cubic feet [pcf]), and a very low void ratio, yielding a porosity of less than 20 percent (Norris and Spieker 1966). Low porosities result in the transmission of very little water through such a unit. Therefore, the till layers divide the sand and gravel deposits into two or more aquifers. Recharge from the upper aquifer to the lower aquifer can be relatively rapid where the till layer is absent, but regionally the till layer provides an effective barrier causing the lower aquifer to be semi-confined.

The till zone overlies at least 50 to 100 feet of sand and gravel that comprise the lower unit. The lower unit is a fully saturated semi-confined aquifer throughout most of the Dayton area; however, there are locations where the till is thin or discontinuous. In areas where the till is absent, the upper and lower aquifers respond as one hydrogeologic unit. Consequently, aquifer parameters vary with the thickness and distribution of the till layer.

Water Levels and Hydraulic Gradient

Water level measurements indicate that the direction of groundwater flow in both aquifers at the site is generally from north to south, with a westerly bend at the southern portion of the site. This bend in the flow pattern corresponds to the trend of the buried bedrock valley.

Historically, pumping water from the lower aquifer has also influenced the flow regime substantially. When supply wells were active in the lower aquifer, as they were prior to 1986, potentiometric elevations were lowered and a vertical gradient from the upper to lower aquifer was created. Sustained pumping had the effect of lowering water levels in both aquifers because the upper aquifer recharges the lower aquifer through the semi-confining till zone. As municipal and industrial pumping slowed in 1986, water levels began to rise in both aquifers. In response to this termination of pumping in the county well field and at the Delphi Thermal site, water levels in both the upper and lower aquifers have risen. Hydrograph records for shallow wells at Delphi Thermal indicate a rise in the shallow aquifer of approximately 10 feet between 1986 and late 1989 when water levels stabilized. Historic water-level data from the deep aquifer (limited to post September 1988 water levels) for Monitor Wells HR-10, HR-12, HR-13, HR-14, and HR-15 indicate a 5-foot rise in the water levels in the deep aquifer between September 1988 and late 1989. Because of the higher water levels in the last few years, there is very little difference between the water-level elevations in the upper aquifer and the potentiometric surface in the lower aquifer. Additionally, the decrease in groundwater pumping at and near the facility has resulted in a decrease in the hydraulic gradient.

Horizontal hydraulic gradients were approximately 0.0017 feet per foot (ft/ft) in both aquifers in 1986 (Geraghty & Miller, Inc. 1991), 0.0005 ft/ft in both aquifers in 1989, and 0.0008 ft/ft in the shallow aquifer and 0.001 ft/ft in the deep aquifer by October

1994. The 1986 hydraulic gradients show the significant influence that industrial and municipal pumping had on the shallow and deep aquifers. In 1989, when pumping at the Delphi Thermal facility and the Dryden Road North Well Field had been curtailed, it can be seen that the natural hydraulic gradient for both aquifers was much lower than under pumping conditions. Finally, the increase in hydraulic gradients in 1994 represents the influence of Montgomery County pumping one well in the Dryden North Well Field (DN-13) as part of their Pump-to-Waste Program.

The gradients, in each instance, vary across the site to reflect local variations in hydraulic characteristics and hydraulic stresses. The thinning of the shallow aquifer in the central portion of the Delphi Thermal facility, beneath the main manufacturing building, causes a decrease in the hydraulic transmissivity resulting in a local steepening of the hydraulic gradient. The gradient flattens out south of the building, then increases again close to DN-13, which is in operation. Using the 1994 quarterly monitoring data from the Eleventh Annual Groundwater Quality Assessment Report (Geraghty & Miller, Inc. 1995), the annual average site-wide gradient for the shallow aquifer was reported as 0.0008 ft/ft. The gradient from HR-9, near Northlawn Avenue, to the north of the Delphi Thermal manufacturing building was 0.0006 ft/ft. The gradients increased to approximately 0.0008 ft/ft at the central area of the site and decreased to approximately 0.0007 ft/ft at the south end of the site. Gradients varied locally, ranging from 0.0009 ft/ft to 0.009 ft/ft.

The hydraulic gradients in the deep aquifer displayed less variability over the site, except near DN-13 where gradients were influenced by pumping. Gradients observed were approximately 0.0007 ft/ft at the northern portion of the site, 0.0008 ft/ft in the central to southern portion of the site, and approximately 0.002 ft/ft near DN-13 in the deep aquifer.

Hydraulic Conductivities

To determine the hydraulic characteristics of the water-table (upper) aquifer, the lower aquifer, and the till zone in the vicinity of the Delphi Thermal site, Geraghty & Miller analyzed time-drawdown data collected during three pumping tests (Geraghty & Miller, Inc. 1990). The data were analyzed using AQTESOLV, an aquifer-test analysis software package (Duffield and Rumbaugh 1989). Upper aquifer tests were performed in June 1985 and August 1989, at the southern end of the North Settling Lagoon (Test Well 1), and south of Landfill L-1 (Test Well 2), respectively. The deep aquifer test was performed just north of Landfill L-1 (Production Well 45) in November 1989.

The median-hydraulic conductivity determined from the upper aquifer tests is 1,756 feet per day (ft/day), which is greater than published values for the upper aquifer in the Great Miami River Valley (Geraghty & Miller, Inc. 1990). This hydraulic conductivity value suggests the presence of a highly localized permeable feature, such as a river point-bar deposit. Point-bar deposits consist of river-washed sediments that generally have high hydraulic conductivities.

The median specific yield determined from the upper aquifer tests is 7.0 x 10^{-2}. Water-table aquifers typically have specific yields of 0.10 to 0.20 (Kruseman and de Ridder 1983). The drawdown response recorded in Well W-3-N may suggest a localized, semi-confined aquifer setting in the upper aquifer. However, the median value for storage determined from the upper aquifer test of 1.1 x 10^{-2} is well above the range for semi-confined aquifers of 1 x 10^{-4} to 1 x 10^{-6} given by Kruseman and de Ridder (1983), suggesting that the upper aquifer in the vicinity of the Delphi Thermal site responds as a water-table aquifer with localized semi-confined characteristics.

The lower aquifer test data were analyzed both for the pumping period and the recovery period after pumping. Therefore, in addition to a spatial comparison, hydraulic parameters were estimated by different methods of analyses and compared again. The median hydraulic conductivity calculated from all of the lower aquifer test analyses is 349 ft/day. This value is within the 125 to 400 ft/day range reported by Norris and Spieker (1966) for the Dayton area. The minimum and maximum estimated hydraulic conductivity values of 262 ft/day and 463 ft/day were estimated at Well GM-19D and Well 45, respectively. The values of the hydraulic parameters estimated by the drawdown data correlate very well with those estimated from the recovery data, and both sets of parameter values are consistent with published values for the Great Miami River Valley.

The aquifer storage values determined from the lower aquifer test indicate a semi-confined aquifer. The median value of storage is 6.65 x 10^{-4}. Kruseman and de Ridder (1983) describe confined aquifers as having a storage coefficient of 1 x 10^{-4} to 1 x 10^{-6} and unconfined aquifer storage (specific yield) values of 0.10 to 0.20. Therefore, the median value estimated from the lower aquifer test data is at the upper limits of the range of values for a confined aquifer and is consistent with the values expected for a semi-confined aquifer. The storage values determined from the lower aquifer test are consistent with values listed in studies conducted in the Dayton area (Norris and Spieker 1966; Fidler 1975; Dover 1961). In addition, the median storage values are characteristic of those values obtained for a semi-confined aquifer.

Previous Detection Monitoring

The detection monitoring system for the Harrison South Lagoon has, in the past, consisted of four monitor wells installed by Bowser-Morner Testing Laboratories, Inc., in 1981 (Figure 1). The three downgradient wells (W-2-S, W-3-S, W-4-S) are situated in arch fashion, semi-perpendicular to the typical groundwater flow direction. The upgradient well used to determine background groundwater quality was W-1-S. Groundwater samples and water-level elevations have been obtained quarterly from W-1-S and semi-annually from W-2-S, W-3-S and W-4-S. Concentrations of the indicator parameters were compared to background concentrations using a student's t-test on a semi-annual basis.

Revised Detection Monitoring Program

Number and Location of New Wells

As specified in the Consent Decree between Ohio EPA and Harrison Radiator, two groundwater monitor wells were installed in 1989 upgradient of the South Lagoon, and screened in the upper aquifer. The locations for these wells are shown on Figure 2. Based on well logs for existing monitor wells in the area, G&M anticipates that the new monitor wells will be approximately 70 feet deep. These new wells were used for the determination of background water quality for the South Lagoon.

Drilling of the shallow boreholes was accomplished using cable tool drilling techniques under the direct supervision of a G&M hydrogeologist. Each shallow borehole was advanced by driving sections of 8-inch ID steel casing into the ground to the top of the clay confining unit, where present. The sediments inside the casing were removed using a steel bailer fitted with a check valve. Complete geologic descriptions of the soil samples were maintained by the G&M representative.

Upon advancing the 8-inch steel casing to the desired depth in the upper aquifer, a four-inch diameter monitor well assembly was installed through the inside of the 8-inch casing. A typical well completion for a shallow four-inch diameter monitor well is shown on Figure 3. Each well was constructed of four-inch ID, flush joint, schedule 40, PVC well casing. Coupled to each well casing was a twenty foot section of schedule 40, flush joint, 0.010-inch slot size, PVC well screen.

After well installation, the 8-inch casing was then partially removed, allowing the formation sands to collapse around and above the well screen. Bentonite pellets were subsequently installed on top of the sand, hydraulically sealing the screened portion of the well. A thick bentonite-amended cement grout was installed above the pellets using the tremie method, thus ensuring an impervious seal above the well screen. The 8-inch casing was progressively removed as additional grout was emplaced.

The riser pipe will be capped with a vented cap to allow equilibration of the water inside the well with atmospheric pressure. A+/- five-foot long steel casing with a hinged lockable lid will be placed over each well and seated into the grout. Surface-water intrusion will be prevented by a sloping pad of cement around the well casing. Specific construction details for each well were maintained by the G&M representative.

Upon completion, each monitor well was developed to remove fine-grained sediments within the well and in the formation adjacent to the screen. Proper development will help to ensure that the information obtained during future monitoring is representative of actual subsurface conditions. Each newly installed monitor well also has permanent, easily identified reference point from which its water-level measurement will be taken. The reference points were surveyed by a licensed surveyor relative to a common datum.

Determination of Background Water Quality

After the two shallow upgradient monitor wells were installed and developed, they were used to determine background water quality for the South Lagoon. Groundwater samples were collected quarterly for a period of one year from the two upgradient wells (HR-16, HR-17). The downgradient monitor wells (W-2-S, W-3-S and W-4-S) were also sampled quarterly during this period.

The water-quality sampling were performed by G&M. The following protocols have been developed to obtain representative groundwater samples from the monitor wells:

1. water-level measurements will be taken from the surveyed measuring point (top of the steel or PVC casing) using an M-scope;

2. three times the volume of standing water will be evacuated from each well using a submersible pump (4-inch diameter wells);

3. samples will be collected using a bottom-filling Teflon bailer. Samples will be gently poured directly into sample containers. Samples for soluble metals analysis will be field filtered immediately after sample collection. The bailer cord will be replaced for each sample collected and the bailer will be decontaminated immediately prior to use with a distilled water and Micro soap wash, followed by a triple rinse with deionized water;

4. measurements of specific conductance, pH, and temperature will be taken in the field immediately following sampling. Four replicate measurements of pH will be taken; and,

5. all samples will be preserved according to EPA protocols, stored on ice, and transported daily to Test America (former NET and Howard Laboratories)

for analysis. Chain-of-Custody forms will accompany each sample package.

The groundwater samples collected during the first year were analyzed by Howard Laboratories for the following parameters:

1. parameters characterizing the suitability of groundwater as a drinking water supply, as specified in Appendix III: arsenic; barium; cadmium; chromium; fluoride; lead; mercury; nitrate (as N); selenium; silver; endrin; lindane; methoxychlor; toxaphene; 2,4-D; 2,4,5-TP silvex, radium, gross alpha, gross beta, coliform bacteria;

2. parameters establishing groundwater quality: chloride, iron, manganese, phenols, sodium, sulfate; and,

3. parameters used as indicators of groundwater contamination: pH, SpC, TOC, TOX. Four replicate measurements will be reported for each indicator parameter.

Each of the metals listed above was analyzed for total metal concentration first. Soluble metal concentrations were then analyzed only for those samples which contained detectable concentrations of total metals. The specific soluble metals to analyze, therefore, were selected individually for each well.

Complete details of the groundwater sampling protocols and analysis plan to be followed, including analytical methods for the South Lagoon samples are provided in Appendix A.

At the completion of the first year of quarterly sampling, the initial background arithmetic mean and variance of the indicator parameters was determined by pooling the replicate measurements for the respective indicator parameter concentrations from the two upgradient wells.

Detection Monitoring

After the first year, the South Lagoon monitor wells indicated on Figure 4 (HR-16, HR-17, W-2-S, W-3-S, W-4-S) will be sampled semi-annually. The groundwater samples collected will be analyzed annually for the groundwater quality parameters (chloride, iron, manganese, phenols, sodium, sulfate) and semi-annually for the indicator parameters (pH, SpC, TOC, TOX). The groundwater sampling protocols to be followed during the semi-annual sampling of the South Lagoon wells will be identical to that of the first year sampling, as presented in Appendix A. The sampling frequency and analyses for the South Lagoon wells are summarized in Table 1.

Statistical Analysis

Water-quality data obtained from each semi-annual sampling event for the indicator parameters will be statistically compared to the background water-quality data to determine whether a statistically significant increase in any indicator parameter concentration has occurred. At this time, G&M anticipates using the Averaged Replicate (AR) t-test at the 1% level of significance during the Harrison South Lagoon detection monitoring program. The actual test to be used, however, may differ depending on the background data collected. Evaluation of the background data may reveal that another statistical technique would be more appropriate for the data generated at the Harrison site. The recent federal regulations (Federal Register, October 11,1988) regarding statistical methods for evaluating groundwater monitoring data from hazardous waste sites specify five statistical techniques that may be used to evaluate the presence or increase of contamination from a regulated unit. The tests presented in the regulations, which became effective April 11, 1989, include: 1) analysis of variance, 2) tolerance intervals, 3) prediction intervals, and 4) control charts. G&M, therefore, proposes to collect the background data during the first year of monitoring, evaluate the data generated, and, based on that evaluation choose the most appropriate statistical technique for evaluating upgradient versus downgradient water quality at the Harrison South Lagoon.

As long as the statistical results do not indicate a statistically significant increase in the concentration of any indicator parameter, Harrison will continue with the semi-annual revised detection monitoring program of its South Lagoon. If the revised detection monitoring program demonstrates a statistically significant increase in contaminants above background concentrations, Harrison will submit a revised groundwater quality assessment plan to Ohio EPA that complies with the provisions of OAC 3745-65-93(D).

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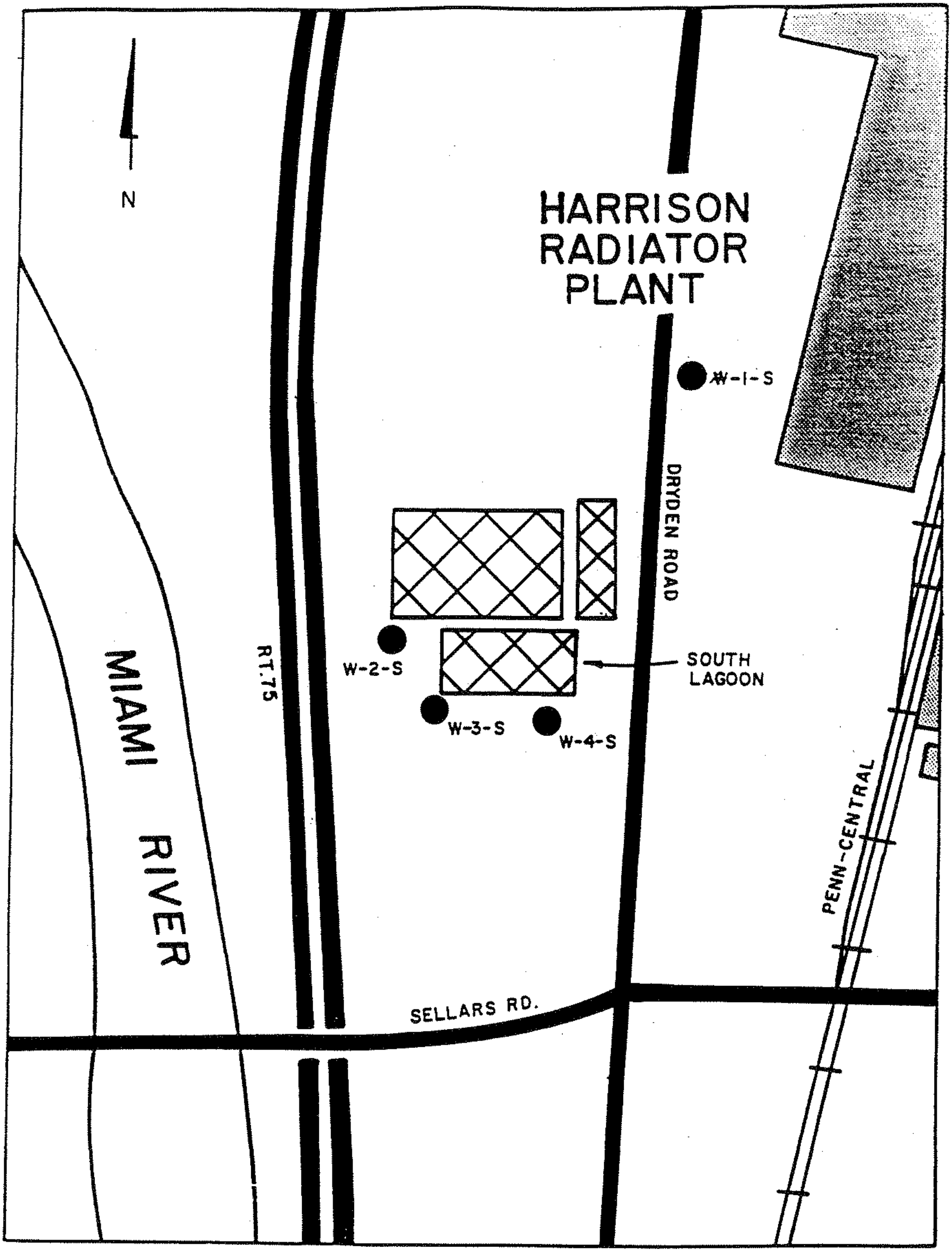
Kruseman, G.P. and N.A. de Ridder. 1983. Analysis and Evaluation of Pumping Test Data. ILRI, Bull. 11, The Netherlands, 200 p.

Norris, N.E. and A.M. Spieker. 1966. Ground-Water Resources of the Dayton Area, Ohio. U.S. Geological Survey Water Supply Paper 1808. Prepared in cooperation with the Miami Conservancy District and the Ohio Department of Natural Resources.

Table 1. Groundwater Quality Parameters and Frequency of Sample Collection for the South Lagoon Detection Monitoring Program.

Groundwater Quality Parameter	**Groundwater Sampling Frequency** **First Monitor Year**	**Second Monitor Year**
Groundwater Contamination Indicators		
pH	Quarterly	Semi-Annually
Specific Conductance	Quarterly	Semi-Annually
Total Organic Carbon	Quarterly	Semi-Annually
Total Organic Halogen	Quarterly	Semi-Annually
	(4 replicate measurements will be obtained for each sample)	
Groundwater Quality Parameters		
Chloride	Quarterly	Annually
Iron	Quarterly	Annually
Manganese	Quarterly	Annually
Phenols	Quarterly	Annually
Sodium	Quarterly	Annually
Sulfate	Quarterly	Annually
Drinking Water Supply Parameters		
Arsenic	Quarterly	--
Barium	Quarterly	--
Cadmium	Quarterly	--
Chromium	Quarterly	--
Fluoride	Quarterly	--
Lead	Quarterly	--
Mercury	Quarterly	--
Nitrate (N)	Quarterly	--
Selenium	Quarterly	--
Silver	Quarterly	--
Endrin	Quarterly	--
Lindane	Quarterly	--
Methoxychlor	Quarterly	--
Toxaphene	Quarterly	--
2,4-D	Quarterly	--
2,4,5-TP Silvex	Quarterly	--
Radium	Quarterly	--
Gross Alpha	Quarterly	--
Gross Beta	Quarterly	--
Coliform Bacteria	Quarterly	--



● Monitor Well

Figure 1. Location of South Lagoon Monitor Wells.

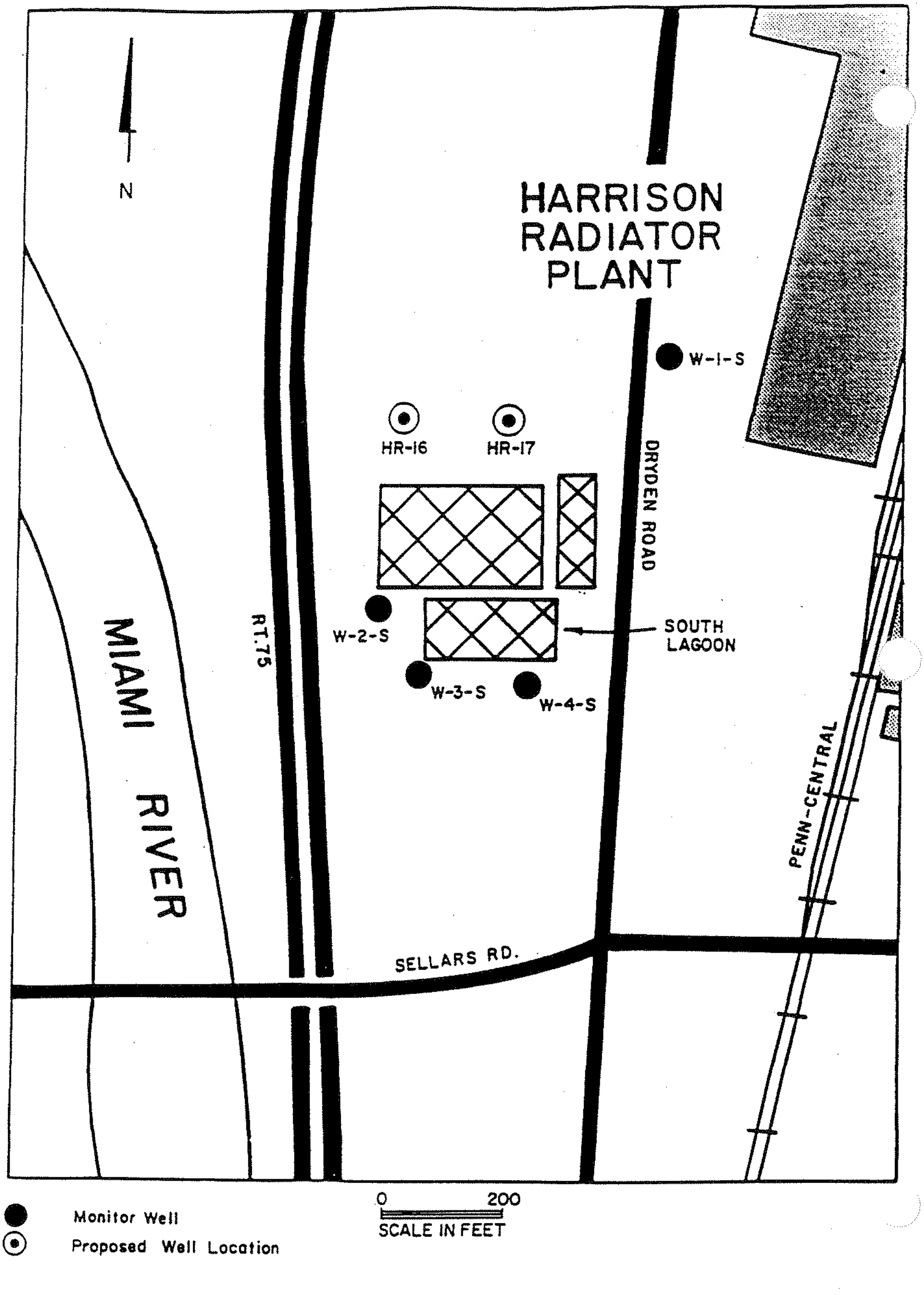


Figure 2. Proposed Locations for New Monitor Wells.

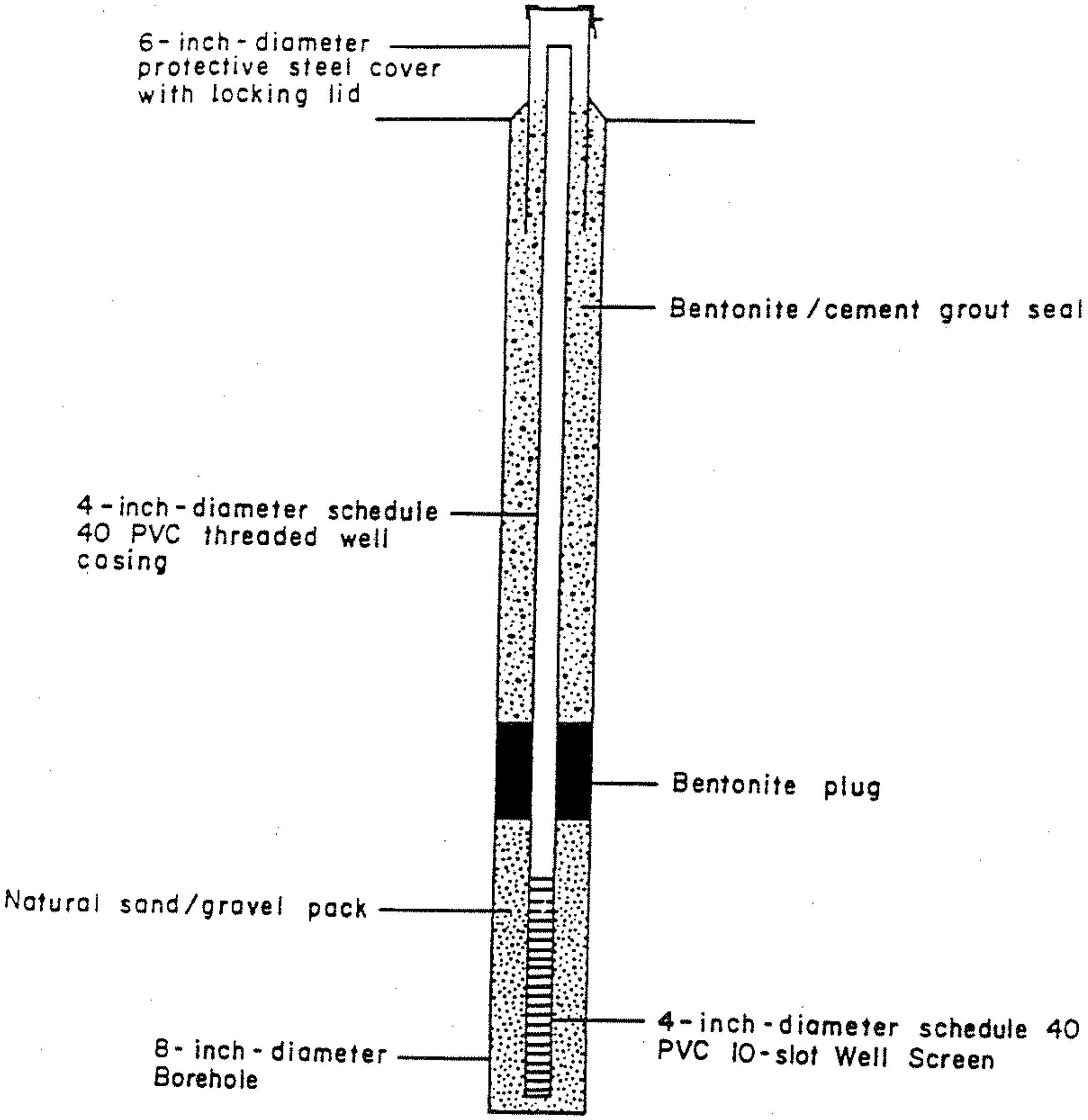


Figure 3. Typical Shallow Well Construction

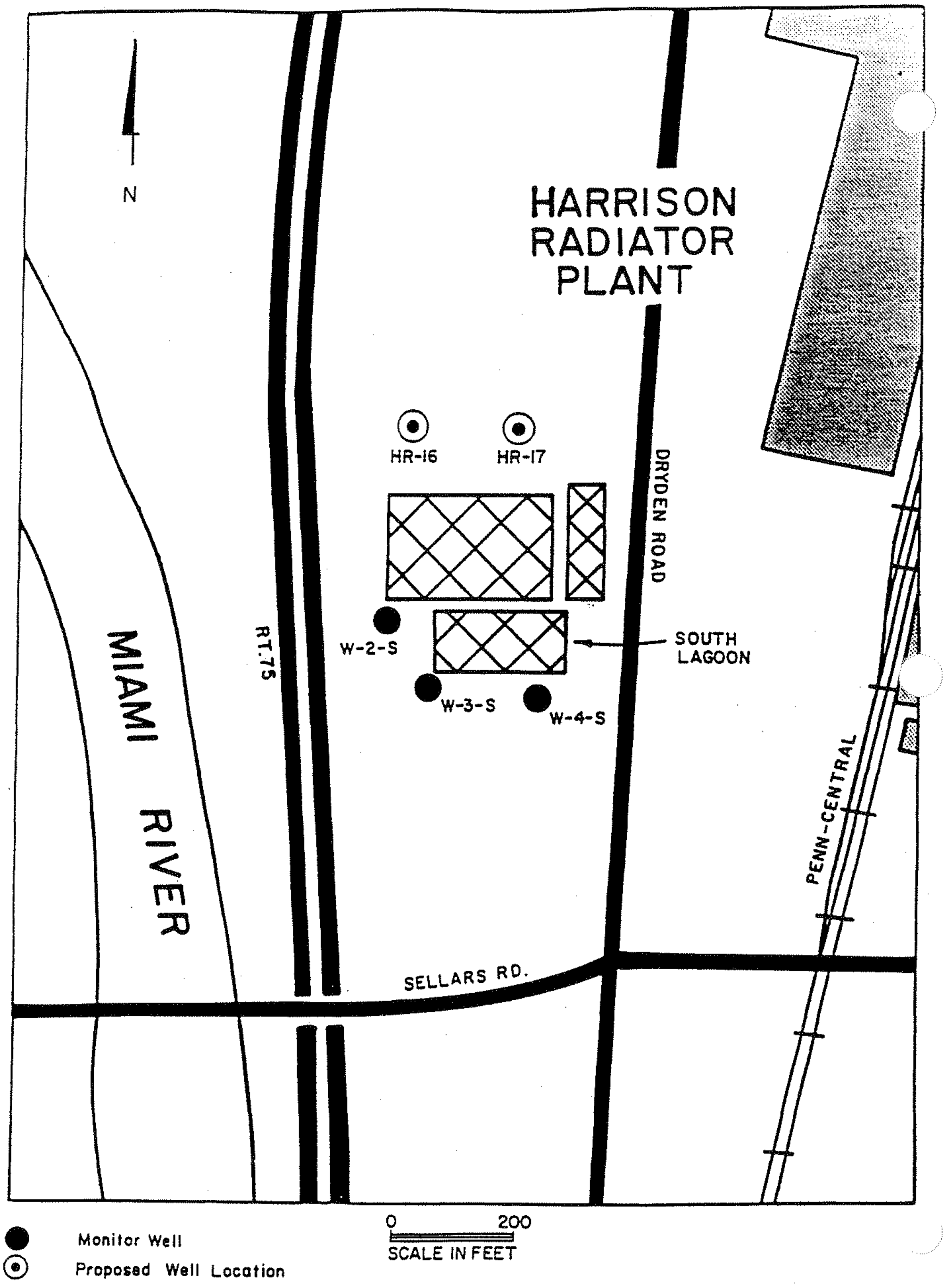


Figure 4. Location of Wells Used in the Detection Monitoring of the Harrison Radiator South Lagoon.

Appendix A

Groundwater Sampling and Analysis Plan for the South Settling Lagoon

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GROUNDWATER SAMPLING AND ANALYSIS PLAN FOR THE SOUTH SETTLING LAGOON

1.0 Introduction

Section 265.92 of the U.S. Environmental Protection Agency Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, requires owners and operators to obtain and analyze samples from their installed groundwater monitoring system. The requirement includes the development of a groundwater sampling plan, which must contain procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain-of-custody control. The following information describes the groundwater sampling and analytical protocols for monitoring at the Harrison Radiator South Lagoon.

2.0 Frequency of Sample Collection

Table A-1 presents the groundwater sampling frequency for wells in the vicinity of the Harrison Radiator plant. Five wells near the South Lagoon are sampled quarterly during the first year of monitoring and semi-annually thereafter.

3.0 Equipment

Sampling equipment needed for collecting representative samples of groundwater are presented below:

1. 100-ft steel measuring tape with weighted bottom (or) water-level indictor ("m-scope") consisting of an ammeter, electrode, and 150-ft cable;
2. Several gallons of potable water, distilled water, and deionized water;
3. Wash bottle;
4. Clean rags;
5. Plastic sheeting or large size garbage bags;
6. Bottom-filling Teflon bailer and polypropylene rope;
7. Submersible pump, discharge tubing, and generator;
8. Bucket;
9. Sample bottles;
10. Waterproof marking pen;
11. pH meter;
12. Thermometer;
13. Specific conductivity meter;
14. Water Sampling Logs, Chain of Custody forms, clipboard, pen;
15. Ice chest and ice or freezer packs.

TABLE A-1

List of Wells Sampled During the Detection Monitoring Program of the South Lagoon

WELL
HR-16*
HR-17*
W-2-S
W-3-S
W-4-S

* Well installed during 1989.

4.0 Laboratory Arrangements

An initial step in sampling is to notify the contract lab (Test America, formerly NET and Howard Laboratories, Inc., of Dayton, Ohio) of the intention to sample. Test America is informed of the number of wells to be sampled, the analysis to be performed, and the date sampling will begin. The lab then prepares the necessary sample containers with the required preservatives (Table A-2). Each sample container, when received by the sampling team, has a label indicating any preservative which has been added, as well as the analyses to be performed on the sample in that bottle.

5.0 Water-Level Measurements

Prior to collection of any water samples, a full round of water-level measurements is taken. The procedure for collecting water-level measurements is as follows:

A. Identify and unlock the well, then remove the well cap.

B. Using an M-scope, drop the probe down the center of the well until contact with the water surface is indicated. Hold the tape at the measuring point, then record the depth to water measurement, the measuring point (top of PVC casing or metal casing), the date and the time.

-or-

Using a steel tape, apply blue carpenters chalk to the bottom two feet of the tape. Slowly drop the weighted tape down the center of the casing. After water is encountered, the tape is held at the closest even foot marker at the top of the well casing, and the measurement recorded. The tape is then reeled out of the well and the measurement where the tape became wet is recorded. Depth to water from measuring point is found by subtracting the "wet" measurement from the "held" measurement. Record "held" measurement, "wet" measurement, depth to water, identify the measuring point (top of PVC casing or metal casing), and note the date and time.

C. Clean the M-scope or tape bottom with distilled water to prevent cross-contamination between wells.

Table A-2. List of Parameters Analyzed, Container Description and Preservation Method.

Groundwater Quality Parameter	Container	Method of Preservation
Groundwater Contamination Indicators		
pH	P, G	Cool, 4°C
Specific Conductance	P, G	Cool, 4°C
Total Organic Carbon	P, G	H_2SO_4 to pH<2; Cool, 4°C
Total Organic Halogen	P, G	Cool, 4°C
Groundwater Quality Parameters		
Chloride	P, G	Cool, 4°C
Iron	P, G	HNO_3 to pH<2
Manganese	P, G	HNO_3 to pH<2
Phenols	G	H_2SO_4 to pH<2; Cool, 4°C
Sodium	P, G	HNO_3 to pH<2; Cool, 4°C
Sulfate	P, G	Cool, 4°C
Drinking Water Supply Parameters		
Arsenic	P, G	HNO_3 to pH<2
Barium	P, G	HNO_3 to pH<2
Cadmium	P, G	HNO_3 to pH<2
Chromium	P, G	HNO_3 to pH<2
Fluoride	P, G	Cool, 4°C
Lead	P, G	HNO_3 to pH<2
Mercury	P, G	HNO_3 to pH<2
Nitrate (N)	P, G	H_2SO_4 to pH<2; Cool, 4°C
Selenium	P, G	HNO_3 to pH<2
Silver	P, G	HNO_3 to pH<2
Endrin	G	Cool, 4°C
Lindane	G	Cool, 4°C
Methoxychlor	G	Cool, 4°C
Toxaphene	G	Cool, 4°C
2,4-D	G	Cool, 4°C
2,4,5-TP Silvex	G	Cool, 4°C
Radium	P, G	HNO_3 to pH<2
Gross Alpha	P, G	HNO_3 to pH<2
Gross Beta	P, G	HNO_3 to pH<2
Coliform Bacteria, Total	P, G	EDTA; Sodium thiosulfate; Cool, 4°C

P - Plastic container.

G - Glass container.

6.0 Well Evacuation Procedures

Standing water must be removed from the well casing prior to collection of groundwater samples. Well evacuation procedures are as follows:

A. Identify the well and record its designation on the G&M Water Sampling Log (Figure A-1). Also record preliminary information such as project, location, time, date, weather and sampling personnel on the water sampling data sheet.

B. Unlock the well and remove the vented well cap.

C. Compute the standing volume (gallons) of water in the well by subtracting the depth to water from the total depth of the well. Then multiply this figure by a coefficient which relates the diameter of the well to gallons per linear foot. Coefficients for commonly encountered well diameters are listed on the bottom of the G&M Water Sampling Log (0.162 gallons/feet for a two-inch diameter well, and 0.652 gallons/feet for a four-inch diameter well).

D. Remove three to five times the volume of standing water in the well using a Teflon bailer or a pump, depending on the diameter of the well and the depth to water. If a pump is used, first place plastic sheeting around the well to protect sampling equipment from potential contamination. The intake opening of the pump is positioned and maintained ± 10 feet below the water. If there is a decrease in a well's water level as a result of pumping, the intake line is lowered as needed. After evacuation is achieved, slowly raise pump until suction is broken to ensure that the well is properly flushed. Prior to sampling, bail an additional 5 gallons from the top of the water column. Collect the sample at the original pump setting. After purging, record the amount of water removed on the Water Sampling Log.

E. As in the past, purge water will continue to be eliminated to the ground surface away from the well head. The South Lagoon is in detection monitoring and utilizing the Average Replicate (AR). Students T-test there has been no statistically significant difference noted for the groundwater quality parameters at a 0.01 level of significance. Since groundwater has not been impacted at South Lagoon, continued elimination of this water to the ground surface, away from the well head, is appropriate.

Figure A-1

ARCADIS GERAGHTY & MILLER

Water Sampling Log

Project
Project No.
Page of
Site Location
Date
Site/Well No.
Replicate No.
Code No.
Weather
Sampling Time: Begin End

Evacuation Data

Measuring Point
MP Elevation (ft)
Land Surface Elevation (ft)
Sounded Well Depth (ft bmp)
Depth to Water (ft bmp)
Water-Level Elevation (ft)
Water Column in Well (ft)
Casing Diameter/Type
Gallons in Well
Gallons Pumped/Bailed Prior to Sampling
Sample Pump Intake Setting (ft bmp)
Purge Time begin end
Pumping Rate (gpm)
Evacuation Method

Field Parameters

Color
Odor
Appearance
pH (s.u.)
Conductivity (mS/cm)
(µmhos/cm)
Turbidity (NTU)
Temperature (°C)
Dissolved Oxygen (mg/L)
Salinity (%)
Sampling Method
Remarks

Constituents Sampled	**Container Description**	**Number**	**Preservative**

Sampling Personnel

Well Casing Volumes

Gal./Ft.	1-¼" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65
	1-½" = 0.09	2-½" = 0.26	3-½" = 0.50	6" = 1.47

bmp	below measuring point	ml	mililiter	NTU	Nephelometric Turbidity Units
°C	Degrees Celsius	mS/cm	Milisiemens per centimeter	PVC	Polyvinyl chloride
ft	feet	msl	mean sea-level	s.u.	Standard units
gpm	Gallons per minute	N/A	Not Applicable	umhos/cm	Micromhos per centimeter
mg/L	Miligrams per liter	NR	Not Recorded	VOC	Volatile Organic Compounds

WTRSAMLG.XLS.xls

7.0 Procedures for Sample Collection and Field Analyses

A. Inspect the sample containers and choose the right type and number based on the analyses plan. Label the sample containers with the well identification number, date, and time.

B. Allow well to recharge sufficiently to obtain samples. For the wells at Harrison, recharge generally occurs immediately.

C. Measurements of pH, temperature and specific conductance are made in the field at the time of sampling because these parameters change rapidly and a laboratory analysis might not be representative of true groundwater quality. The pH meter is calibrated at the start of each day with pH buffer solutions of 4.0 and 7.0. The conductivity meter is also calibrated at the start of each day with a standard of 1000 umhos/cm. The calibration is checked periodically throughout the day and recalibration performed when necessary. Enough water is removed from the well to determine temperature of the water, specific conductivity, and pH. Four replicate measurements of pH are recorded on the Water Sampling Log; one measurement each of specific conductivity and temperature are also recorded.

D. Water samples are collected using a bottom-filling Teflon bailer. If a pump was used to evacuate the well, bail an additional five gallons of water prior to sample collection.

E. The bailer is lowered into the well in a manner that minimizes disturbances to the water table. The bailer is carefully removed from the well and the water sample gently poured into the sample containers provided by the laboratory; container lids are replaced and sealed. Samples for soluble metals analysis are field filtered.

F. After the samples have been collected, they are placed into coolers with ice to provide thermal preservation until they are delivered to the laboratory.

G. Care is taken to avoid cross-contamination between wells by careful cleaning and rinsing of the bailer and/or pump. The bailer, pump and discharge tubing are decontaminated immediately after sampling with distilled water, Micro soap, and a triple rinse with deionized water. The bailer cord is replaced for each sample collected. Disposable gloves are worn by sampling personnel and are changed prior to collecting each sample.

H. Several quality control samples are also sent to the laboratory to monitor sampling and laboratory performance. One trip blank accompanies each round of samples. The trip blank is a vial filled with organic-free water in the laboratory that travels unopened with the sample bottles and is analyzed for VOCs. Field blanks are made by pouring deionized water into a bailer which has been cleaned, and then pouring from the bailer into the sample bottles; field blanks are analyzed for the entire suite of parameters. In addition, a duplicate sample is collected from one well and analyzed for the entire parameter list.

I. After sample collection is completed each day, the samples are hand-delivered to Test America in the coolers.

8.0 Chain of Custody

The sampling team is responsible for the custody and care of collected samples until the containers have been transferred to the custody of the laboratory. A chain-of-custody form is completed to establish the necessary documentation to track possession from time of collection to analysis. The chain-of-custody form is shown on Figure A-2 and includes the following information:

- Project identification or location
- Sampling personnel
- Identity of sample(s)
- Date of sampling
- Signatures of persons involved in the chain-of-custody and the dates and times of possession.

9.0 Laboratory Analysis of Samples

The sampling frequency and analyses for the South Lagoon wells are summarized on Table A-3. The analytical methods used by Test America are listed on Table A-4.

Figure A-2

ARCADI

Laboratory Task Order No./P.O. No. ______

CHAIN-OF-CUSTODY RECORD

Page ___ of ___

Project Number/Name ______

Project Location ______

Laboratory ______

Project Manager ______

Sampler(s)/Affiliation ______

Sample ID/Location	Matrix	Date/Time Sampled	Lab ID	ANALYSIS / METHOD / SIZE						Remarks	Total

Sample Matrix: L = Liquid; S = Solid; A = Air

Total No. of Bottles/ Containers ______

Relinquished by: ______	Organization: ______	Date ___/___/___	Time ______	Seal Intact?
Received by: ______	Organization: ______	Date ___/___/___	Time ______	Yes No N/A
Relinquished by: ______	Organization: ______	Date ___/___/___	Time ______	Seal Intact?
Received by: ______	Organization: ______	Date ___/___/___	Time ______	Yes No N/A

Special Instructions/Remarks: ______

Delivery Method: ☐ In Person ☐ Common Carrier ______ SPECIFY ☐ Lab Courier ☐ Other ______ SPECIFY

Table A-3. Groundwater Quality Parameters and Frequency of Sample Collection for the South Lagoon Detection Monitoring Program.

Groundwater Quality Parameter	**Groundwater Sampling Frequency**	
	First Monitor Year	**Second Monitor Year**
Groundwater Contamination Indicators		
pH	Quarterly	Semi-Annually
Specific Conductance	Quarterly	Semi-Annually
Total Organic Carbon	Quarterly	Semi-Annually
Total Organic Halogen	Quarterly	Semi-Annually
	(4 replicate measurements will be obtained for each sample)	
Groundwater Quality Parameters		
Chloride	Quarterly	Annually
Iron	Quarterly	Annually
Manganese	Quarterly	Annually
Phenols	Quarterly	Annually
Sodium	Quarterly	Annually
Sulfate	Quarterly	Annually
Drinking Water Supply Parameters		
Arsenic	Quarterly	--
Barium	Quarterly	--
Cadmium	Quarterly	--
Chromium	Quarterly	--
Fluoride	Quarterly	--
Lead	Quarterly	--
Mercury	Quarterly	--
Nitrate (N)	Quarterly	--
Selenium	Quarterly	--
Silver	Quarterly	--
Endrin	Quarterly	--
Lindane	Quarterly	--
Methoxychlor	Quarterly	--
Toxaphene	Quarterly	--
2,4-D	Quarterly	--
2,4,5-TP Silvex	Quarterly	--
Radium	Quarterly	--
Gross Alpha	Quarterly	--
Gross Beta	Quarterly	--
Coliform Bacteria	Quarterly	--

TABLE A-4
Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
South Settling Lagoon Detection Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
<u>Ground-Water Contamination Indicators</u>					
pH		Field Measurement			
Specific Conductance	9050	SW-846	1	umhos/cm	28 days
Total Organic Carbon	9060	SW-846	1	mg/L	28 days
Total Organic Halogen	9020	SW-846	10	ug/L	28 days
<u>Ground-Water Quality Parameters</u>					
Chloride	9252	SW-846	1	mg/L	28 days
Iron	7380/6010	SW-846	0.1	mg/L	6 months
Manganese	7460/6010	SW-846	0.01	mg/L	6 months
Phenols	9065	SW-846	0.01	mg/L	28 days
Sodium	D-1428/6010	ASTM/SW-846	1	mg/L	6 months
Sulfate	9038	SW-846	1	mg/L	28 days
<u>Drinking Water Supply Parameters</u>					
Arsenic	7061/7060	SW-846	0.005	mg/L	6 months
Barium	7080/7081/6010	SW-846	0.2	mg/L	6 months
Cadmium	7130/6010/7131	SW-846	0.001	mg/L	6 months
Chromium	7190/6010/7191	SW-846	0.002	mg/L	6 months
Fluoride	413B	STM	0.02	mg/L	28 days
Lead	7420/6010/7421	SW-846	0.005	mg/L	6 months
Mercury	7470	SW-846	0.0002	mg/L	28 days
Nitrate (N)	418C/APHA 4500-N03F	STM	0.02	mg/L	48 hours
Selenium	7741/7740	SW-846	0.005	mg/L	6 months
Silver	7760/6010/7761	SW-846	0.001	mg/L	6 months
Endrin	8080	SW-846	0.2	ug/L	7 days
Lindane	8080	SW-846	0.2	ug/L	7 days
Methoxychlor	8080	SW-846	0.2	ug/L	7 days
Toxaphene	8080	SW-846	0.5	ug/L	7 days
2,4-D	509B	STM	1	ug/L	7 days
2,3,5-TP Silvex	509B	STM	0.5	ug/L	7 days
Radium (Total)	903/904	EPA 600	1	pCi/L	6 months
Gross alpha	900	EPA 600	3	pCi/L	6 months
Gross beta	900	EPA 600	4	pCi/L	6 months
Coliform (Total)	*	ODH	NA	NA	30 hours

References:
SW-846 = Test Methods for Evaluating Solid Waste, U.S. EPA-SW-846, 1986, Third Edition.
STM = Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1986, ALPHA-AWWA-WPCF.
ASTM = American Society for Testing and Materials.
EPA 600 = Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA 600/4-80-032, U.S. EPA, 1980.
ODH = Certification for Bacteriological Water Analysis, Ohio Department of Health, 1985.

DELPHI
Harrison Thermal Systems

April 1, 1996

Mr. Chris Cotton
Ohio Environmental Protection Agency
Southwest District Office
401 East Fifth Street
Dayton, Ohio 45402-2911

Re: GM Delphi-Harrison Thermal Systems
OHD000817577
Montgomery County
Groundwater

Dear Mr. Cotton:

This letter is in response to your February 23, 1996 correspondence concerning Ohio EPA's Comprehensive Monitoring Evaluation ("CME") dated September 29, 1995. As discussed in detail in General Motors' correspondence dated November 16, 1995, General Motors objects to the claim, both in the CME and your February 23, 1996 correspondence, alleging that General Motors is in violation of the applicable requirements of the Ohio Administrative Code relating to groundwater monitoring requirements.

The groundwater monitoring program in question was approved by Ohio EPA pursuant to a Consent Decree October 26, 1988. General Motors' November 16, 1995 correspondence discusses in detail how the groundwater monitoring program was reviewed (at length) by Ohio EPA and approved as meeting the requirements of the Ohio Administrative Code. Even though the Consent Decree requiring the review and approval of the revised groundwater monitoring program has expired, that does not change the fact that the plan, as written, was approved by Ohio EPA as meeting the requirements of the Ohio Administrative Code. The Agency's current claims alleging violations with the previously approved plans represents a contradiction of the Agency's own previous position. The Agency cannot now declare these plans in violation of the rules without contravening its own previous approval. Consequently, the concerns cited in the CME cannot constitute violations of the rules.

While General Motors objects to Ohio EPA's claims of violations of the regulations, General Motors is willing to discuss with the members of your staff possible revisions to the Sampling and Analysis Plans ("SAPs") as requested in the CME. Harrison is prepared to amend the respective SAPs to include the additional information the Agency has requested. With that in mind, Harrison has prepared drafts to the SAPS for Ohio EPA review. These drafts are submitted as attachments to this letter as follows:

Attachment #1: Draft revisions to Section 6.0 of Appendix A to the North and South Lagoon SAPs which addresses the management and disposal of purge water at each unit.

Attachment #2: Revisions to the appropriate table of each SAP to include detection limits and sample holding times. Additionally, these tables have been updated to include additional methods which Ohio EPA has approved.

Attachment #3: A revised "General Site Conditions" section which includes the site-specific hydrogeologic information. This revised section would subsequently be incorporated into the North and South Lagoon Groundwater Plans.

General Motors is prepared to make the above proposed revisions if the Agency resolves the perception of non-compliance created by its previous correspondence by sending a letter indicating that no non-compliance ever occurred and the parties have agreed to the revisions to the SAPs as contained in this Harrison letter. If you have any further questions concerning any of the technical issues related to this matter, please feel free to contact Robert Kerr at 513-455-4424.

Very truly yours,

BA Scherschel

B.A. Scherschel
Plant Manager

BAS/REKerr/lbc

c: Pamela S. Allen

Attachments

/REK04016

GERAGHTY
& MILLER INC.
Environmental Services

A Heidemij company

April 1, 1996

Norman J Sawdey
General Motors Corporation
3600 Dryden Road
Moraine, Ohio 45439-1410

RE: April 1, 1996 Draft Attachments 1, 2, and 3 in Response to Ohio EPA's February 23, 1996 Letter Concerning Delphi Harrison Thermal Systems, Moraine, Ohio, CME

Dear Norm,

Please find the following April 1, 1996 draft attachments to be included in response to Ohio EPA's February 23, 1996 letter concerning Delphi-Harrison Thermal Systems, Moraine, Ohio CME: 1) a draft revision to Section 6.0 of Appendix A to the North and South Settling Lagoons SAP's addressing the management of purgewater; 2) Tables A-3 of the North Settling Lagoon Assessment Monitoring Plan and Table A-4 of the South Settling Lagoon Detection Monitoring Plan including detection limits, sample holding times; and 3) a revised "General Site Conditions" section which includes site specific hydrogeological information to be incorporated into the North and South Settling Lagoon Groundwater Monitoring Plans.

As discussed in an April 1, 1996 conference call between Laura Tucker, Mike Born (Fuller & Henry), Bob Kerr, Larry Graves, Richard Astle, and yourself, the following revisions have been made: "DRAFT For Settlement Discussions ONLY" has been added to each attachment cover page; the wording of the first and last sentences in Paragraph E of Attachment 1 has been revised to reflect current practices; and a header stating "DRAFT April 1, 1996" has been added to each page of each attachment.

Should you have any questions or comments regarding this information, please do not hesitate to contact me at (614) 764-2310.

Sincerely,

GERAGHTY & MILLER, INC.

Richard Astle
Project Manager/Staff Scientist

cc: John Ridd
Bob Kerr

[illegible] • (614) 764-2310 • FAX (614) 764-[illegible]

ATTACHMENT #1

DRAFT

For Settlement Discussions

ONLY

C. Clean the M-Scope or tape bottom with distilled water to prevent cross-contamination between wells.

6.0 Well Evacuation Procedures

Standing water must be removed from the well casing prior to collection of groundwater samples. Well evacuation procedures are as follows:

A. Identify the well and record its designation on the G&M Waster Sampling Log (Figure A-1). Also, record preliminary information such as project, location, time, date, weather, and sampling personnel on the water sampling data sheet.

B. Unlock the well and remove the vented well cap.

C. Compute the standing volume (gallons) of water in the well by subtracting the depth to water from the total depth of the well. Then multiply this figure by a coefficient which relates the diameter of the well to gallons per linear foot. Coefficients for commonly encountered well diameters are limited on the bottom of the G&M Water Sampling Log (0.162 gallons/feet for a 2-inch diameter well, and 0.652 gallons/feet for a four-inch diameter well).

D. Remove three to five times the volume of standing water in the well using a Teflon bailer or a pump, depending on the diameter of the well and the depth to water. If a pump is used, first place plastic sheeting around the well to protect sampling equipment from potential contamination. The intake opening of the pump is positioned and maintained ±10 feet below the water. If there is a decrease in a well's water level as a result of pumping, the intake line is lowered as needed. After evaluation is achieved, slowly raise pump until suction is broken to ensure that the well is properly flushed. Prior to sampling, bail an additional 5 gallons from the top of the water column. Collect the sample at the original pump setting. After purging, record the amount of water removed on the Water Sampling Log.

E. As in the past, purge water will continue to be eliminated to the ground surface away from the well head. The North Lagoon's latest Part A permit revision dated June 13, 1988 list it as containing F006, F007, F009, F012, and F019 waste. Review of latest eight quarters of groundwater monitoring data (1994 and 1995) show that groundwater does not contain the hazardous constituents for which the unit was listed. Namely, in no downgradient well was cyanide, dissolved cadmium, dissolved chrome or dissolved nickel detected. Further analysis of this data show that groundwater does not exhibit any of the characteristics identified in Rules 3745-51-20 to 3745-51-24 of the Ohio Administrative Code. Since groundwater from North Lagoon is not considered to be a hazardous waste, continued elimination of this water to the ground surface, away from the well head, is appropriate.

6.0 Well Evacuation Procedures

Standing water must be removed from the well casing prior to collection of groundwater samples. Well evacuation procedures are as follows:

A. Identify the well and record its designation on the G&M Waster Sampling Log (Figure A-1). Also, record preliminary information such as project, location, time, date, weather and sampling personnel on the water sampling data sheet.

B. Unlock the well and remove the vented well cap.

C. Compute the standing volume (gallons) of water in the well by subtracting the depth to water from the total depth of the well. Then multiply this figure by a coefficient which relates the diameter of the well to gallons per linear foot. Coefficients for commonly encountered well diameters are limited on the bottom of the G&M Water Sampling Log (0. 162 gallons/feet for a 2-inch diameter well, and 0.652 gallons/feet for a four-inch diameter well).

D. Remove three to five times the volume of standing water in the well using a Teflon bailer or a pump, depending on the diameter of the well and the depth to water. If a pump is used, first place plastic sheeting around the well to protect sampling equipment from potential contamination. The intake opening of the pump is positioned and maintained ±10 feet below the water. If there is a decrease in a well's water level as a result of pumping, the intake line is lowered as needed. After evaluation is achieved, slowly raise pump until suction is broken to ensure that the well is properly flushed. Prior to sampling, bail an additional 5 gallons from the top of the water column. Collect the sample at the original pump setting. After purging, record the amount of water removed on the Water Sampling Log.

E. As in the past, purge water will continue to be eliminated to the ground surface away from the well head. The South Lagoon is in detection monitoring and utilizing the Average Replicate (AR). Students T-test there has been no statistically significant difference noted for the groundwater quality parameters at a 0.01 level of significance. Since groundwater has not been impacted at South Lagoon, continued elimination of this water to the ground surface, away from the well head, is appropriate.

ATTACHMENT #2

DRAFT

For Settlement Discussions

ONLY

DRAFT
April 1, 1996

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
pH	9040	SW-846	0.1	S.U.	24 hours*
Specific Conductance	9050	SW-846	1	umhos/cm	28 days
<u>Volatile Organic Compounds</u>					
1,1,1,2-Tetrachloroethane	8240	SW-846	1	ug/L	14 days
1,1,1-Trichloroethane	8240	SW-846	1	ug/L	14 days
1,1,2,2-Tetrachloroethane	8240	SW-846	1	ug/L	14 days
1,1,2-Trichloroethane	8240	SW-846	1	ug/L	14 days
1,1-Dichloroethane	8240	SW-846	1	ug/L	14 days
1,1-Dichloroethene	8240	SW-846	1	ug/L	14 days
1,2,3-Trichloropropane	8240	SW-846	5	ug/L	14 days
1,2-Dibromo-3-chloropropane	8240	SW-846	5	ug/L	14 days
1,2-Dibromoethane	8240	SW-846	5	ug/L	14 days
1,2-Dichloroethane	8240	SW-846	1	ug/L	14 days
1,2-Dichloropropane	8240	SW-846	1	ug/L	14 days
2-Butanone (methyl ethyl ketone)	8240	SW-846	10	ug/L	14 days
2-Chloro-1,3-butadiene (Chloroprene)	8240	SW-846	5	ug/L	14 days
2-Hexanone	8240	SW-846	10	ug/L	14 days
4-Methyl-2-pentanone (methyl isobutyl ketone)	8240	SW-846	10	ug/L	14 days
Acetone	8240	SW-846	20	ug/L	14 days
Acrolein	8240	SW-846	50	ug/L	14 days
Acrylonitrile	8240	SW-846	50	ug/L	14 days
Allyl chloride	8240	SW-846	5	ug/L	14 days
Benzene	8240	SW-846	1	ug/L	14 days
Bromodichloromethane	8240	SW-846	1	ug/L	14 days
Bromoform	8240	SW-846	1	ug/L	14 days
Bromomethane	8240	SW-846	5	ug/L	14 days
Carbon disulfide	8240	SW-846	1	ug/L	14 days
Carbon tetrachloride	8240	SW-846	1	ug/L	14 days
Chlorobenzene	8240	SW-846	1	ug/L	14 days
Chloroethane	8240	SW-846	10	ug/L	14 days
Chlorofrom	8240	SW-846	1	ug/L	14 days
Chloromethane	8240	SW-846	10	ug/L	14 days
Dibromochloromethane	8240	SW-846	1	ug/L	14 days
Dibromomethane	8240	SW-846	1	ug/L	14 days
Dichlorodifluoromethane	8240	SW-846	10	ug/L	14 days
Ethyl methacrylate	8240	SW-846	5	ug/L	14 days
Ethylbenzene	8240	SW-846	1	ug/L	14 days
Iodomethane	8240	SW-846	5	ug/L	14 days
Methacrylonitrile	8240	SW-846	5	ug/L	14 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Methylene chloride	8240	SW-846	10	ug/L	14 days
Methylmethacrylate	8240	SW-846	5	ug/L	14 days
Pentachloroethane	8240	SW-846	5	ug/L	14 days
Propionitrile	8240	SW-846	50	ug/L	14 days
Styrene	8240	SW-846	1	ug/L	14 days
Tetrachloroethene	8240	SW-846	1	ug/L	14 days
Toluene	8240	SW-846	1	ug/L	14 days
Trichloroethene	8240	SW-846	1	ug/L	14 days
Trichlorofluoromethane (Fluorotrichloromethane)	8240	SW-846	1	ug/L	14 days
Vinyl acetate	8240	SW-846	10	ug/L	14 days
Vinyl chloride	8240	SW-846	5	ug/L	14 days
Xylenes, Total	8240	SW-846	1	ug/L	14 days
cis-1,3-Dichloropropene	8240	SW-846	1	ug/L	14 days
trans-1,2-Dichloroethene	8240	SW-846	1	ug/L	14 days
trans-1,3-Dichloropropene	8240	SW-846	1	ug/L	14 days
trans-1,4-Dichloro-2-butene	8240	SW-846	5	ug/L	14 days
<u>Semi-Volatile Organic Compounds</u>					
Acenaphthene	8270	SW-846	10	ug/L	7 days
Acenaphthylene	8270	SW-846	10	ug/L	7 days
Acetophenone	8270	SW-846	20	ug/L	7 days
2-Acetylaminofluorene (2-AAF)	8270	SW-846	20	ug/L	7 days
4-Aminobiphenyl	8270	SW-846	20	ug/L	7 days
Aniline	8270	SW-846	10	ug/L	7 days
Anthracene	8270	SW-846	10	ug/L	7 days
Aramite	8270	SW-846	15	ug/L	7 days
Benzo(a)anthracene	8270	SW-846	10	ug/L	7 days
Benzo(b)fluoranthene	8270	SW-846	10	ug/L	7 days
Benzo(k)fluoranthene	8270	SW-846	10	ug/L	7 days
Benzo(ghi) perylene	8270	SW-846	10	ug/L	7 days
Benzo(a)pyrene	8270	SW-846	10	ug/L	7 days
Benzy alcohol	8270	SW-846	10	ug/L	7 days
Bis(2-chloroethoxy)methane	8270	SW-846	10	ug/L	7 days
Bis(2-chloroethyl)ether	8270	SW-846	10	ug/L	7 days
Bis(2-ethylhexyl)phthalate	8270	SW-846	10	ug/L	7 days
4-Bromophenyl phenyl ether	8270	SW-846	10	ug/L	7 days
Butyl benzyl phthalate	8270	SW-846	10	ug/L	7 days
p-Chloroaniline	8270	SW-846	10	ug/L	7 days
Chlorobenzilate	8270	SW-846	50	ug/L	7 days
2-Chloronaphthalene	8270	SW-846	10	ug/L	7 days
4-Chlorophenyl phenyl ether	8270	SW-846	10	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Chrysene	8270	SW-846	10	ug/L	7 days
Diallate	8270	SW-846	30	ug/L	7 days
Dibenzo(a,h)anthracene	8270	SW-846	10	ug/L	7 days
Dibenzofuran	8270	SW-846	10	ug/L	7 days
Di-n-butyl phthalate	8270	SW-846	10	ug/L	7 days
o-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
m-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
p-Dichlorobenzene	8270	SW-846	10	ug/L	7 days
3,3'-Dichlorobenzidine	8270	SW-846	20	ug/L	7 days
2,2'-Dichlorodiisopropyl ether	8270	SW-846	10	ug/L	7 days
Diethyl phthalate	8270	SW-846	10	ug/L	7 days
Thionazin	8270	SW-846	20	ug/L	7 days
Dimethoate	8270	SW-846	100	ug/L	7 days
p-(Dimethylamino)azobenzene	8270	SW-846	50	ug/L	7 days
7,12-Dimethylbenz(a)anthracene	8270	SW-846	20	ug/L	7 days
3,3'-Dimethylbenzidine	8270	SW-846	20	ug/L	7 days
a,a-Dimethyl-phenethylamine	8270	SW-846	50	ug/L	7 days
Dimethyl phthalate	8270	SW-846	10	ug/L	7 days
m-Dinitrobenzene	8270	SW-846	20	ug/L	7 days
2,4-Dinitrotoluene	8270	SW-846	10	ug/L	7 days
2,6-Dinitrotoluene	8270	SW-846	10	ug/L	7 days
Di-n-octyl phthalate	8270	SW-846	10	ug/L	7 days
Diphenylamine	8270	SW-846	20	ug/L	7 days
Disulfoton	8270	SW-846	20	ug/L	7 days
Ethyl methanesulfonate	8270	SW-846	20	ug/L	7 days
Famphur	8270	SW-846	10	ug/L	7 days
Fluoranthene	8270	SW-846	10	ug/L	7 days
Fluorene	8270	SW-846	10	ug/L	7 days
Hexachlorobenzene	8270	SW-846	10	ug/L	7 days
Hexachlorobutadiene	8270	SW-846	10	ug/L	7 days
Hexachlorocyclopentadiene	8270	SW-846	10	ug/L	7 days
Hexachloroethane	8270	SW-846	10	ug/L	7 days
Hexachlorophene	8270	SW-846	500	ug/L	7 days
Hexachloroprophene	8270	SW-846	30	ug/L	7 days
Indeno(1,2,3-cd)pyrene	8270	SW-846	10	ug/L	7 days
Isodrin	8270	SW-846	30	ug/L	7 days
Isophorone	8270	SW-846	10	ug/L	7 days
Isosafrole	8270	SW-846	20	ug/L	7 days
Kepone	8270	SW-846	250	ug/L	7 days
Methapyrilene	8270	SW-846	100	ug/L	7 days
3-Methylcholanthrene	8270	SW-846	30	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Methyl methanesulfonate	8270	SW-846	20	ug/L	7 days
2-Methylnaphthalene	8270	SW-846	10	ug/L	7 days
Methyl parathion	8270	SW-846	20	ug/L	7 days
Naphthalene	8270	SW-846	10	ug/L	7 days
1,4-Naphthoquinone	8270	SW-846	100	ug/L	7 days
1-Naphthylamine	8270	SW-846	30	ug/L	7 days
2-Naphthylamine	8270	SW-846	30	ug/L	7 days
o-Nitroaniline	8270	SW-846	15	ug/L	7 days
m-Nitroaniline	8270	SW-846	15	ug/L	7 days
p-Nitroaniline	8270	SW-846	15	ug/L	7 days
Nitrobenzene	8270	SW-846	10	ug/L	7 days
4-Nitroquinoline 1-oxide	8270	SW-846	30	ug/L	7 days
N-Nitrosodi-n-butylamine	8270	SW-846	20	ug/L	7 days
N-Nitrosodiethylamine	8270	SW-846	30	ug/L	7 days
N-Nitrosodimethylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosodiphenylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosodipropylamine	8270	SW-846	10	ug/L	7 days
N-Nitrosomethylethylamine	8270	SW-846	20	ug/L	7 days
N-Nitrosomorpholine	8270	SW-846	20	ug/L	7 days
N-Nitrosopiperidine	8270	SW-846	20	ug/L	7 days
N-Nitrosopyrrolidine	8270	SW-846	20	ug/L	7 days
5-Nitro-o-toluidine	8270	SW-846	20	ug/L	7 days
Parathion	8270	SW-846	20	ug/L	7 days
Pentachlorobenzene	8270	SW-846	20	ug/L	7 days
Pentachloronitrobenzene	8270	SW-846	20	ug/L	7 days
Phenacetin	8270	SW-846	20	ug/L	7 days
Phenanthrene	8270	SW-846	10	ug/L	7 days
p-Phenylenediamine	8270	SW-846	30	ug/L	7 days
Phorate	8270	SW-846	20	ug/L	7 days
2-Picoline	8270	SW-846	20	ug/L	7 days
Pronamide	8270	SW-846	20	ug/L	7 days
Pyrene	8270	SW-846	10	ug/L	7 days
Pyridine	8270	SW-846	10	ug/L	7 days
Safrole	8270	SW-846	20	ug/L	7 days
1,2,4,5-Tetrachlorobenzene	8270	SW-846	20	ug/L	7 days
Sulfotepp	8270	SW-846	20	ug/L	7 days
o-Toluidine	8270	SW-846	20	ug/L	7 days
1,2,4-Trichlorobenzene	8270	SW-846	10	ug/L	7 days
Triethyl phosphorothioate	8270	SW-846	20	ug/L	7 days
1,3,5-Trinitrobenzene	8270	SW-846	30	ug/L	7 days
2-Chlorophenol	8270	SW-846	10	ug/L	7 days

TABLE A-3

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
North Settling Lagoon Assessment Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Water Quality Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
4-Chloro-3-methyl phenol	8270	SW-846	10	ug/L	7 days
ortho-Methylphenol	8270	SW-846	10	ug/L	7 days
meta- & para-Methylphenol	8270	SW-846	10	ug/L	7 days
2,4-Dichlorophenol	8270	SW-846	10	ug/L	7 days
2,6-Dichlorophenol	8270	SW-846	10	ug/L	7 days
2,4-Dimethylphenol	8270	SW-846	10	ug/L	7 days
4,6-Dinitro-2-methylphenol	8270	SW-846	10	ug/L	7 days
2,4-Dinitrophenol	8270	SW-846	10	ug/L	7 days
o-Nitrophenol	8270	SW-846	10	ug/L	7 days
p-Nitrophenol	8270	SW-846	10	ug/L	7 days
Pentachlorophenol	8270	SW-846	10	ug/L	7 days
Phenol	8270	SW-846	10	ug/L	7 days
2,3,4,6-Tetrachlorophenol	8270	SW-846	20	ug/L	7 days
2,4,5-Trichlorophenol	8270	SW-846	10	ug/L	7 days
2,4,6-Trichlorophenol	8270	SW-846	10	ug/L	7 days
<u>Inorganic Compounds</u>					
Antimony	7040/6010/7041	SW-846	0.02	mg/L	6 months
Arsenic	7061/7060	SW-846	0.005	mg/L	6 months
Barium	7080/7081/6010	SW-846	0.2	mg/L	6 months
Cadmium	7130/6010/7131	SW-846	0.001	mg/L	6 months
Chromium	7190/6010/7191	SW-846	0.002	mg/L	6 months
Cobalt	7200/6010/7201	SW-846	0.005	mg/L	6 months
Copper	7210/6010	SW-846	0.02	mg/L	6 months
Lead	7420/6010/7421	SW-846	0.005	mg/L	6 months
Mercury	7470	SW-846	0.0002	mg/L	28 days
Nickel	7521/6010	SW-846	0.01	mg/L	6 months
Selenium	7741/7740	SW-846	0.005	mg/L	6 months
Silver	7760/6010/7761	SW-846	0.001	mg/L	6 months
Tin	7870/6010	SW-846	2	mg/L	6 months
Vanadium	7910/7911/6010	SW-846	0.05	mg/L	6 months
Zinc	7950/6010	SW-846	0.05	mg/L	6 months
Cyanide	9010	SW-846	0.005	mg/L	14 days

* Laboratory pH analyzed within 24 hours of sample reciept.

References:
SW-846 = Test Methods for Evaluating Solid Waste, U.S. EPA-SW 846, 1986, Third Edition.

TABLE A-4

Analytical Methods, Method References, Pratical Quanitation Limits, Reporting Units, and Holding Times for Laboratory Analyses of Required Groundwater Sample Parameters
South Settling Lagoon Detection Monitoring Program
Delphi Harrison Thermal Systems, Moraine, Ohio

Parameter	Analytical Method	Method Reference	PQL	Reporting Units	Holding Times
Ground-Water Contamination Indicators					
pH		Field Measurement			
Specific Conductance	9050	SW-846	1	umhos/cm	28 days
Total Organic Carbon	9060	SW-846	1	mg/L	28 days
Total Organic Halogen	9020	SW-846	10	ug/L	28 days
Ground-Water Quality Parameters					
Chloride	9252	SW-846	1	mg/L	28 days
Iron	7380/6010	SW-846	0.1	mg/L	6 months
Manganese	7460/6010	SW-846	0.01	mg/L	6 months
Phenols	9065	SW-846	0.01	mg/L	28 days
Sodium	D-1428/6010	ASTM/SW-846	1	mg/L	6 months
Sulfate	9038	SW-846	1	mg/L	28 days
Drinking Water Supply Parameters					
Arsenic	7061/7060	SW-846	0.005	mg/L	6 months
Barium	7080/7081/6010	SW-846	0.2	mg/L	6 months
Cadmium	7130/6010/7131	SW-846	0.001	mg/L	6 months
Chromium	7190/6010/7191	SW-846	0.002	mg/L	6 months
Fluoride	413B	STM	0.02	mg/L	28 days
Lead	7420/6010/7421	SW-846	0.005	mg/L	6 months
Mercury	7470	SW-846	0.0002	mg/L	28 days
Nitrate (N)	418C/APHA 4500-N03F	STM	0.02	mg/L	48 hours
Selenium	7741/7740	SW-846	0.005	mg/L	6 months
Silver	7760/6010/7761	SW-846	0.001	mg/L	6 months
Endrin	8080	SW-846	0.2	ug/L	7 days
Lindane	8080	SW-846	0.2	ug/L	7 days
Methoxychlor	8080	SW-846	0.2	ug/L	7 days
Toxaphene	8080	SW-846	0.5	ug/L	7 days
2,4-D	509B	STM	1	ug/L	7 days
2,3,5-TP Silvex	509B	STM	0.5	ug/L	7 days
Radium (Total)	903/904	EPA 600	1	pCi/L	6 months
Gross alpha	900	EPA 600	3	pCi/L	6 months
Gross beta	900	EPA 600	4	pCi/L	6 months
Coliform (Total)	*	ODH	NA	NA	30 hours

References:
SW-846 = Test Methods for Evaluating Solid Waste, U.S. EPA-SW-846, 1986, Third Edition.
STM = Standard Methods for the Examination of water and Wastewater, 16th Edition, 1986, ALPHA-AWWA-WPCF.
ASTM = American Society for Testing and Materials
EPA 600 = Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA 600/4-80-032, U.S. EPA, 1980.
ODH = Certification for Bacteriological Water Analysis, Ohio Department of Health, 1985.

ATTACHMENT #3

DRAFT

For Settlement Discussions

ONLY

GENERAL SITE CONDITIONS

The North Lagoon is located at the north end of the Harrison plant, and is bounded to the south by plant buildings, to the east by Penn Central railroad tracks, to the west by Dryden Road, and to the north and northeast by an inactive waste disposal site. The North Lagoon was constructed in 1972 and is actually comprised of two lagoon separated by earthen dikes. The total area of the North lagoon is approximately three acres.

The following sections provide a summary of the site hydrogeology, based on data collected over the past 10 years, as presented in the Description of Current Conditions (DOCC) (Geraghty & Miller, Inc. 1991) and the Draft Resource and Recovery Act Facility Investigation (RFI) Final Report (Geraghty & Miller, Inc. 1996).

Hydrogeologic Units

The Delphi Thermal site lies over the Great Miami River buried valley aquifer, which consists of valley fill deposits composed of sand and gravel outwash separated by locally discontinuous silt and clay units, frequently referred to as till zones. Beneath the facility, these glacial deposits have been divided into the following hydrogeologic units: the upper sand and gravel unit, the till zone, and the lower sand and gravel unit. Plates 2 and 3 in the DOCC (Geraghty & Miller, Inc. 1991) illustrate generalized cross sections of these three geologic units. Boring logs indicated a large amount of variability in the lithology within each of the three units; however, this lithologic variability within units was generalized in the cross sections. Ordovician shales and limestones of the Richmond Group comprise the dominant bedrock units forming the valleys in the Dayton area. The Richmond Group is overlain by the Silurian Brassfield Limestone in upland areas. The bedrock units are not considered important sources of groundwater because their transmissivity values are lower than those of the buried valley aquifer.

The upper sand and gravel unit is generally 30 to 70 feet thick and contains minor till lenses. This unit is considered a water-table aquifer with saturated thicknesses ranging from 10 to 40 feet. Based on a review of water well logs at the Ohio Department of Natural Resources, there are no known users of groundwater from this upper water-table aquifer in the immediate vicinity of the Delphi Thermal site.

The till zone has a varied thickness and continuity, but appears to be discernable throughout the region; it ranges from being absent to in excess of 50 feet thick beneath the Delphi Thermal site. An isopach map of the till is presented in the Draft RFI Final Report. The thickest portion of the till is centered to the east of the Delphi Thermal facility.

Although the till deposit constitutes a relatively small portion of the valley fill deposits, it is a major hydrologic factor because it can retard recharge to the lower sand and gravel unit. These glacial till deposits are, therefore, referred to as an aquitard. Clay and silt tills have a very low permeability (10^{-7} centimeters per second [cm/sec] or less), a very high unit weight (on the order of 140 pounds per cubic feet [pcf]), and a very low void ratio, yielding a porosity of less than 20 percent (Norris and Spieker 1966). Low porosities result in the transmission of very little water through such a unit. Therefore, the till layers divide the sand and gravel deposits into two or more aquifers. Recharge from the upper aquifer to the lower aquifer can be relatively rapid where the till layer is absent, but regionally the till layer provides an effective barrier causing the lower aquifer to be semi-confined.

The till zone overlies at least 50 to 100 feet of sand and gravel that comprise the lower unit. The lower unit is a fully saturated semi-confined aquifer throughout most of the Dayton area; however, there are locations where the till is thin or discontinuous. In areas where the till is absent, the upper and lower aquifers respond as one hydrogeologic unit. Consequently, aquifer parameters vary with the thickness and distribution of the till layer.

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pumping had on the shallow and deep aquifers. In 1989, when pumping at the Delphi Thermal facility and the Dryden Road North Well Field had been curtailed, it can be seen that the natural hydraulic gradient for both aquifers was much lower than under pumping conditions. Finally, the increase in hydraulic gradients in 1994 represents the influence of Montgomery County pumping one well in the Dryden North Well Field (DN-13) as part of their Pump-to-Waste Program.

The gradients, in each instance, vary across the site to reflect local variations in hydraulic characteristics and hydraulic stresses. The thinning of the shallow aquifer in the central portion of the Delphi Thermal facility, beneath the main manufacturing building, causes a decrease in the hydraulic transmissivity resulting in a local steepening of the hydraulic gradient. The gradient flattens out south of the building, then increases again close to DN-13, which is in operation. Using the 1994 quarterly monitoring data from the Eleventh Annual Groundwater Quality Assessment Report (Geraghty & Miller, Inc. 1995), the annual average site-wide gradient for the shallow aquifer was reported as 0.0008 ft/ft. The gradient from HR-9, near Northlawn Avenue, to the north of the Delphi Thermal manufacturing building was 0.0006 ft/ft. The gradients increased to approximately 0.0008 ft/ft at the central area of the site and decreased to approximately 0.0007 ft/ft at the south end of the site. Gradients varied locally, ranging from 0.0009 ft/ft to 0.009 ft/ft.

The hydraulic gradients in the deep aquifer displayed less variability over the site, except near DN-13 where gradients were influenced by pumping. Gradients observed were approximately 0.0007 ft/ft at the northern portion of the site, 0.0008 ft/ft in the central to southern portion of the site, and approximately 0.002 ft/ft near DN-13 in the deep aquifer.

Hydraulic Conductivities

To determine the hydraulic characteristics of the water-table (upper) aquifer, the lower aquifer, and the till zone in the vicinity of the Delphi Thermal site, Geraghty &

Miller analyzed time-drawdown data collected during three pumping tests (Geraghty & Miller, Inc. 1990). The data were analyzed using AQTESOLV, an aquifer-test analysis software package (Duffield and Rumbaugh 1989). Upper aquifer tests were performed in June 1985 and August 1989, at the southern end of the North Settling Lagoon (Test Well 1), and south of Landfill L-1 (Test Well 2), respectively. The deep aquifer test was performed just north of Landfill L-1 (Production Well 45) in November 1989.

The median-hydraulic conductivity determined from the upper aquifer tests is 1,756 feet per day (ft/day), which is greater than published values for the upper aquifer in the Great Miami River Valley (Geraghty & Miller, Inc. 1990). This hydraulic conductivity value suggests the presence of a highly localized permeable feature, such as a river point-bar deposit. Point-bar deposits consist of river-washed sediments that generally have high hydraulic conductivities.

The median specific yield determined from the upper aquifer tests is 7.0×10^{-2}. Water-table aquifers typically have specific yields of 0.10 to 0.20 (Kruseman and de Ridder 1983). The drawdown response recorded in Well W-3-N may suggest a localized, semi-confined aquifer setting in the upper aquifer. However, the median value for storage determined from the upper aquifer test of 1.1×10^{-2} is well above the range for semi-confined aquifers of 1×10^{-4} to 1×10^{-6} given by Kruseman and de Ridder (1983), suggesting that the upper aquifer in the vicinity of the Delphi Thermal site responds as a water-table aquifer with localized semi-confined characteristics.

The lower aquifer test data were analyzed both for the pumping period and the recovery period after pumping. Therefore, in addition to a spatial comparison, hydraulic parameters were estimated by different methods of analyses and compared again. The median hydraulic conductivity calculated from all of the lower aquifer test analyses is 349 ft/day. This value is within the 125 to 400 ft/day range reported by Norris and Spieker (1966) for the Dayton area. The minimum and maximum estimated hydraulic conductivity values of 262 ft/day and 463 ft/day were estimated at Well GM-19D and Well 45, respectively. The values of the hydraulic parameters estimated by the drawdown data correlate very well with those estimated from the recovery data, and both sets of parameter values are consistent with published values for the Great Miami River Valley.

The aquifer storage values determined from the lower aquifer test indicate a semi-confined aquifer. The median value of storage is 6.65×10^{-4}. Kruseman and de Ridder (1983) describe confined aquifers as having a storage coefficient of 1×10^{-4} to 1×10^{-6} and unconfined aquifer storage (specific yield) values of 0.10 to 0.20. Therefore, the median value estimated from the lower aquifer test data is at the upper limits of the range of values for a confined aquifer and is consistent with the values expected for a semi-confined aquifer. The storage values determined from the lower aquifer test are consistent with values listed in studies conducted in the Dayton area (Norris and Spieker 1966; Fidler 1975; Dover 1961). In addition, the median storage values are characteristic of those values obtained for a semi-confined aquifer.

References

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Kruseman, G.P. and N.A. de Ridder. 1983. Analysis and Evaluation of Pumping Test Data. ILRI, Bull. 11, The Netherlands, 200 p.

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GENERAL SITE CONDITIONS

The South Lagoon is located southwest of the Harrison plant, just east of Interstate 75 and west of Dryden Road. The South Lagoon was constructed in 1966 and is actually comprised of three smaller lagoons bounded by earthen dikes. The total area of the South Lagoon is approximately 5.3 acres.

The following sections provide a summary of the site hydrogeology, based on data collected over the past 10 years, as presented in the Description of Current Conditions (DOCC) (Geraghty & Miller, Inc. 1991) and the Draft Resource and Recovery Act Facility Investigation (RFI) Final Report (Geraghty & Miller, Inc. 1996).

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DRAFT
April 1, 1996

Water Levels and Hydraulic Gradient

Water level measurements indicate that the direction of groundwater flow in both aquifers at the site is generally from north to south, with a westerly bend at the southern portion of the site. This bend in the flow pattern corresponds to the trend of the buried bedrock valley.

Historically, pumping water from the lower aquifer has also influenced the flow regime substantially. When supply wells were active in the lower aquifer, as they were prior to 1986, potentiometric elevations were lowered and a vertical gradient from the upper to lower aquifer was created. Sustained pumping had the effect of lowering water levels in both aquifers because the upper aquifer recharges the lower aquifer through the semi-confining till zone. As municipal and industrial pumping slowed in 1986, water levels began to rise in both aquifers. In response to this termination of pumping in the county well field and at the Delphi Thermal site, water levels in both the upper and lower aquifers have risen. Hydrograph records for shallow wells at Delphi Thermal indicate a rise in the shallow aquifer of approximately 10 feet between 1986 and late 1989 when water levels stabilized. Historic water-level data from the deep aquifer (limited to post September 1988 water levels) for Monitor Wells HR-10, HR-12, HR-13, HR-14, and HR-15 indicate a 5-foot rise in the water levels in the deep aquifer between September 1988 and late 1989. Because of the higher water levels in the last few years, there is very little difference between the water-level elevations in the upper aquifer and the potentiometric surface in the lower aquifer. Additionally, the decrease in groundwater pumping at and near the facility has resulted in a decrease in the hydraulic gradient.

Horizontal hydraulic gradients were approximately 0.0017 feet per foot (ft/ft) in both aquifers in 1986 (Geraghty & Miller, Inc. 1991), 0.0005 ft/ft in both aquifers in 1989, and 0.0008 ft/ft in the shallow aquifer and 0.001 ft/ft in the deep aquifer by October 1994. The 1986 hydraulic gradients show the significant influence that industrial and municipal pumping had on the shallow and deep aquifers. In 1989, when pumping at the Delphi Thermal facility and the Dryden Road North Well Field had been curtailed, it can be seen that the natural hydraulic gradient for both aquifers was much lower than under pumping conditions. Finally, the increase in hydraulic gradients in 1994 represents the influence of Montgomery County pumping one well in the Dryden North Well Field (DN-13) as part of their Pump-to-Waste Program.

The gradients, in each instance, vary across the site to reflect local variations in hydraulic characteristics and hydraulic stresses. The thinning of the shallow aquifer in the central portion of the Delphi Thermal facility, beneath the main manufacturing building, causes a decrease in the hydraulic transmissivity resulting in a local steepening of the hydraulic gradient. The gradient flattens out south of the building, then increases again close to DN-13, which is in operation. Using the 1994 quarterly monitoring data from the Eleventh Annual Groundwater Quality Assessment Report (Geraghty & Miller, Inc. 1995), the annual average site-wide gradient for the shallow aquifer was reported as 0.0008 ft/ft. The gradient from HR-9, near Northlawn Avenue, to the north of the Delphi Thermal manufacturing building was 0.0006 ft/ft. The gradients increased to approximately 0.0008 ft/ft at the central area of the site and decreased to approximately 0.0007 ft/ft at the south end of the site. Gradients varied locally, ranging from 0.0009 ft/ft to 0.009 ft/ft.

The hydraulic gradients in the deep aquifer displayed less variability over the site, except near DN-13 where gradients were influenced by pumping. Gradients observed were approximately 0.0007 ft/ft at the northern portion of the site, 0.0008 ft/ft in the central to southern portion of the site, and approximately 0.002 ft/ft near DN-13 in the deep aquifer.

Hydraulic Conductivities

To determine the hydraulic characteristics of the water-table (upper) aquifer, the lower aquifer, and the till zone in the vicinity of the Delphi Thermal site, Geraghty &

Miller analyzed time-drawdown data collected during three pumping tests (Geraghty & Miller, Inc. 1990). The data were analyzed using AQTESOLV, an aquifer-test analysis software package (Duffield and Rumbaugh 1989). Upper aquifer tests were performed in June 1985 and August 1989, at the southern end of the North Settling Lagoon (Test Well 1), and south of Landfill L-1 (Test Well 2), respectively. The deep aquifer test was performed just north of Landfill L-1 (Production Well 45) in November 1989.

The median-hydraulic conductivity determined from the upper aquifer tests is 1,756 feet per day (ft/day), which is greater than published values for the upper aquifer in the Great Miami River Valley (Geraghty & Miller, Inc. 1990). This hydraulic conductivity value suggests the presence of a highly localized permeable feature, such as a river point-bar deposit. Point-bar deposits consist of river-washed sediments that generally have high hydraulic conductivities.

The median specific yield determined from the upper aquifer tests is 7.0 x 10^{-2}. Water-table aquifers typically have specific yields of 0.10 to 0.20 (Kruseman and de Ridder 1983). The drawdown response recorded in Well W-3-N may suggest a localized, semi-confined aquifer setting in the upper aquifer. However, the median value for storage determined from the upper aquifer test of 1.1 x 10^{-2} is well above the range for semi-confined aquifers of 1 x 10^{-4} to 1 x 10^{-6} given by Kruseman and de Ridder (1983), suggesting that the upper aquifer in the vicinity of the Delphi Thermal site responds as a water-table aquifer with localized semi-confined characteristics.

The lower aquifer test data were analyzed both for the pumping period and the recovery period after pumping. Therefore, in addition to a spatial comparison, hydraulic parameters were estimated by different methods of analyses and compared again. The median hydraulic conductivity calculated from all of the lower aquifer test analyses is 349 ft/day. This value is within the 125 to 400 ft/day range reported by Norris and Spieker (1966) for the Dayton area. The minimum and maximum estimated hydraulic conductivity values of 262 ft/day and 463 ft/day were estimated at Well GM-19D and Well 45, respectively. The values of the hydraulic parameters estimated by the drawdown data correlate very well with those estimated from the recovery data, and both sets of parameter values are consistent with published values for the Great Miami River Valley.

The aquifer storage values determined from the lower aquifer test indicate a semi-confined aquifer. The median value of storage is 6.65×10^{-4}. Kruseman and de Ridder (1983) describe confined aquifers as having a storage coefficient of 1×10^{-4} to 1×10^{-6} and unconfined aquifer storage (specific yield) values of 0.10 to 0.20. Therefore, the median value estimated from the lower aquifer test data is at the upper limits of the range of values for a confined aquifer and is consistent with the values expected for a semi-confined aquifer. The storage values determined from the lower aquifer test are consistent with values listed in studies conducted in the Dayton area (Norris and Spieker 1966; Fidler 1975; Dover 1961). In addition, the median storage values are characteristic of those values obtained for a semi-confined aquifer.

References

Dover, D.G., 1961. A Hydrologic Study of the Valley-Fill Deposits in the Venice Area, Ohio. Ohio Department of Natural Resources, Division of Water, Technical Report No. 4.

Duffield, G.M. and J.O. Rumbaugh, 1989. AQTESOLV: Aquifer Test Solver, Version 1.0 Documentation, Geraghty & Miller Modeling Group, Reston, Virginia.

Fidler, F.E., 1975. Digital Model Simulation of the Glacial Outwash Aquifer at Dayton, Ohio. U.S. Geological Survey Waste Water WRI Report 18-75 in Cooperation with the Miami Conservancy District, September 1975.

Geraghty & Miller, Inc., 1990. Data Analysis and Evaluation of Aquifer Tests Harrison Radiator Facility, Moraine, Ohio, Prepared for Harrison Radiator Division of General Motors Corporation.

Geraghty & Miller, Inc. 1991. Description of Current Conditions (DOCC) Task 1 of the RCRA Facility Investigation for Harrison Radiator Division - GMC, Moraine, Ohio. January 1991.

Geraghty & Miller, Inc. 1995. Eleventh Annual Groundwater Quality Assessment, Harrison North Settling Lagoon, January through December 1994, Moraine, Ohio.

Kruseman. G.P. and N.A. de Ridder. 1983. Analysis and Evaluation of Pumping Test Data. ILRI. Bull. 11, The Netherlands, 200 p.

Norris, N.E. and A.M. Spieker. 1966. Ground-Water Resources of the Dayton Area, Ohio. U.S. Geological Survey Water Supply Paper 1808. Prepared in cooperation with the Miami Conservancy District and the Ohio Department of Natural Resources.

OhioEPA
State of Ohio Environmental Protection Agency

Southwest District Office

401 East Fifth Street
Dayton, OH 45402-2911

TELE: (937) 285-6357 FAX: (937) 285-6249

George V. Voinovich, Governor
Nancy P. Hollister, Lt. Governor
Donald R. Schregardus, Director

October 20, 1997

RE: GM DELPHI HARRISON
THERMAL SYSTEMS
MONTGOMERY COUNTY
HAZARDOUS WASTE
OHD000817577
GROUND WATER MONITORING

Mr. Robert Kerr
Plant Engineer
GM-Delphi Harrison Thermal Systems
3600 Dryden Road
Moraine, OH 45401

Dear Bob:

This letter serves to return GM Delphi-Harrison Thermal Systems to compliance with all violations noted in the October 4, 1995 Comprehensive Ground Water Monitoring Evaluation report.

Please contact me or Jay Cavender if you have any questions.

Sincerely,

Chris Cotton
Division of Hazardous Waste Management

CC/bp

cc: Jay Cavender, DDAGW, SWDO
Linda Neumann, CO, DHWM, CAS
Jim Tichich, CO, DHWM

Harrison D
Moraine Plant
OCT 23 1997
Plant/Environmental Engineering

ARCADIS GERAGHTY & MILLER

ARCADIS Geraghty & Miller, Inc.
4700 Lakehurst Court
Suite 100
Dublin
Ohio 43016
Tel 614 764 2310
Fax 614 764 1270

ENVIRONMENTAL

Mr. Jay Cavender
Ohio EPA
Division of Drinking and Groundwater
Southwest District Office
401 E. Fifth Street
Dayton, Ohio 45402-2911

Subject:
North Settling Lagoon Assessment Monitoring Program, Delphi Harrison Thermal Systems, Moraine, Ohio
ARCADIS Geraghty & Miller Project No. OH000486.0002.00001

Dublin
17 March 1999

Contact:
Rich Astle

Extension:
614 799 4711

Dear Jay:

The purpose of this letter is to commemorate our telephone conversation on March 4, 1999 regarding updating the analytical method for volatile organic compounds (VOCs) analyses required by the North Settling Lagoon Groundwater Quality Assessment Program at Delphi Harrison Thermal Systems (Delphi Thermal) located in Moraine, Ohio. Beginning with the first quarter of 1999, Delphi Thermal will analyze VOCs using analytical Method 8260a, replacing analytical method 8240. Table A-3 of the Sampling and Analyses Plan (Appendix A of the Revised Groundwater Quality Assessment Plan for the Harrison Radiator North Lagoon, June 1989) has been revised to reflect this change, and is attached for your records.

Should you have any questions regarding this information, please do not hesitate to contact me.

Sincerely,

ARCADIS Geraghty & Miller, Inc.

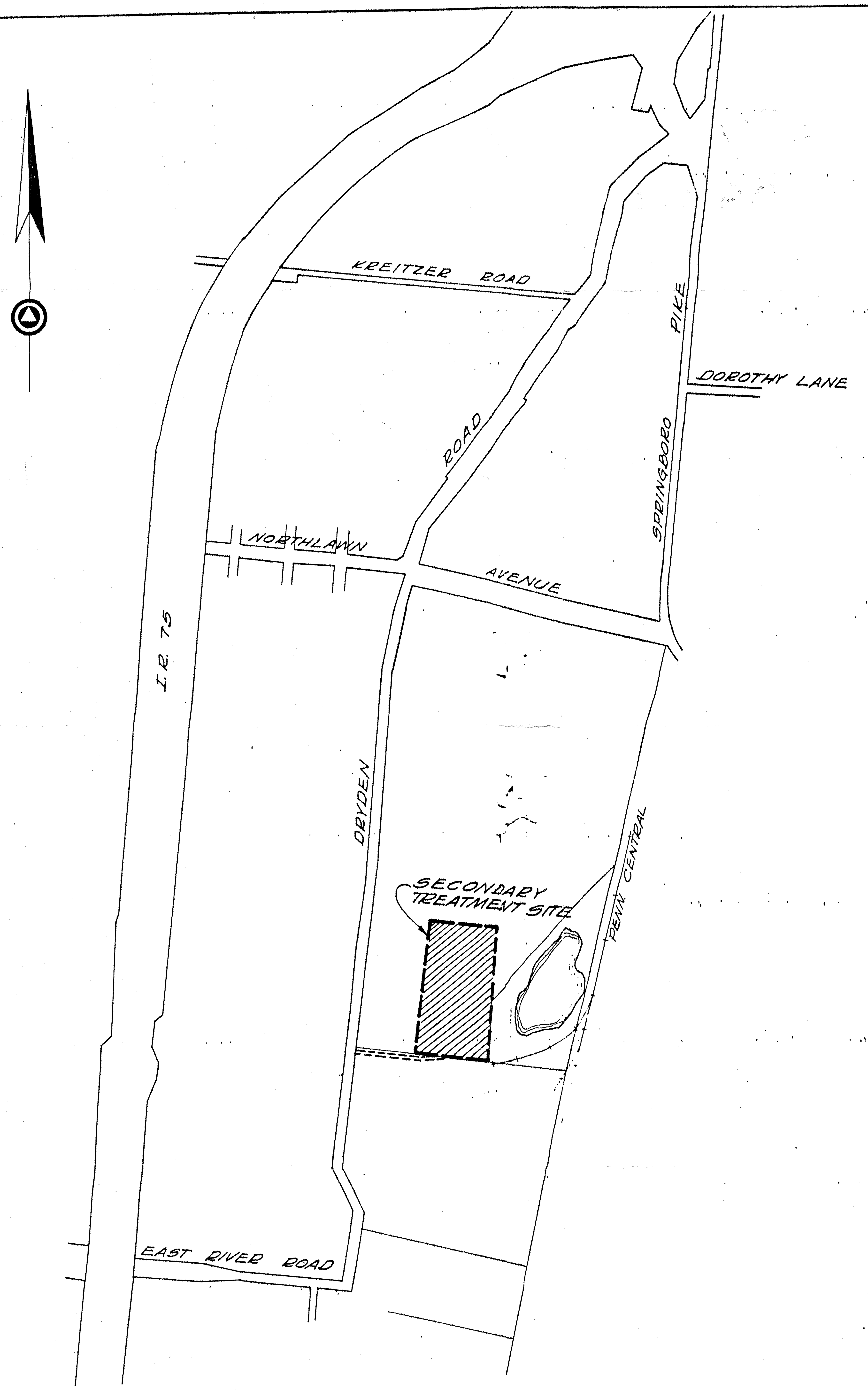
Richard Astle
Staff Scientist

Enclosure

Copies:
C. Cotton, Ohio EPA-SWDO
B. Kerr, Delphi Thermal
J. Caufield, GMC
T. Conway, GMC
T. Thrubis, GMC
M. Born, Shumaker, Loop & Kendrick

APPENDIX C

LAGOON HISTORIC CONSTRUCTION DRAWINGS



SITE PLAN
Scale 1" = 400'

1970
CONTRACT DRAWINGS
FOR

PLANT N°3
SECONDARY TREATMENT SYSTEM

INDUSTRIAL WASTE DISPOSAL
APPROVED
STATE OF OHIO [illegible]
AS EVID[illegible]

FRIGIDAIRE DIVISION
GENERAL MOTORS CORPORATION
MORAINE, OHIO

Rec'd 7-10-70

PREPARED BY
RALPH L. WOOLPERT COMPANY
CONSULTING ENGINEERS and PLANNERS
DAYTON, OHIO

ISSUED
JUL 8 1970
RALPH L. WOOLPERT CO.

SHEET 1 OF 9 #7961 J.G.B.

APPROVED
STATE OF OHIO DEPARTMENT OF HEALTH

RECEIVED
JUL 10 1970
OHIO DEPARTMENT OF HEALTH

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

SECONDARY TREATMENT SYSTEM
SITE PLAN

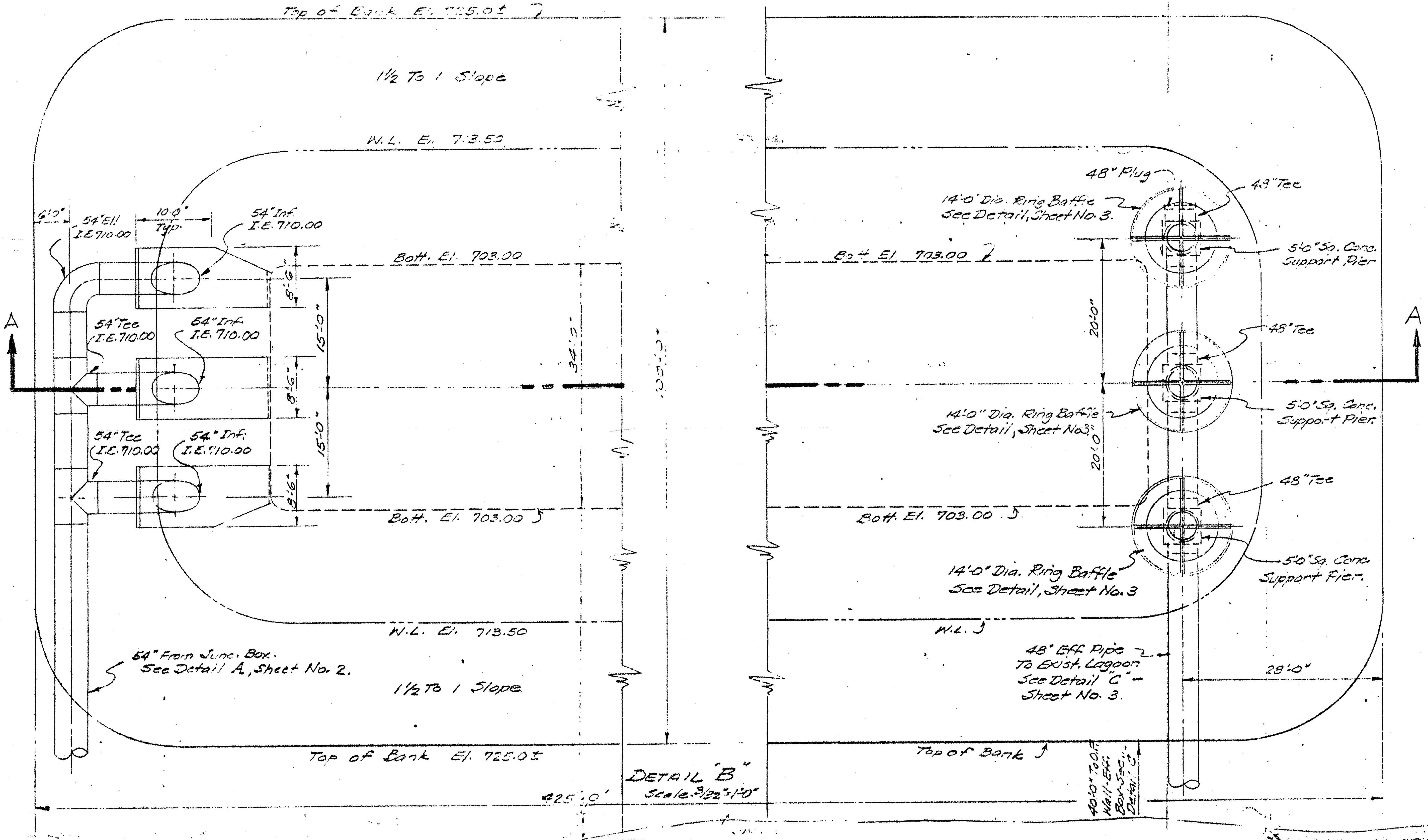
Scale: 1" = 40'
Date: MAY 1970

Des:..............
Dr.:..............
Ckd:..............

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 7961
Sheet No. 2 of 2

Approved:.. Engineer



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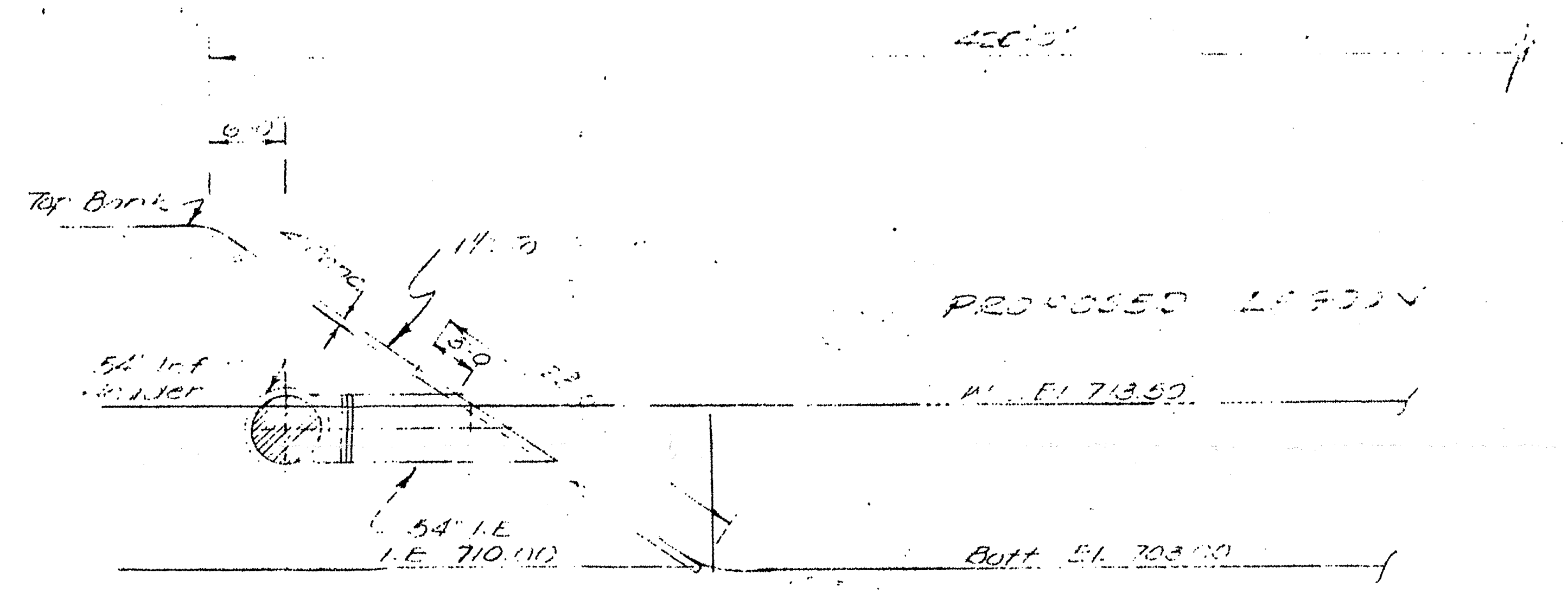

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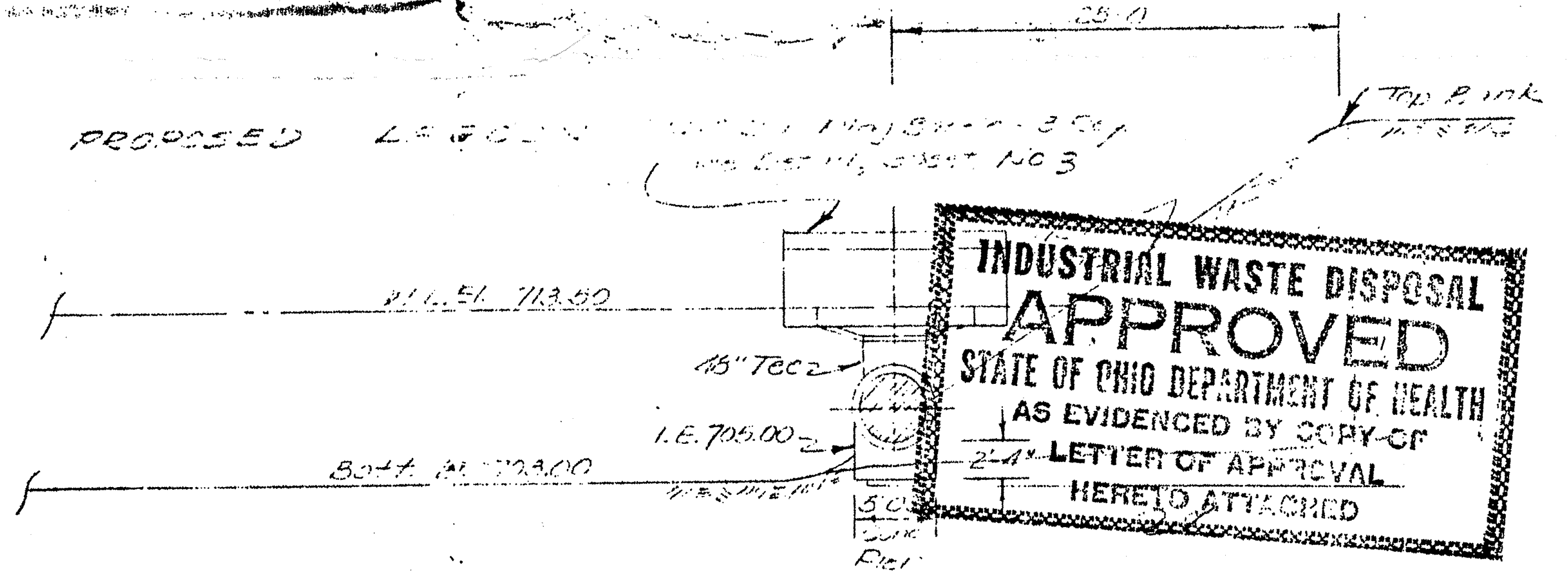

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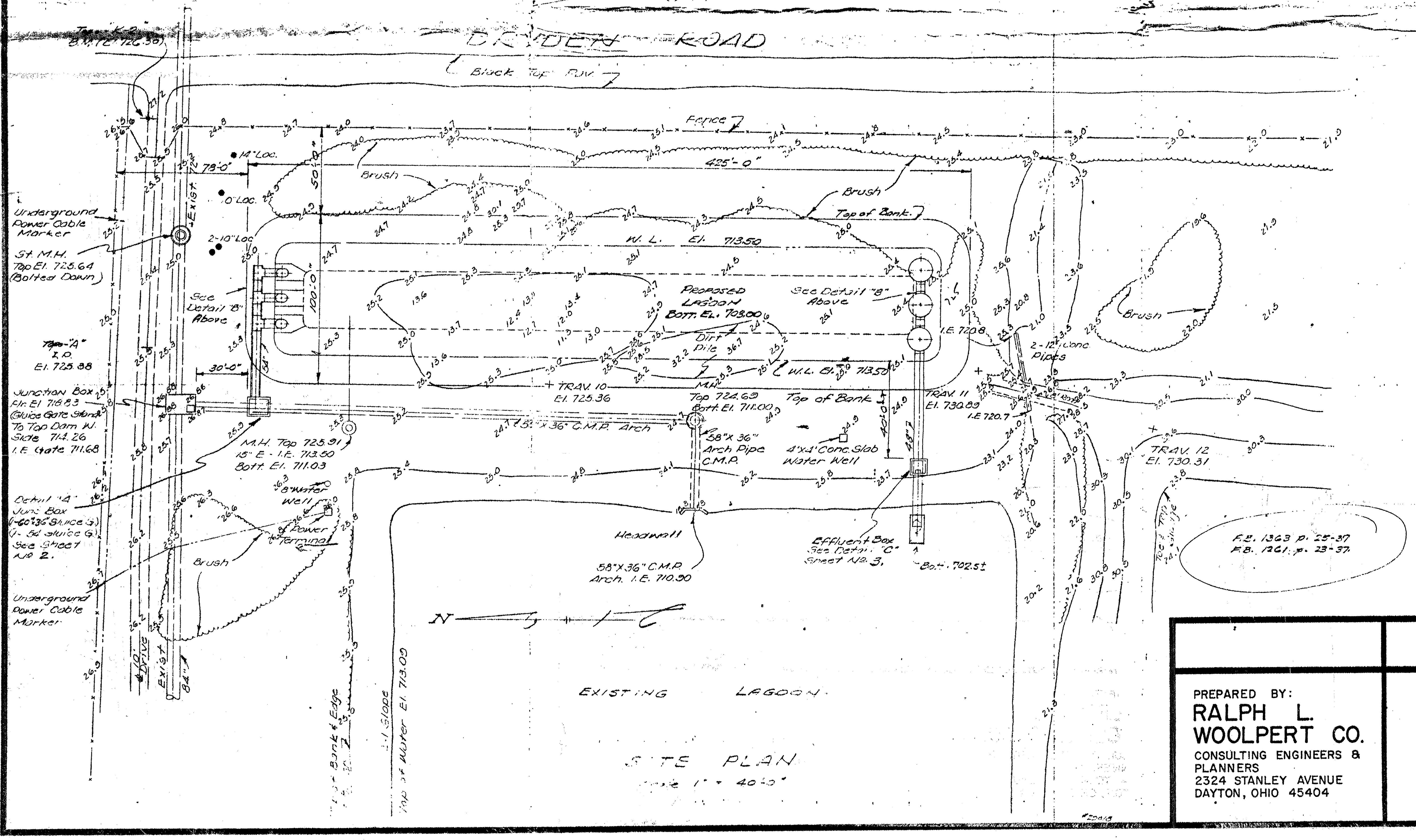

SITE PLAN
Scale 1" = 40'0"

INDUSTRIAL WASTE DISPOSAL
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SEP 5 1972
OHIO [illegible]
SOUTHWEST DISTRICT OFFICE

(VINCE J FESTA
445-2622)

Submitted by
H. S. Kline
Frigidaire
Sept. 4, 1972

PLANT 2 LAGOON IMPROVEMENT - PROJECT #1545

SECONDARY WASTEWATER TREATMENT SYSTEM
FRIGIDAIRE DIVISION - GENERAL MOTORS CORPORATION

PREPARED BY:
RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 STANLEY AVENUE
DAYTON, OHIO 45404

Revisions

Architects
Engineers
Planners

Winters Bank Building
Dayton, Ohio 45402
Telephone 513/223-6500

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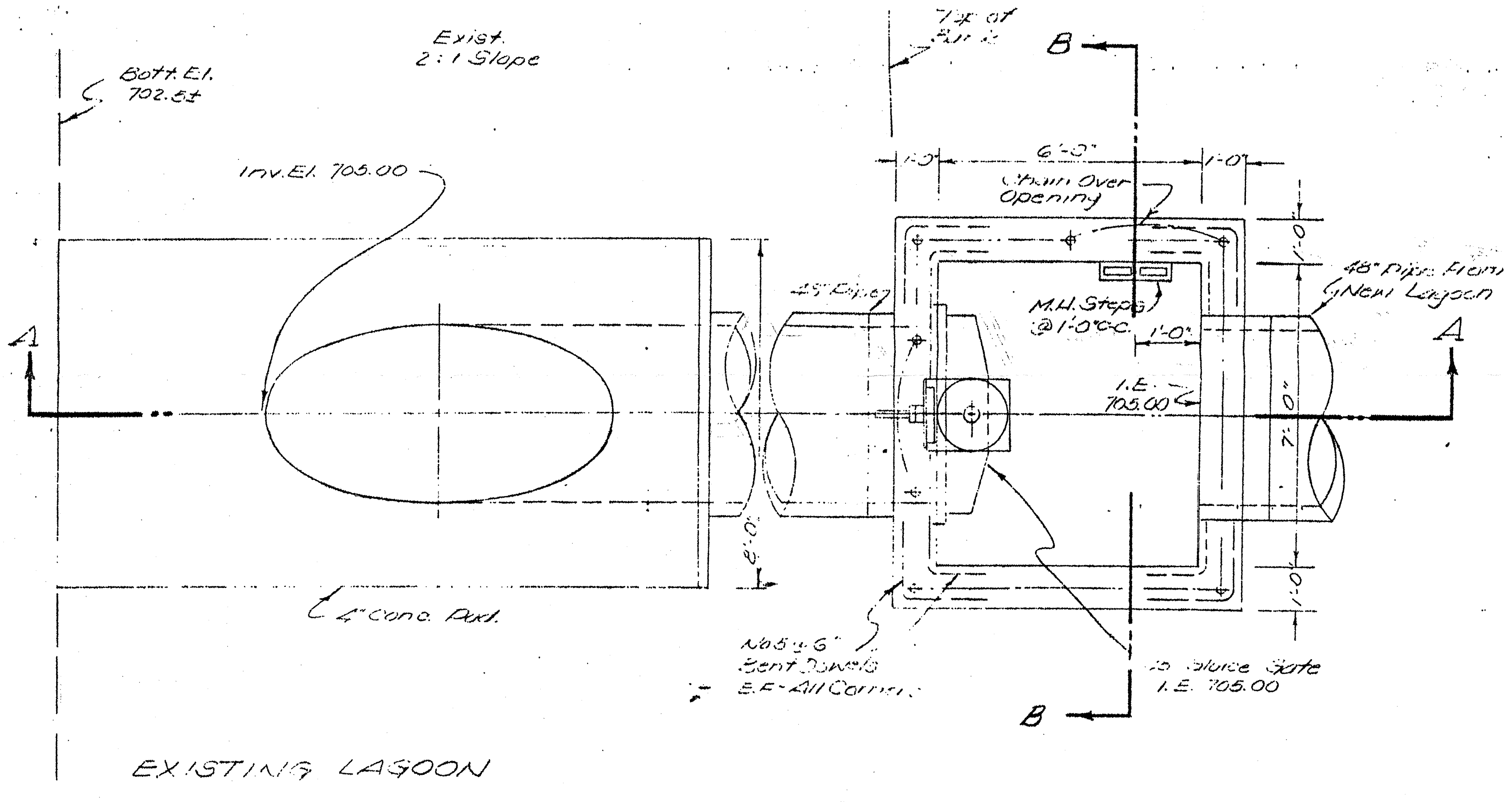
WILLIAMS
LIVELY
AND
LIKENS

LORENZ 701
WILLIAMS 1710
WILLIAMS 1965
LIVELY 2534

O.E. LIKENS 10564

PIERCE 4123
PARKER 2126
ANDERSON 4191
LAUTERBACH 3952
ROEDIGER 2972

Date 8-31-72
Drawn By S.O.S.
Comm. No. 865-36
Set of 3
Sheet No. 36-1



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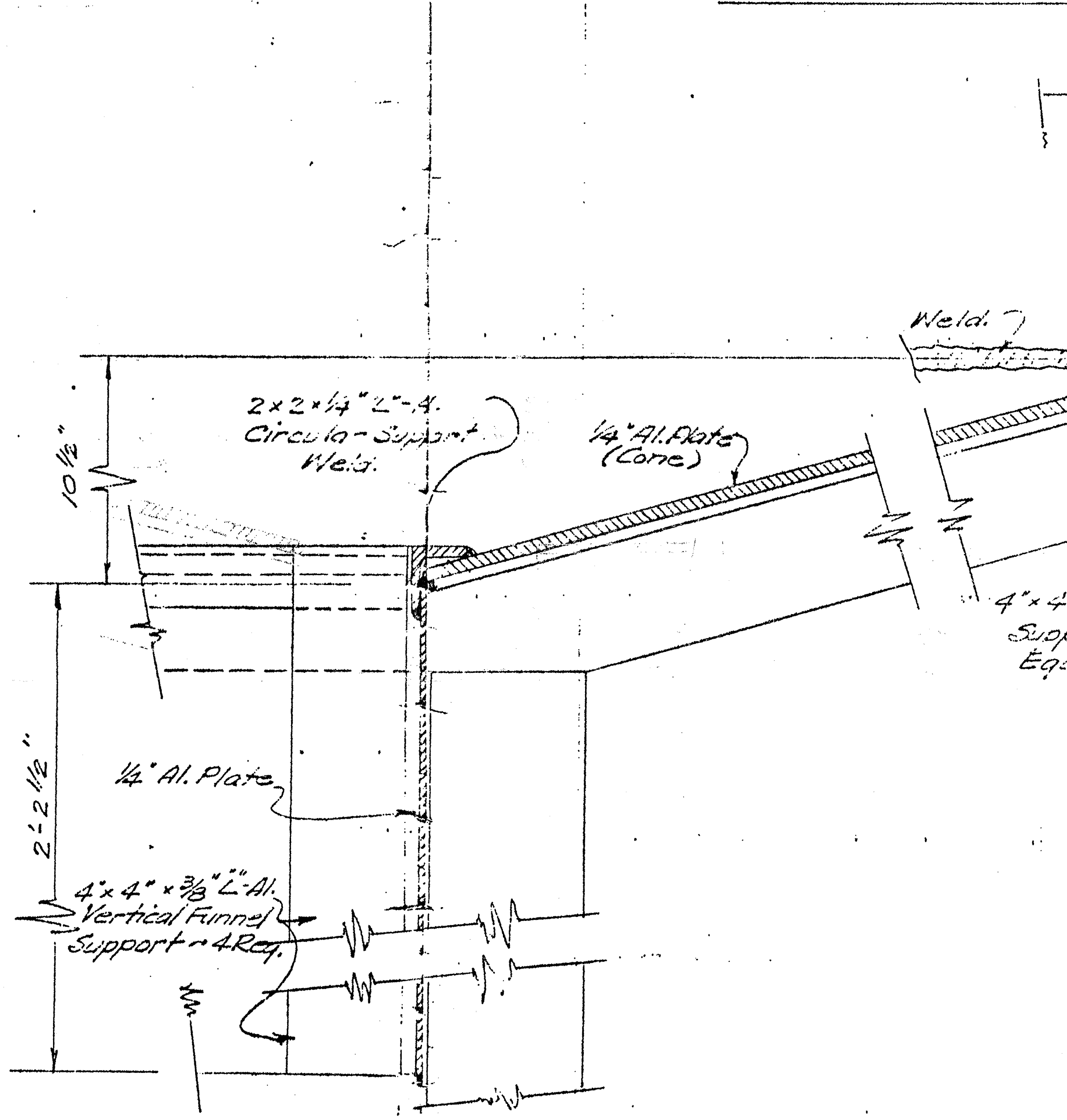

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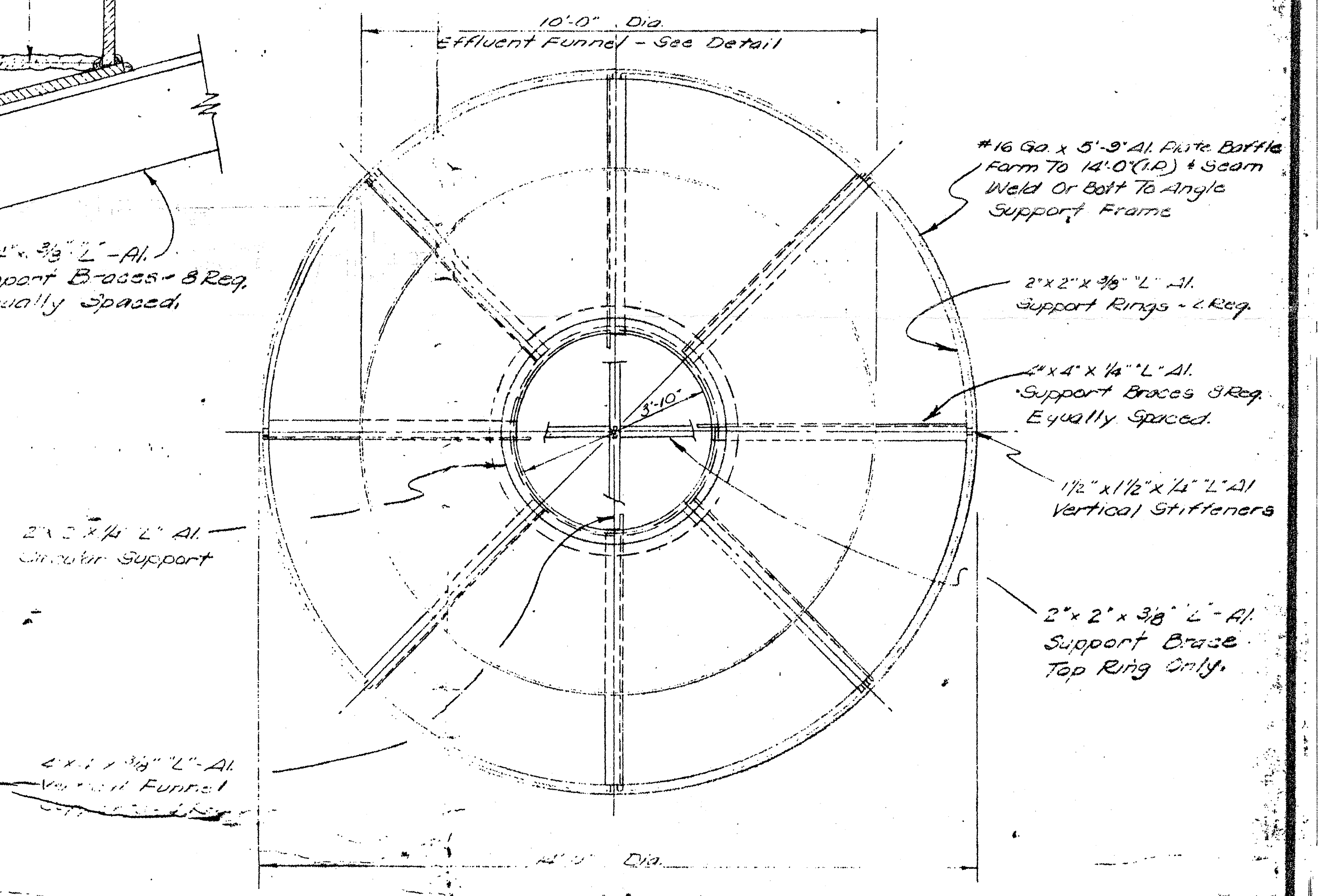
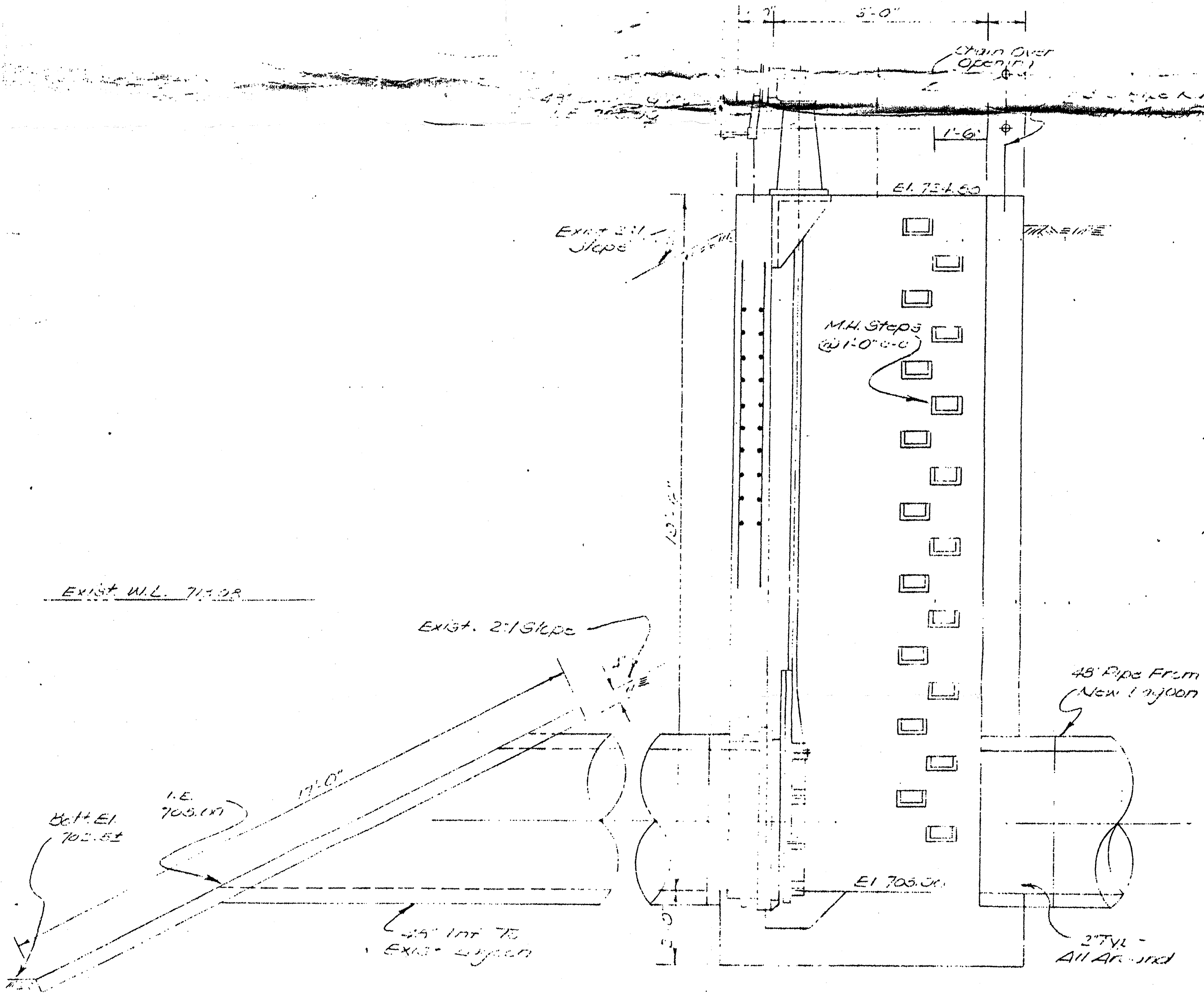


PLAN ~ RING BAFFLE
Scale ~ 1/2"



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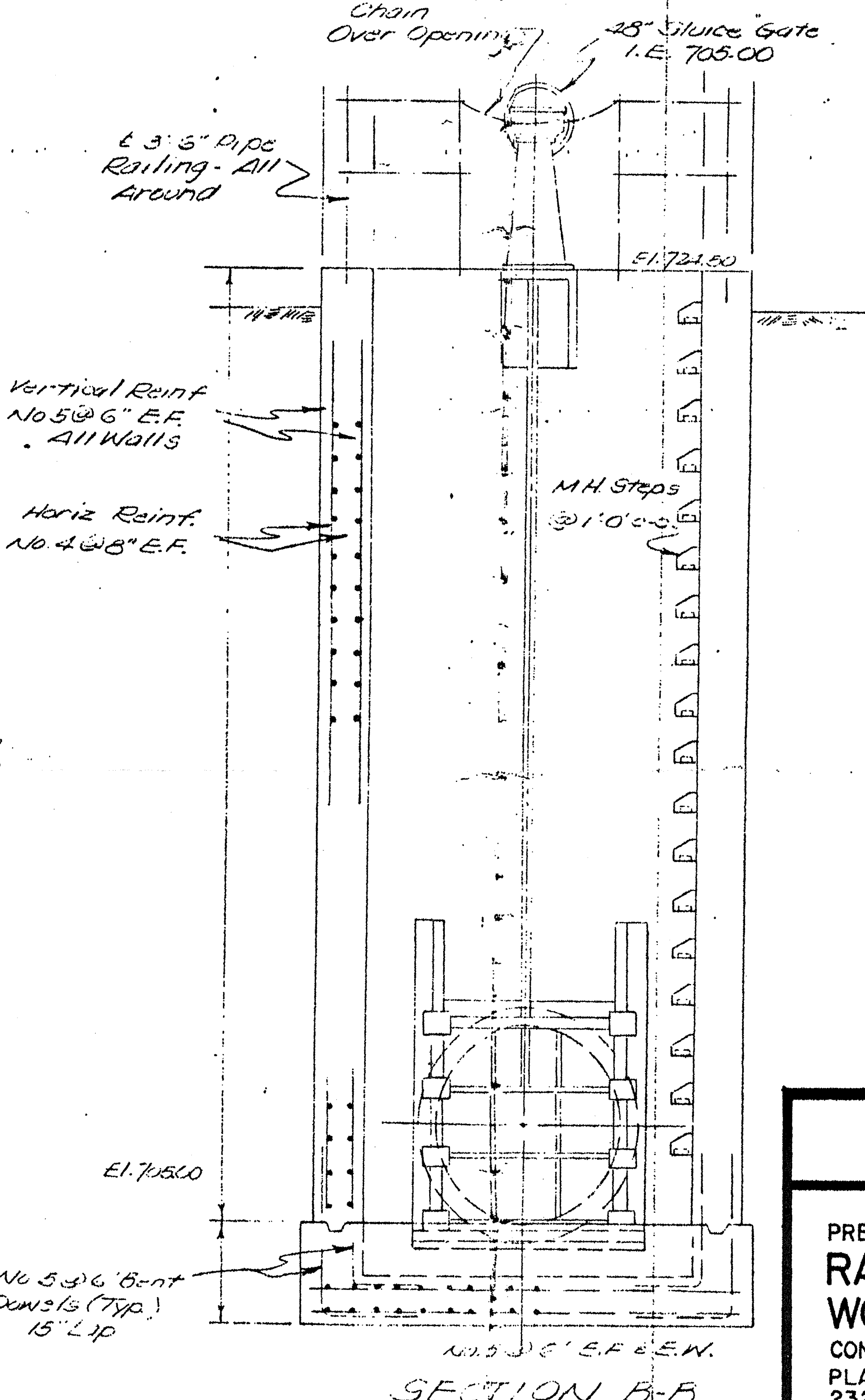

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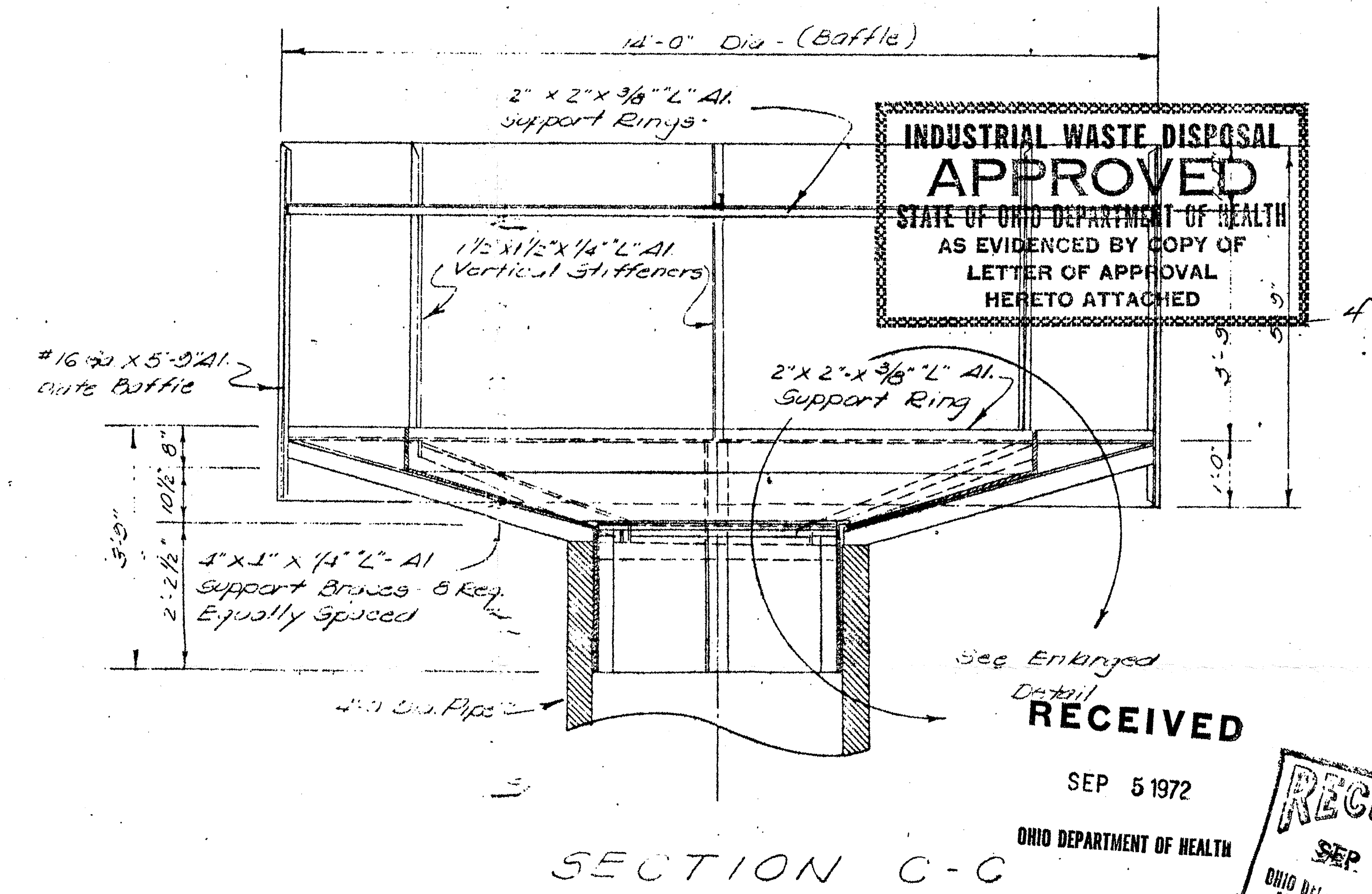


SECTION C-C
Scale ~ 1/2" = 1'-0"

SECONDARY WASTEWATER TREATMENT SYSTEM
FRIGIDAIRE DIVISION~ GENERAL MOTORS CORPORATION

PREPARED BY:
RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 STANLEY AVENUE
DAYTON, OHIO 45404

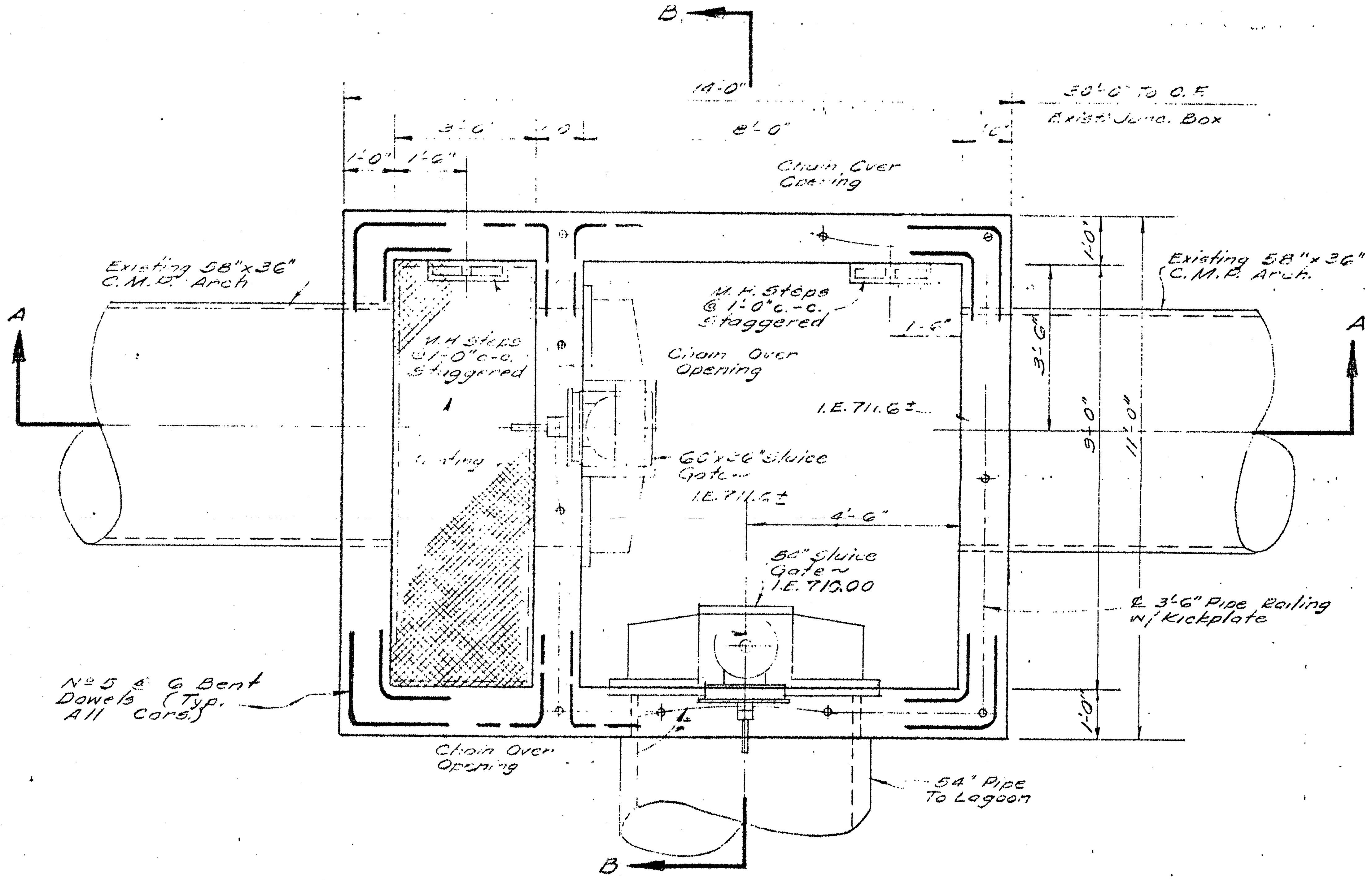
Architects
Engineers
Planners

Winters Bank Building
Dayton, Ohio 45402
Telephone 513/223-6500

LORENZ WILLIAMS WILLIAMS LIVELY AND LIKENS

LORENZ WILLIAMS WILLIAMS LIVELY
O.E. LIKENS
PIERCE PARKER ANDERSON LAUTERBACH ROEDIGER

Date 8-31-72
Drawn By S.O.S.
Comm. No. 835-36
Set of 3
Sheet No. 3-3



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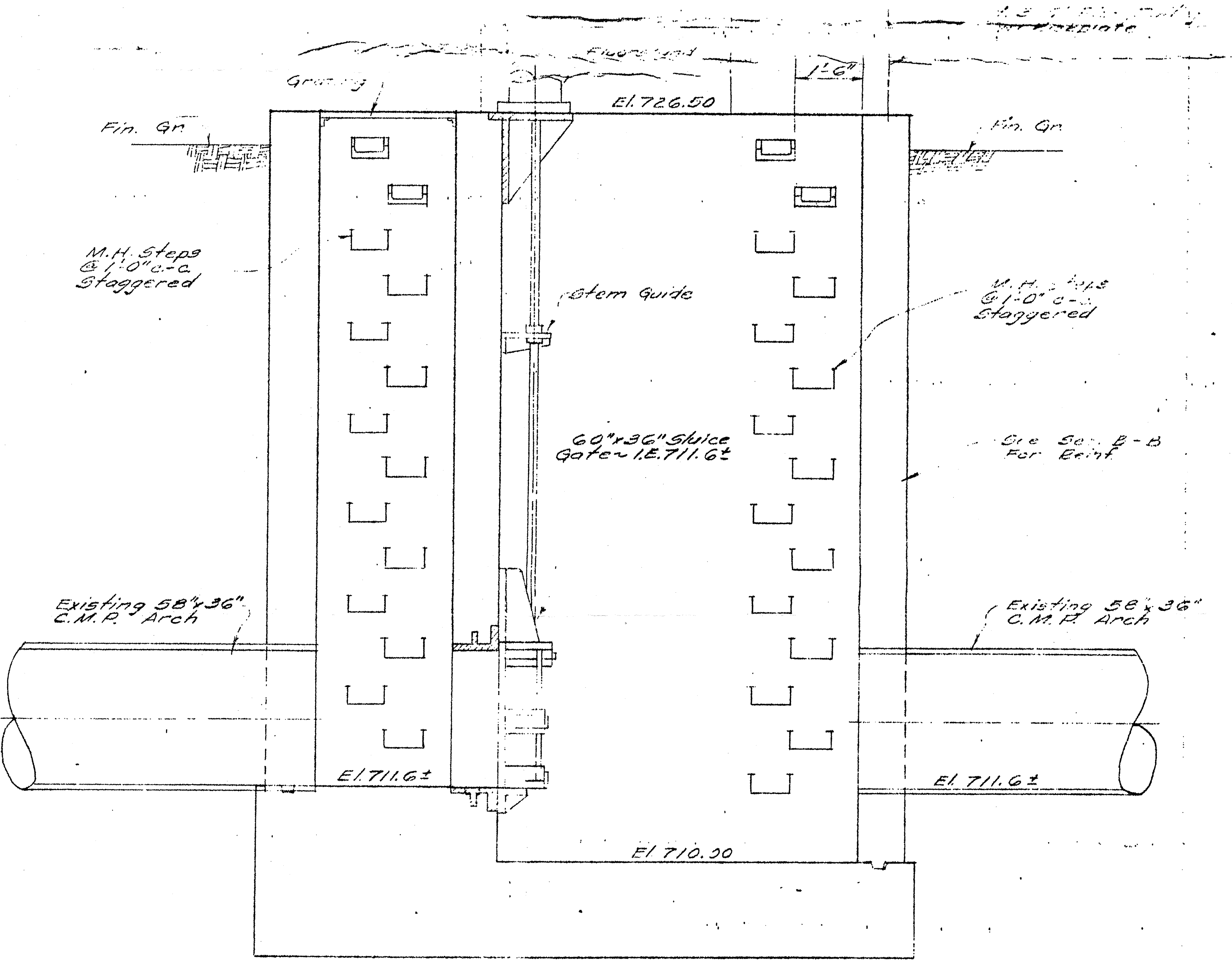

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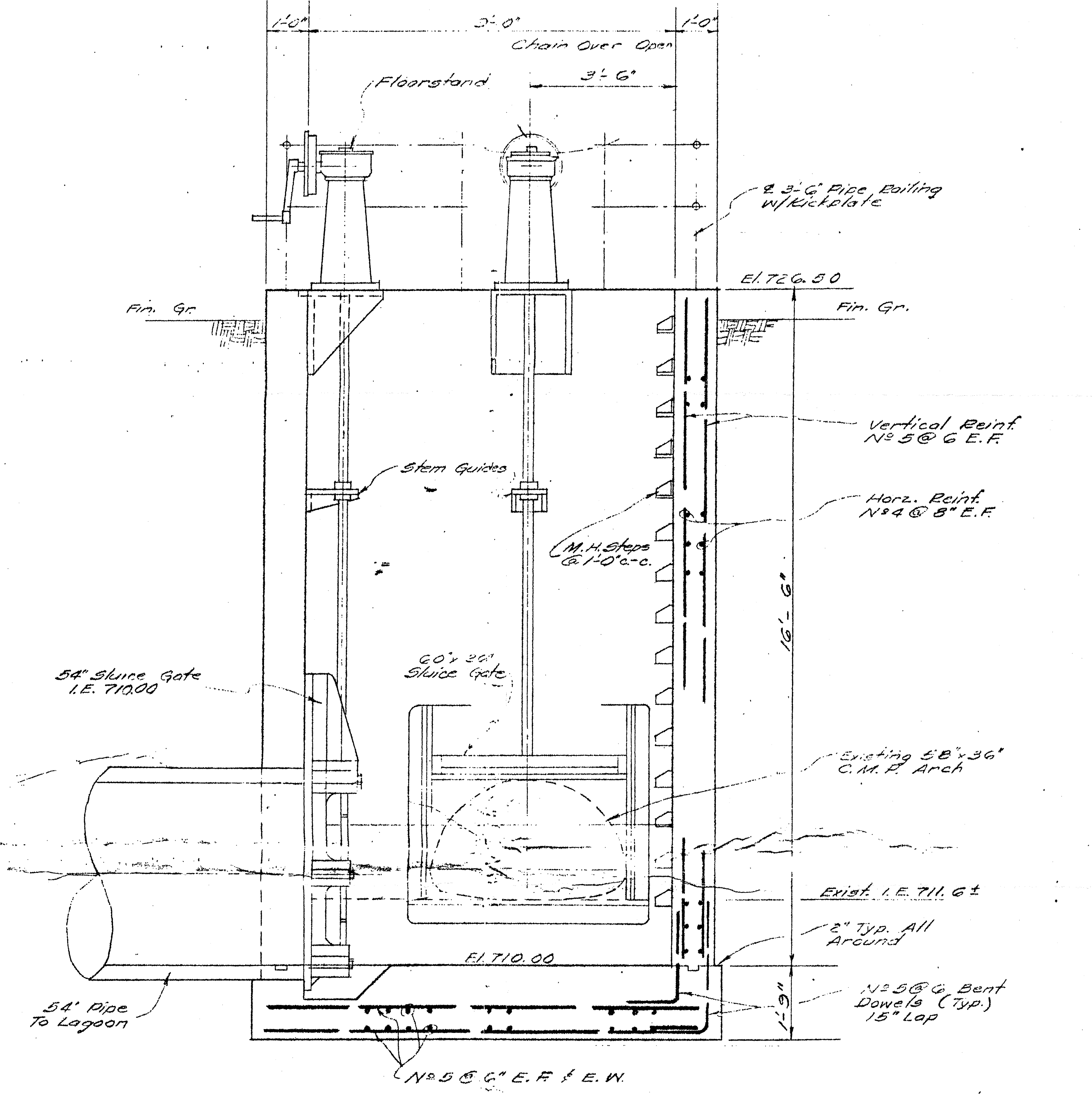

SECTION B - B

Scale 1/2" = 1'-0"

INDUSTRIAL WASTE DISPOSAL
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Structure Details

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SOUTHWEST DISTRICT OFFICE

SECONDARY WASTEWATER TREATMENT SYSTEM
FRIGIDAIRE DIVISION - GENERAL MOTORS CORPORATION

PREPARED BY:
RALPH L.
WOOLPERT CO.
CONSULTING ENGINEERS &
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DAYTON, OHIO 45404

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AND
LIKENS

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O.E. LIKENS 18564

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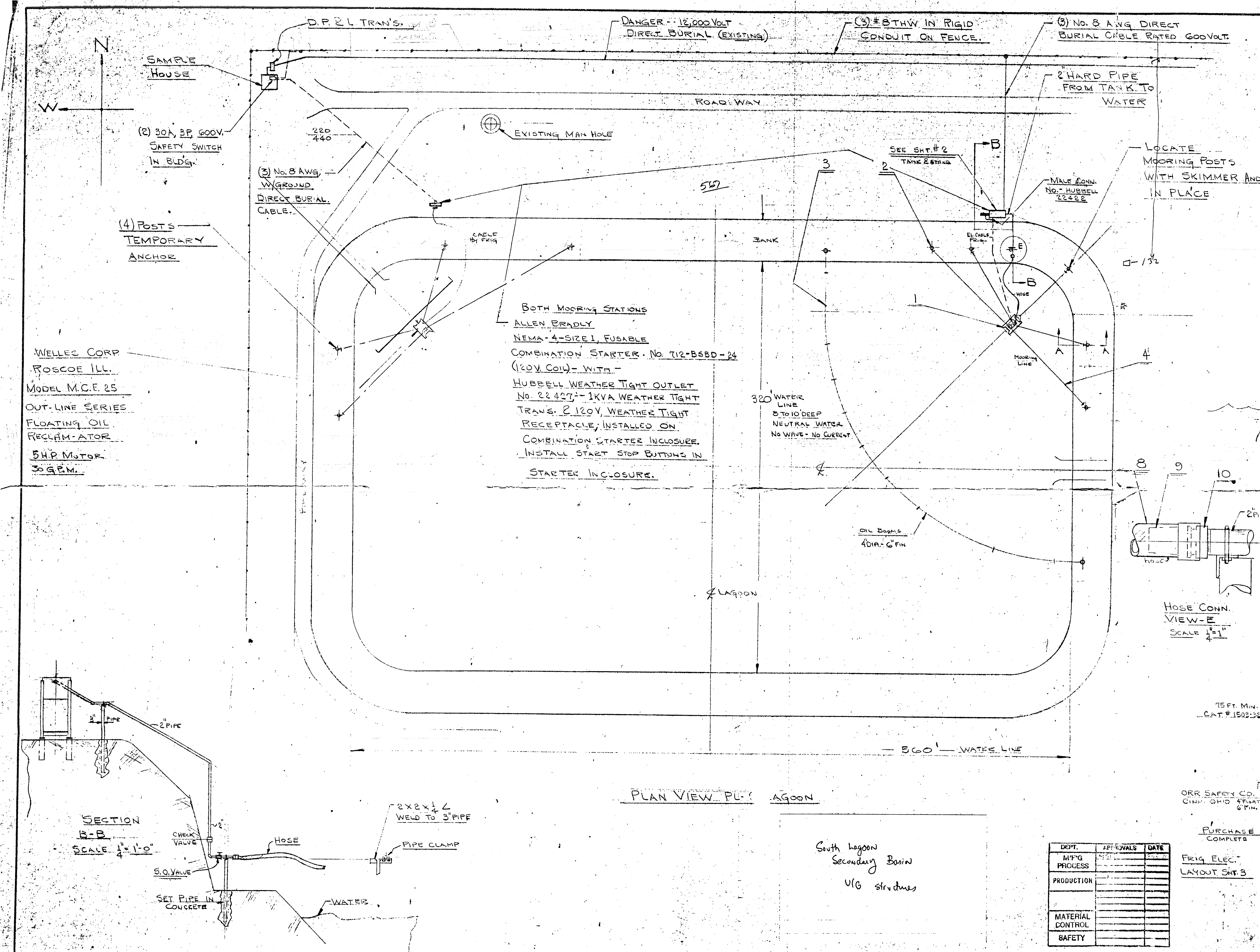
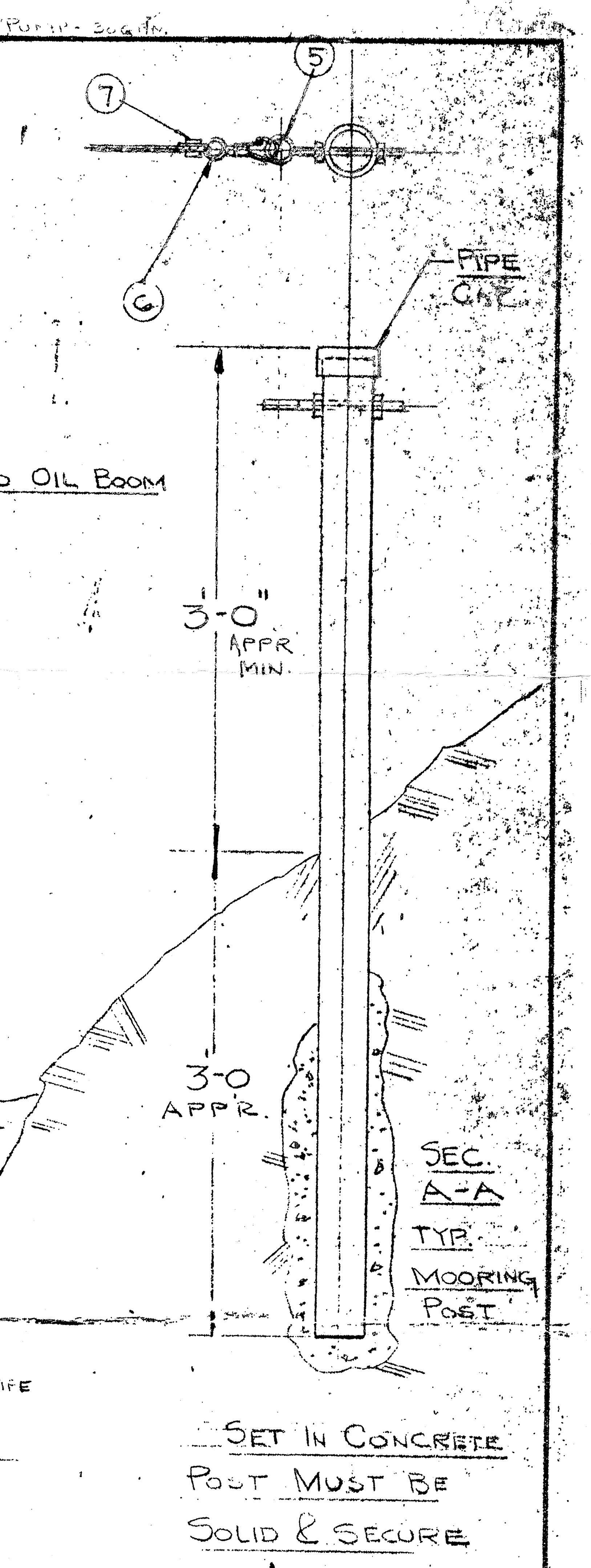
ROEDIGER 2972

Date 8-31-72
Drawn By J.B.
Comm. No. 865-34
Set of 3
Sheet No. 3





South Lagoon
Secondary Basin
U/G structures

75 FT. MIN.
CAT. # 1503-32

ORR SAFETY CO.
CINN. OHIO 4' FLOAT
6" FIN.

PURCHASE
COMPLETE

DET. NO.	AMT.	MATERIAL	DESCRIPTION
10	2		EVER TITE QUICK COUPLING (1½) FEM ADP. PART "A"
9	1.		EVER-TITE QUICK COUPLING (1½) HOSE SHANK PART C
8	1		THE PAQUIN CO. CINN. OHIO SYN. RUBBER HOSE I.D. - 1½"
7	9		CABLE CLAMP (5/16 CABLE)
6	9		SWIVEL EYE ROPE SNAP
5	9		5/8 DIA. x 8" LG. EYE BOLT & LOCK NUTS.
4	5 LEN. TO SUIT		PRE-FORMED GALVANIZED AIR CRAFT CABLE 5/16 DIA.
3	1		SLICK BAR (PURCHASE) (320 FT. MIN. FLOATING OIL BOOM)
2	9		3" GALV. IRON PIPE (SEE SEC.)
1	1		MODEL MCE 25 WELLES CORP. RECLAM-ATOR

DEPT.	APPROVALS	DATE
M'F'G PROCESS		
PRODUCTION		
MATERIAL CONTROL		
SAFETY		

FRIG ELEC.
LAYOUT SHT. 3

FRIGIDAIRE DIVISION PL 2
OF GENERAL MOTORS CORPORATION 71
MANUFACTURING PROCESS DEPARTMENT
DAYTON, OHIO PLANT

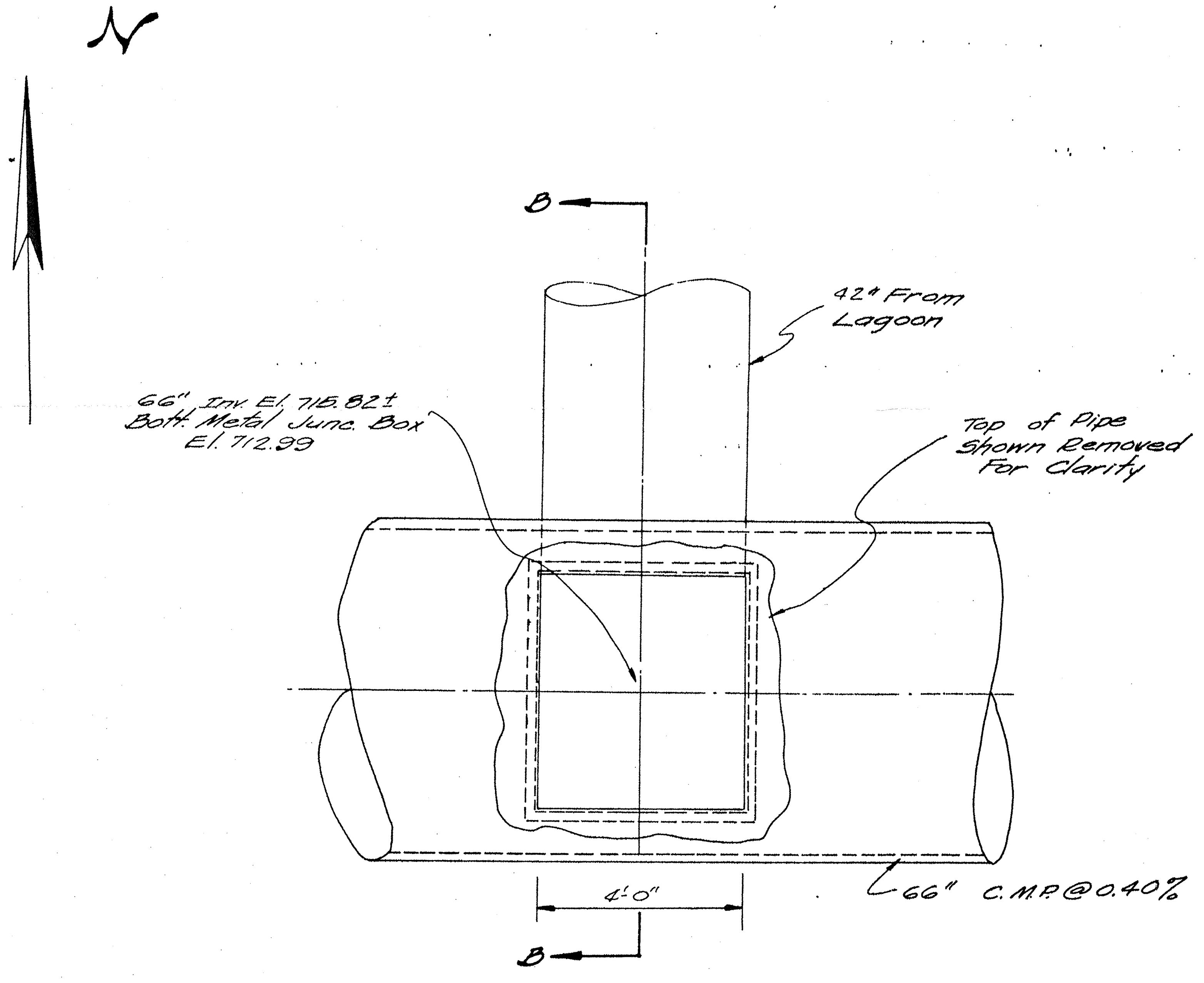
TITLE OIL SALVAGE STATION
OIL SKIMMER - PL#2 LAGOON

SCALE 1/32" = 1'-0"	ORDER NO. MP 66127
DRAWN BY	FOR DEPT. NO. 251
DATE 8-18-71	BLDG. NO.
PC. NO.	SHEET NO. 1 OF 2
APPROVED	DRG. NO. D 68427

(B) SIZE OIL BOOM LAYOUT) ~~REF. B-68427~~

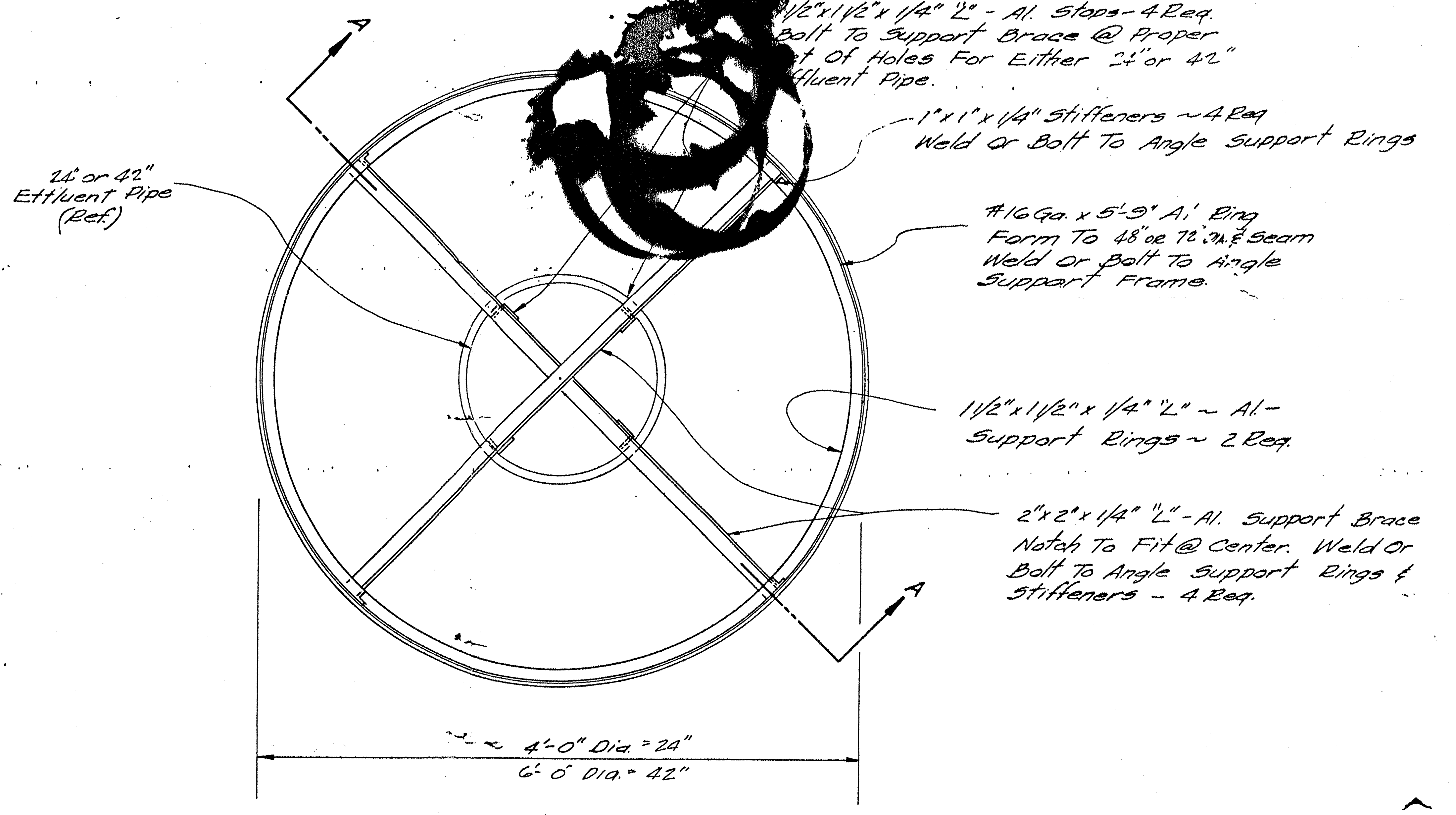
STAMP PIECE AND TOOL No. ON COMPLETED TOOL

SHT.-3 (C SIZE)



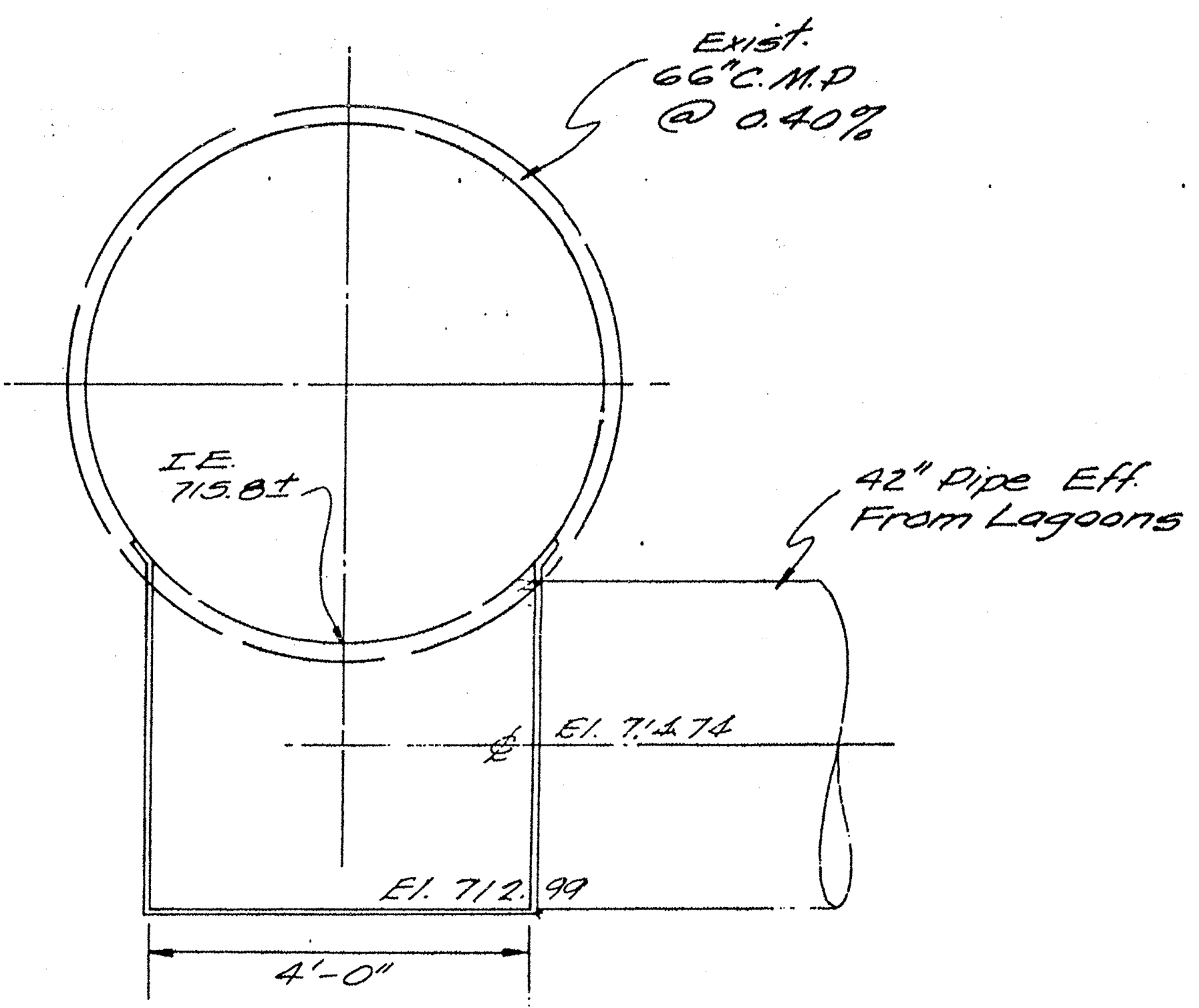
DETAIL "G"
PLAN EFFLUENT CONN

Scale 1/2" = 1'-0"



PLAN - RING BAFFLE

Not To Scale



SECTION B-B

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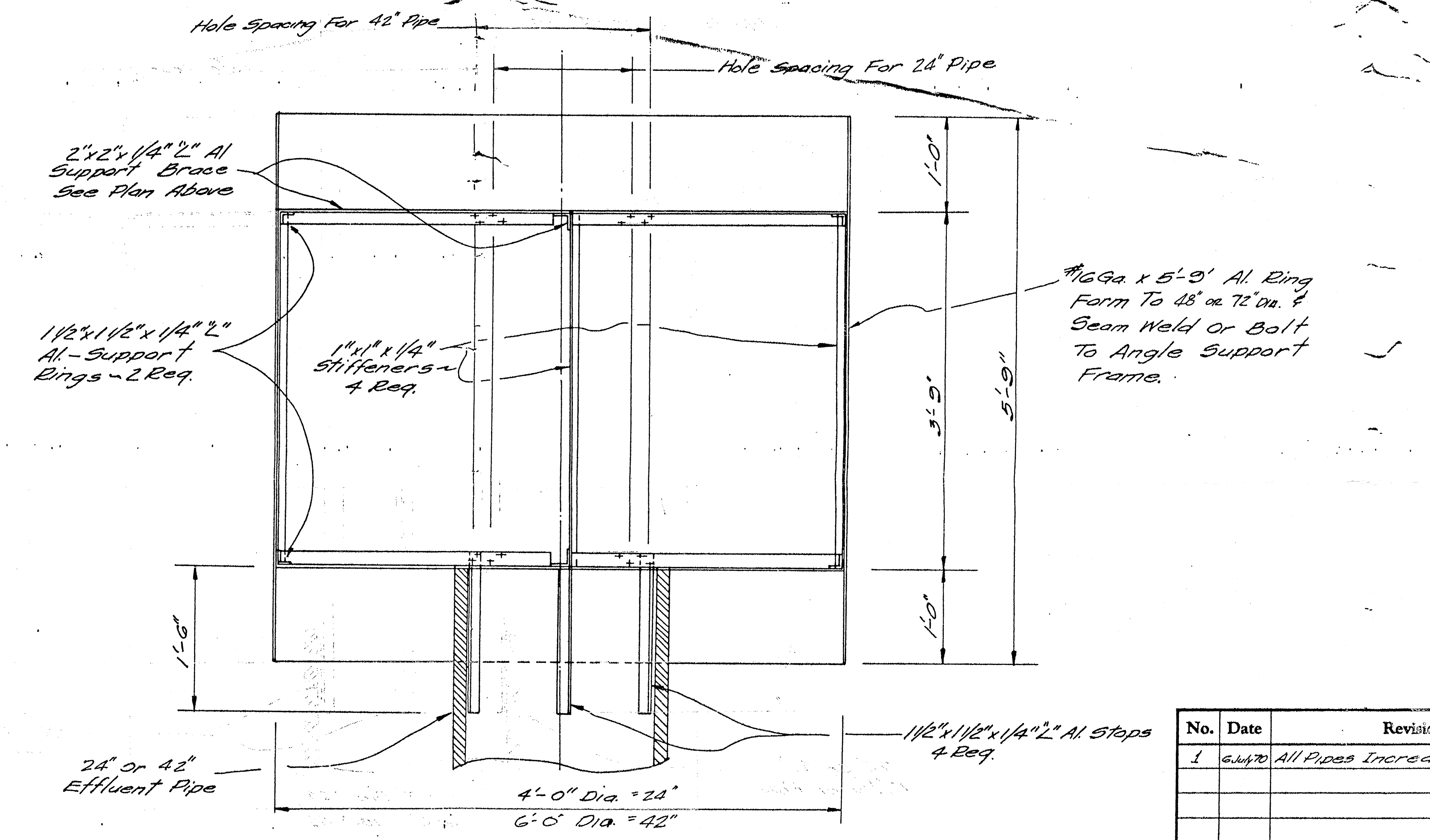


SECTION A-A

Not To Scale

No.	Date	Revision
1	6 July 70	All Pipes Increased In Size

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

SECONDARY TREATMENT SYSTEM
DETAIL "G"

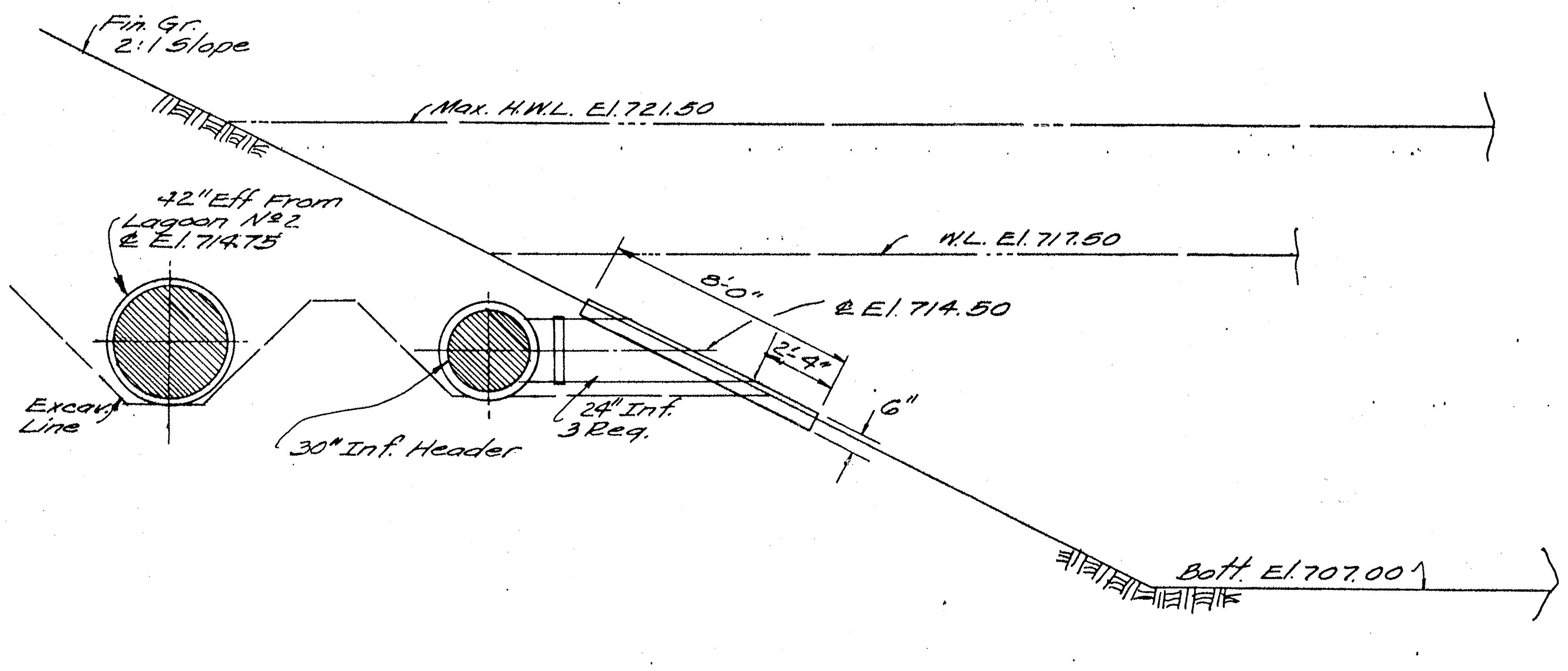
Scale: As Noted
Date: MAY 1970

Des:............
Dr.:............
Ckd:............

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

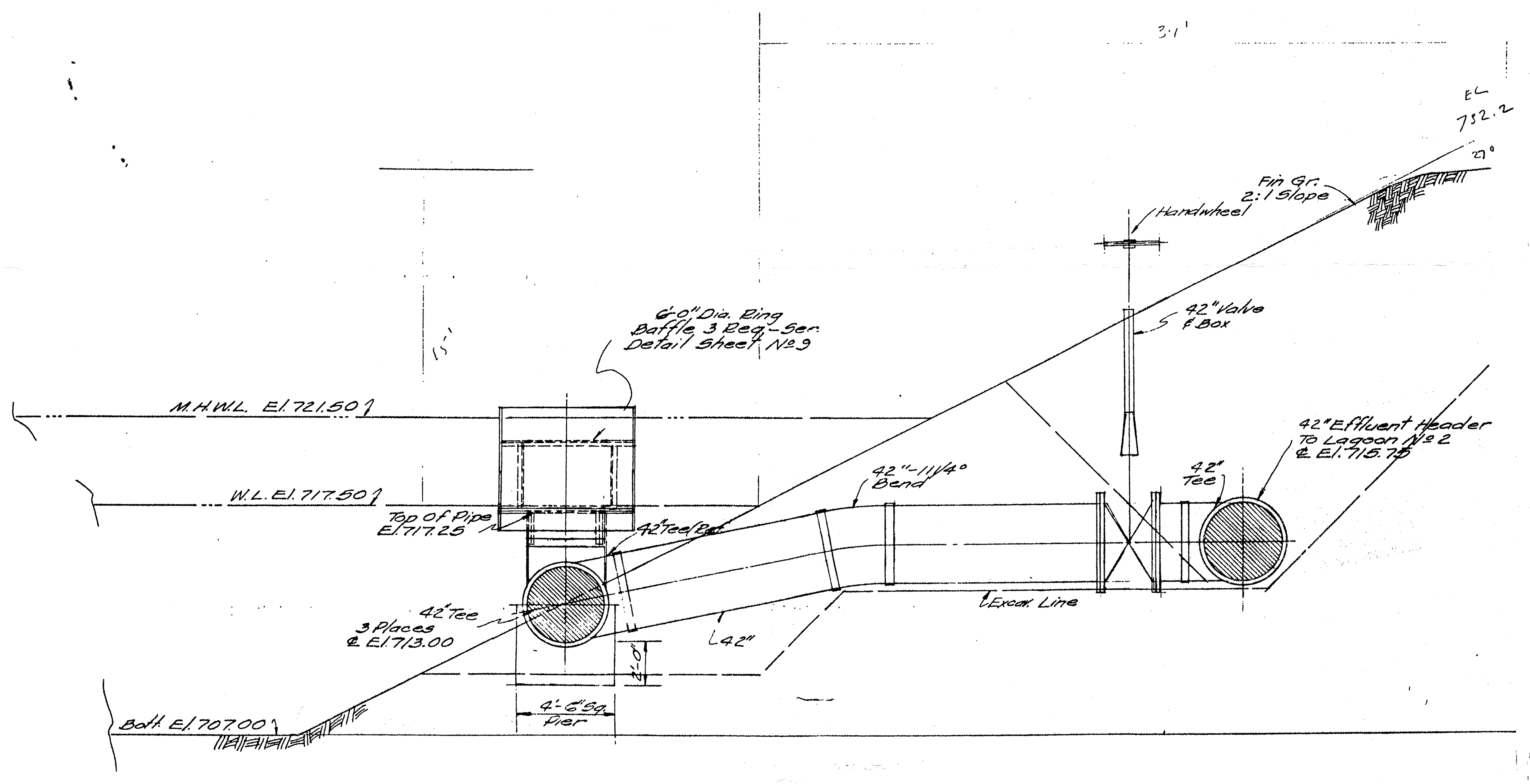
Contract No. 7961
Sheet No. 9 of 9

Approved:............ Engineer



SECTION A-A
Scale 1/4" = 1'-0"

Note: For Mechanical Equipment See Specs.



SECTION B-B
Scale 1/4" = 1'-0"

INDUSTRIAL WASTE DISPOSAL
APPROVED
STATE OF OHIO DEPARTMENT OF HEALTH
AS EVIDENCED BY COPY OF
LETTER OF APPROVAL
HERETO ATTACHED

No.	Date	Revision
1	6 July 70	All Pipes Increased In Size

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

SECONDARY TREATMENT SYSTEM

SECTIONS

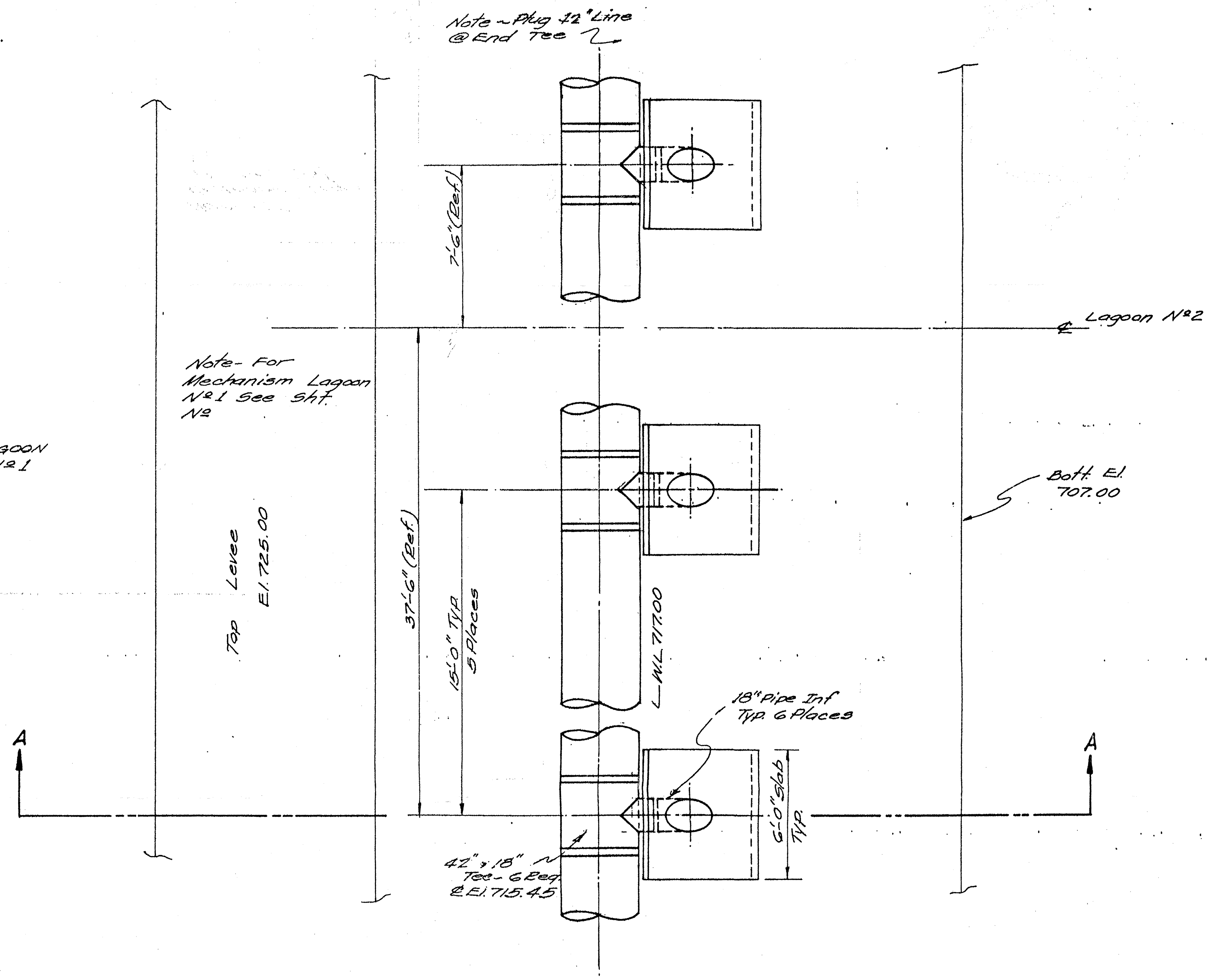
Scale: 1/4" = 1'-0"
Date: MAY 1970

Des:............
Dr.:............
Ckd:............

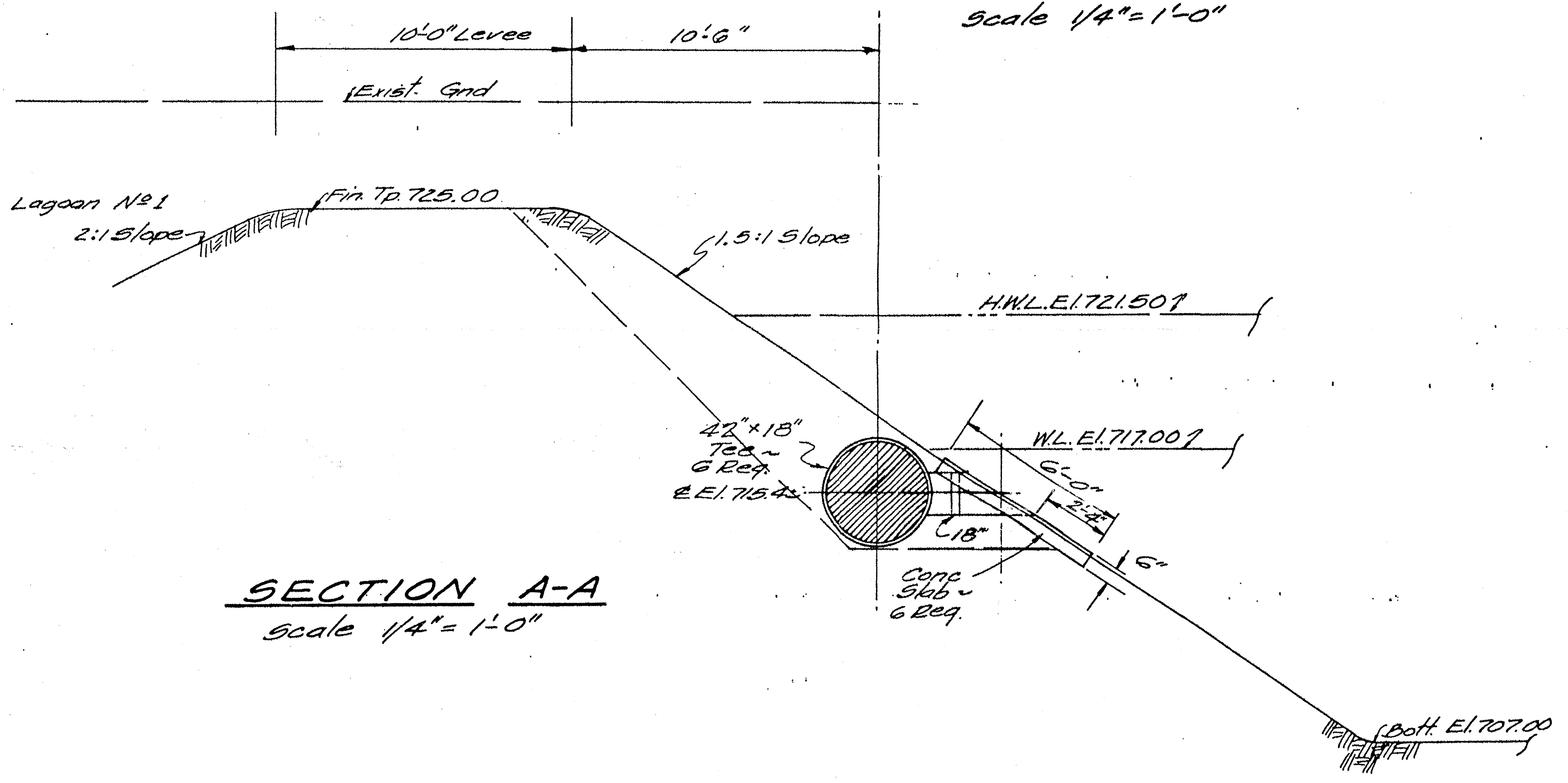
RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 7961
Sheet No. 7 of 9

Approved:.. Engineer



DETAIL "E"
PLAN INFLUENT
LAGOON Nº 2
Scale 1/4" = 1'-0"



SECTION A-A
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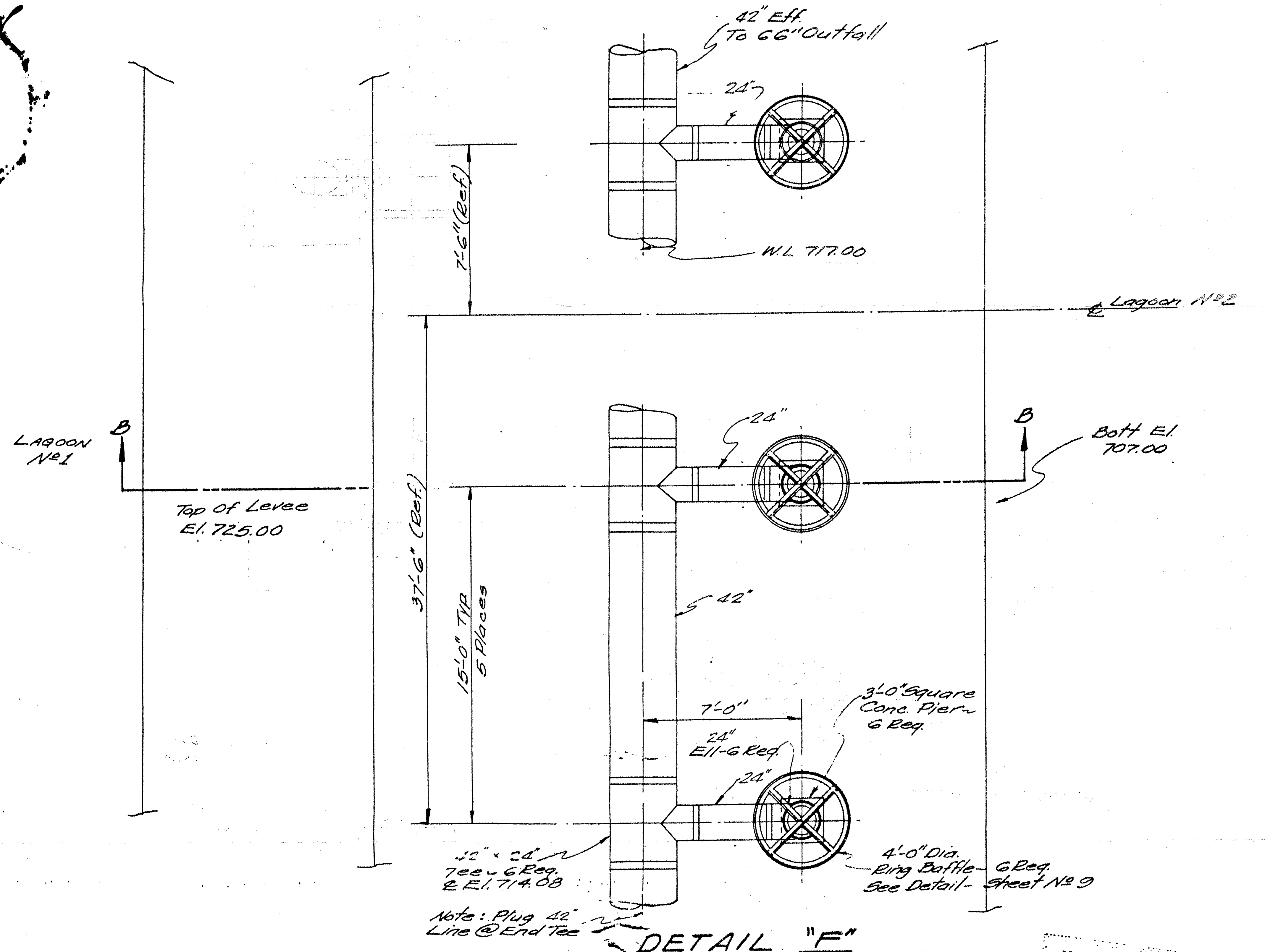
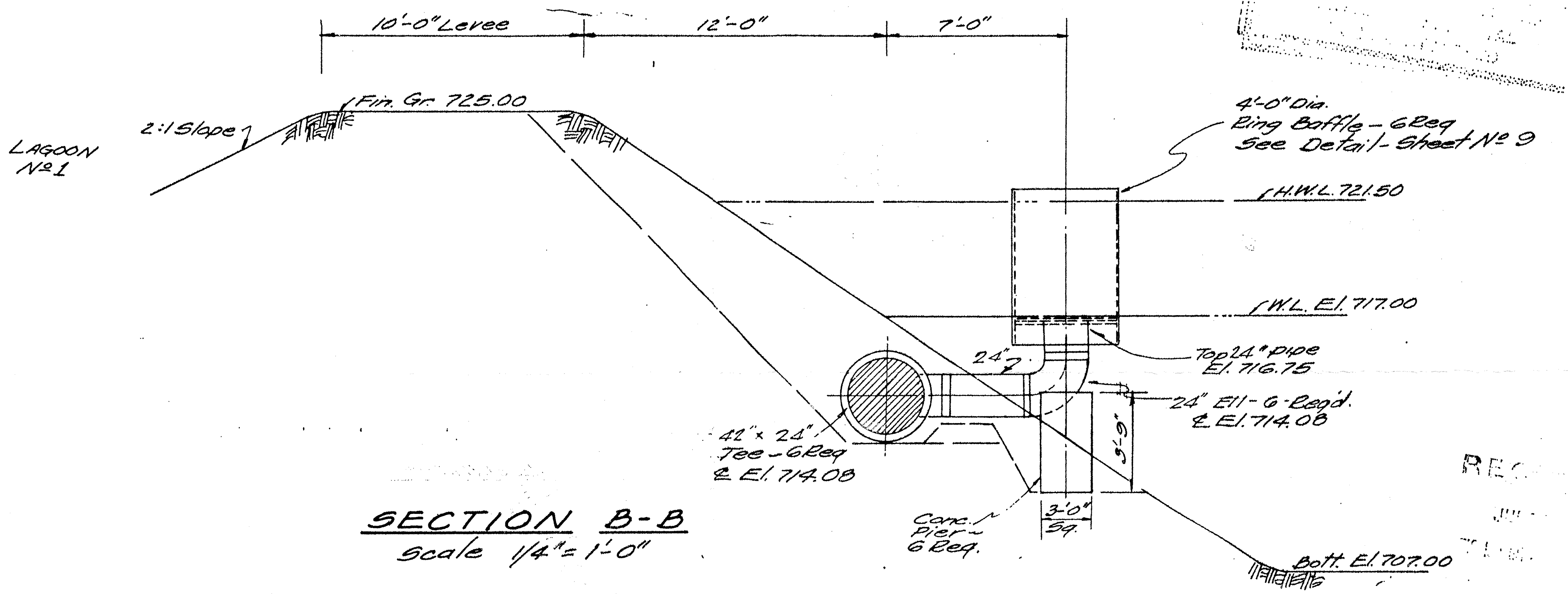


DETAIL "F"
PLAN EFFLUENT
LAGOON Nº 2
Scale 1/4" = 1'-0"



SECTION B-B
Scale 1/4" = 1'-0"

No.	Date	Revision
1.	7-6-70	Piping Size Increased.

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

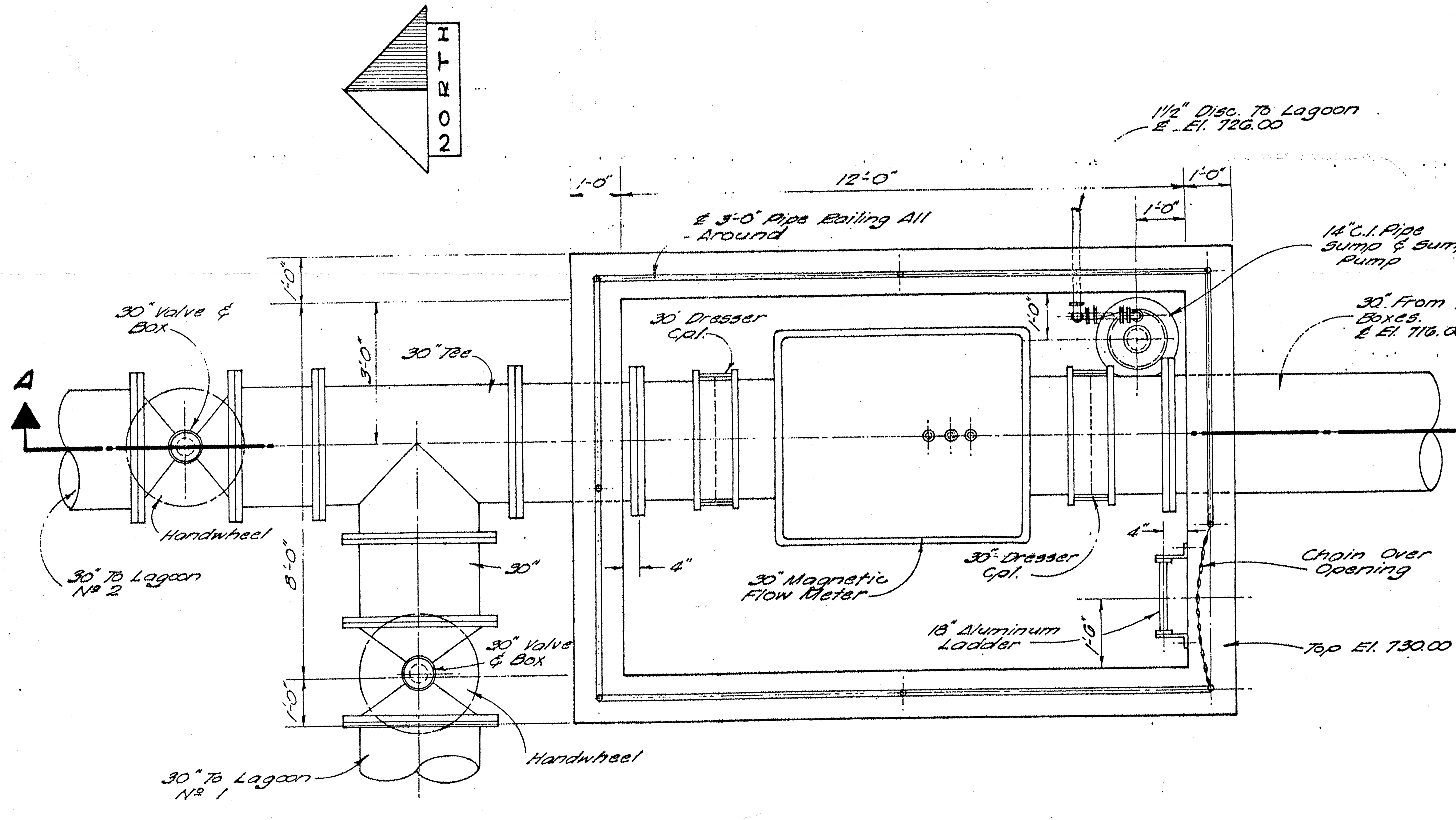
SECONDARY TREATMENT SYSTEM
DETAIL "E" & "F" PLAN

Scale: 1/4" = 1'-0"
Date: MAY 1970
Des:............
Dr.:............
Ckd:............

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45401

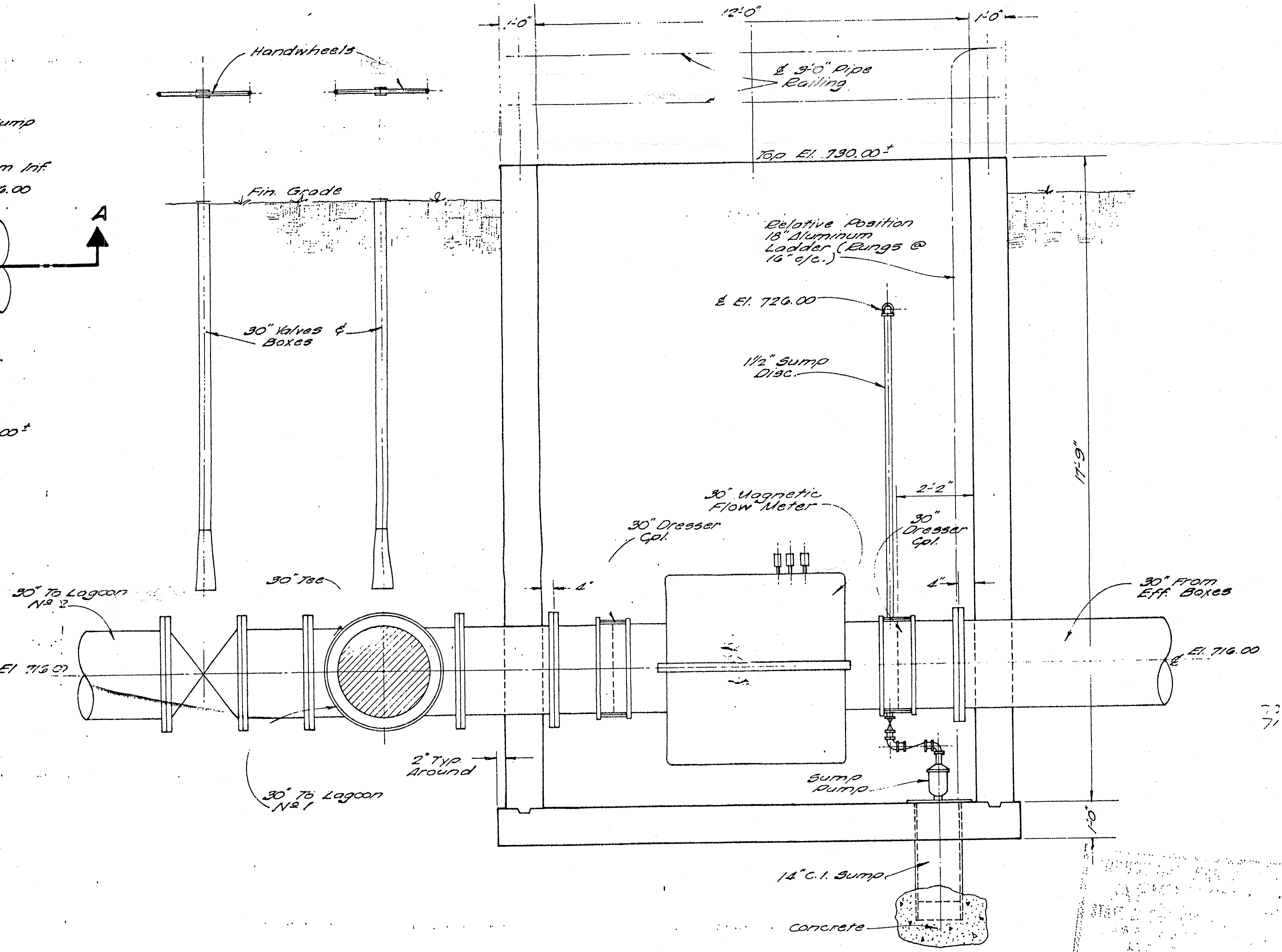
Contract No. 7961
Sheet No. 8 of 9

Approved:.. Engineer



DETAIL "B"
PLAN – METER PIT

scale ~ ½" = 1'-0"



SECTION A-A

scale ~ ½" = 1'-0"

No.	Date	Revision
1.	7-6-70	Piping Size Increased.

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

SECONDARY TREATMENT SYSTEM
DETAIL "B"

Scale: ½" = 1'-0" Date: MAY 1970

Des: ....
Dr.: W.L.W.
Ckd: ....

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 7961
Sheet No. 5 of 9

Approved: .... Engineer

INDUSTRIAL WASTE DISPOSAL
APPROVED
STATE OF OHIO DEPARTMENT OF HEALTH
AS EVIDENCED BY COPY OF
LETTER OF APPROVAL
HERETO ATTACHED

RECEIVED
JUL 10 1970
OHIO DEPARTMENT OF HEALTH

No.	Date	Revision
1.	7-6-70	Piping Size Increased.

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

SECONDARY TREATMENT SYSTEM
PIPING

Scale: 1" = 40'
Date: MAY 1970

Des:............
Dr.:............
Ckd:............

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 7961
Sheet No. 3 of 9

Approved:.. Engineer

DETAIL "C"
PLAN ~ INFLUENT
LAGOON Nº 1

Scale ~ 1/4" = 1'-0"

DETAIL "D"
PLAN ~ EFFLUENT
LAGOON Nº 1

Scale ~ 1/4" = 1'-0"

RECEIVED
JUL 10 1970
DEPARTMENT OF HEALTH

No.	Date	Revision
1.	7-6-70	Piping Size Increased.

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

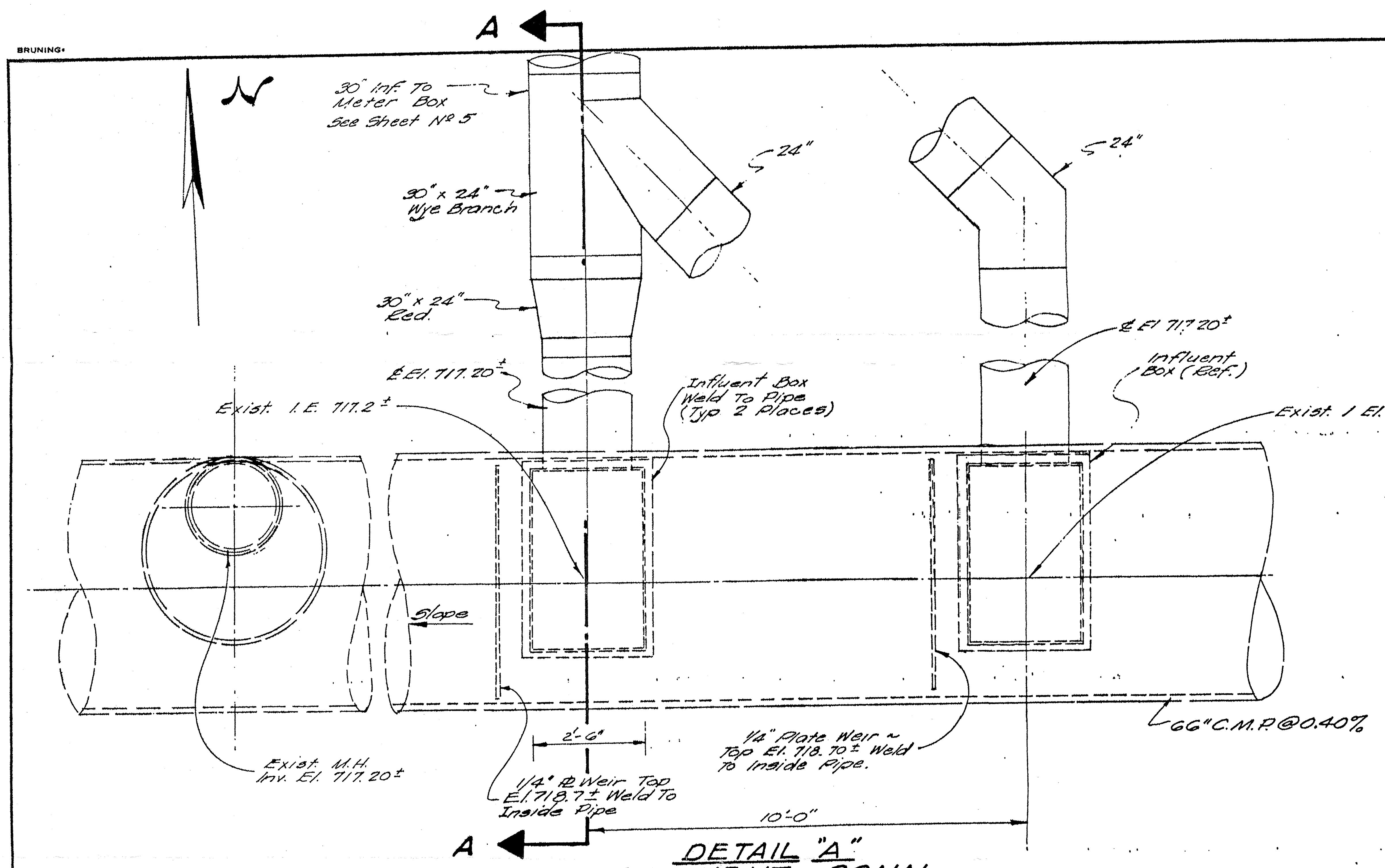
SECONDARY TREATMENT SYSTEM
DETAIL "C&D" PLAN

Scale: 1/4" = 1'-0"
Date: MAY 1970
Des:.............
Dr.:.............
Ckd:.............

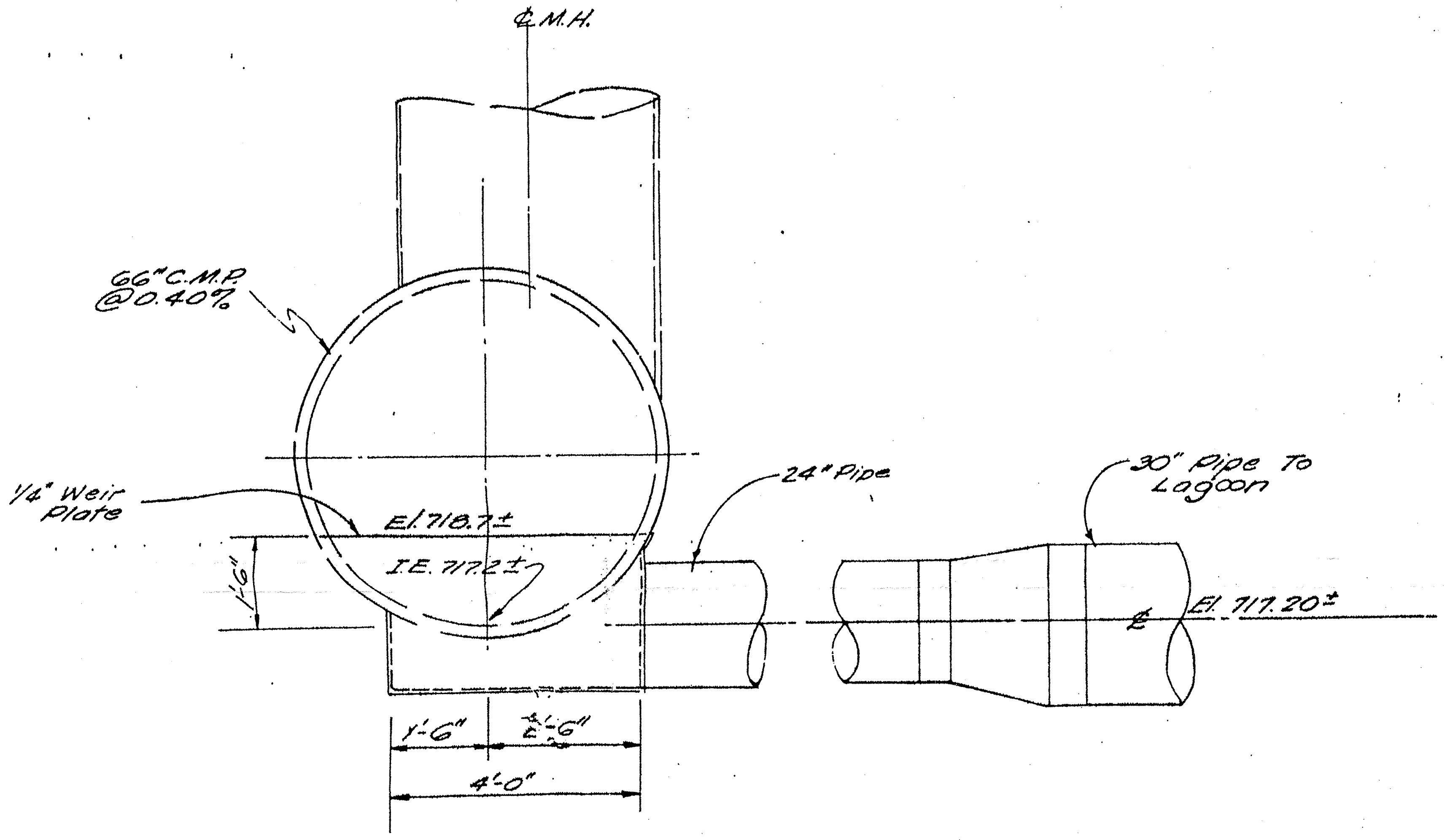
RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 796
Sheet No. 6 of 9

Approved:.. Engineer



DETAIL "A"
PLAN ~ INFLUENT CONN.
Scale 1/2"=1'-0"



Typical ~ Both Influent Pipes.

SECTION A-A
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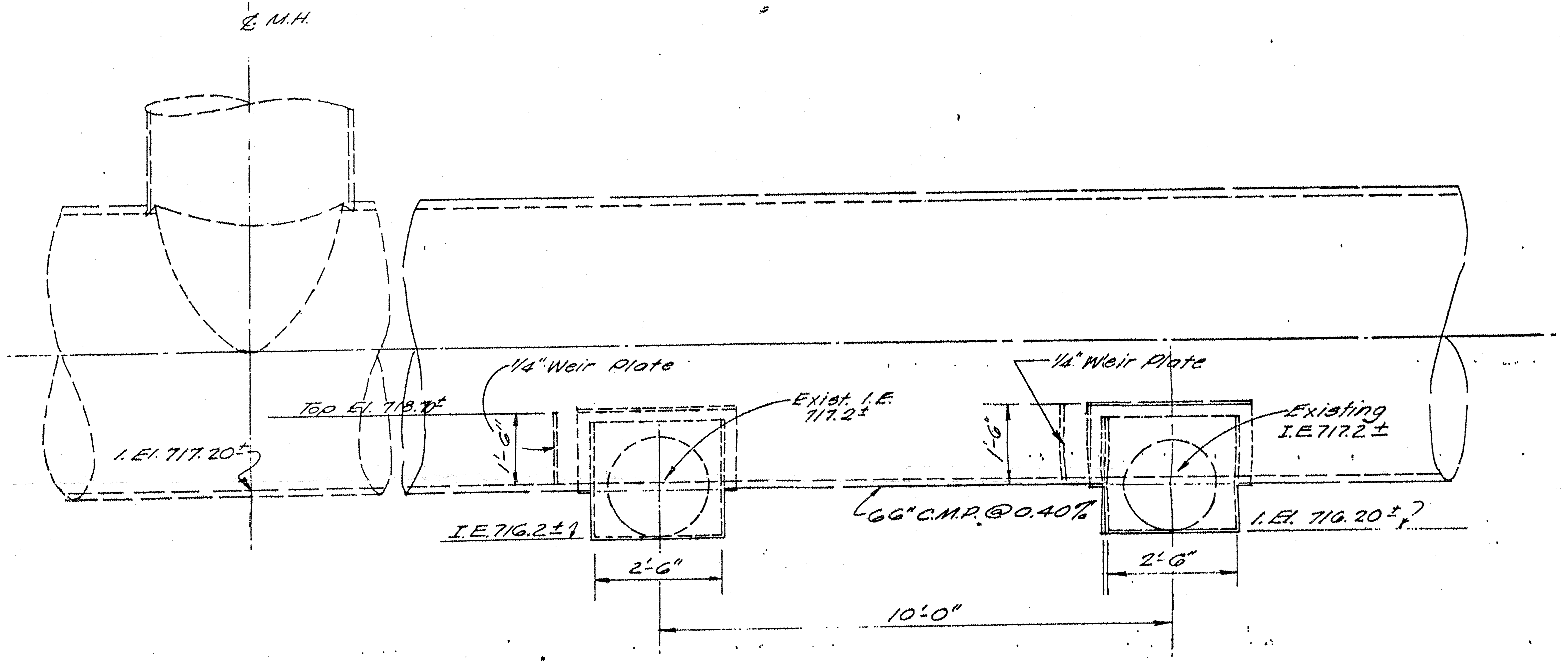


ELEVATION
Scale 1/2"=1'-0"

INDUSTRIAL WASTE DISPOSAL
APPROVED
STATE OF [illegible]
[illegible]

RECEIVED
JU[illegible]

No.	Date	Revision
1.	7-6-70	Piping Size Increased.

FRIGIDAIRE DIVISION, MORAINE
GENERAL MOTORS CORPORATION

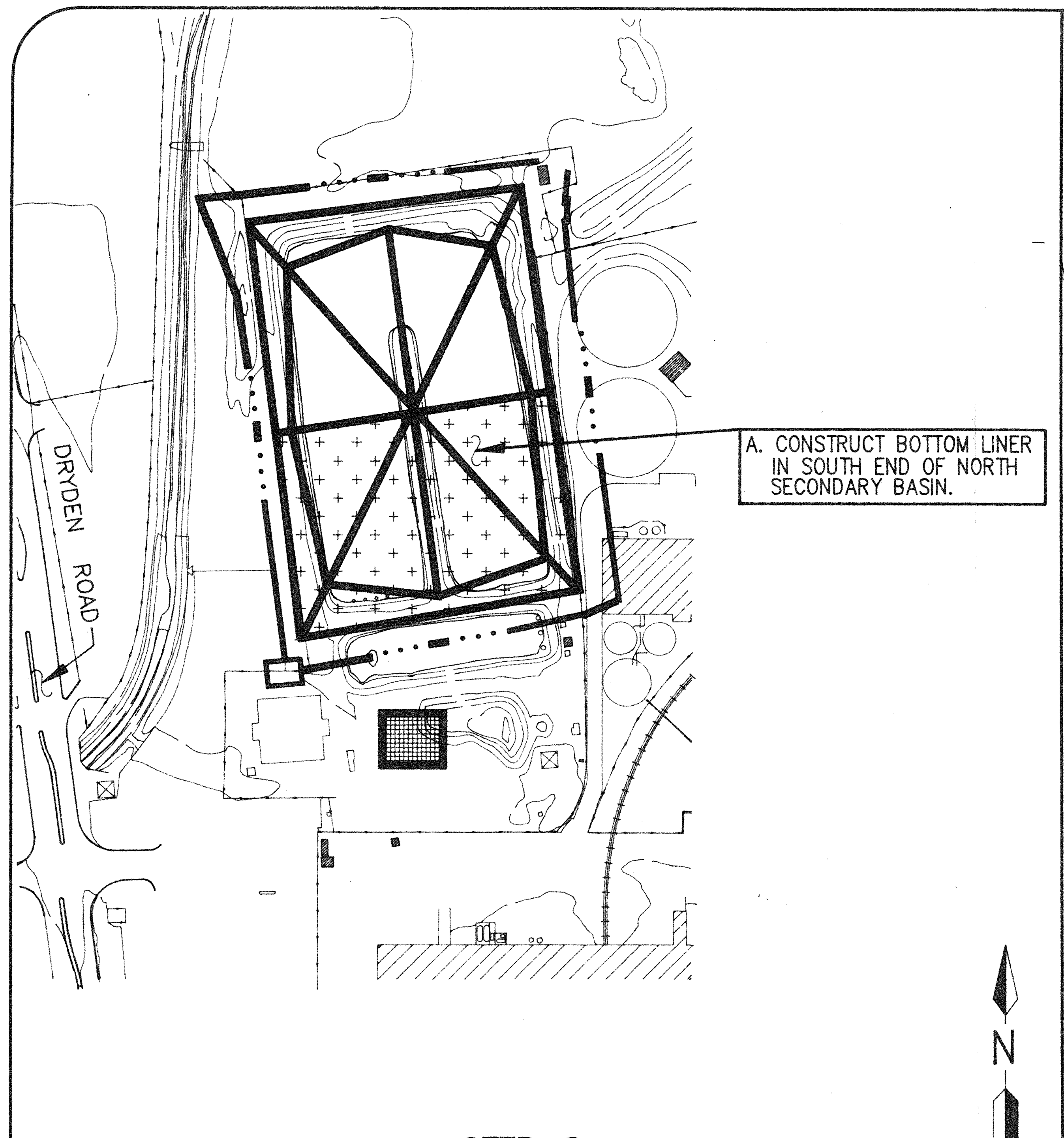
SECONDARY TREATMENT SYSTEM
DETAIL "A"

Scale: 1/2"=1'-0"
Date: MAY 1970
Des:............
Dr.:............
Ckd:............

RALPH L. WOOLPERT CO.
CONSULTING ENGINEERS & PLANNERS
2324 Stanley Avenue Dayton, Ohio 45404

Contract No. 7961
Sheet No. 4 of 9

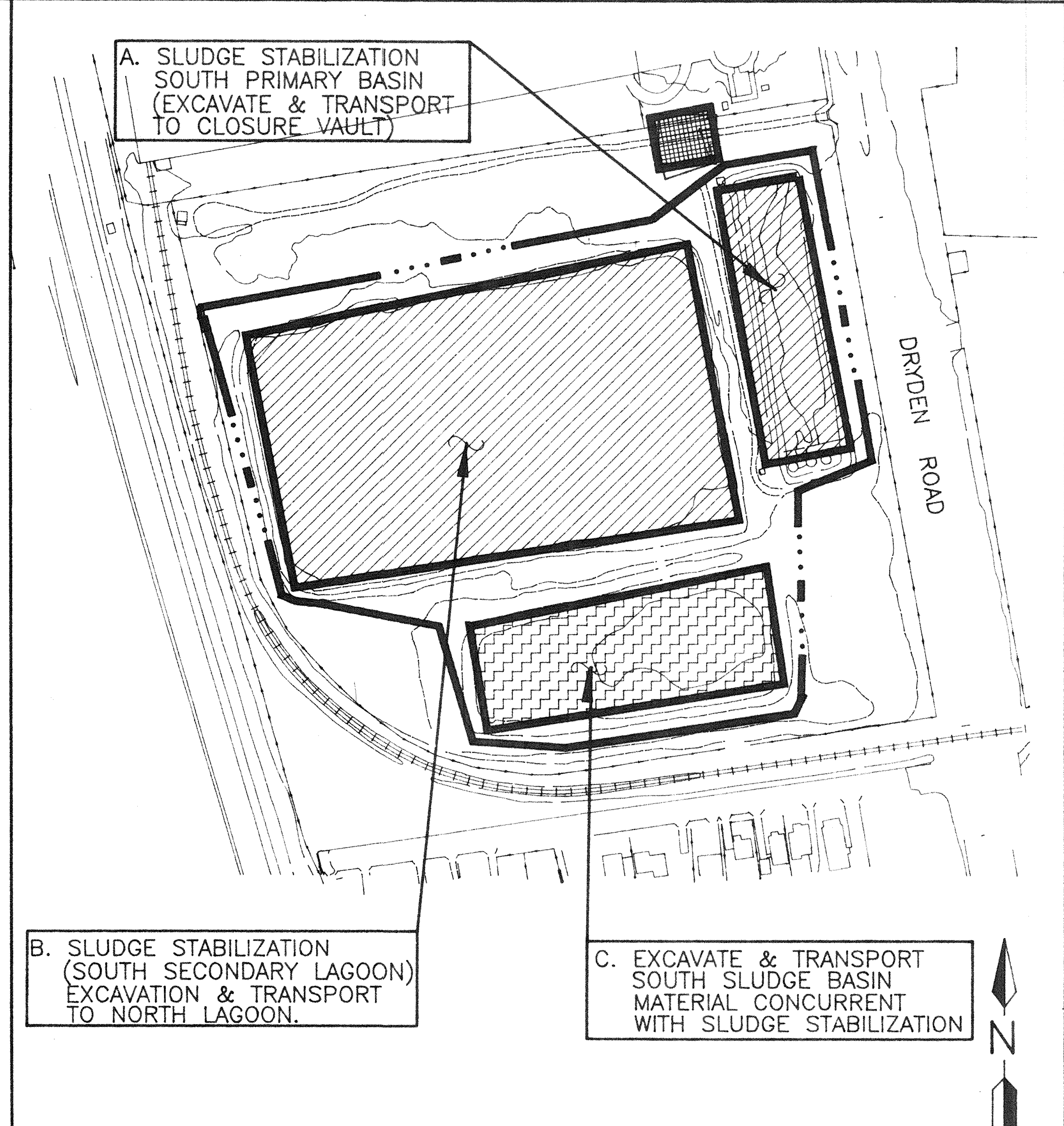
Approved:.. Engineer



STEP–8

2ND HALF BOTTOM LINER SYSTEM

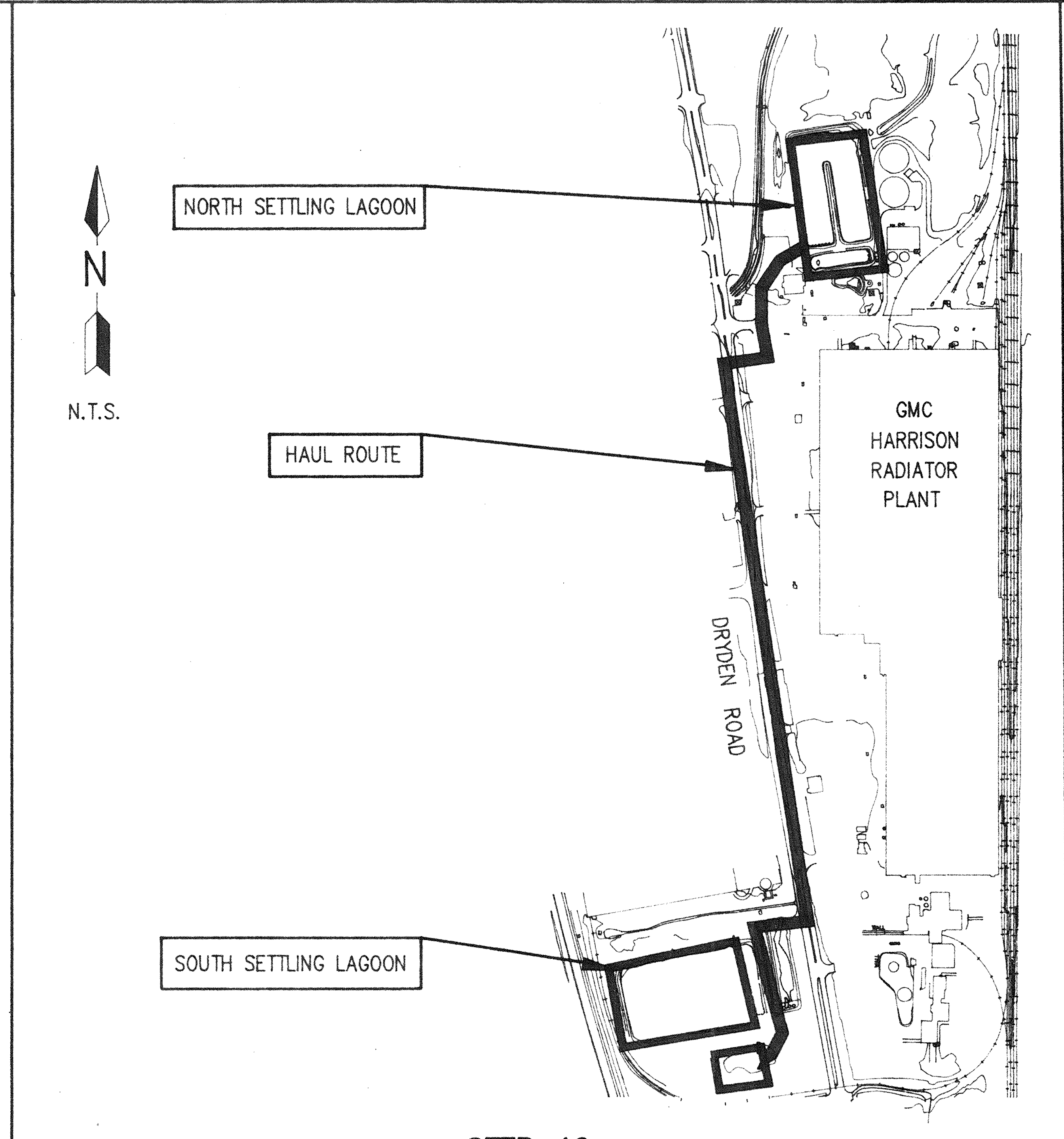
N.T.S.



STEP–9

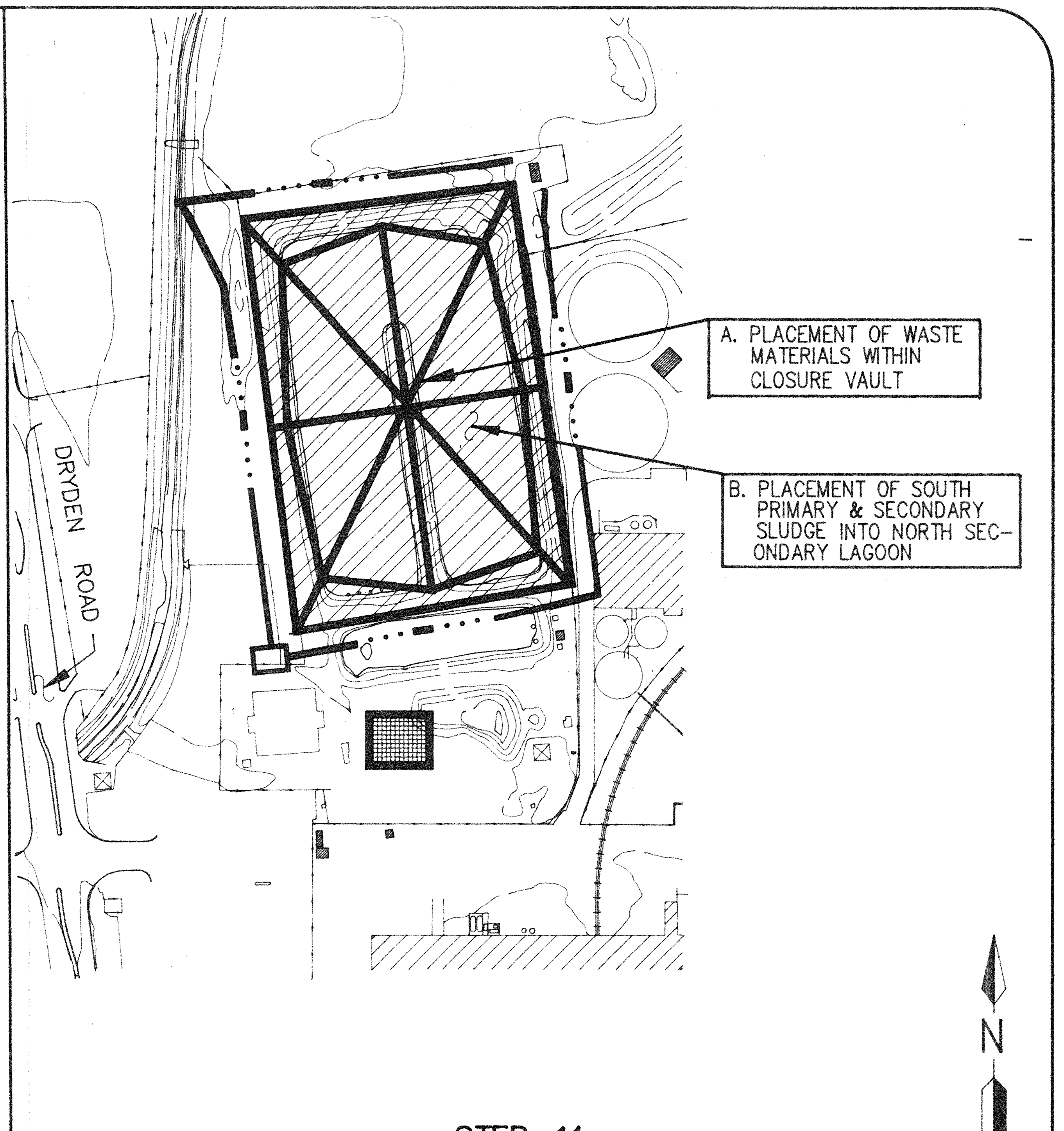
SLUDGE STABILIZATION & EXCAVATION–SOUTH SETTLING LAGOON

N.T.S.



STEP–10

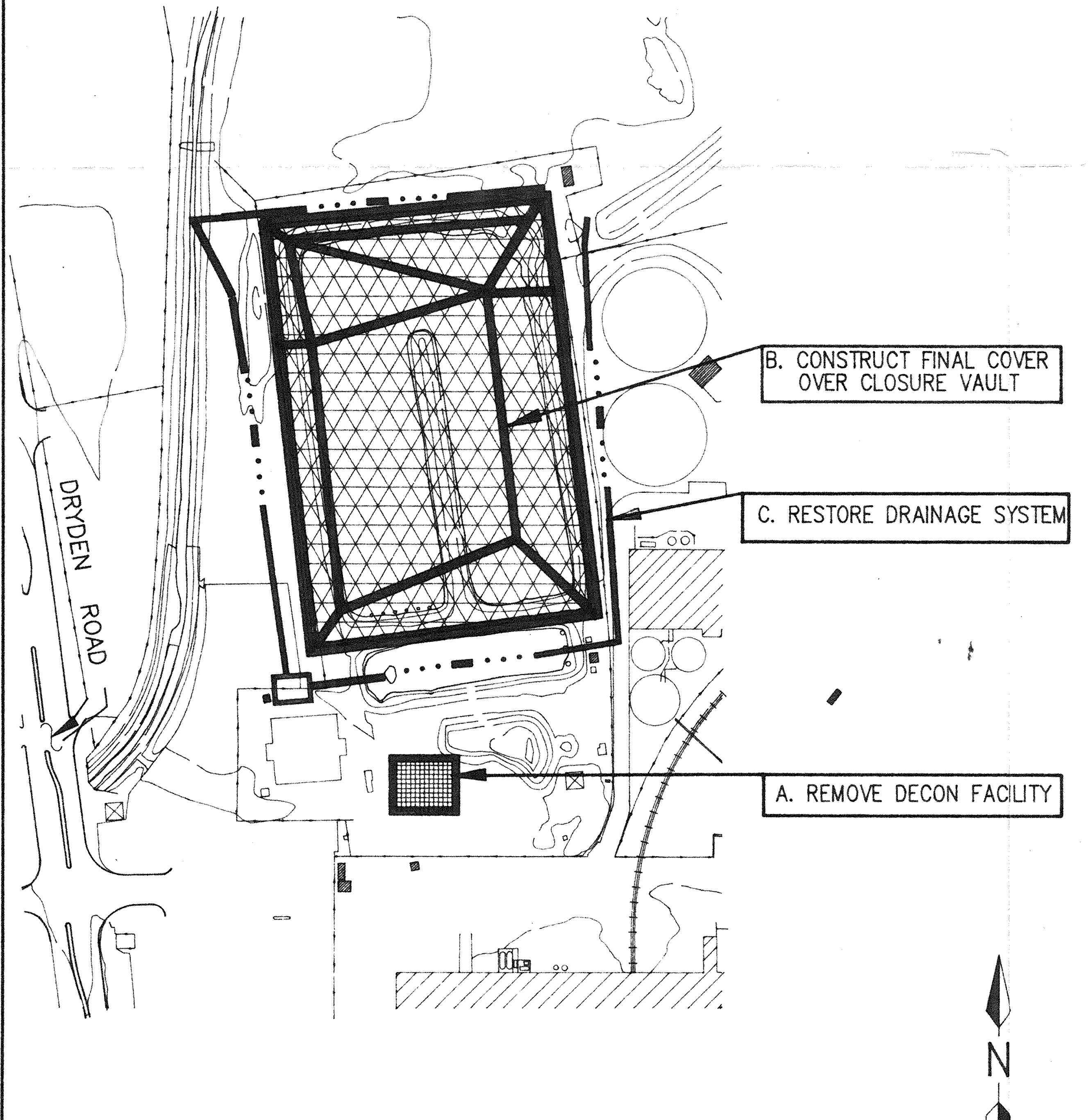
HAUL ROUTE



STEP–11

SLUDGE PLACEMENT

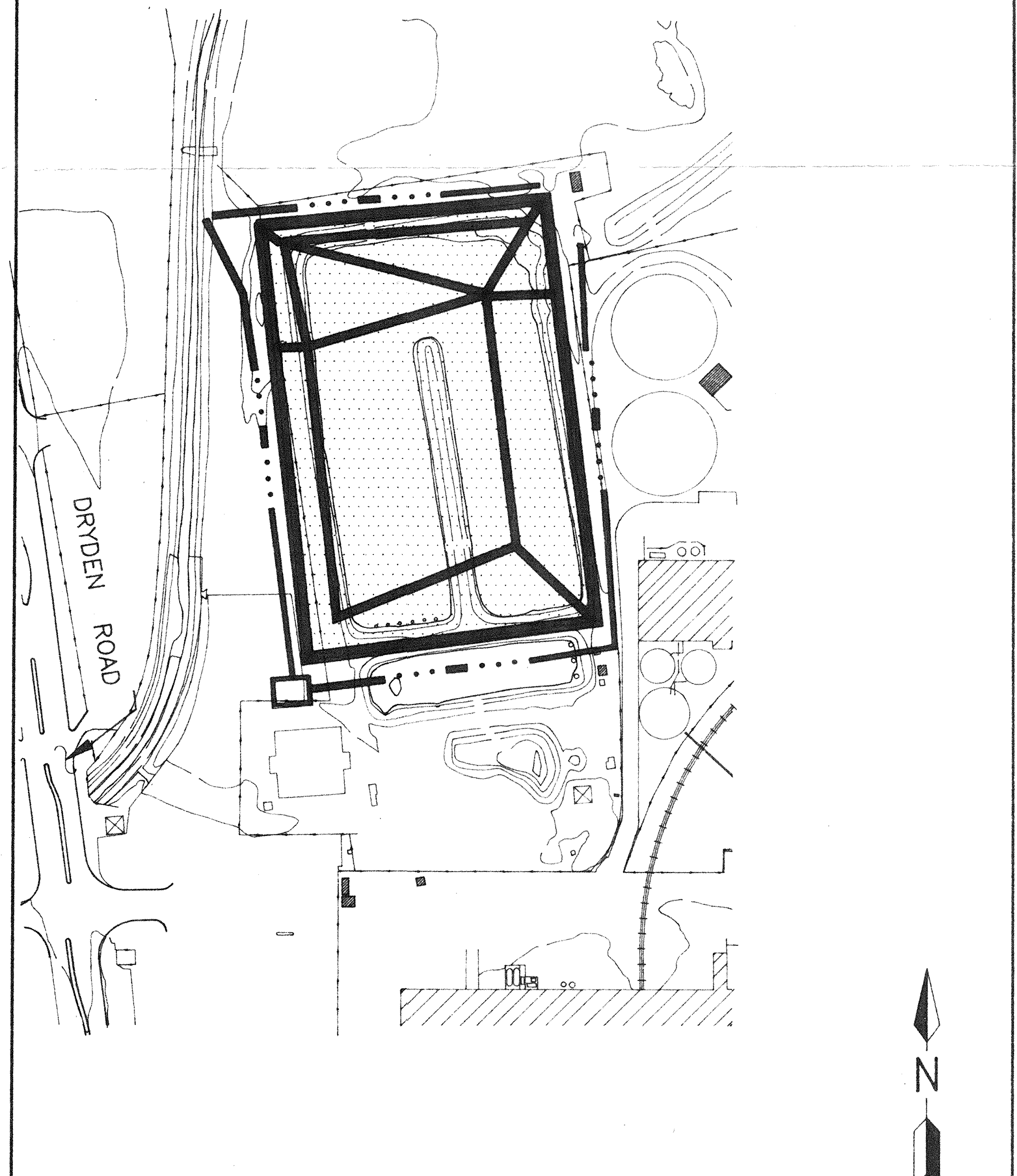
N.T.S.



STEP–12

SITE RESTORATION–SOUTH SETTLING LAGOON

N.T.S.

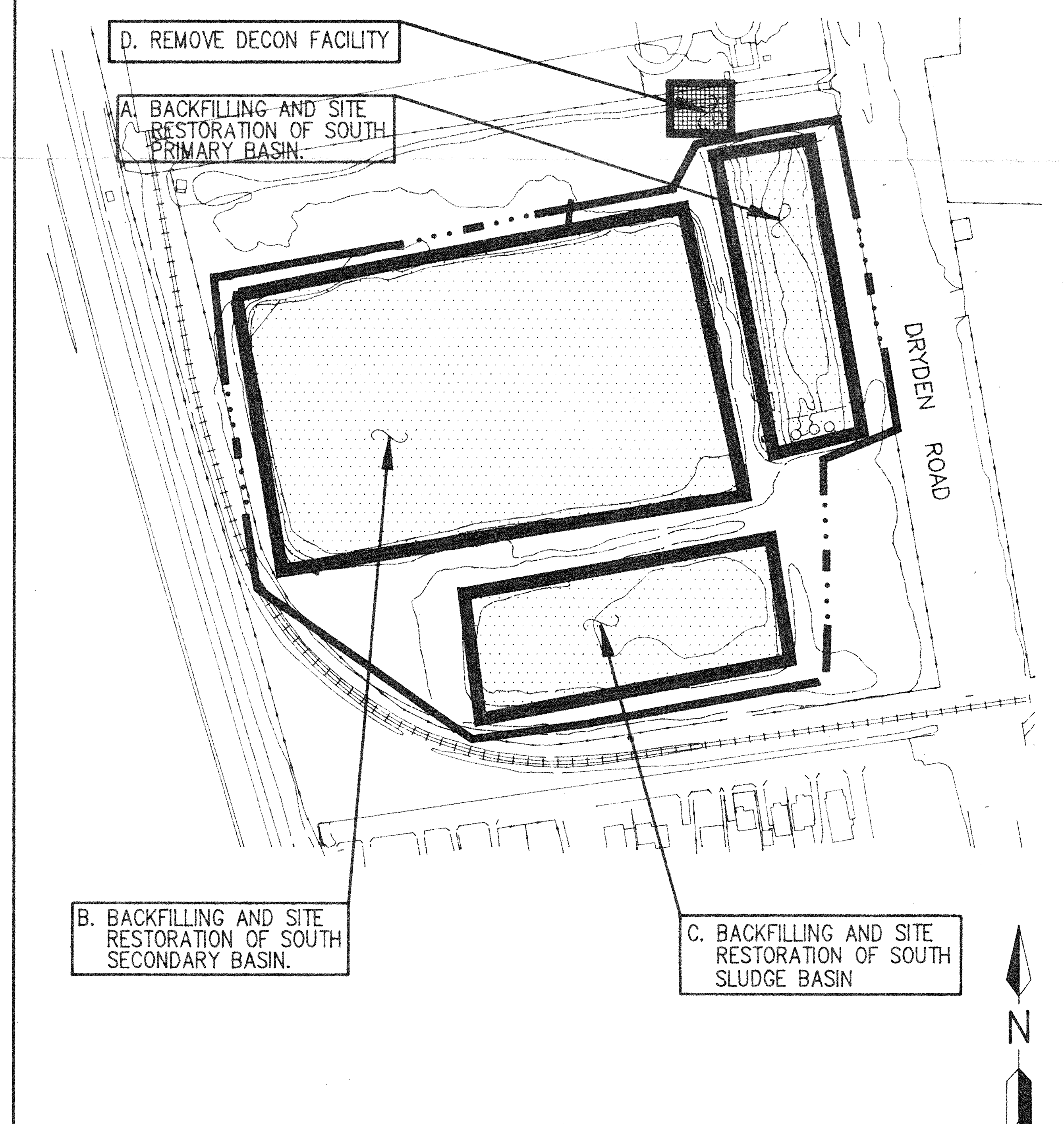


STEP–13

FINAL COVER AND FINAL DRAINAGE SYSTEM

N.T.S.

BREAK FOR WINTER



STEP–14

FINAL SITE CONFIGURATION

N.T.S.

LEGEND

- ▨ = SLUDGE STABILIZATION
- ▩ = FOUNDATION PREPARATION
- ▨ = STOCKPILING
- ▦ = REGRADING
- ☐ = BOTTOM LINER SYSTEM
- ▤ = TEMPORARY COVER
- ▦ = EXCAVATION
- ☐ = SITE RESTORATION
- ▩ = FINAL COVER SYSTEM
- ■ = DECONTAMINATION PAD
- — ··· — ··· — = DRAINAGE SWALE
- ━━━ = HAUL ROUTE

FIGURE 3-1B

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SCALE VERIFICATION
THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING:
0 1"
USE TO VERIFY FIGURE SCALE

FOR REGULATORY

REVIEW ONLY

REV. NO.	DATE	DESCRIPTION	BY	APPR.

DRAWING NO: FLOO087-CL3-D11

DRAWN BY:	DATE: 11-2-89
CHECKED BY:	DATE: 11-2-89
APPROVED BY: R. W. Fox	DATE: 11-2-89

GERAGHTY & MILLER ENGINEERS, INC.

ANTICIPATED CONSTRUCTION SEQUENCE FOR RCRA CLOSURE VAULT

SETTLING LAGOON CLOSURE PLANS
GMC-HARRISON RADIATOR
MORAINE, OHIO

APPENDIX D

GM LETTER TO ARMY CORP. OF ENGINEERS, DATED NOVEMBER 11, 1999 AND DEPARTMENT OF THE ARMY LETTER DATED JANUARY 10, 2000

REALM

GMC Moraine Facilities
3600 Dryden Road
Moraine, OH 45439-1410

November 11, 1999

Mr. Douglas Shelton
Chief, Regulatory Branch
Louisville District
U.S. Army Corps of Engineers
P.O. Box 59
Louisville, Kentucky 40201-0059

RE: Request for Jurisdictional Determination
RCRA Hazardous Waste Lagoons
General Motors Moraine Facilities
Moraine, Ohio

Dear Mr. Shelton:

On behalf of General Motors Corporation (GMC), Remediation and Liability Management Company (REALM), a GMC subsidiary, is providing the following information to assist your office in making a determination of Corps of Engineers jurisdiction over two hazardous waste lagoons at GMC properties in Moraine, Ohio. The two lagoons are scheduled to be closed under the federal Resource Conservation and Recovery Act (RCRA). However, parts of the bottom of each lagoon have developed potential wetland characteristics, and GMC wishes to be certain of the status of the lagoons with respect to Section 404 of the Clean Water Act before mechanized land clearing of those parts commences. This letter is provided pursuant to your conversation on August 31, 1999, with Ms. Pam Lewis of REALM and Mr. David Marschall of CRA Services regarding this matter.

BACKGROUND

Various past industrial activities conducted on the GMC properties located in Moraine, Ohio, formerly included the operation of two series of impoundments for containment and settling of solids from various process wastewaters generaged at the plant. The impoundments are referred to as the North Lagoon and the South Lagoon. Typically, wastewater was pumped to each lagoon and was diverted by internal berms to increase settling time. Solids contained in the effluent settled and the liquids were routed to a ditch for eventual discharge under an NPDES permit to the Great Miami River. Residual materials in the lagoons are industrial wastes and the impoundments are classified as regulated units under RCRA. Figure 1 is a vicinity map showing the location of the GMC facilities and the two lagoons.

The North Lagoon is approximately 4.6 acres and consists of a primary basin and a secondary basin separated by an earthen berm. Currently, the North Lagoon contains approximately 12,800 cubic yards of sludge. The South Lagoon is approximately 7.9 acres and consists of two separate basins. Currently, the South Lagoon holds approximately 67,200 cubic yards of sludge. Figures 2 and 3 are plan views of the two lagoons showing topographic elevations. Exhibit 1 is a recent aerial photograph of the GMC facilities showing the lagoons.

Both lagoons continue to hold waste sludge treated as hazardous under RCRA.

JURISDICTIONAL CONSIDERATIONS

Hydrology. Wetland hydrology may be established in large areas of each lagoon in large part by the accumulation of stormwater runoff. The lagoons are no longer part of the plant's NPDES water treatment program, and there is no longer a discharge from the lagoons.

Soils. REALM/CRA Services has reviewed the *Soil Survey of Montgomery County, Ohio* (USDA Soil Conservation Service 1972) to determine if the lagoons were excavated in hydric soils. According to the soil survey, both the North Lagoon and the South Lagoon were excavated in areas of Fox silt loam, either 0 to 2 percent slopes or 2 to 6 percent slopes. Fox silt loam is not listed as a hydric soil on either the Montgomery County list or the National List of Hydric Soils. Exhibit 2 is a portion of the soil survey showing the lagoons.

Vegetation. Saturated areas of each lagoon support obligate wetland vegetation including cattails (*Typha spp*), black willows (*Salix nigra*), and various rushes and sedges. Approximately 0.66 acre of the North Lagoon and 3.17 acres of the South Lagoon are vegetated with plants that meet the vegetation criterion for jurisdictional wetlands. These areas are hatched on Figures 2 and 3.

DISCUSSION

The lagoons were excavated approximately twenty feet below grade and the natural surface soils were removed. The substratum upon which the vegetation is growing is sludge. Figures 4 and 5 are cross-section drawings of the two lagoons.

Although wet habitats that meet certain of the diagnostic criteria for jurisdictional wetlands may have developed in the two lagoons, these habitats provide very limited wetlands functions and values. Both the North Lagoon and the South Lagoon are isolated from the natural hydrologic systems by manmade berms. The lagoons were created as wastewater-treatment impoundments prior to promulgation of the Section 404 regulatory program, and have continued to hold listed hazardous sludge since they began operation about 27 to 34 years ago. Neither lagoon has been abandoned. Therefore, it is the opinion of GMC and REALM that these lagoons do not contain jurisdictional wetlands.

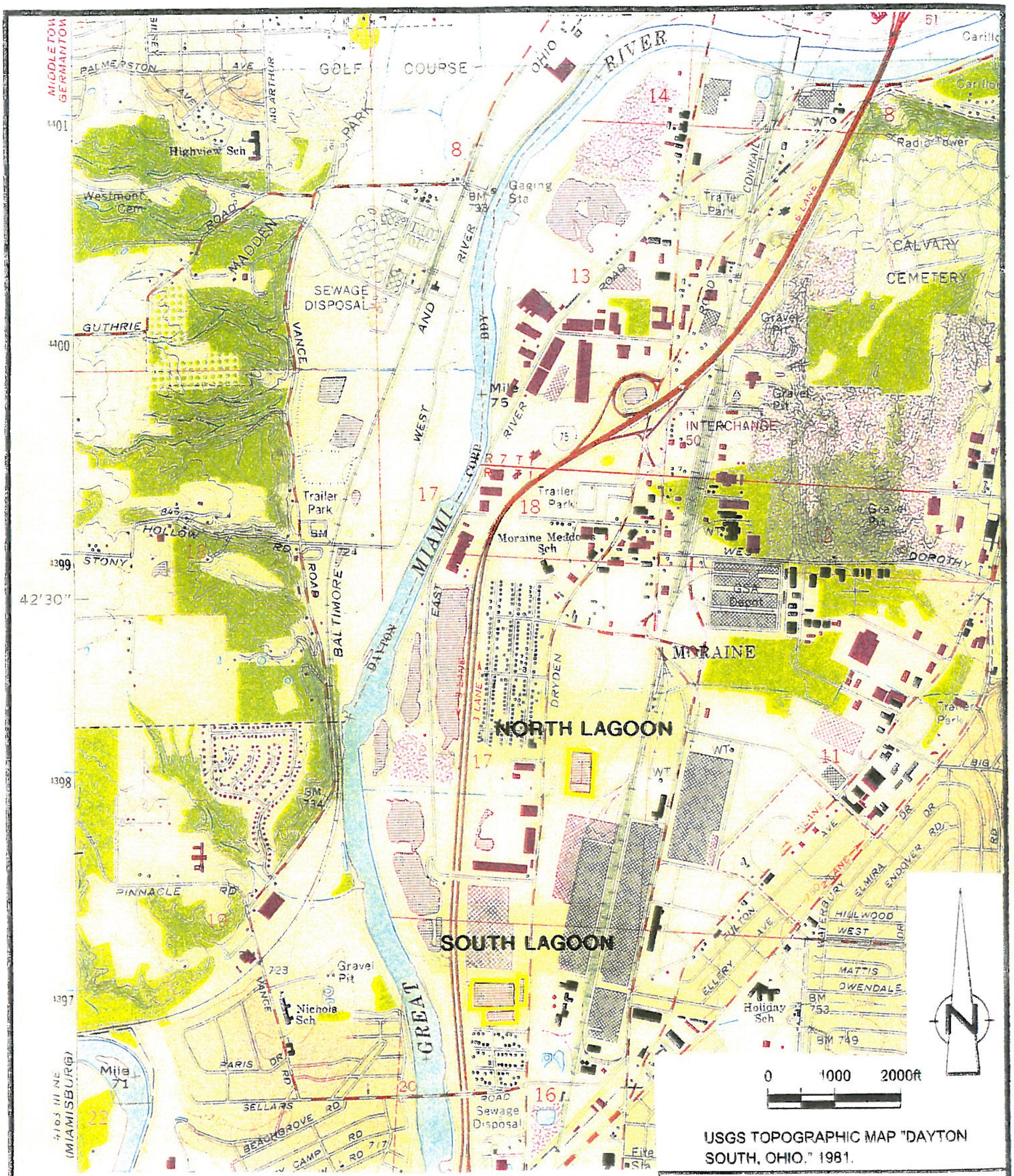
REALM requests that your office review the foregoing and attached information and provide a determination of jurisdiction for the areas of the North Lagoon and the South Lagoon described above. GMC is obligated to close the lagoons under RCRA regulations. It is intended that the closure of the lagoons will commence during November 1999. If you have questions or need additional information, please call at your earliest convenience.

Sincerely,

Pamela L. Lewis
REALM Project Manager

cc: Jean Caufield, GMC
Laura Tucker, GMC

Attachments:
Figure 1 – Vicinity Map
Figure 2 – North Lagoon Site Plan
Figure 3 – South Lagoon Site Plan
Figure 4 – North Lagoon Cross Sections
Figure 5 – South Lagoon Cross Sections
Exhibit 1 – 1999 Aerial Photograph
Exhibit 2 – Soil Survey Map Sheet



USGS TOPOGRAPHIC MAP "DAYTON SOUTH, OHIO," 1981.

CRA SERVICES
G&E ENGINEERING DIVISION

JSR	qua		9/20/99	001	0
Drawn By	Checked By	Approved By	Date	File No.	Rev. No.

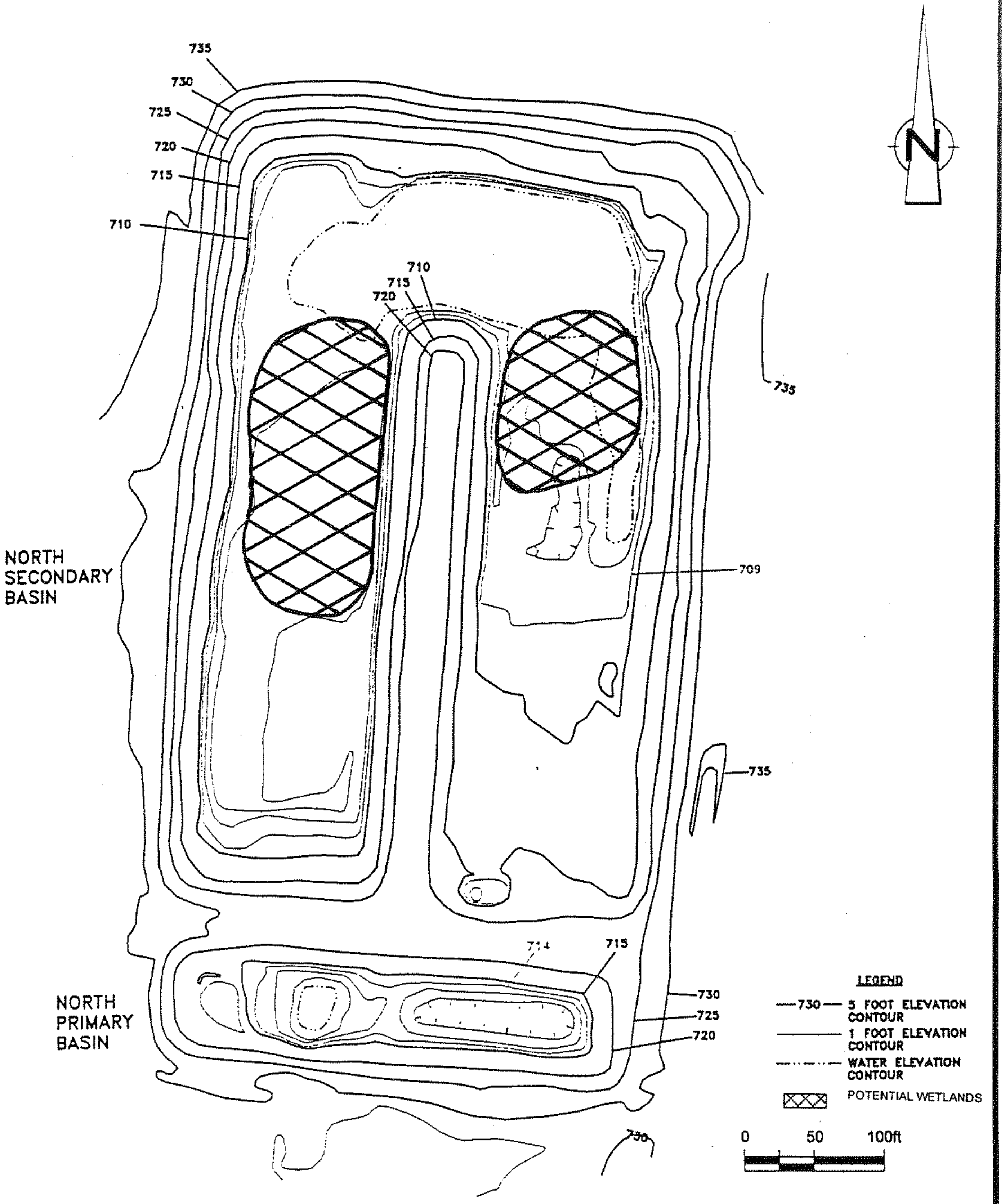
GENERAL MOTORS CORPORATION
Client

RCRA LAGOON CLOSURE
MORAINE, OHIO
Project Location

VICINITY MAP

1
Fig. No.

12611-00(SHEL001)GN-BR001 SEP 21/1999



SOURCE: ARCADIS GERAGHTY & MILLER DRAWING LC-02

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Drawn By	Checked By	Approved By	Date	File No.	Rev. No.

CRA SERVICES
G&E ENGINEERING DIVISION

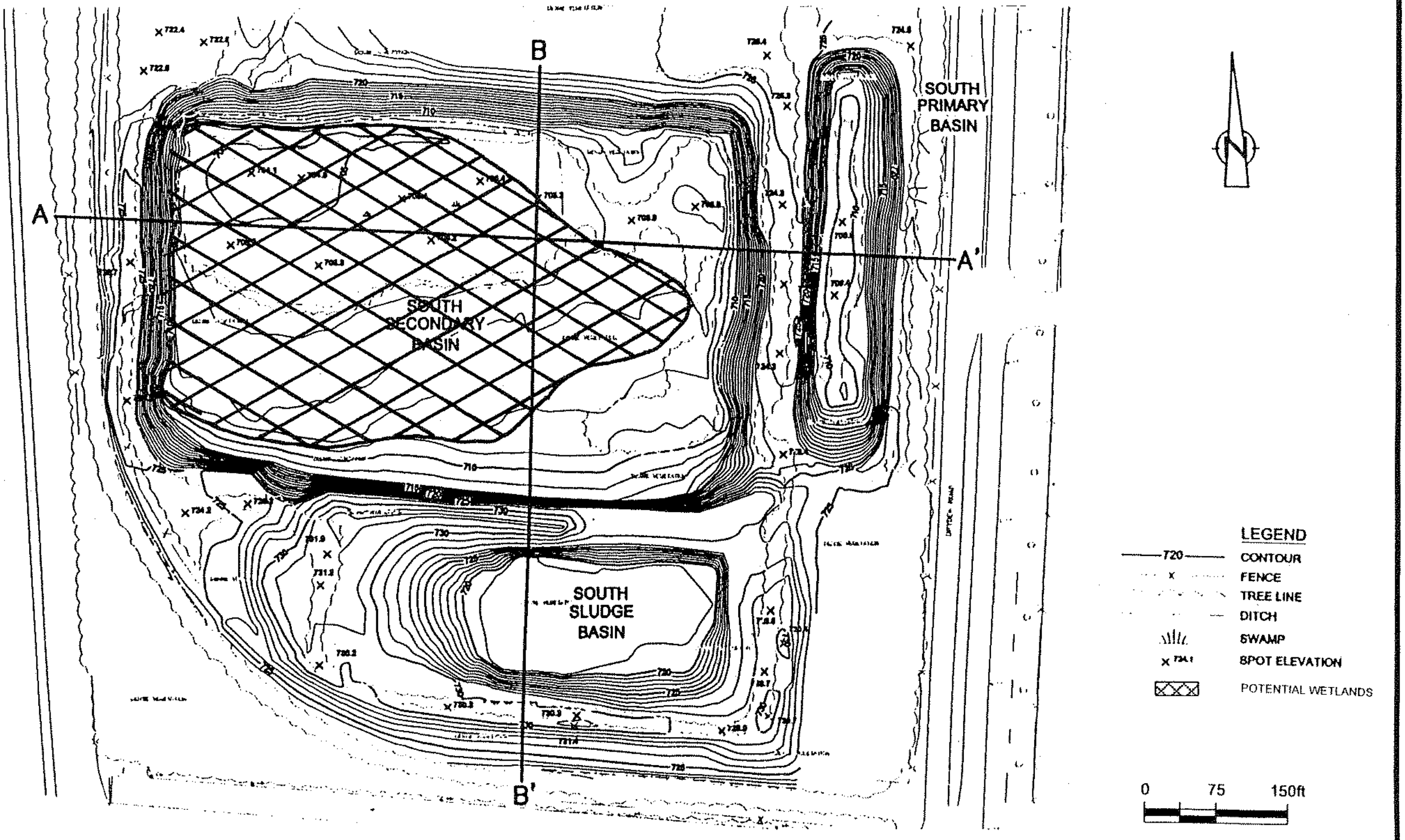
GENERAL MOTORS CORPORATION
Client

RCRA LAGOON CLOSURE
MORAINE, OHIO
Project Location

NORTH LAGOON PLAN VIEW

2
Fig. No.

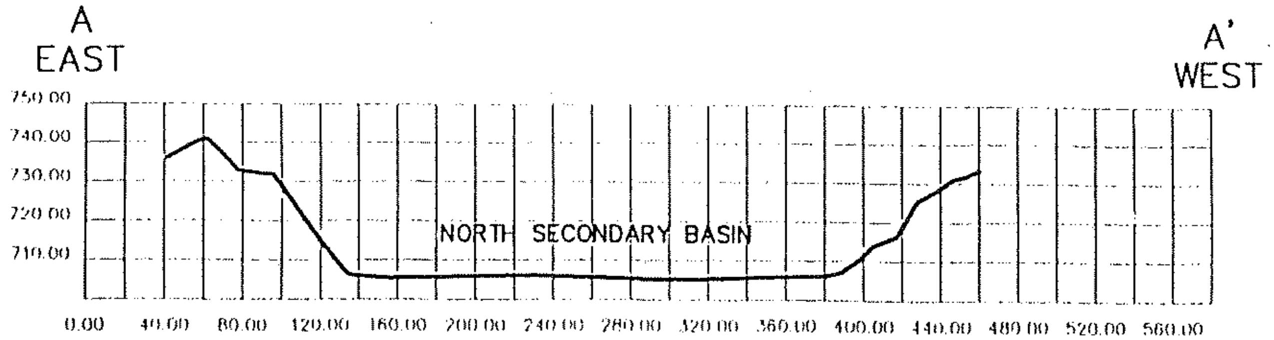
12611-00(SHEL001)GN-BR002 SEP 21/1999



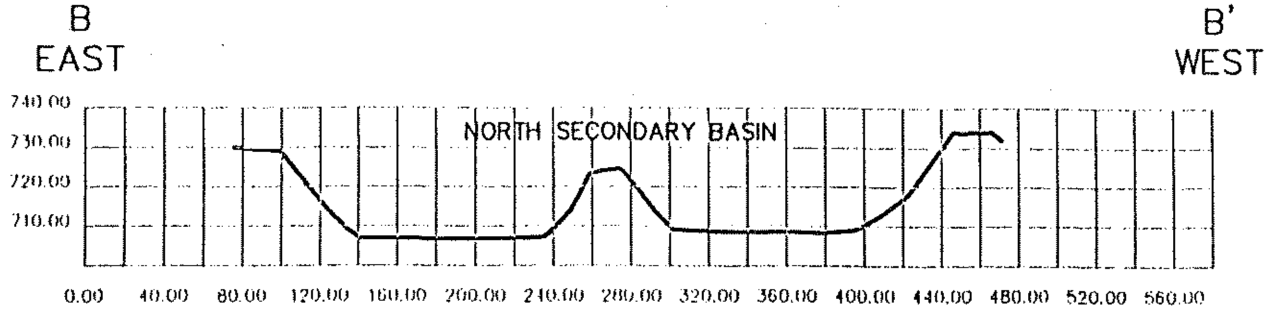
CRA SERVICES
G&E ENGINEERING DIVISION

RE: CRA DRAWING 12611-00(003)GN-WA007

9/20/99 Date	0 Rev. No.	003 File No.	GENERAL MOTORS CORPORATION Client	**RCRA LAGOON CLOSURE** MORAINE, OHIO Project Location	**SOUTH LAGOON PLAN VIEW**	**3** Figure
JSR Drawn by	Checked By	Approved By				



SECTION A–A'



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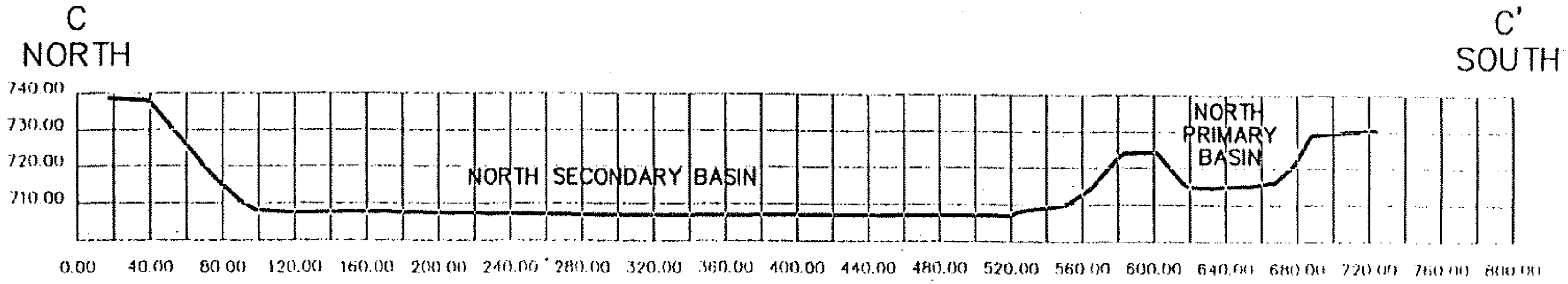


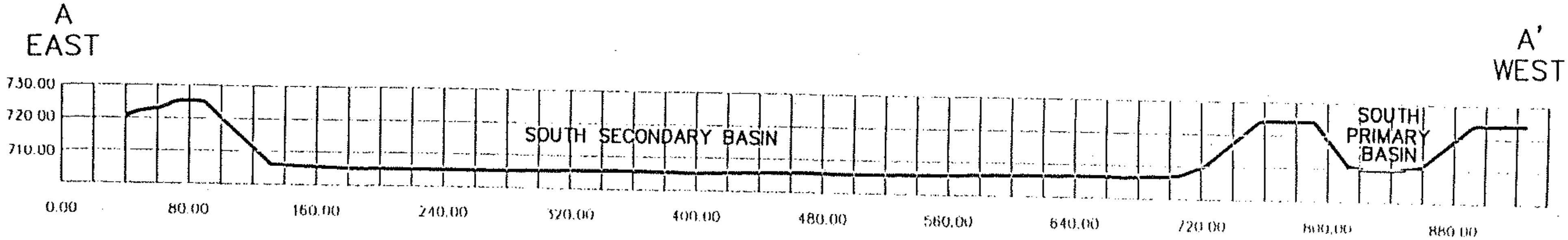
SECTION C–C'

SCALE: HOR 1"=100'
VERT 1"=50'

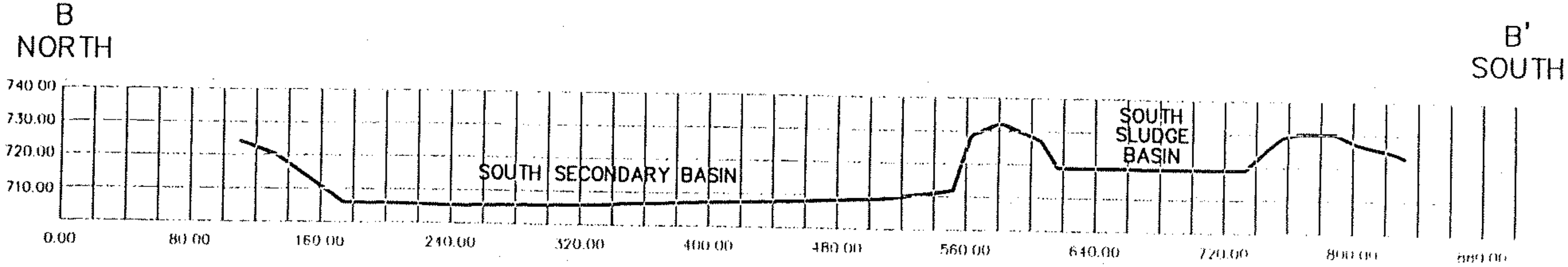
RE: CRA DRAWING 12611-00(003)GN-WA008

CRA SERVICES
G&E ENGINEERING DIVISION

9/20/99 Date	0 Rev. No.	004 File No.	GENERAL MOTORS CORPORATION Client	**RCRA LAGOON CLOSURE** MORAINE, OHIO Project Location	**NORTH LAGOON CROSS SECTIONS**	**4** Figure
JSR Drawn by	gma Checked By	Approved By				



SECTION A–A'



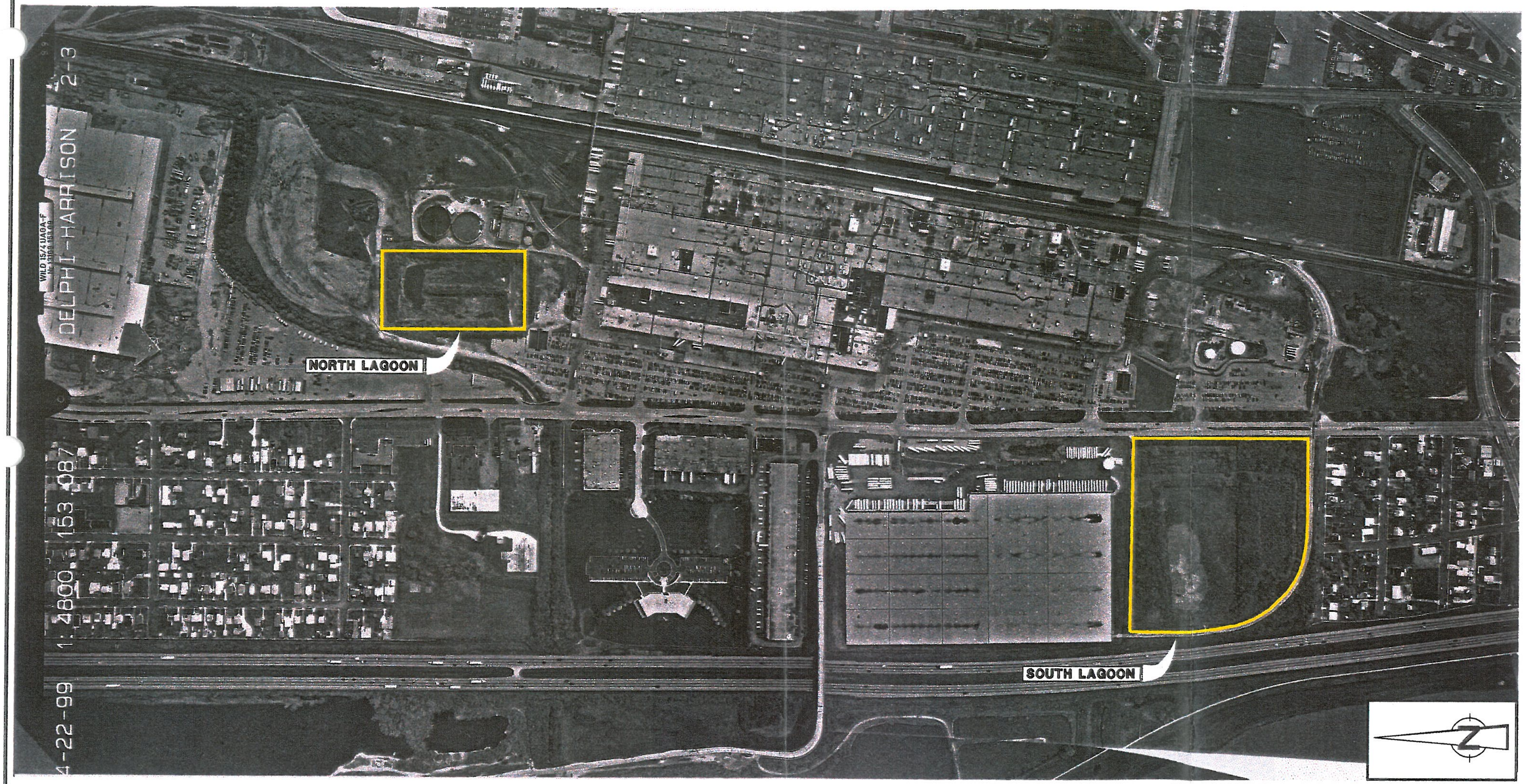
SECTION B–B'

SCALE: HOR 1"=100'
VERT 1"=50'

RE: CRA DRAWING 12611-00(003)GN-WA009

CRA SERVICES
G&E ENGINEERING DIVISION

9/20/99 Date	0 Rev. No.	005 File No.	GENERAL MOTORS CORPORATION Client	**RCRA LAGOON CLOSURE** MORAINE, OHIO Project Location	**SOUTH LAGOON CROSS SECTIONS**	**5** Figure
JSR Drawn by	Checked By	Approved By				



CRA SERVICES
G&E ENGINEERING DIVISION

DATE	NO.	REVISION	BY

DESIGNED BY:
DRAWN BY: P. KERR 11/08/99
CHECKED BY: 11/08/99
APPROVED BY: 11/08/99

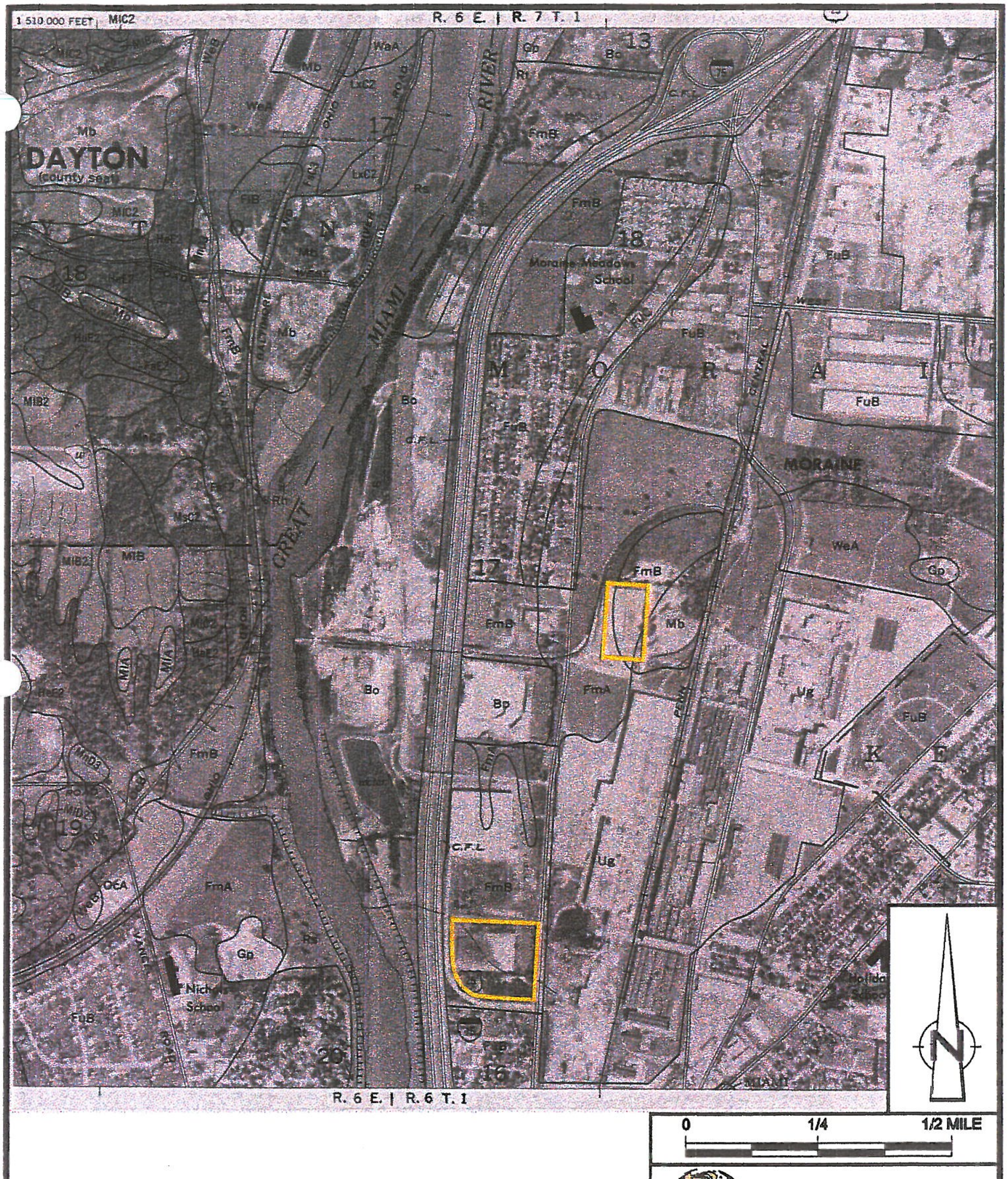
GENERAL MOTORS CORPORATION
Client

RCRA LAGOON CLOSURE
MORAINE, OHIO
Project Location

1999 AERIAL PHOTOGRAPH

SCALE
006 FILE No.
0 REV.
1 Exhibit

12611-00(SHEL001)GN-BR006 NOV 8/1999



RE: *SOIL SURVEY OF MONTGOMERY COUNTY, OHIO*; SHEET 55
USDA SOIL CONSERVATION SERVICE, 1970 PHOTOGRAPHY.

PWK	gma		11/08/99	007	0
Drawn By	Checked By	Approved By	Date	File No.	Rev. No.

CRA SERVICES
G&E ENGINEERING DIVISION

GENERAL MOTORS CORPORATION
Client

RCRA LAGOON CLOSURE
MORAINE, OHIO
Project Location

SOIL SURVEY MAP SHEET

2
Exhibit

12611-00(SHEL001)]GN-BR007 NOV 8/1999

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059
FAX: (502) 582-5072

January 10, 2000

Operations Division
Regulatory Branch (North)
ID No. 199901583-gdn

Ms. Pamela L. Lewis
Remediation and Liability
Management Company, Inc.
3600 Dryden Road
Plant Engineering
Dayton, Ohio 45439-1410

Dear Ms. Lewis:

This is in regard to your letter dated November 11, 1999, which you submitted on behalf of General Motors Corporation, requesting a jurisdictional determination for two wastewater lagoons. The two lagoons are located at the General Motors Corporation facility, in Moraine, Montgomery County, Ohio.

Based on the information provided by you, it does not appear that a Department of the Army permit will be needed under Section 404 of the Clean Water Act (CWA) although portions of both lagoons contain wetland vegetation and would meet the three parameter criteria for jurisdictional wetlands.

In accordance with our regulations, outlined in 33 CFR Section 328.3 (a), waste treatment systems including treatment ponds or lagoons are not "waters of the United States." If the project would necessitate the discharge of dredged or fill material into the lagoons to facilitate closure under the Resources Conservation and Recovery Act (RCRA), authorization pursuant to Section 404 of the CWA will not be required.

Our comments on this project are limited to only those activities that may fall within our permitting jurisdiction. Lack of comments on other environmental aspects should not be construed as either concurrence or non-concurrence with stated environmental effects.

A copy of this letter has been forwarded to the Ohio Environmental Protection Agency. You may wish to contact them regarding any concerns they may have about the closure of the two lagoons under RCRA.

If we can be of any further assistance, please contact us by writing to the above address, ATTN: CELRL-OP-FN, or call me at (502) 582-5241. Any correspondence on this matter should refer to our ID Number 199901583-gdn

Sincerely,

Gerry Newell

Gerry Newell
Project Manager
Regulatory Branch

APPENDIX E

HEALTH AND SAFETY PLAN

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

(Following Report)

LIST OF TABLES

LIST OF ATTACHMENTS

1.0 INTRODUCTION

The Health and Safety Plan (HASP) presented herein describes the health and safety procedures and emergency response guidelines to be implemented during the Lagoon Closure Program at the Harrison Facility (Site), located in Moraine, Ohio. Figures 1.1 and 2.1 of the Lagoon Closure Plan, respectively, represent the Site location and Site layout.

The scope of work to be completed during the performance of the Lagoon Closure Program activities includes the following work activities:

i) mobilization and demobilization of labor, materials, and equipment to and from the Site;

ii) surveying activities;

iii) Site setup activities including clearing of work areas and construction of a decontamination pads;

iv) solidification of the sludge;

v) backfilling of the lagoons;

vi) installation of an asphalt parking lot over the North Lagoon;

vii) Site restoration activities including placing clay and topsoil cover over the South Lagoon;

viii) decontamination activities; and

ix) demobilization.

During completion of the Lagoon Closure Program activities, personnel may come in contact with soils, sediments, groundwater, sludge, and waste materials which potentially contain hazardous substances. This HASP has been developed to ensure the following:

i) that Site personnel are not adversely exposed to the compounds of concern;

ii) compliance with applicable governmental and non-governmental (American Conference of Governmental Industrial Hygienists [ACGIH]) regulations and guidelines. In particular, the amended rules of the Occupational Safety and Health Administration (OSHA) for Subpart D of Part 1926 (Title 29 Code of Code of Federal Regulations [CFR] Part 1926.65) will be implemented for Site work where there is a potential to come in contact with hazardous substances; and

iii) initiation of proper emergency response procedures to minimize the potential for any adverse impact to Site workers, the general public, or the environment.

For the purpose of this HASP, only work activity items iv), v), vi), viii), and ix) are activities where compliance with 1926.65 will be required including the use of 40-hour hazardous waste trained Site personnel. The preparation of a written HASP will only be required of contractors who are conducting these work activities. All contractors, including those who are not required to provide a written HASP are required to comply with the applicable OSHA standards found in Parts 1910 and 1926.

The applicability of this HASP extends to all personnel who will be on the Site, including Conestoga-Rovers & Associates (CRA) and its employees, contractors, subcontractors, and visitors to the Site. Contractors who are contracted to conduct work identified in items iv), v), vi), viii), or ix) at the Site will be required to prepare a HASP for their portion of the project. The selected contractor's HASP must minimally meet the requirements of this HASP.

All Lagoon Closure Program activities at the Site will be conducted in accordance with applicable standards, the provisions of the selected contractor's approved Site-specific HASP (if required) and employer-specific Standard Operating Procedures (SOPs). A copy of any required HASPs will be maintained on Site whenever project activities are in progress.

1.1 PROJECT ORGANIZATION

There is a potential for several contractors to be working on Site including CRA. The selected contractor(s) will be responsible for providing both a Site Supervisor and a Health and Safety Officer (HSO) to direct their Lagoon Closure Program activities. The Site Supervisor, if qualified, may fulfill the duties of the HSO. These individuals will be responsible for ensuring that all contract specifications are met, including those related to Site health and safety. The names of these individuals will be presented in the HASPs of the contractors who will be required to prepare one.

2.0 SITE CHARACTERIZATION AND POTENTIALLY HAZARDOUS COMPOUNDS

Section 3.1.1 of the Lagoon Closure Plan presents a detailed description of the Site. A detailed sample collection and analysis of the lagoons has been completed. Table 2.1 identifies the chemical compounds of concern and their maximum detected levels in the lagoon sludge. Table 2.2 presents the time-weighted average (TWA) exposure levels for the chemical compounds of concern. These levels are set to protect the health of the workers who may be exposed to them.

3.0 BASIS FOR DESIGN

Regulations set forth by OSHA in Title 29, Code of Federal Regulations, Parts 1910 and 1926 (29 CFR 1910 and 1926) form the basis of this HASP. Emphasis is placed on Sections 1926.65 (Hazardous Waste Operations and Emergency Response), 1910 Subpart I (Personal Protective Equipment), 1910 Subpart Z (Toxic and Hazardous Substances), 1926 Subpart O (Motor Vehicles, Mechanized Equipment, and Marine Operations), and 1926 Subpart P (Excavations). Some of the specifications within this section are in addition to the OSHA regulations, and reflect the positions of the United States Environmental Protection Agency (USEPA), the National Institute of Occupational Safety and Health (NIOSH), and the United States Coast Guard (USCG) regarding safe operating procedures at hazardous waste sites.

The health and safety of the public and Site personnel and the protection of the environment will take precedence over cost and scheduling considerations for all project work.

4.0 RESPONSIBILITIES AND ADMINISTRATION

A Site Superintendent will be assigned to this project and shall be responsible, along with the HSO, for all decisions regarding operations and work stoppage due to health and safety considerations. The HSO will have prior experience in working at hazardous waste sites.

The on-Site HSO responsibilities include:

i) supervision and enforcement of safety equipment usage, including the required use of extra equipment if appropriate;

ii) supervision and inspection of equipment cleaning;

iii) supervision of decontamination activities;

iv) conduct the on-Site personnel safety indoctrination training session for potential hazards, personal hygiene principles, confined space entry procedures, all other SOPs, safety equipment usage, emergency procedures, and location of first aid kits and identification of personnel trained in first aid and cardiopulmonary resuscitation (CPR);

v) maintain Exclusion Zone (EZ) and Contaminant Reduction Zone (CRZ) work areas;

vi) review and modify the HASP as more information becomes available or conditions warrant;

vii) authority to suspend work activity due to unsafe working conditions;

viii) coordination of emergency procedures;

ix) be responsible for performing air monitoring and sampling;

x) ensure that all on-Site personnel have obtained the required medical examination prior to arrival at the Site, have met the OSHA training requirements, and have been fit tested for the respiratory equipment they may use;

xi) maintain the on-Site Hazard Communication Program including copies of Material Safety Data Sheets (MSDSs); and

xii) conduct brief daily safety meetings.

5.0 WORKER TRAINING AND EDUCATION

Prior to commencing Site activities, a Health and Safety/Site Indoctrination Session will be presented. Attendance is mandatory for all personnel who will be or are expected to be involved with project activities at the Site.

The training program will stress the importance that each attendee understands the basic principles of personnel protection and safety, be able to perform their assigned job tasks in a safe and environmentally responsible manner, and be prepared to respond in an appropriate manner to any emergency which may arise. A brief history of the Site will be included and the various components of the project HASP will be presented followed by an opportunity to ask questions to ensure that each attendee understands the HASP. Personnel not successfully completing this training program will not be permitted to enter or work in potentially contaminated areas of the Site. Personnel successfully completing this training program shall sign an acknowledgment form, a copy of which is presented in Attachment A.

This training will be given in addition to the basic training required under OSHA and is not intended to meet the requirements of 29 CFR 1926.65. Prior to working in or entering an EZ environment (as defined in Section 6.0), all personnel will be required to provide documentation to the HSO indicating successful completion of the training requirements of 29 CFR 1926.65. This includes a certificate for the initial 40 hours of training, a current 8-hour refresher certificate, and additional 8-hour certificates for managers or supervisors.

6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

This section of the HASP describes the requirements for PPE and the specific levels of protection required for each work task to be conducted at the Site during project activities. Basic PPE in all Site areas will consist of hard hats, safety glasses, and safety boots/shoes.

6.1 PROTECTION LEVELS

Personnel will wear protective equipment when project activities involve potential exposure to contaminants from vapors, gases, or particulates that may be generated on Site or when direct contact with potentially hazardous substances may occur. Chemical resistant clothing protects the skin from contact with skin-destructive and absorbable contaminants. Respirators protect lungs, the gastrointestinal tract, and if a full-face respirator is worn, the eyes, against airborne toxicants. Respiratory protection levels will be based on the real-time air monitoring results and the action levels that are presented in Section 6.5.

Protection levels are selected based upon the following:

i) measured concentrations of the known Site contaminants in worker breathing zones;

ii) potential for exposure to contaminants in air, splashes of liquids, or other contact due to the nature of work tasks; and

iii) Site contaminants toxicity, route of exposure, and contaminant matrices.

The specific protection levels to be employed at the Site for each work task are listed in Table 6.1. All project activities conducted at the Site will require the use of one of the following levels of PPE:

Level B:

i) supplied air respirator (NIOSH) approved. Respirators may be positive pressure-demand, self-contained breathing apparatus (SCBA), or positive pressure-demand airline respirator (with escape bottle for Immediate Danger to Life and Health [IDLH] or potential for IDLH atmosphere);

ii) polycoated tyvek® or saranex® coveralls;

iii) steel toe work boots and disposable boot covers or neoprene overboots;

iv) disposable nitrile inner gloves - chemical resistant;

v) outer nitrile work gloves - chemical resistant;

vi) hearing protection as necessary; and

vii) hard hat.

Level C:

i) tyvek® coveralls (polycoated tyvek® when handling or working with liquids [e.g., decontamination]);

ii) steel toe work boots and disposable boot covers or neoprene overboots;

iii) disposable nitrile inner gloves - chemical resistant;

iv) outer nitrile work gloves - chemical resistant;

v) half-face or full-face air purifying respirator (APR), equipped with combination cartridges for organic vapors and particulates (P-100);

vi) hearing protection as necessary; and

vii) hard hat.

Modified Level D:

i) tyvek® coveralls (polycoated tyvek® when handling or working with liquids);

ii) steel toe work boots;

iii) gloves as necessary;

iv) safety glasses;

v) splash shields as necessary;

vi) hearing protection as necessary; and

vii) hard hat.

Level D:

i) standard work uniform or coveralls;

ii) steel toe work boots;

iii) gloves as necessary;

iv) safety glasses;

v) splash shield as needed;

vi) hearing protection as necessary; and
vii) hard hat.

PPE will be maintained in a clean sanitary condition and ready for use. Disposable coveralls shall be discarded when torn and as personnel leave the contaminated work zone. Hard hats shall be thoroughly cleaned after leaving the contaminated work zone. Respirators shall be cleaned after each day's use and cartridges discarded. A sufficient quantity of potable water shall be supplied for washing, cleaning PPE, and drinking. A potable water supply for washing and cleaning PPE will be maintained adjacent to the decontamination area described in Section 9.0. Fresh potable water for drinking will be supplied on a daily basis and be maintained at a location removed from the active work area.

6.2 REASSESSMENT OF PROTECTION LEVELS

Protection levels provided by PPE selection shall be upgraded or downgraded based upon a change in Site conditions or the review of the results of monitoring.

When a significant change occurs, the hazards should be reassessed. Some indicators of the need for reassessment are as follows:

i) commencement of a new work phase;
ii) change in job tasks during a work phase;
iii) change of season/weather;
iv) when temperature extremes or individual medical considerations limit the effectiveness of PPE;
v) contaminants other than those expected to be encountered are identified;
vi) change in ambient levels of contaminants; and
vii) change in work scope which effects the degree of contact with potentially contaminated areas.

All proposed changes to protection levels and PPE requirements will be reviewed and approved prior to their implementation by the HSO and Site Superintendent.

6.3 DURATION OF WORK TASKS

The duration of project activities involving the usage of PPE will be established by the HSO based upon ambient temperature and weather conditions, the capacity of personnel to work in the designated level of PPE (heat stress and cold stress, see Section 12.3-Environmental Control), and limitations of the protective equipment (i.e., ensemble permeation rates, life expectancy of air-purifying respirator cartridges, etc.). As a minimum, rest breaks will be observed at the following intervals:

i) 15 minutes midway between shift startup and lunch;

ii) 1/2 to 1 hour for lunch; and

iii) 15 minutes in the afternoon, between lunch and shift end.

All rest breaks will be taken in a clean area (e.g., Support Zone) after full decontamination and PPE removal. Additional rest breaks will be observed, based upon the heat stress monitoring guidelines presented in Attachment B.

6.4 LIMITATIONS OF PROTECTIVE CLOTHING

PPE ensembles designated for use during the project activities have been selected to provide protection against contaminants at anticipated concentrations in the soil. However, no protective garment, glove, or boot is chemical-proof, nor will it afford protection against all chemical types. Permeation of a given chemical through PPE is a complex process governed by contaminant concentrations, environmental conditions, physical condition of the protection garment, and the resistance of a garment to a specific contaminant; chemical permeation may continue even after the source of contamination has been removed from the garment.

In order to obtain optimum usage from PPE, the following procedures are to be followed by all Site personnel using PPE:

i) when using disposable coveralls, don a clean, new garment after each rest break or at the beginning of each shift;

ii) inspect all clothing, gloves, and boots both prior to and during use for:
   a) imperfect seams,
   b) non-uniform coatings,
   c) tears, and

  - d) poorly functioning closures; and
- iii) inspect reusable garments, boots, and gloves both prior to and during use for:
  - a) visible signs of chemical permeation,
  - b) swelling,
  - c) discoloration,
  - d) stiffness,
  - e) brittleness,
  - f) cracks,
  - g) any sign of puncture, and
  - h) any sign of abrasion.

Reusable gloves, boots, or coveralls exhibiting any of the characteristics listed above will be discarded. PPE used in areas known or suspected to exhibit elevated concentrations of contaminants will not be reused.

Additional PPE usage guidelines are as follows:

- i) ankles/wrists will be secured tightly with the use of duct tape;
- ii) prescription eyewear used on Site shall be safety glasses equipped with side shields when full-face respirators are not required;
- iii) all EZ workers will have received training in the usage of full-face air purifying respirators and SCBAs which may be required in an emergency;
- iv) steel toe leather footwear shall be covered with neoprene overboots prior to entering the EZ and immediately upon entering the CRZ; and
- v) safety footwear and hard hats are to be worn by Site personnel at all times.

EZ personnel also carry certain responsibilities for their own health and safety, and are required to observe the following safe work practices:

- i) familiarize themselves with this HASP;
- ii) use the "buddy system" when working in a contaminated operation;
- iii) use the safety equipment in accordance with training received, labeling instructions, and common sense;
- iv) maintain safety equipment in good condition and proper working order;

v) refrain from activities that would create additional hazards (i.e., smoking, eating, etc. in restricted areas, leaning against dirty, contaminated surfaces);

vi) smoking and eating will be prohibited except in designated areas. These designated areas may change during the duration of the project to maintain adequate separation from the active work area(s). Designation of these areas will be the responsibility of the HSO; and

vii) soiled disposable outerwear shall be removed and placed into a covered, labeled container prior to washing hands and face, eating, using lavatory facilities, or leaving the Site.

6.5 RESPIRATORY PROTECTION PROGRAM

Prior to arriving at the Site, all on-Site personnel will have received training in the use of, and have been fit tested for either a half-face or a full-facepiece respirator. All on-Site personnel will be required to comply with their employer specific written respiratory protection program developed in accordance with OSHA 29 CFR 1910.134. All personnel working in the EZ shall wear an APR until such time it can be documented that airborne levels of lead, arsenic, and cadmium are below the regulatory action level of these compounds.

An initial sample(s) will be collected and analyzed for total suspended particulate following NIOSH Method 0500. The sample(s) will then be analyzed for lead, arsenic, and cadmium following NIOSH Method 7300. This sampling will be conducted to comply with the OSHA standards 1926.62, 1926.1118, and 1926.1127 for lead, arsenic, and cadmium, respectively. The continued use of APRs or their removal will depend on the detected levels of these substances. If the data reveals that levels are safe to discontinue the use of respiratory protection, personnel may continue to wear respirators if they so choose.

A photoionization detector (PID) equipped with a 10.6 eV lamp will be used to determine if organic vapors are present. A background reading will be established prior to commencing work activities at each active work area.

Action levels to determine the level of respiratory protection necessary for organic vapors during project activities are based on the concentration of the Site contaminants measured within the breathing zone. The action levels and appropriate respiratory protection for these Site activities are as follows:

Sustained Organic Vapor Reading Above Background within Worker Breathing Zone in Parts Per Million (ppm)	*Action Taken*
0 or Background - 25	Half-Face or Full-Face Respirator Available
25 - 250	Wear Half-Face or Full-Face Respirator
250 - 1,000	Must Wear Full-Face Respirator
>1,000	Wear Supplied Air Respirator, Implement Additional Engineering Controls

However, if the ambient concentrations of organic vapors are due to identifiable substances, the level of respiratory protection may be altered by the HSO.

The appropriate air purifying respirator cartridge to be used at the Site is a combination organic vapor/P-100 particulate cartridge. The cartridge used must be of the same manufacturer as the respiratory facepiece.

6.6 SITE CONTROL

Designated work areas will be set up as appropriate during project activities, as required. The purpose of these procedures is to limit access to potentially contaminated areas, and prevent the migration of potentially hazardous materials into adjacent non-contaminated areas. These areas are described in the following.

i) The Exclusion Zone (EZ) is the area immediately surrounding the active work area. Sufficient area will be provided for efficient movement of personnel and equipment as well as contaminant control. Boundaries are modifiable depending on operational requirements. The HSO will be responsible for maintaining the boundaries of this area. Personnel entering this area are required to wear the PPE as defined previously. At no time will personnel be allowed to walk on unsolidified sludge material in the lagoons. A wind direction indication device (i.e., flagging, windsock, etc.) will be mounted in the area of any EZ during Site activities.

   All personnel (including visitors) entering the EZ or CRZ using respiratory protection must have successfully passed a qualitative respirator fit test in accordance with OSHA 29 CFR 1910.134. Documentation of fit testing is the responsibility of each employer.

In the event that unauthorized personnel enter the EZ, work will stop. Work will not resume until the unauthorized personnel have been removed from the EZ or have been moved to an acceptable on-Site area. A log of all visitors to the Site, including those entering the EZ, will be maintained.

ii) The Contaminant Reduction Zone (CRZ) will provide a location for removal of contaminated PPE and final removal and decontamination of personnel and equipment. Supplemental safety equipment, such as fire extinguishers, portable eyewash, and extra quantities of PPE may be stored in this area. The order in which safety equipment is to be donned is as follows:

a) tyvek® suit;
b) neoprene overboot;
c) gloves;
d) respirator (if required); and
e) hard hat.

The following order applies when removing safety equipment:

a) wash off boots and outer gloves prior to removal;
b) tyvek® suit;
c) hard hat;
d) respirator; and
e) inner gloves.

iii) The Support Zone (SZ) is situated in clean areas where there is a minimal risk of encountering hazardous materials or conditions. PPE beyond standard construction safety equipment is therefore not required.

7.0 ACTIVITY HAZARD/RISK ANALYSIS

This section identifies the general hazards associated with specific project activities and presents the documented or potential health and safety hazards that exist at the Site. Every effort will be made to reduce or eliminate these hazards. Those which cannot be eliminated must be guarded against by use of engineering controls and/or PPE. Table 7.1 presents the anticipated hazards/risks and hazard controls.

In addition to the chemical hazards presented in Section 2.0 of this HASP, physical and biological hazards including uneven terrain, steep slopes, slippery surfaces, the use of heavy equipment, potential entanglement in drill rigs, potential injuries or death caused by being struck or run over by heavy equipment, the use of decontamination equipment, poisonous vegetation, bites and/or stings from ticks, bees, wasps, and potential heat and cold stress exist at the Site. It will be the responsibility of all Site personnel to identify the physical hazards posed by the various project activities and implement preventative and corrective action.

7.1 CHEMICAL EXPOSURE

Preventing exposure to toxic chemicals is a primary concern. Chemical substances can enter the unprotected body by inhalation, skin absorption, ingestion, or through a puncture wound (injection). A contaminant can cause damage at the point of contact or can act systematically, causing a toxic effect at a part of the body distant from the point of initial contact.

Chemical exposures are generally divided into two categories: acute and chronic. Symptoms resulting from acute exposures usually occur during or shortly after exposure to a sufficiently high concentration of a contaminant. The concentration required to produce such effects varies widely from chemical to chemical. The term "chronic exposure" generally refers to exposures to "low" concentrations of a contaminant over a long period of time. The "low" concentrations required to produce symptoms of chronic exposure depend upon the chemical, the duration of each exposure, and the number of exposures. For a given contaminant, the symptoms of an acute exposure may be completely different from those resulting from chronic exposure.

For either chronic or acute exposure, the toxic effect may be temporary and reversible, or may be permanent (disability or death). Some chemicals may cause obvious symptoms such as burning, coughing, nausea, tearing eyes, or rashes. Other chemicals may cause health damage without any such warning signs (this is a particular concern for chronic exposures to low concentrations). Health effects such as cancer or respiratory disease may not become manifest for several years or decades after exposure. In addition, some toxic chemicals may be colorless and/or odorless, may dull the sense of smell, or may not produce any immediate or obvious physiological sensations. Thus, a worker's senses or feelings cannot be relied upon in all cases to warn of potential toxic exposure.

The effects of exposure not only depend on the chemical, its concentration, route of entry, and duration of exposure, but may also be influenced by personal factors such as the individual's smoking habits, alcohol consumption, medication use, nutrition, age, and sex.

An important exposure route of concern at the Site is inhalation. The lungs are extremely vulnerable to chemical agents. Even substances that do not directly affect the lungs may pass through lung tissue into the bloodstream, where they are transported to other vulnerable areas of the body. Some toxic chemicals present in the atmosphere may not be detected by human senses (i.e., they may be colorless, odorless, and their toxic effects may not produce any immediate symptoms). Respiratory protection is therefore extremely important if there is a possibility that the work site atmosphere may contain such hazardous substances. Chemicals also can enter the respiratory tract through punctured eardrums. Where this is a hazard, individuals with punctured eardrums should be medically evaluated specifically to determine if such a condition would place them at an unacceptable risk and preclude their working at the task in question.

Direct contact of the skin and eyes by hazardous substances is another important route of exposure. Some chemicals directly injure the skin. Some pass through the skin into the bloodstream where they are transported to vulnerable organs. Skin absorption is enhanced by abrasions, cuts, heat, and moisture. The eye is particularly vulnerable because airborne chemicals can dissolve in its moist surface and be carried to the rest of the body through the bloodstream (capillaries are very close to the surface of the eye). Wearing protective equipment, not using contact lenses in contaminated atmospheres (since they may trap chemicals against the eye surface), keeping hands away from the face, and minimizing contact with liquid and solid chemicals can help protect against skin and eye contact.

Although ingestion should be the least significant route of exposure at the Site, it is important to be aware of how this type of exposure can occur. Deliberate ingestion of chemicals is unlikely, however, personal habits such as chewing gum or tobacco, drinking, eating, smoking cigarettes, and applying cosmetics at the Site may provide a route of entry for chemicals.

The last primary route of chemical exposure is injection, whereby chemicals are introduced into the body through puncture wounds (i.e., by stepping or tripping and falling onto contaminated sharp objects). Wearing safety shoes, avoiding physical hazards, and taking common sense precautions are important protective measures against injection.

8.0 AIR MONITORING

During the progress of RA activities, monitoring of particulate levels and organic vapors will be taken by the HSO.

The following air monitoring instrumentation will be used for this purpose:

i) a PID equipped with an 10.6 eV lamp; and
ii) a realtime digital particulate monitor (Mini Ram PDM 3 or equivalent).

All monitoring equipment will be calibrated on a daily basis in accordance with the manufacturer's guidelines, and such calibrations will be recorded in the Site daily log book. Results of all daily air monitoring also will be recorded in the Site daily log book.

Air monitoring will be conducted hourly in the breathing zone of workers in the EZ or as deemed necessary by the HSO based on Site-specific conditions. Background measurements immediately upwind of the EZ will be taken before activities commence. Respiratory action levels for organic vapors are discussed in Section 6.5.

Immediately upon identifying sustained elevated levels of organic vapors (greater than 1,000 parts per million [ppm]) within the Work Zone, the air monitoring results will be reported to the HSO and work activities will be shut down. The HSO will determine the cause of the sustained elevated levels of organic vapors and alternate work methods or engineering controls will be implemented to rectify the release of elevated concentrations of organic vapors, or upgrade levels of PPE as required.

The contractor will implement a personnel air monitoring program for workers having the highest potential for exposure to total suspended particulates, lead, arsenic, and cadmium present on Site. Samples will be collected during the startup of activities where personnel would face potential exposure to verify the adequacy of personal protection and to document the actual exposure level to these selected chemicals of concern. Additional samples may be collected and analyzed for other chemical compounds of concern as determined by the Project Management Team. Appropriate NIOSH procedures and methods will be followed and all samples are to be sent to an American Industrial Hygiene Association (AIHA) accredited laboratory. Results of the air sampling program will be posted for personnel to review.

8.1 COMMUNITY AIR MONITORING

Air monitoring will be performed during performance of the project activities to ensure that the community will not be adversely impacted during Site activities. The community air monitoring plan is described below.

8.1.1 COMMUNITY AIR MONITORING PLAN

This Community Air Monitoring Plan will be implemented during all ground intrusive activities at the Site. Realtime air monitoring for VOCs and respirable dust levels will be performed at the perimeter of the EZ. Monitoring will be conducted during ground invasive activities and any other activity which may potentially create an airborne hazard.

Community air monitoring will be conducted in accordance with the following:

i) VOCs will be monitored continuously at the downwind perimeter of the EZ. Readings will be recorded at 15-minute intervals or sooner if an action level has been exceeded. If sustained (15 minutes) total organic vapor levels exceed 5 ppm above background, work activities will be halted and monitoring continued under the provisions of the Vapor Emission Response Plan (see Section 8.1.2). All monitoring readings will be recorded and available for review; and

ii) a fugitive dust suppression and particulate monitoring program will be conducted in accordance with the procedures presented in Section 8.1.5.

8.1.2 STEP 1 VAPOR EMISSION MONITORING

If the ambient air concentrations of organic vapors exceeds 5 ppm above background at the downwind perimeter of the EZ then a check of the downwind Site perimeter will be made to verify that the level is less than 5 ppm. Activities will be halted and monitoring at the downwind perimeter of the Site will be continued if levels at the downwind perimeter are greater than 5 ppm. If the organic vapor level decreases below 5 ppm above background at the downwind perimeter of the Site, work activities can resume.

If the organic vapor level is above 25 ppm at the downwind perimeter of the EZ, air monitoring at 200 feet downwind of the Site perimeter or half the distance to the nearest residential or commercial structure, whichever is less, will be performed to ensure that vapor emission does not impact the nearest residential or commercial structure at levels exceeding those specified in the Step 2 Vapor Emission Monitoring section (Section 8.1.3).

8.1.3 STEP 2 VAPOR EMISSION MONITORING

If any organic vapor levels greater than 5 ppm over background are identified 200 feet downwind from the work area or half the distance to the nearest residential or commercial property, whichever is less, then the air quality will be monitored within 20 feet of the perimeter of the nearest residential or commercial structure (20 Foot Zone).

If effort to abate the emission source are unsuccessful and if any of the organic vapor levels persist at 5 ppm above background or greater for more than 30 minutes in the 20 Foot Zone, then the Vapor Emission Response Plan (see Section 8.1.4) will automatically be placed into effect.

However, the Vapor Emission Response Plan will be immediately placed into effect if organic vapor levels are greater than 10 ppm above background at the 20 Foot Zone for any one time.

8.1.4 VAPOR EMISSION RESPONSE PLAN

Upon activation, the following activities will be undertaken:

i) all emergency response contacts, as listed in Section 13.1 of this HASP, will be notified so that evacuation procedures may begin and/or the Emergency Response Plan, will go into effect; and

ii) frequent air monitoring will be conducted at 30 minute intervals within the 20 Foot Zone. If two successive readings below action levels are measured, air monitoring may be halted or modified by the HSO.

8.1.5 FUGITIVE DUST SUPPRESSION AND PARTICULATE MONITORING PROGRAM

The following fugitive dust suppression and particulate monitoring program will be employed at the Site during ground invasive activities or during other activities which may potentially create an airborne hazard:

i) reasonable fugitive dust suppression techniques will be employed during all Site activities which may generate fugitive dust;

ii) particulate monitoring will be employed during ground invasive activities or activities which may generate fugitive dust;

iii) particulate monitoring will be performed using a realtime particulate monitor that is capable of monitoring particulate matter less than 10 microns in size. Particulate levels will be monitored at the downwind side of the EZ. Readings will be based on the 15-minute average concentrations;

iv) the particulate monitoring will be performed by a trained technician who fully understands the operation of the monitoring equipment and necessary calibration procedure. The technician will be responsible for keeping the air monitoring log book which will contain records of equipment calibration and all air monitoring readings;

v) the action level will be set at 150 micrograms per cubic meter ($\mu g/m^3$) based on a 15-minute average. If particulate levels are detected in excess of 150 $\mu g/m^3$ the upwind background level will be measured immediately using the same portable monitor. If the working site particulate measurement is greater than 100 $\mu g/m^3$ above the background level, additional dust suppression techniques will be implemented to reduce the generation of fugitive dust and corrective actions will be taken to protect Site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection and implementing additional dust suppression techniques. These may include:

   a) applying water on haul roads,

   b) wetting equipment and excavation faces,

   c) spraying water on buckets during excavation and dumping,

   d) hauling materials in tarped containers,

   e) restricting vehicle speed,

   f) immediately covering excavation areas or materials upon completion, and

   g) reducing the size and/or number of excavations;

vi) if dust is observed leaving the working site, additional dust suppression techniques will be employed; and

vii) if the dust suppression techniques being utilized at the Site do not lower particulates to an acceptable level (below 150 $\mu g/m^3$) work will be suspended until appropriate corrective measures are approved to remedy the situation.

9.0 DECONTAMINATION PROCEDURES

In general, everything that enters the EZ at the Site must either be decontaminated or properly discarded upon exit from the EZ. All personnel, including any Federal, State, and local officials, must enter and exit the EZ through the decontamination area. Prior to demobilization, potentially contaminated equipment will be decontaminated and inspected by the Site Superintendent before it is moved into the clean zone. Any material that is generated by decontamination procedures will be stored in a designated area in the EZ until disposal arrangements are made.

The type of decontamination solution to be used is dependent on the type of chemical hazards. The decontamination solution for heavy equipment and for any reusable PPE is Liquinox soap. The MSDSs for Liquinox and for all other Site chemical products will be maintained by the HSO in a separate binder kept on Site.

9.1 EQUIPMENT DECONTAMINATION PROCEDURES

All equipment must be decontaminated within the CRZ or on the decontamination pad by a pressure water cleaner upon exit from the EZ. Decontamination procedures should include: knocking soil/mud from machines; water rinsing using a solution of water and Liquinox; and a final water rinse. Personnel shall wear as a minimum modified Level D protection when decontaminating equipment . Runoff will be collected and stored until proper disposal arrangements have been made. Following decontamination and prior to exit from the EZ, the Site Superintendent shall be responsible for ensuring that the item has been sufficiently decontaminated. This inspection shall be included in the Site log.

9.2 PERSONNEL DECONTAMINATION PROCEDURES

The following describes the procedures to be followed by all personnel when leaving the EZ.

Station 1: Equipment Drop

Deposit equipment used on Site (tools, sampling devices, monitoring instruments, radios, etc.) on plastic drop cloths. These items must be decontaminated or discarded as waste prior to removal from the EZ.

Station 2: Outer Boot, Glove, and Garment Wash and Rinse

Scrub outer boots, outer gloves, and/or splash suit with decontamination solution or detergent wash. Rinse off using water.

Station 3: Outer Boot and Glove Removal

Remove outer boots and gloves. If outer boots are disposable, deposit in a covered container. If non-disposable, store in a clean dry place.

Station 4: Outer Garment Removal

Remove outer garments and deposit in a covered container. Decontaminate or dispose of splash suits as necessary.

Station 5: Respiratory Protection Removal

Remove hard hat and facepiece, and deposit on a clean surface. Air purifying respirator cartridges will be discarded at the end of each day or upon breakthrough, whichever occurs first. Wash and rinse respirator at least daily. Wipe off and store respiratory gear in a clean, dry location.

Station 6: Inner Glove Removal

Remove inner gloves. Deposit in a covered container for disposal.

Station 7: Field Wash

Thoroughly wash hands and face with soap and water.

10.0 GENERAL SAFETY AND PERSONAL HYGIENE

1. Eating at the Site is prohibited except in specifically designated areas. Designation of eating areas will be the responsibility of the HSO. The location of these areas may change during the duration of the project to maintain adequate separation from the active work area(s).
2. Smoking at the Site is prohibited except in specifically designated areas.
3. Individuals getting wet to the skin with effluent from the washing operation must wash the affected area immediately. If clothes in contact with skin are wet, then these must be changed.
4. Hands must be washed with soap and water before eating, drinking, smoking, and before using toilets.
5. All disposable coveralls and soiled gloves will be placed in covered containers at the end of every shift or sooner, if deemed necessary by the HSO. Wastes will be stored until such time that it is properly disposed of during completion of project activities.
6. Individuals wearing respiratory protection shall be clean shaven each morning as they report for work. Facial hair shall not interfere with the sealing surface of the respirator.

11.0 MEDICAL SURVEILLANCE

In accordance with the requirements detailed in 29 CFR 1910.120 and 29 CFR 1910.134, all Site personnel who will come in contact with potentially contaminated materials will have received, within one year prior to starting field activities, medical surveillance by a licensed physician or physician's group.

Medical records for all on-Site personnel will be maintained by their respective employers. The medical records will detail the tests that were taken and will include a copy of the consulting physician's statement regarding the tests and the employee's suitability for work.

The medical records will be available to the employee or his/her designated representative upon written request, as outlined in 29 CFR 1910.1020.

Each employer will provide certifications to the HSO that its personnel involved in Site activities will have all necessary medical examinations prior to commencing work which requires respiratory protection or potential exposure to hazardous materials. Personnel not obtaining medical certification will not perform work within contaminated areas.

Interim medical surveillance will be completed if an individual exhibits poor health or high stress responses due to any Site activity or when accidental exposure to elevated concentrations of contaminants occur.

12.0 ENVIRONMENTAL CONTROL PROGRAM

This section of the HASP outlines measures to be implemented at the Site to prevent hazards associated with environmental conditions.

12.1 WEATHER MONITORING

The HSO or Site Superintendent will be responsible for checking weather forecasts for the next day and week of work to provide advance notification of any severe weather conditions. Severe weather conditions (e.g., heavy rains) may cause unsafe conditions at the Site and in some situations work may have to be stopped.

12.2 RAIN AND SNOW

Excessive amounts of precipitation may cause potential safety hazards for all work tasks. The hazards would be most commonly associated with slipping, tripping, or falling due to slippery surfaces and further hazards are detailed by work task (Table 7.1).

Severe weather conditions will result in work stoppage and the implementation of further emergency measures, as described in Attachment C of this HASP.

12.3 TEMPERATURE

The project activities are expected to be conducted year round. Low and high temperatures may be experienced which require measures to be implemented to prevent health and safety hazards from occurring. Potential hazards arising from temperature extremes are heat stress and cold exposure.

The potential hazard due to worker heat stress is particularly important if high protection levels of PPE are in use (e.g., respirators). A detailed monitoring program and prevention measures to implement to reduce heat stress are detailed in Attachment B. It is the responsibility of the HSO to determine which measures are appropriate to implement to prevent heat stress; these will depend largely on daily Site conditions.

Exposure to cold is similar to heat stress in that the HSO must determine the appropriate preventative measures to implement. Some of the measures which may be implemented include: more frequent breaks, additional clothing, and partial enclosure of work areas. Detailed cold exposure prevention measures are also included in Attachment B.

12.4 WIND

High winds may be encountered at the Site and these can cause hazards that may affect Site personnel health and safety. Preventative measures that will be implemented if necessary are as follows:

i) restricted Site activity;
ii) battening down light equipment or building materials;
iii) partially enclosing work areas; and
iv) reduction or stoppage of work activities.

13.0 EMERGENCY RESPONSE

It is essential that Site personnel be prepared in the event of an emergency. Emergencies can take many forms; illnesses or injuries, chemical exposure, fires, explosions, spills, leaks, releases of harmful contaminants, or sudden changes in the weather. The following sections outline the general procedures for emergencies. Emergency information should be posted as appropriate.

13.1 EMERGENCY CONTACTS

Ambulance:	911
Fire Department:	911
Police Department:	911
Hospital:	

Directions to Hospital: (See Figure 13.1).

13.2 ADDITIONAL EMERGENCY NUMBERS

National Response Center (NRC):	800-424-8802
State of Ohio Emergency Response Commission:	614-644-2260
Poison Control Center:	800-282-3171
CRA Project Manager (Henry Cooke):	513-326-7600
CRA Project Industrial Hygienist (Craig Gebhardt):	716-297-6150
Ohio Utilities Protection Service:	800-362-2764

Communication between work areas and the command post, located within the SZ, will be via verbal communication, auto horn, or walkie-talkie. The HSO will use the nearest telephone on Site to communicate with outside emergency and medical facilities.

The following signals shall be established for use with auto or compressed air-type horns:

i) 1 Long Blast (2 Second Duration): evacuate exclusion area, meet at CRZ or designated area;

ii) 1 Long Blast (2 Short Blasts): prepare for removal of injured personnel, evacuate work area; and

iii) 3 Short Blasts: all clear.

The following hand signals will be used by downrange field teams in conjunction with the "buddy" system. These signals are very important when working with heavy equipment. They shall be known by the entire field team before operations commence.

Signal	*Meaning*
• Hand Gripping Throat	Out of Air; Can't Breathe
• Grip Partner's Wrist	Leave Area Immediately
• Hands on Top of Head	Need Assistance
• Thumbs Up	Ok, I'm All Right, I Understand
• Thumbs Down	No, Negative

13.3 EMERGENCY AND FIRST AID EQUIPMENT

Emergency safety equipment will be available for use by Site personnel and will be located and maintained on Site. The safety equipment will include, but is not limited to, the following:

i) portable emergency eyewash;

ii) two 20-pound ABC type dry chemical fire extinguishers and one on each piece of heavy equipment;

iii) approved first aid kit for a minimum of ten personnel;

iv) one SCBA unit;

v) portable air horn; and

vi) adequate supply of spill response equipment and material.

13.4 PROJECT PERSONNEL RESPONSIBILITIES DURING EMERGENCIES

HEALTH AND SAFETY OFFICER (HSO)

The HSO has overall responsibility for the project health and safety. He must ensure that adequate staff and resources are available to conduct an effective emergency response program. As the administrator of the project, the HSO has primary responsibility for responding to and correcting emergency situations. The HSO will:

i) take appropriate measures to protect personnel including: determining and communicating evacuation routes and places of safe refuge, withdrawal from the EZ, total evacuation and securing of the Site, or upgrading or downgrading the level of protective clothing and respiratory protection;

ii) take appropriate measures to protect the public and the environment including isolating and securing the Site, preventing runoff to surface waters, and ending or controlling the emergency to the extent possible;

iii) ensure that appropriate Federal, State, local agencies, and Project Management Team are informed, and emergency response plans are coordinated. In the event of fire or explosion, the local fire department should be summoned immediately. In the event of an air release of toxic materials, the local authorities should be informed in order to assess the need for evacuation. In the event of a spill, sanitary districts and drinking water systems may need to be alerted;

iv) ensure that appropriate decontamination, treatment, or testing for exposed or injured personnel is obtained;

v) determine the cause of the incident and make recommendations to prevent the recurrence;

vi) ensure that all required reports have been prepared; and

vii) conduct routine emergency response drills.

13.5 MEDICAL EMERGENCIES

Any person who becomes ill or injured in the EZ must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport. If the patient's condition is serious, at least partial decontamination should be completed as much as possible without causing further harm to the patient. First aid should be administered while awaiting an ambulance or paramedics. All injuries and illnesses must immediately be reported to the HSO and Site Superintendent.

Any person transporting an injured/exposed person to a clinic or hospital for treatment should take with them directions to the hospital and a copy of the identified chemicals on Site to which they may have been exposed.

Any vehicle used to transport contaminated personnel will be cleaned or decontaminated as necessary.

13.6 FIRE OR EXPLOSION

The local fire department will be contacted and given an opportunity to attend preconstruction conference, tour the Site, and discuss necessary response actions with the Site Superintendent and HSO in case of an emergency.

In the event of a fire or explosion, the local fire department should be summoned immediately. Upon their arrival, the HSO or designated alternate will advise the fire commander of the location, nature, and identification of the hazardous materials on Site.

If it is safe to do so, Site personnel may :

i) if hazardous, report to the Agency On-Scene Coordinator and/or Project Manager;
ii) use fire fighting equipment available on Site; or
iii) remove or isolate flammable or other hazardous materials which may contribute to the fire.

13.7 SPILLS OR CONTAINER LEAKS

In the event of a spill or leak, Site personnel will:

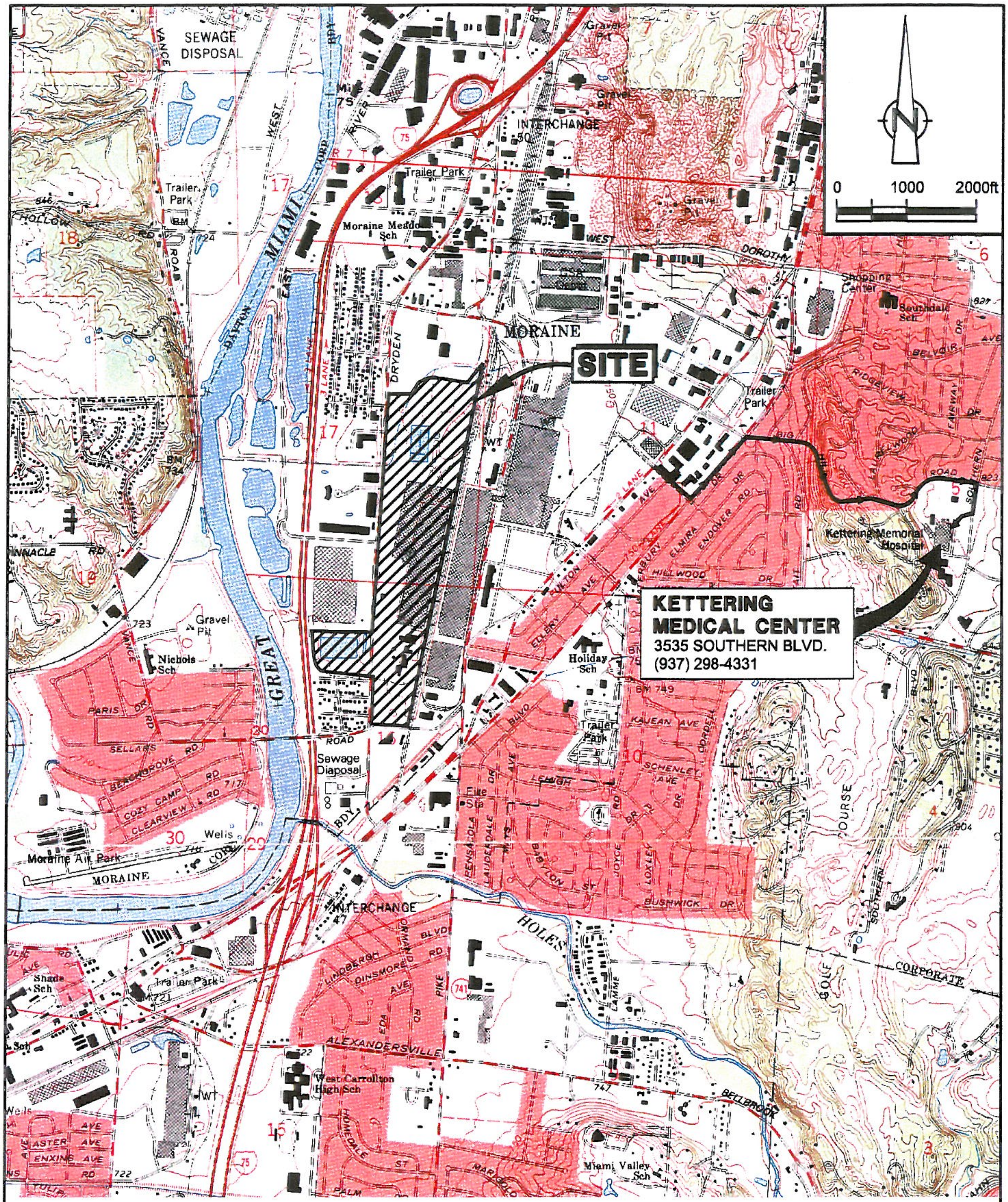
i) report spills and releases to the Agency On-Scene Coordinator, Project Managers, the NRC, and State Emergency Response Commission (SERC);
ii) locate the source of the spillage and stop the flow if it can be done safely; and
iii) begin containment and recovery of the spilled materials.

14.0 RECORDKEEPING

The HSO shall establish and maintain records of all necessary and prudent monitoring activities as described below:

i) name and job classification of the employees involved on specific tasks;
ii) records of qualitative fit testing and physical examination results for Site personnel;
iii) records of all OSHA training certification for Site personnel;
iv) records of training acknowledgment forms;
v) emergency report sheets describing any incidents or accidents;
vi) security logs;
vii) safety logs/safety meeting minutes; and
viii) record documentation monitoring.

FIGURES



SOURCE: USGS QUADRANGLE MAP
DAYTON SOUTH, OHIO

CRA

figure 13.1

HOSPITAL ROUTE
HARRISON FACILITY
Moraine, Ohio

TABLES

TABLE 2.1

CHEMICAL COMPOUNDS OF CONCERN AND THEIR MAXIMUM DETECTED LEVELS IN THE LAGOON SLUDGE
LAGOON CLOSURE PROGRAM
GENERAL MOTORS HARRISON RADIATOR
MORAINE, OHIO

Chemical Compounds of Concern	*Maximum Detected Level in Lagoon Sludge (mg/kg)*
Metals	
Antimony	54.8
Arsenic	158
Barium	6,740
Cadmium	1,430
Chromium	3,630
Cobalt	1,210
Copper	16,900
Lead	5,970
Mercury	4.03
Nickel	3,250
Selenium	76.6
Silver	2.45
Tin	741
Vanadium	30.7
Zinc	10,501
Volatile Organics	
1,2-Dichlorobenzene	1.52
Ethylbenzene	3.4
Tetrachloroethene	4.7
Toluene	10.1
Trichloroethylene	6.66
Xylene	9.25
Semi-Volatile Organics	
bis(2-Ethylhexyl)phthalate	31.2
Fluoranthene	104
Fluorene	18.5
2-Methylnaphthalene	9.54
Phenanthrene	41.7
Pyrene	81.5
di-n-Butylphthalate	1.99
Miscellaneous	
Cyanide	18.9
Polychlorinated biphenyls	206

Note:
mg/kg Milligrams Per Kilogram.

TABLE 2.2

EXPOSURE ROUTES AND EXPOSURE LEVELS FOR THE CHEMICAL COMPOUNDS OF CONCERN LAGOON CLOSURE PROGRAM GENERAL MOTORS HARRISON RADIATOR MORAINE, OHIO

Chemical Compound	*Ionization Potential*	*Exposure Routes*	*Acceptable Exposure Levels in Air*
Antimony	NA	Inhalation, Ingestion	0.5 mg/m^{3} (1) 0.5 mg/m^{3} (2) 50 mg/m^{3} (3)
Arsenic	NA	Inhalation, Ingestion Human Carcinogen	0.01 mg/m^{3} (1) 0.01 mg/m^{3} (2) 10 mg/m^{3} (3)
Barium	NA	Inhalation, Ingestion	NE
Cadmium	NA	Inhalation, Ingestion Suspected Human Carcinogen	0.1 mg/m^{3} (1) 0.005 mg/m^{3} (2) 9 mg/m^{3} (3)
Chromium	NA	Inhalation, Ingestion	0.5 mg/m^{3} (1) 0.5 mg/m^{3} (2) 250 mg/m^{3} (3)
Cobalt	NA	Inhalation, Ingestion Animal Carcinogen	0.02 mg/m^{3} (1) 0.1 mg/m^{3} (2) 20 mg/m^{3} (3)
Copper	NA	Inhalation, Ingestion	1 mg/m^{3} (1) 1 mg/m^{3} (2) 100 mg/m^{3} (3)
Lead	NA	Inhalation, Ingestion Animal Carcinogen	0.05 mg/m^{3} (1) 0.05 mg/m^{3} (2) 100 mg/m^{3} (3)
Mercury	NA	Inhalation, Ingestion Skin Absorption	0.025 mg/m^{3} (1) 10 mg/m^{3} (3)
Nickel	NA	Inhalation, Ingestion	1 mg/m^{3} (1) 1 mg/m^{3} (2) 10 mg/m^{3} (3)
Selenium	NA	Inhalation, Ingestion	0.2 mg/m^{3} (1) 0.2 mg/m^{3} (2) 1 mg/m^{3} (3)

TABLE 2.2

EXPOSURE ROUTES AND EXPOSURE LEVELS FOR THE CHEMICAL COMPOUNDS OF CONCERN LAGOON CLOSURE PROGRAM GENERAL MOTORS HARRISON RADIATOR MORAINE, OHIO

Chemical Compound	*Ionization Potential*	*Exposure Routes*	*Acceptable Exposure Levels in Air*
Silver	NA	Inhalation, Ingestion	0.1 mg/m^3 (1) 0.01 mg/m^3 (2) 10 mg/m^3 (3)
Tin	NA	Inhalation, Ingestion	2 mg/m^3 (1) 2 mg/m^3 (2) 100 mg/m^3 (3)
Vanadium	NA	Inhalation, Ingestion	NE
Zinc	NA	Inhalation, Ingestion	NE
1,2-Dichlorobenzene	NA	Inhalation, Ingestion	25 mg/m^3 (1) 50 mg/m^3 (2) Ceiling level 200 mg/m^3 (3)
Ethylbenzene	8.8	Inhalation, Ingestion	100 ppm (1) 100 ppm (2) 800 ppm (3)
Tetrachloroethene	9.3	Inhalation, Ingestion Animal Carcinogen	25 ppm (1) 100 ppm (2) 150 ppm (3)
Toluene	8.8	Inhalation, Ingestion Skin Absorption	50 ppm (1) 200 ppm (2) 500 ppm (3)
Trichloroethylene	9.5	Inhalation, Ingestion	50 ppm (1) 100 ppm (2) 1000 ppm (3)
Xylene	8.5	Inhalation, Ingestion	100 ppm (1) 100 ppm (2) 900 ppm (3)
bis(2-Ethylhexyl)phthalate	NA	Inhalation, Ingestion	NE
Fluoranthene	NA	Inhalation, Ingestion	NE
Fluorene	NA	Inhalation, Ingestion	NE
2-Methylnaphthalene	NA	Inhalation, Ingestion	NE

TABLE 2.2

EXPOSURE ROUTES AND EXPOSURE LEVELS FOR THE CHEMICAL COMPOUNDS OF CONCERN LAGOON CLOSURE PROGRAM GENERAL MOTORS HARRISON RADIATOR MORAINE, OHIO

Chemical Compound	*Ionization Potential*	*Exposure Routes*	*Acceptable Exposure Levels in Air*
Phenanthrene	NA	Inhalation, Ingestion	NE
Pyrene	NA	Inhalation, Ingestion	NE
di-n-Butylphthalate	NA	Inhalation, Ingestion	5 mg/m$^{3 (1)}$ 5 mg/m$^{3 (2)}$ 4000 mg/m$^{3 (3)}$
Cyanide	NA	Inhalation, Ingestion	NE
PCBs	NA	Inhalation, Ingestion Skin Absorption Animal Carcinogen	0.5 mg/m$^{3 (1)}$ 0.5 mg/m$^{3 (2)}$ 5 mg/m$^{3 (3)}$

Notes:

(1)	1998-1999 Values, American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs).
(2)	Federal Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).
(3)	Immediately Dangerous to Life and Health (IDLH).
NA	Not Applicable.
NE	Not Established.
PCBs	Polychlorinated Biphenyls.
ppm	Parts Per Million.
mg/m^3	Milligrams per Cubic Meter.

TABLE 6.1

SPECIFIC PERSONAL PROTECTION LEVELS
LAGOON CLOSURE PROGRAM
GENERAL MOTORS HARRISON RADIATOR
MORAINE, OHIO

Work Task	*Maximum Protection Level*[1]	*Alternate Protection Level*[2]
Mobilization and Demobilization of Labor, Materials, and Equipment to and from the Site	Modified D	D
Surveying Activities	Modified D	D
Site Setup Activities Including Clearing of Work Areas and Construction of a Decontamination Pad	Modified D	D
Installation of Soil Borings and Soil Sampling Activities:		
• Activities with Potential Contact to Contaminants of Concern	C	Modified D
• Activities with no Potential Contact to Contaminants of Concern	Modified D	D
Sludge Solidification Activities:		
• Activities with Potential Contact to Contaminants of Concern	C	Modified D
• Activities with no Potential Contact to Contaminants of Concern	Modified D	D
Backfilling of the Five Separate Lagoons:		
• Activities with Potential Contact to Contaminants of Concern	C	Modified D
• Activities with no Potential Contact to Contaminants of Concern	Modified D	D
Site Restoration Activities Including Placing Clay and Topsoil Over the South Lagoons and Asphalt Over the North Lagoons		
• Activities with Potential Contact to Contaminants of Concern	C	Modified D
• Activities with no Potential Contact to Contaminants of Concern	Modified D	D
Decontamination Activities	C	Modified D

Notes:
Specific requirements of protection levels are detailed in Section 6.1.

(1) Level C: To be worn when the criterion for using air purifying respirators (APRs) are met and a lesser level of skin protection is needed.
Modified Level D: To be worn when dermal protection is required, however, no respiratory hazards are present. It provides minimal protection against chemical hazards.

(2) Alternate protection levels will be used if monitoring indicates that conditions are appropriate or the Health and Safety Officer (HSO) and Site Supervisor agree that there is a reduced potential of exposure.

TABLE 7.1

ANTICIPATED HAZARDS/RISKS AND HAZARD CONTROLS
LAGOON CLOSURE PROGRAM
GENERAL MOTORS HARRISON RADIATOR
MORAINE, OHIO

Activity	*Anticipated Hazards/Risks*	*Appropriate Precautions*
1. Mobilization and Demobilization Activities, Surveying Activities, Site Restoration Activities where there is no Potential Contact with the Contaminants of Concern and Clearing of Work Area	• slip/trip/fall hazards • potential back injuries from lifting heavy objects • potential heat or cold stress • severe weather • electrical hazards from power sources • moving or backing vehicles • cuts to hands from using utility knives and tools • potential contact with poison ivy • bites and/or stings from ticks, bees, wasps	• Modified D or Level D personal protection • practice safe lifting practices • participate in on-Site training programs • practice good personal hygiene practices • use a spotter around moving or backing equipment • work activities will be reduced or suspended during severe weather conditions • ground fault circuit interrupters (GFCIs) should be used to reduce the hazard of electrical shock. Do not stand in water when handling equipment. Electrical equipment will be approved • keep first aid supplies readily available, including antidote kit for those allergic to bees or wasps
2. Installation of Soil Borings and Soil Sampling Activities, Sludge Solidification Activities, Backfilling of the Lagoons, Site Restoration Activities Where There is a Potential for Contact to the Contaminants of Concern and Decontamination Activities	• slip/trip/fall hazards • potential back injuries from lifting heavy objects • potential heat or cold stress • severe weather • electrical hazards from power sources • moving or backing vehicles and equipment • personnel injuries from sharp objects, falling debris or pinch points, and entanglement in drill rig • direct contact with potentially contaminated	• Levels B and C, Modified Level D, based on realtime air monitoring or established protection levels (see Table 6.1) • practice safe lifting techniques • participate in all on-Site training programs • be trained with all appropriate equipment standard operating procedures • practice good personal hygiene principles • take proper precautions in unsafe areas • use the "Buddy System" • perform an underground utilities search

TABLE 7.1

ANTICIPATED HAZARDS/RISKS AND HAZARD CONTROLS
LAGOON CLOSURE PROGRAM
GENERAL MOTORS HARRISON RADIATOR
MORAINE, OHIO

Activity	*Anticipated Hazards/Risks*	*Appropriate Precautions*
(Continued from Page 1)	soils, sediment, groundwater, sludge, and waste materials • hazard presented by the use of heavy equipment overhead and underground utility hazards (e.g., electrical lines) • potential burns from hot equipment hazards presented by the use of specialized equipment (e.g., decontamination equipment) • potential contact with poison ivy • bites and/or stings from ticks, bees, wasps	• only essential personnel allowed in work area • use a spotter around moving or backing equipment • identify all high temperature objects or equipment • work activities will be reduced or suspended during severe weather conditions • GFCIs should be used to reduce the hazard of electrical shock. Do not stand in water when handling equipment. Electrical equipment will be approved • keep first aid supplies readily available including antidote kit for those allergic to bees or wasps

ATTACHMENT A

TRAINING ACKNOWLEDGEMENT FORM

TRAINING ACKNOWLEDGEMENT FORM

I have read and understand the HASP and/or I have attended the mandatory Site-specific initiation session and understand the information presented in the HASP. I fully understand the known potential hazards present on Site, the required levels of PPE to complete my work, and the emergency procedures for the Site. I further confirm that I have the required training to participate in the Lagoon Closure activities that I will be involved with. I agree to work in accordance with the guidelines presented in the HASP and I understand that failure to do so could result in removal from the Site.

Date	*Printed Name*	*Signature*	*Position*	*Company Name*

ATTACHMENT B

TEMPERATURE STRESS PREVENTION AND MONITORING

HEAT STRESS PREVENTION AND MONITORING[1]

Heat stress may occur at any time work is being performed at elevated temperatures. Wearing of chemical protective clothing, which may result in decreasing natural body ventilation, increases the risk of heat stress.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur, ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity movement) to fatal. Because heat stress is one of the most common and potentially serious illnesses at hazardous waste sites, regular monitoring and other preventative measures are vital.

Site workers must learn to recognize and treat the various forms of heat stress. The best approach is preventative heat stress management. In general, if possible:

1. have workers drink 16 ounces of water before beginning work, such as in the morning or after lunch. Provide disposable 4-ounce cups, and water that is maintained at 50 to 60°F. Urge workers to drink one to two of these cups of water every 20 minutes for a total of 1 to 2 gallons per day. Provide a cool area for rest breaks. Discourage the intake of coffee during working hours. Monitor for signs of heat stress;
2. acclimate workers to Site work conditions by slowly increasing workloads (e.g., do not begin Site work activities with extremely demanding activities);
3. provide cooling devices to aid natural body ventilation. These devices, however, add weight and their use should be balanced against worker efficiency. An example of a cooling aid is long cotton underwear which acts as a wick to absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing;
4. in extremely hot weather, conduct field activities in the early morning and evening;
5. ensure that adequate shelter is available to protect personnel against heat as well as cold, rain, snow, etc., which can decrease physical efficiency and increase the probability of both heat and cold stress. If possible, set up the command post in the shade;
6. in hot weather, rotate shifts of workers wearing impervious clothing; and

---

[1] Sources: (USEPA, 1985) 29 United States Code of Federal Regulations, 1910.29.

7. good hygienic standards must be maintained by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

The following is a discussion of specific results of heat stress.

Heat Stroke

Heat stroke is an acute and dangerous reaction to heat stress caused by failure of heat regulating mechanisms of the body; the individual's temperature control system that causes sweating stops working correctly. Body temperature rises so high that brain damage and death will result if the person is not cooled quickly.

- Symptoms - Red, hot, dry skin, although person may have been sweating earlier; nausea; dizziness; confusion; extremely high body temperature; rapid respiratory and pulse rate; unconsciousness or coma.
- Treatment - Cool the victim quickly. If the body temperature is not brought down fast, permanent brain damage or death will result. Soak the victim in cool, but not cold water; sponge the body with cool water or pour water on the body to reduce the temperature to a safe level (102°F). Observe the victim and obtain medical help. Do not give coffee, tea, or alcoholic beverages.

Heat Exhaustion

Heat exhaustion is a state of every definite weakness or exhaustion caused by the loss of fluids from the body. The condition is much less dangerous than heat stroke, but it nonetheless must be treated.

- Symptoms - Pale, clammy, moist skin; profuse perspiration and extreme weakness. Body temperature is normal, pulse is weak and rapid, breathing is shallow. The person may have a headache, may vomit and may be dizzy.
- Treatment - Remove the person to a cool, air conditioned place, loosen clothing, place in a head-low position and provide bed rest. Consult physician, especially in severe cases. The normal thirst mechanism is not sensitive enough to ensure body fluid replacement. Have patient drink one to two cups of water immediately, and every 20 minutes thereafter until symptoms subside. Total water consumption should be about one to two gallons per day.

Heat Cramps

Heat cramps are caused by perspiration that is not balanced by adequate fluid intake. Heat cramps are often the first sign of a condition that can lead to heat stroke.

- Symptoms - Acute painful spasms of voluntary muscles (e.g., abdomen and extremities).
- Treatment - Remove victim to cool area and loosen clothing. Have patient drink one to two cups of water immediately and every 20 minutes thereafter until symptoms subside. Total water consumption should be 1 to 2 gallons per day.

Heat Rash

Heat rash is caused by continuous exposure to heat and humid air and is aggravated by chafing clothes. The condition decreases ability to tolerate heat.

- Symptoms - Mild red rash, especially in areas of the body that come into contact with protective gear.
- Treatment - Decrease amount of time in protective gear and provide powder to help absorb moisture and decrease chafing.

Heat Stress Monitoring and Work Cycle Management

For strenuous field activities that are part of ongoing Site work activities in hot weather, the following procedures shall be used to monitor the body's physiological response to heat, and to manage the work cycle, even if workers are not wearing impervious clothing. These procedures are to be instituted when the temperature exceeds 70°F. If possible these measures will be supplemented by the use of automatic monitoring equipment which can be worn by the workers under their PPE.

- Measure Heart Rate - Heart rate (HR) should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 110 beats/minute.

- Measure Body Temperature - When ambient temperature is over 90°F, body temperatures should be measured with a clinical thermometer as early as possible in the resting period. If oral temperature (OT) at the beginning of the rest period exceeds 99.6°F, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the OT exceeds 99.6°F at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The procedure is continued until the body temperature is maintained below 99.6°F.
- Physiological Monitoring Schedule - The following Suggested Frequency of Physiological Monitoring Schedule for Fit and Acclimated Workers shall be used as a guideline.

Temperature (Adjusted)	*(Level D)*	*(Level C)*
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°F (30.8°-32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5°-87.5°F (28.1°-32.2°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5°F (25.3°-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Measure the air temperature with a standard thermometer. Estimate the fraction of sunshine by judging what percent of the sun is out.

100% sunshine = no cloud cover = 1.0
50% sunshine = 50% cloud cover = 0.5
0% sunshine = full cloud cover = 0.0
Adjusted temp. = actual temp. + 13 x (% sunshine factor).

The length of work period is governed by Frequency of Physiological Monitoring. The length of the rest period is governed by physiological parameters (heart rate and oral temperature). For example, if an individual's heart rate exceeds 110 beats/minute at the beginning of the rest period, that individual will remain on rest-time until his/her heart rate drops well below 110 beats/minute and their next work period (= duration of time before suggested physiological monitoring) is decreased by 33 percent.

COLD STRESS PREVENTION AND MONITORING

Persons working outdoors in low temperatures, especially at or below freezing are subject to cold stress. Exposure to extreme cold for a short time causes severe injury to the surface of the body, or results in profound generalized cooling, causing death. Areas of the body which have a high surface area-to-volume ratio such as fingers, toes, and ears, are the most susceptible.

Chemical protective clothing generally does not afford protection against cold stress. In many instances, it increases susceptibility. Hazardous waste Site workers must learn to dress carefully to provide chemical protection and thermal insulation while not dressing so warmly that exercise or strenuous activity will result in heat stress.

Provisions must also be made for the fact that after physical activity and accumulation of body heat, sudden chilling during decontamination and rest breaks may increase susceptibility to colds, etc.

Two factors influence the development of a cold injury: ambient temperature and the velocity of the wind. Wind Chill Indices describe the chilling effect of moving air in combination with low temperature.

As a general rule, the greatest incremental increase in wind chill occurs with a wind of 5 miles per hour (mph). Additionally, water conducts heat 240 times faster than air; thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration-soaked.

Frostbite

Local injury resulting from cold is included in the generic term frostbite. Frostbite of the extremities can be categorized into:

1. frost nip or incipient frostbite is characterized by sudden blanching or whitening of skin;
2. superficial frostbite is characterized by skin with a waxy or white appearance and is firm to the touch, but tissue beneath is resilient; and
3. deep frostbite is characterized by tissues that are cold, pale, and solid.

To administer first aid for frostbite:

1. take the victim indoors and rewarm the areas quickly in water that is between 39°C and 41°C (102°F to 105°F);
2. give a warm drink - water or juices, no coffee, tea or alcohol. The victim must not smoke;
3. keep the frozen parts in warm water or covered with warm clothes for 30 minutes even though the tissue will be very painful as it thaws;
4. then elevate the injured area and protect it from injury;
5. do not allow blisters to be broken;
6. use sterile, soft, dry material to cover the injured areas; and
7. keep victim warm and get immediate medical care.

After thawing, the victim should try to move the injured areas a little, but no more than can be done alone, without help. Seek medical attention as soon as possible.

Note:

1. Do not rub the frostbitten part (this may cause gangrene).
2. Do not use ice, snow, gasoline or anything cold on the frostbitten area.
3. Do not use heat lamps or hot water bottles to rewarm the part.
4. Do not place the part near a hot stove.

Hypothermia

Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages:

1. shivering;
2. apathy, listlessness, sleepiness;
3. (sometimes) rapid cooling of the body to less than 95°F;
4. unconsciousness, glassy stare, slow pulse, slow respiration; and
5. death.

If hypothermia is suspected in any field personnel, move person to a warmer location until symptoms recede.

ATTACHMENT C

SEVERE WEATHER PROCEDURES

SEVERE WEATHER

When projects are conducted outside, the potential for severe weather must be considered. Thunderstorms, tornadoes and winter storms can develop quickly, jeopardizing Site safety. The following emergency procedures are to be followed in the event of severe weather.

Thunderstorms and Lightning

1. Monitor weather conditions at all times while working. At a sign of an impending storm - increased cloudiness, darkened skies, increased wind, listen to a radio for the latest weather information.
2. When a thunderstorm accompanied by lightning is in the project area, reduce activities or cease work immediately.
3. Perform decontamination as quickly and orderly as possible, if work stoppage is necessary.
4. Seek shelter inside nearest building or Site trailer.
5. If you are caught in an open area and you feel your hair stand on end, lightning may be about to strike you. Drop to your knees and bend forward, putting your hands on your knees. DO NOT LIE FLAT ON THE GROUND.
6. If someone has been struck by lightning, monitor life signs and begin administering mouth-to-mouth resuscitation or cardiopulmonary resuscitation as needed. Send for help.
7. Check conscious victims for burns, especially at the fingers and toes and next to buckles and jewelry. Administer first aid for shock. Do not let the victim walk around.

Tornadoes

1. Tornadoes usually develop from thunderstorms and normally occur at the trailing edge of the storm. Most tornadoes occur in the months of April, May, June, and July in the late afternoon and early evening hours.
2. When storms are predicted for the project area, monitor weather conditions on a radio. A tornado watch is issued when favorable conditions exist for the development of a tornado. A tornado warning is issued by the local weather service office whenever a tornado has actually been sighted or is strongly indicated by radar.

3. If a tornado warning is issued, seek shelter immediately.
4. If a tornado warning is issued and you are in a vehicle or a Site trailer, leave and go to the nearest building.
5. Once a tornado has passed the Site, Site personnel are to assemble at the designated SZ area to determine if anyone is missing. Administer first aid and seek medical attention as needed.

Winter Storms

1. When snow or ice storms are predicted for the project area, Site personnel should monitor weather conditions on a radio. A winter storm watch is issued when a storm has formed and is approaching the area. A winter storm warning is issued when a storm is imminent and immediate action is to be taken.
2. When a storm watch is issued, monitor weather conditions and be prepared to halt Site activities. Seek shelter in Site buildings or the Site trailer.

APPENDIX F

LAGOON GEOTECHNICAL DRILLING PROGRAM

DRILLING PROGRAM SCOPE OF WORK
GMC – HARRISON RADIATOR
MORAINE, OHIO

- Development of a Contractor Site Health and Safety Plan;
- drill pilot borings taking continuous split-spoon sampling at each sample location shown on Figures 1 and 2;
- all locations are to be drilled to a depth of at least 2 feet below the sludge/native soil interface or until refusal;
- following drilling of pilot boring, conduct drilling at a new location within 4 feet of the pilot boring taking shelby tube sample(s) at locations specified by the Engineer;
- conduct shear vane testing on undisturbed sludge material above and below shelby tube location(s) as directed by the Engineer;
- conduct dynamic cone testing to a depth of at least 1 foot below sludge/native soil interface or until refusal, at locations shown on Figures 1 and 2;
- drill rig and/or equipment potentially in contact with sludge material must be decontaminated using high pressure, low volume water spray, before removal from each lagoon;
- deliver shelby tube samples to laboratory for geotechnical testing specified in Attachment 1; and
- all drilling to be conducted by 40-hour OSHA trained personnel wearing appropriate PPE to allow drilling activities to be completed in accordance with the contractor's Site Health and Safety Plan.

Note:

Drilling activities may involve exposure to hazardous materials. Lagoon sludge is characterized as a hazardous waste containing USEPA listed hazardous waste codes F006, F007, F009, F012, and F019.

ATTACHMENT 1

SUMMARY OF GEOTECHNICAL TESTING
GMC – HARRISON RADIATOR
MORAINE, OHIO

A. South Lagoon Sampling

i) Location 1 (2 Shelby tubes)
  - 2 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

ii) Location 2 (0 Shelby tubes)
  - No sludge encountered.

iii) Location 3 (0 Shelby tubes)
  - No sludge encountered.

iv) Location 4 (0 Shelby tubes)
  - No sludge encountered.

v) Location 5 (1 Shelby tube)
  - 1 grain size (hydrometer), atterberg limits, specific gravity, moisture content, and unit density tests.

vi) Location 6 (1 Shelby tube)
  - 1 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

vii) Location 7 (2 Shelby tubes)
  - 2 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

viii) Location 8 (1 Shelby tube)
  - 1 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

ix) Location 9 (1 Shelby tube)
  - 1 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

B. North Lagoon Sampling

i) Location 10 (2 Shelby tubes)

- 2 grain size (hydrometer), atterberg limits, specific gravity, moisture content, and unit density, and consolidation test.

ii) Location 11 (0 Shelby tubes)

- No sludge encountered.

iii) Location 12 (2 Shelby tubes)

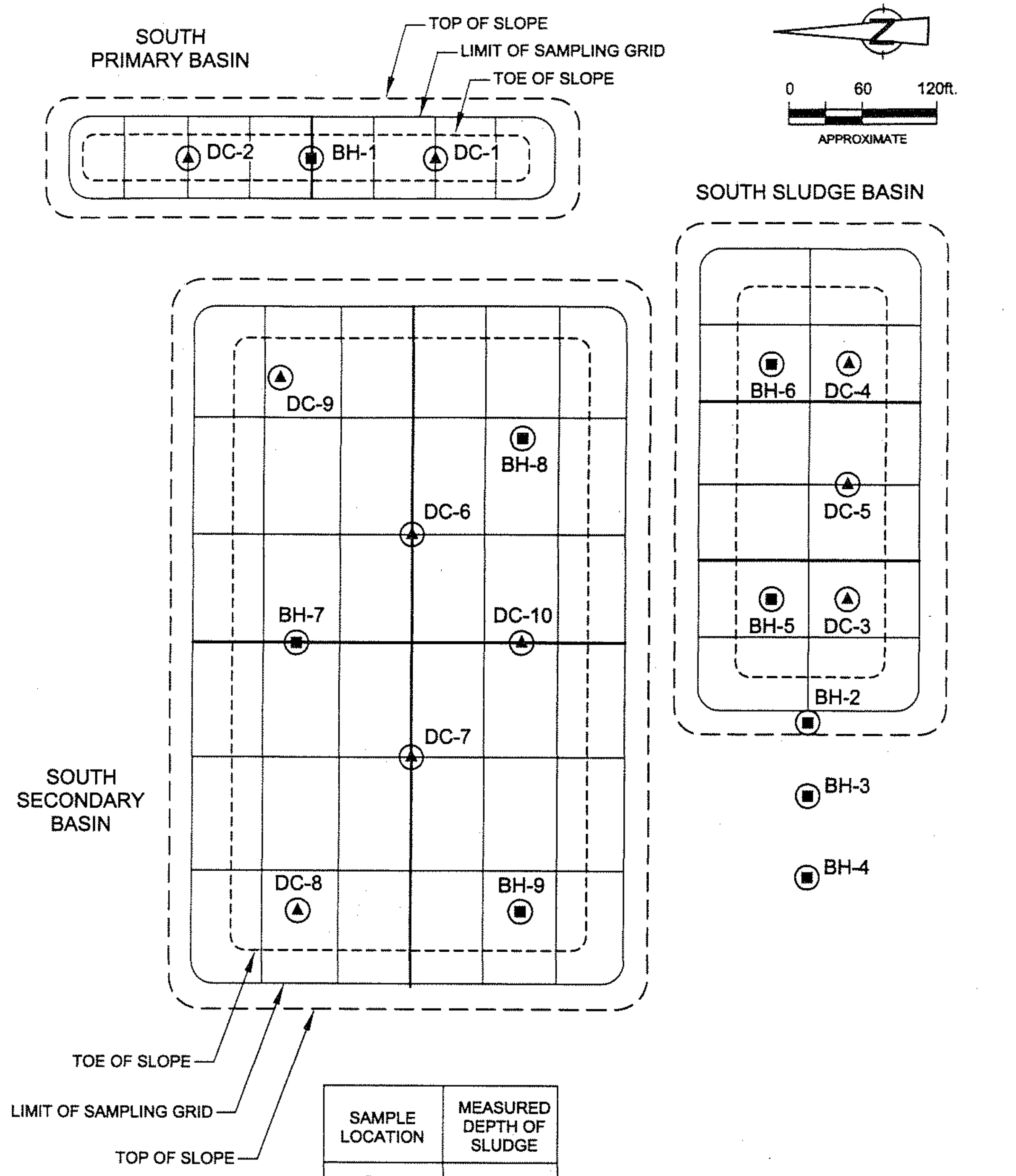
- 2 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density.

iv) Location 13 (1 Shelby tube)

- 1 grain size (hydrometer), atterberg limits, specific gravity, moisture content, unit density, and consolidation tests.

C. Testing Procedures

- Sieve and Hydrometer Analysis, ASTM D422
- Atterberg Limits, ASTM D4318
- Specific Gravity, ASTM D854
- Moisture Content, ASTM D2216
- One Dimensional Consolidation (total load of 4000 lbs./ft2), ASTM D2435



SAMPLE LOCATION	MEASURED DEPTH OF SLUDGE
BH-1	7.5'
BH-2	0'
BH-3	0'
BH-4	0'
BH-5	4'
BH-6	3.5'
BH-7	8.5'
BH-8	3.5'
BH-9	3'

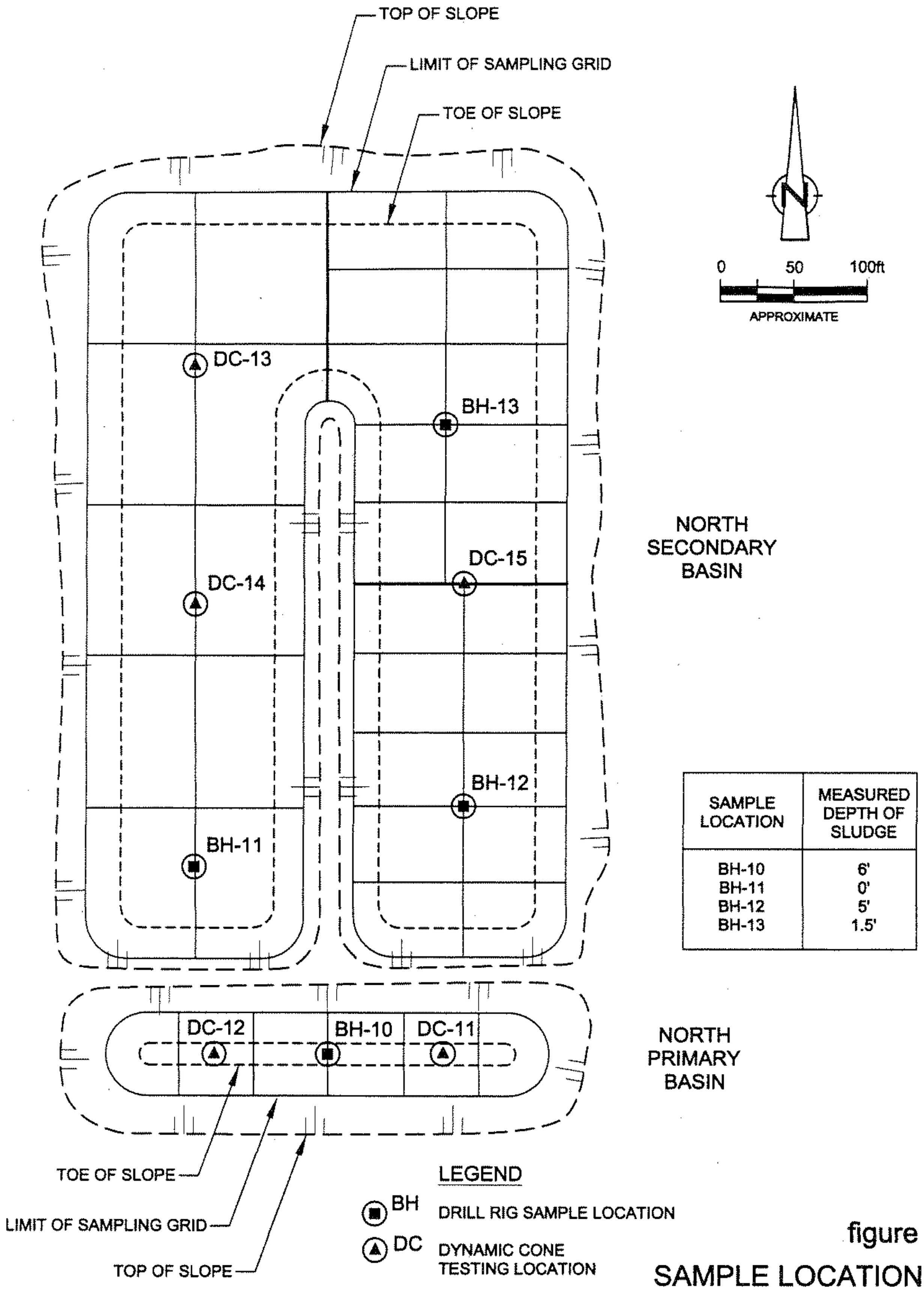
LEGEND

■ BH	DRILL RIG SAMPLE LOCATION
▲ DC	DYNAMIC CONE TESTING LOCATION

figure 1

SAMPLE LOCATIONS
SOUTH SETTLING POND
GMC-HARRISON RADIATOR
Moraine, Ohio

CRA



SAMPLE LOCATION	MEASURED DEPTH OF SLUDGE
BH-10	6'
BH-11	0'
BH-12	5'
BH-13	1.5'

LEGEND

■ BH DRILL RIG SAMPLE LOCATION

▲ DC DYNAMIC CONE TESTING LOCATION

figure 2

SAMPLE LOCATIONS
NORTH SETTLING POND
GMC-HARRISON RADIATOR
Moraine, Ohio

CRA

12611-00(003)GN-WA023 DEC 23/1999

TT 12611

H. C. NUTTING COMPANY
EMPLOYEE OWNED
GEOTECHNICAL, ENVIRONMENTAL AND TESTING ENGINEERS
SINCE 1921

CORPORATE CENTER
4120 AIRPORT ROAD
CINCINNATI, OHIO 45226
(513) 321-5816
FAX (513) 321-0294

Order NO. 11294.019

October 20, 1999

Mr. Henry Cooke
Conestoga-Rovers & Associates
2441 Crowne Pointe Dr.
Cincinnati, OH 45241

Re: **Laboratory Tests**
Project: **GMC-Harrison Radiator Site**

Dear Mr. Cooke:

Submitted herewith is our report containing the results of various tests you requested be performed for the referenced project. Samples were obtained and submitted to laboratory by our representatives.

H.C. Nutting Company thanks **CRA** for allowing us this opportunity to be of service. Should any discussion be required concerning this report, please feel free to contact the undersigned. Attached are the tabulated and plotted results.

Respectfully submitted,

H.C. NUTTING COMPANY

Robert L. House

Robert L. House,
Vice President/Lab. Director

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

10/1/99smo

Conestoga-Rovers & Assoc. LTD
GMC-Harrison Radiator Site
Moraine, OH
HCN W.O. # 11294.019

TABLE I

CLASSIFICATION TEST DATA

				Mechanical Analysis					Atterberg Limits			
Depth (Ft.)	Sample No.	Depth (Ft.)	Moisture Content (%)	% Gravel	% Sand	% Silt	% Clay	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	U.S.C.S Classification
BH-1	ST-1	1-3	80.9	0	11	61	28	2.42	86	54	32	MH
	ST-2	4.5-6.5	148.2	0	20	50	30	2.05	84	47	37	MH
BH-5	ST-1	1-3	90.3	0	2	75	23	2.49	108	65	43	MH
BH-6	ST-1	1-3	73.1	0	9	75	16	2.35	107	61	46	MH
BH-7	ST-1	1-3	305.0	0	23	56	21	2.38	117	79	38	MH
	ST-2	5-7	300.9	0	20	58	22	2.42	112	75	37	MH
BH-8	ST-1	1-3	61.1	0	24	64	12	2.27	93	61	32	MH
BH-9	ST-1	0-2	95.2	0	40	37	23	2.23	129	88	41	MH
BH-10	ST-1	1-3	101.1	0	19	77	4	2.23	61	36	25	MH
	ST-2	3.5-5.5	104.4	0	4	89	7	2.13	68	39	29	MH
BH-12	ST-1	0-2	108.0	0	26	64	10	2.05	49	27	22	CL
	ST-2	2-4	166.0	0	25	59	16	2.36	80	51	29	MH
BH-13	ST-1	0-2	140.9	0	10	85	5	2.17	81	48	33	MH

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

10/1/99

Conestoga-Rovers & Assoc. LTD
GMC-Harrison Radiator Site
Moraine, OH
HCN W.O. # 11294.019

TABLE II

TABULATION OF UNDISTURBED TEST DATA

PAGE 1 OF 2

Boring No.	Sample No.	Depth (Ft.)	Unconfined Compressive Strength (TSF)	Confining Pressure P.S.I.	Failure Strain (%)	Dry Density (Lbs./Cu. Ft.)	Water Content (%)	Remarks
BH-1	ST-1	1-3	---	---	---	37.2	80.9	
	ST-2	4.5-6.5	---	---	---	74.2	148.2	UNIT WT.
	"	"	---	---	---	30.6	149.4	CV
BH-7	ST-1	1-3	---	---	---	18.0	305.0	UNIT WT.
	"	"	---	---	---	17.9	309.8	CV
	ST-2	5-7	---	---	---	17.9	300.9	UNIT WT.
	"	"	---	---	---	21.6	240.9	CV
BH-8	ST-1	1-3	---	---	---	35,5	61.1	
BH-9	ST-1	0-2	---	---	---	24.1	95.2	

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Conestoga-Rovers & Assoc. LTD
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Moraine, OH
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10/1/99

TABLE II

TABULATION OF UNDISTURBED TEST DATA

PAGE 2 OF 2

Boring No.	Sample No.	Depth (Ft.)	Unconfined Compressive Strength (TSF)	Confining Pressure P.S.I.	Failure Strain (%)	Dry Density (Lbs./Cu. Ft.)	Water Content (%)	Remarks
BH-10	ST-1	1-3	---	---	---	41.1	101.1	UNIT WT.
	"	"	---	---	---	43.0	95.2	CV
	ST-2	3.5-5.5	---	---	---	41.4	104.4	UNIT WT.
	"	"	---	---	---	41.9	98.4	CV
BH-12	ST-1	0-2	---	---	---	34.7	108.0	UNIT WT.
	"	"	---	---	---	44.0	80.4	CV
	ST-2	2-4	---	---	---	29.6	166.0	UNIT WT.
	"	"	---	---	---	30.3	153.2	CV
BH-13	ST-1	0-2	---	---	---	31.7	140.9	UNIT WT.
	"	"	---	---	---	28.8	163.0	CV

2TB10-1

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.2	10.4	61.2	28.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	99.8		
#10	99.1		
#20	96.7		
#40	93.9		
#100	90.8		
#200	89.4		
#270	88.0		

* (no specification provided)

Soil Description

Elastic silt (SLUDGE)

Atterberg Limits

PL= 54 LL= 86 PI= 32

Coefficients

D_{85}= 0.0387 D_{60}= 0.0075 D_{50}= 0.0049
D_{30}= 0.0022 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7291

Sample No.: ST-1 **Source of Sample:** L-7291 **Date:** 9/27/99
Location: BORING:BH-1 **Elev./Depth:** 1-3'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019 **Plate**

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	20.3	49.9	29.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	89.9		
#40	84.1		
#100	81.4		
#200	79.7		
#270	79.4		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 47 LL= 84 PI= 37

Coefficients

D_{85}= 0.492 D_{60}= 0.0113 D_{50}= 0.0082
D_{30}= 0.0022 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7292

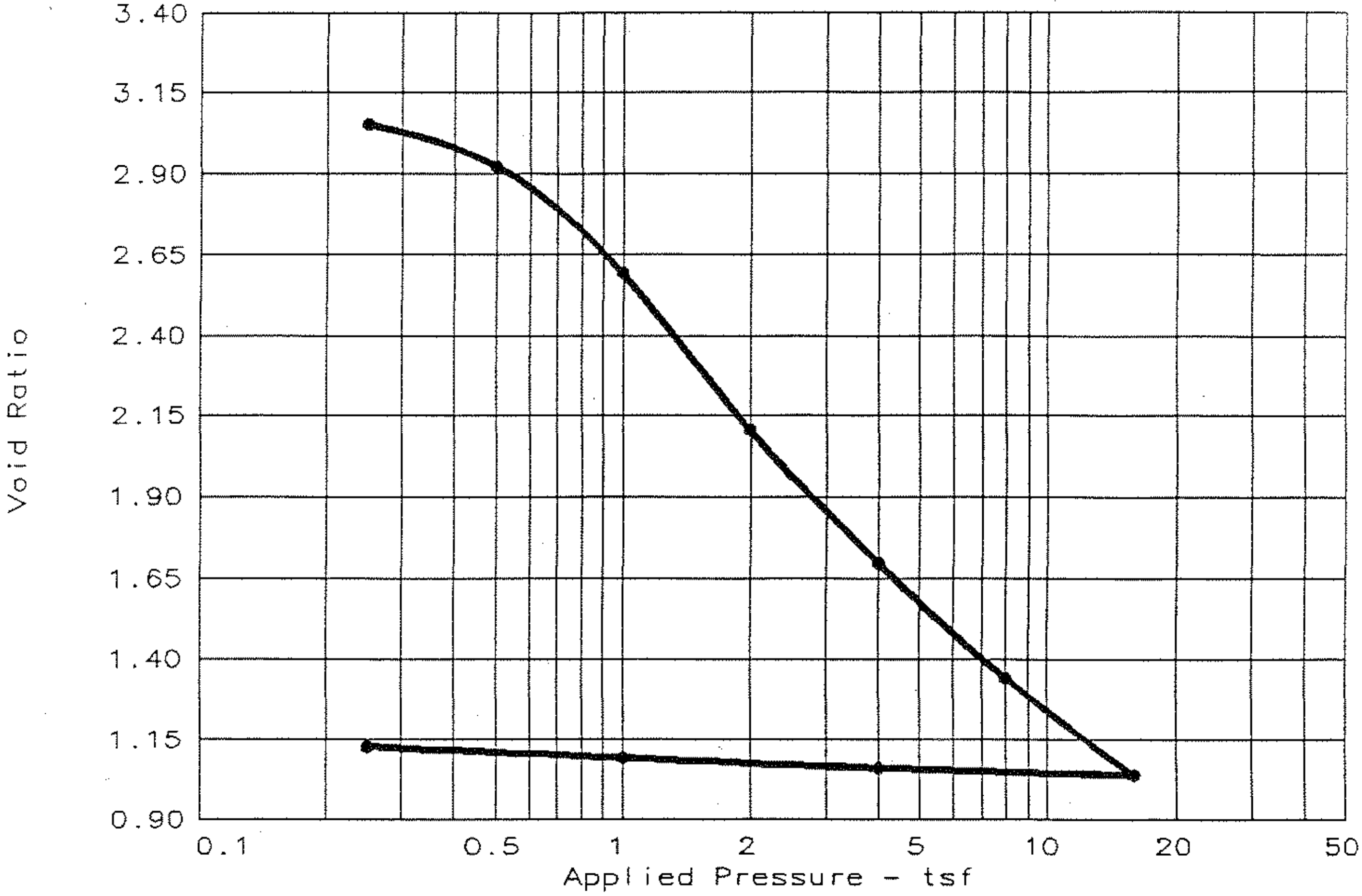
Sample No.: ST-2 **Source of Sample:** L-7292 **Date:** 9/27/99
Location: BORING:BH-1 **Elev./Depth:** 4.5-6.5'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)							
No.	Load	No	Cv	Load	No	Cv	Load
1	0.25		0.029				
2	0.50		0.023				
3	1.00		0.018				
4	2.00		0.024				
5	4.00		0.007				
6	8.00		0.004				
7	16.00		0.003				

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
96.2 %	149.4	30.6	84	37	2.050	3.1837

TEST RESULTS

MATERIAL DESCRIPTION

(SLUDGE) ELASTIC SILT
WITH SAND

Class: MH

Remarks:

CLIENT: CONESTOGA-
ROVERS & ASSOC. LTD

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-1 LAB NO. 7292
SAMPLE:ST-2 DEPTH:4.5-6.5'
Date: 10/5/99

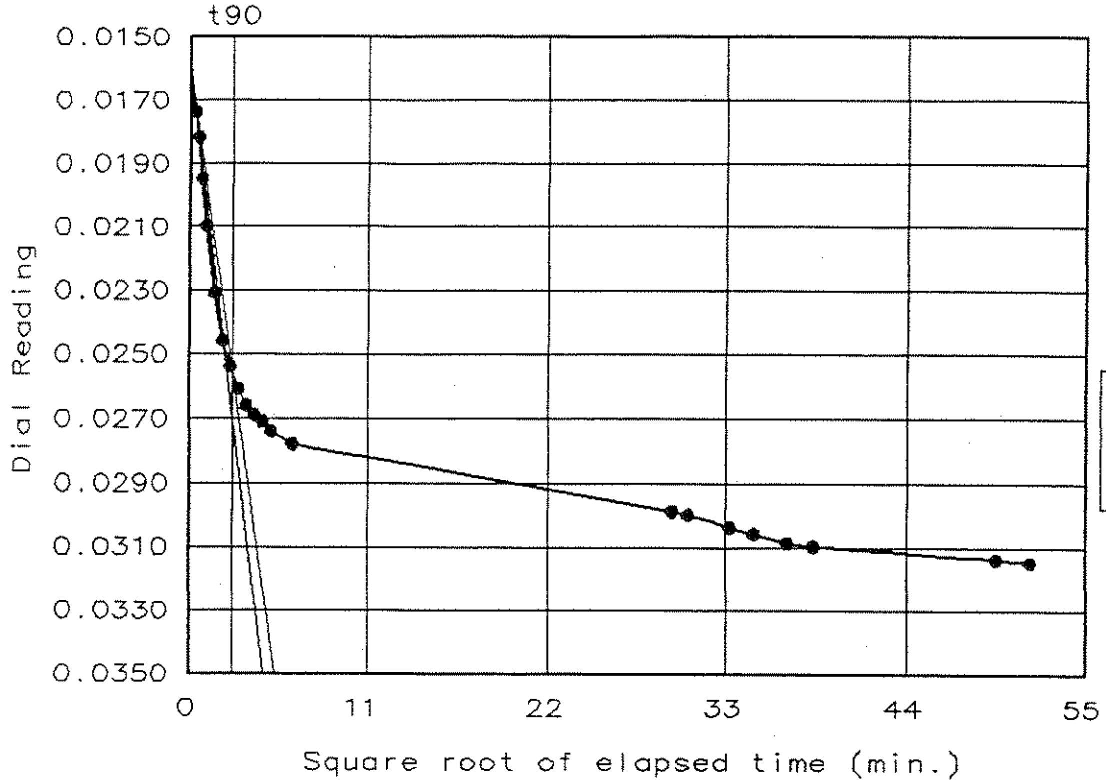
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No. ______

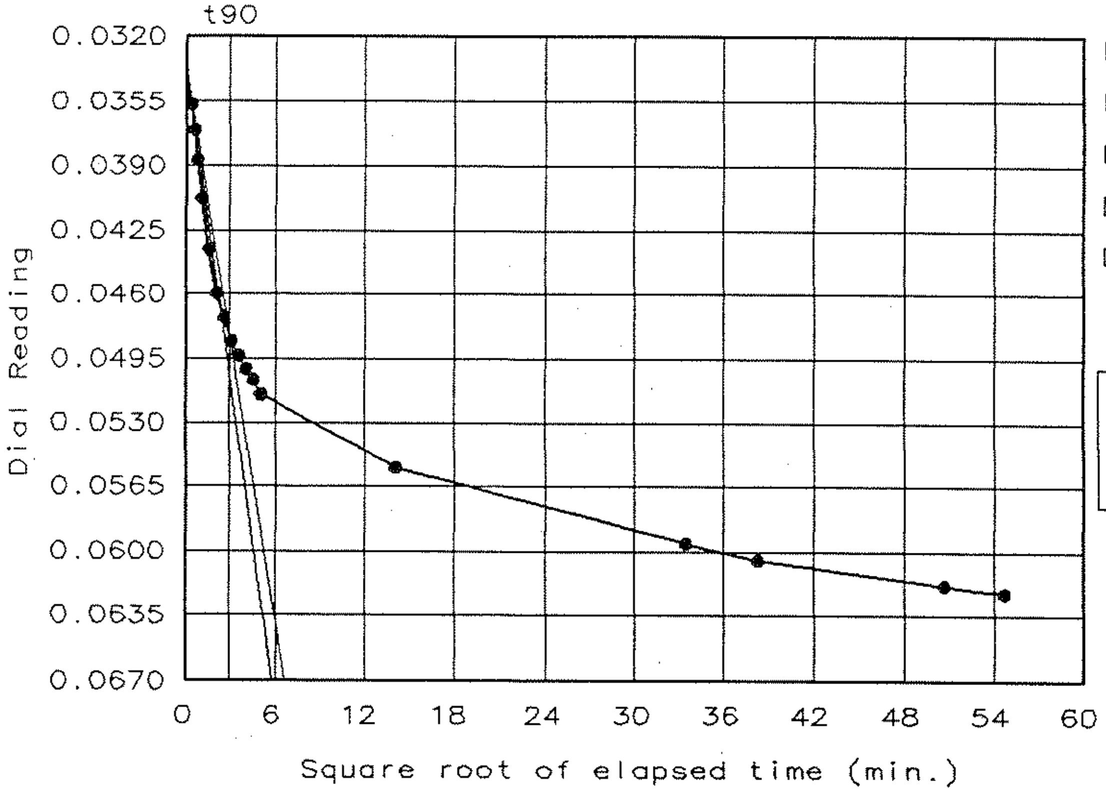
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-1 LAB NO. 7292
SAMPLE:ST-2 DEPTH:4.5-6.5'
Date: 10/5/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0161
D_{90} = 0.0256
D_{100}= 0.0266
T_{90}= 6.93 min.

C_v @ T_{90} =
.029 in.^{2}/min.

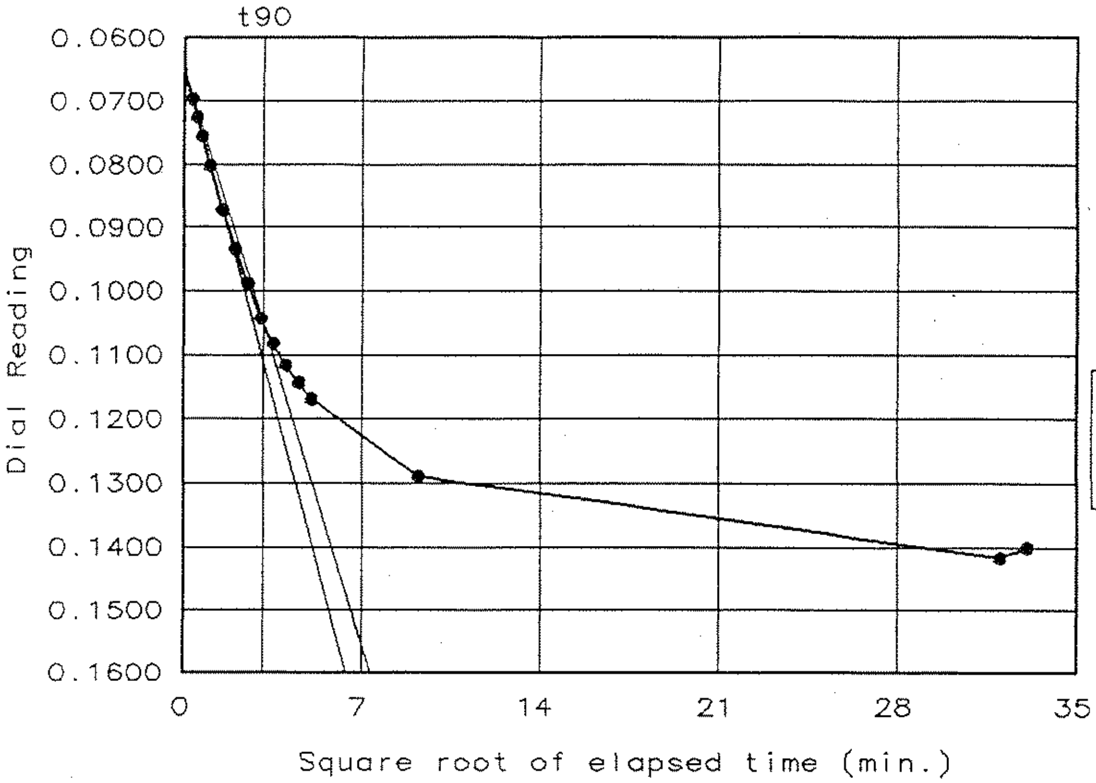


Load No.= 2
Load= 0.50 tsf
D_0 = 0.0339
D_{90} = 0.0483
D_{100}= 0.0499
T_{90}= 8.27 min.

C_v @ T_{90} =
.023 in.^{2}/min.

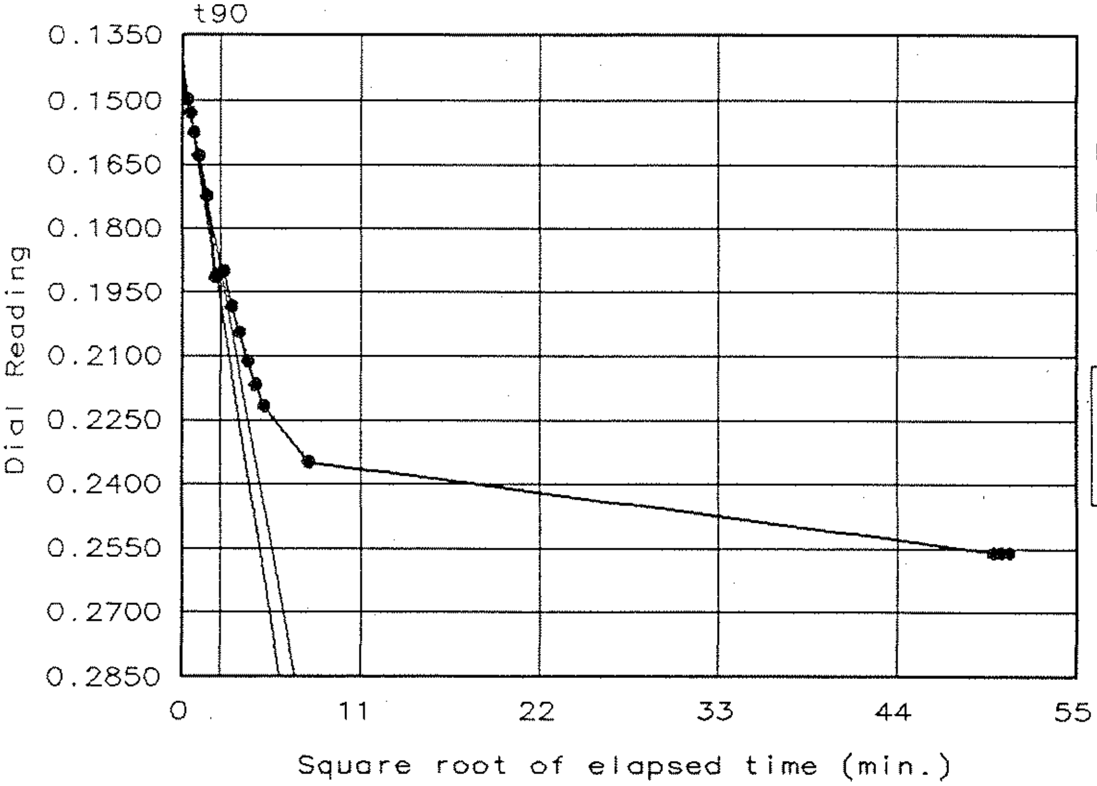
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-1 LAB NO. 7292
SAMPLE:ST-2 DEPTH:4.5-6.5'
Date: 10/5/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.0651
D_{90} = 0.1051
D_{100}= 0.1095
T_{90}= 9.52 min.

C_v @ T_{90} =
.018 in.²/min.

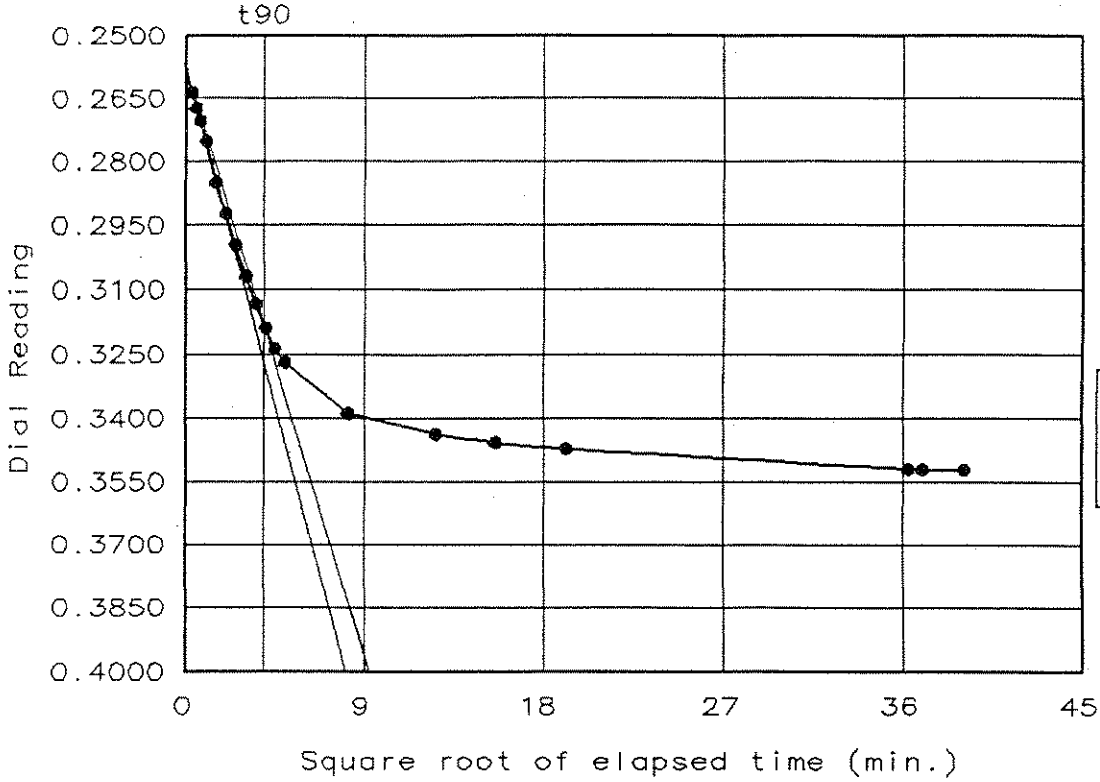


Load No.= 4
Load= 2.00 tsf
D_0 = 0.1423
D_{90} = 0.1906
D_{100}= 0.1960
T_{90}= 5.45 min.

C_v @ T_{90} =
.024 in.²/min.

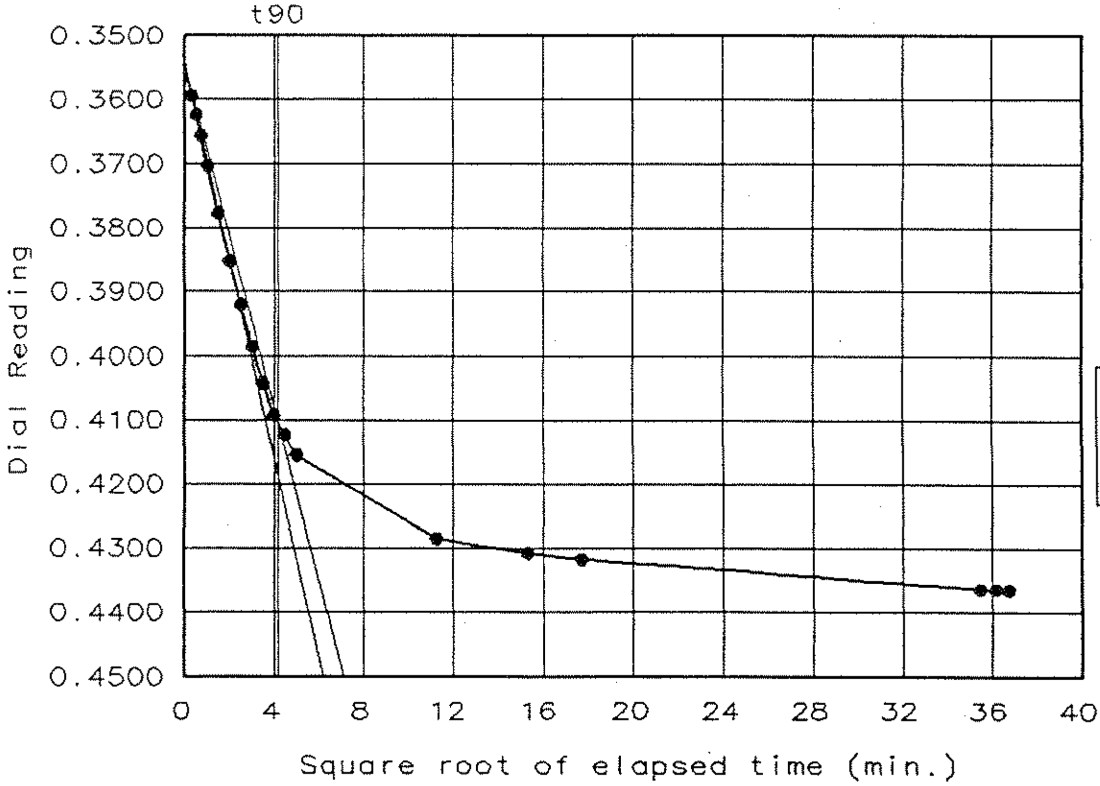
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-1 LAB NO. 7292
SAMPLE:ST-2 DEPTH:4.5-6.5'
Date: 10/5/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.2582
D_{90} = 0.3179
D_{100}= 0.3246
T_{90}= 15.17 min.

C_v @ T_{90} =
.007 in.^{2}/min.

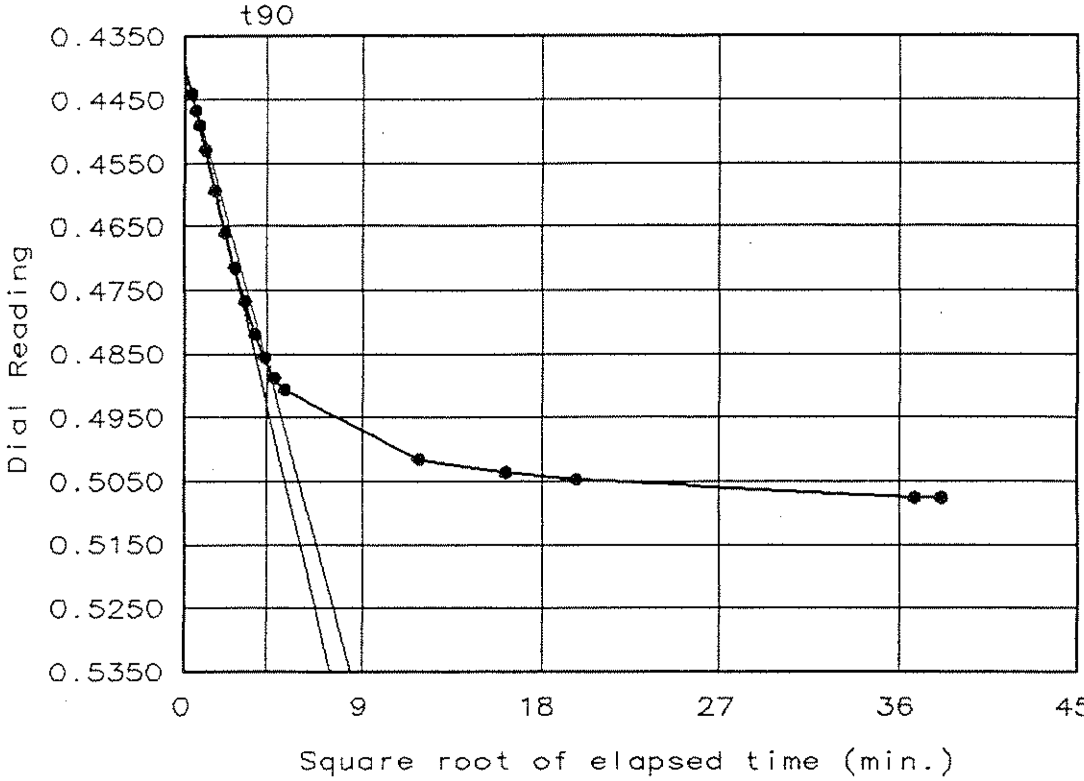


Load No.= 6
Load= 8.00 tsf
D_0 = 0.3546
D_{90} = 0.4103
D_{100}= 0.4165
T_{90}= 17.20 min.

C_v @ T_{90} =
.004 in.^{2}/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-1 LAB NO. 7292
SAMPLE:ST-2 DEPTH:4.5-6.5'
Date: 10/5/99



Load No.= 7
Load= 16.00 tsf
D_0 = 0.4401
D_{90} = 0.4864
D_{100}= 0.4916
T_{90}= 16.92 min.

C_v @ T_{90} =
.003 in.^{2}/min.

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	1.8	75.4	22.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	100.0		
#100	99.4		
#200	98.2		

* (no specification provided)

Soil Description

Elastic silt (SLUDGE)

Atterberg Limits

PL= 65 LL= 108 PI= 43

Coefficients

D_{85}= 0.0575 D_{60}= 0.0139 D_{50}= 0.0068
D_{30}= 0.0029 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7373

Sample No.: ST-1
Location: BORING:BH-5
Source of Sample: L-7373
Date: 10/6/99
Elev./Depth: 1-3

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019
Plate

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	9.5	74.5	16.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.7		
#40	99.5		
#100	98.2		
#200	90.5		

* (no specification provided)

Soil Description

Elastic silt (SLUDGE)

Atterberg Limits

PL= 61 LL= 107 PI= 46

Coefficients

D_{85}= 0.0685 D_{60}= 0.0420 D_{50}= 0.0161
D_{30}= 0.0052 D_{15}= 0.0017 D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7374

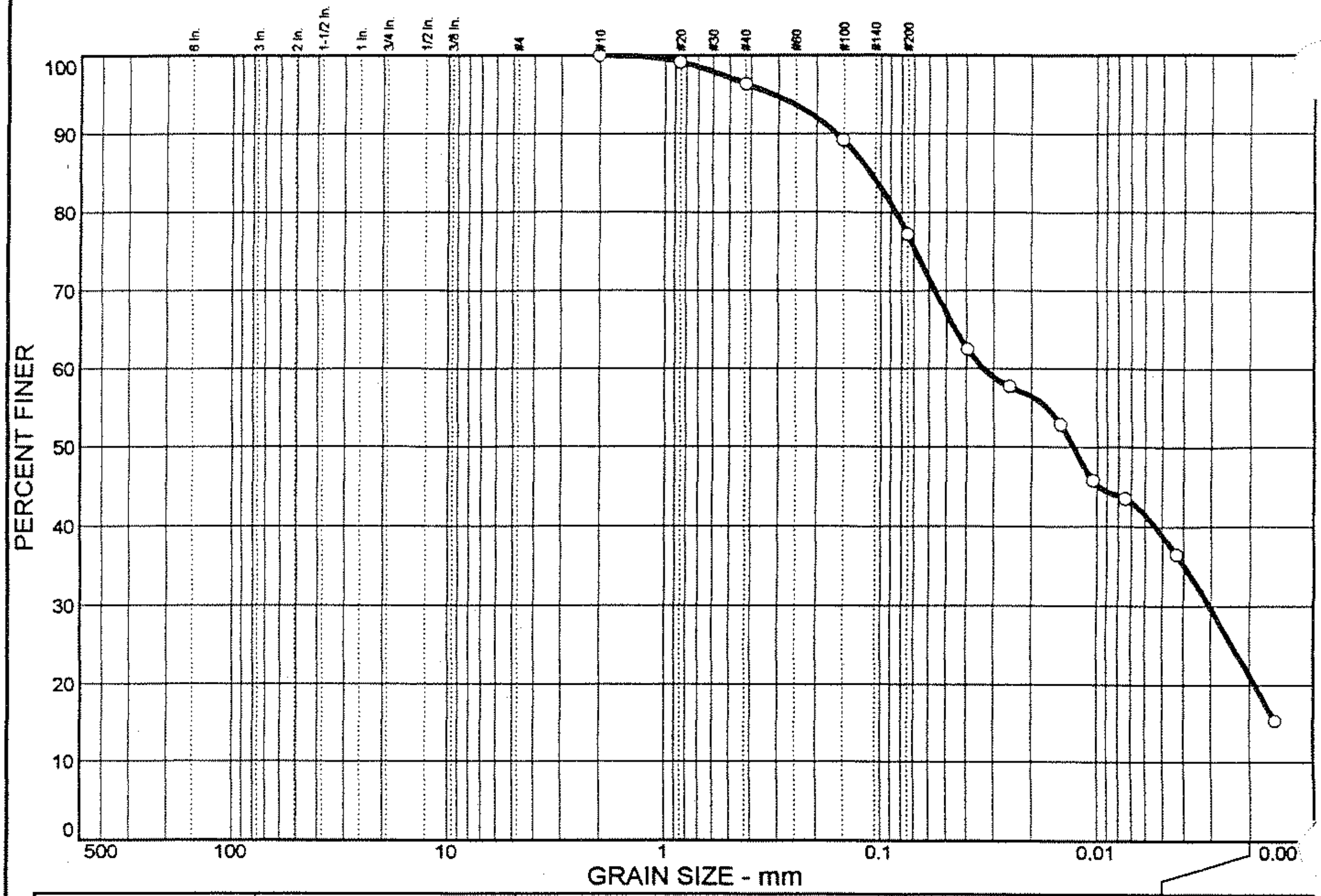
Sample No.: ST-1 **Source of Sample:** L-7374 **Date:** 10/6/99
Location: BORING:BH-6 **Elev./Depth:** 1-3'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	22.8	55.9	21.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.2		
#40	96.4		
#100	89.2		
#200	77.2		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 79 LL= 117 PI= 38

Coefficients

D_{85}= 0.111 D_{60}= 0.0333 D_{50}= 0.0128
D_{30}= 0.0030 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

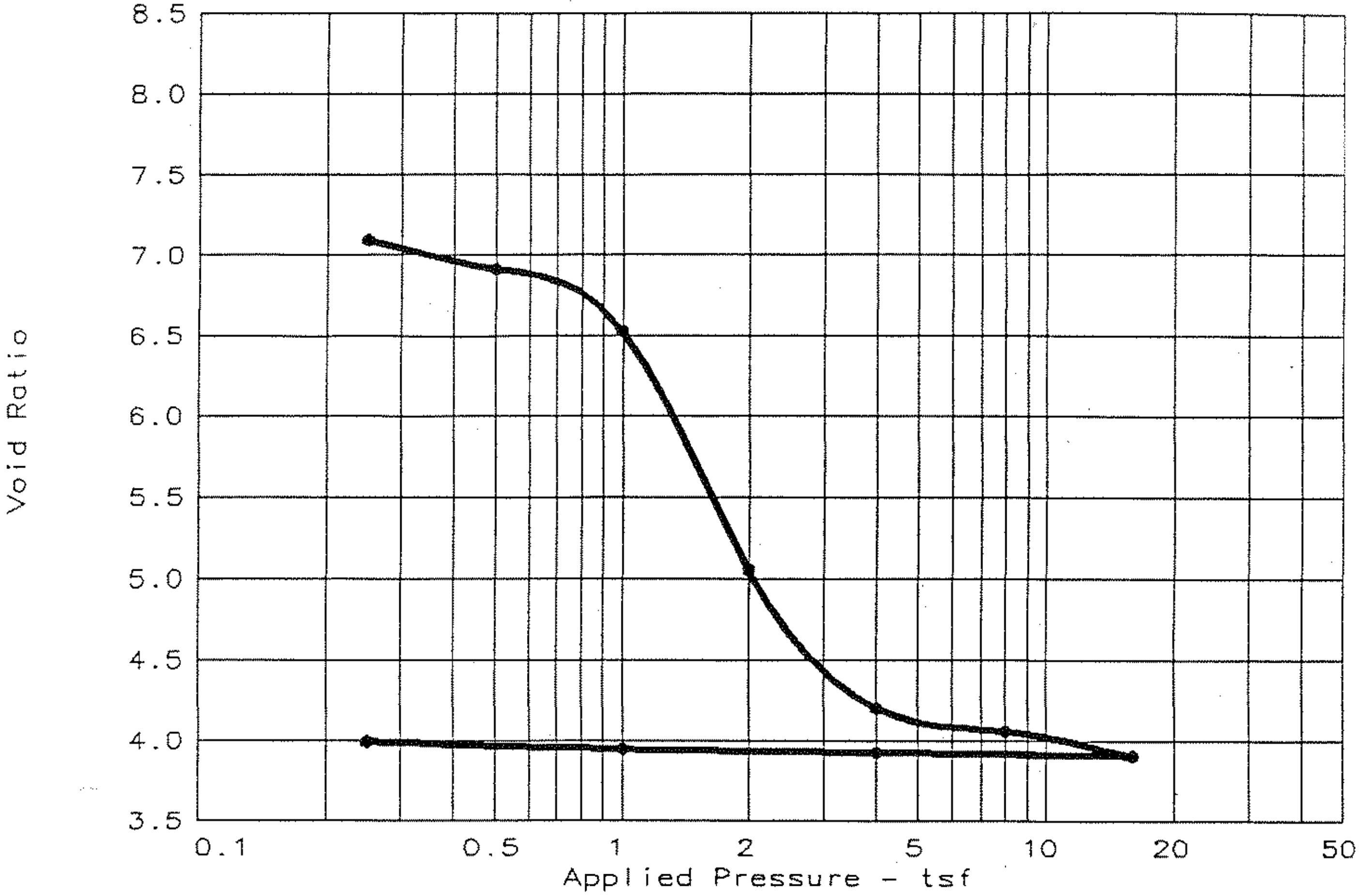
LAB NO. 7375

Sample No.: ST-1 **Source of Sample:** L-7375 **Date:** 10/6/99
Location: BORING:BH-7 **Elev./Depth:** 1-3'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)					
No.	Load	No Cv	Load	No Cv	Load
1	0.25	0.064			
2	0.50	0.029			
3	1.00	0.041			
4	2.00	0.009			
5	4.00	0.027			
6	8.00	0.023			
7	16.00	0.008			

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
101.1 %	309.8	17.9	117	78	2.380	7.2965

TEST RESULTS

MATERIAL DESCRIPTION

ELASTIC SILT W/SAND
(SLUDGE)

Class: MH

Remarks:

CLIENT:
CONESTOGA-ROVERS &
ASSOC. LTD

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7375
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/7/99

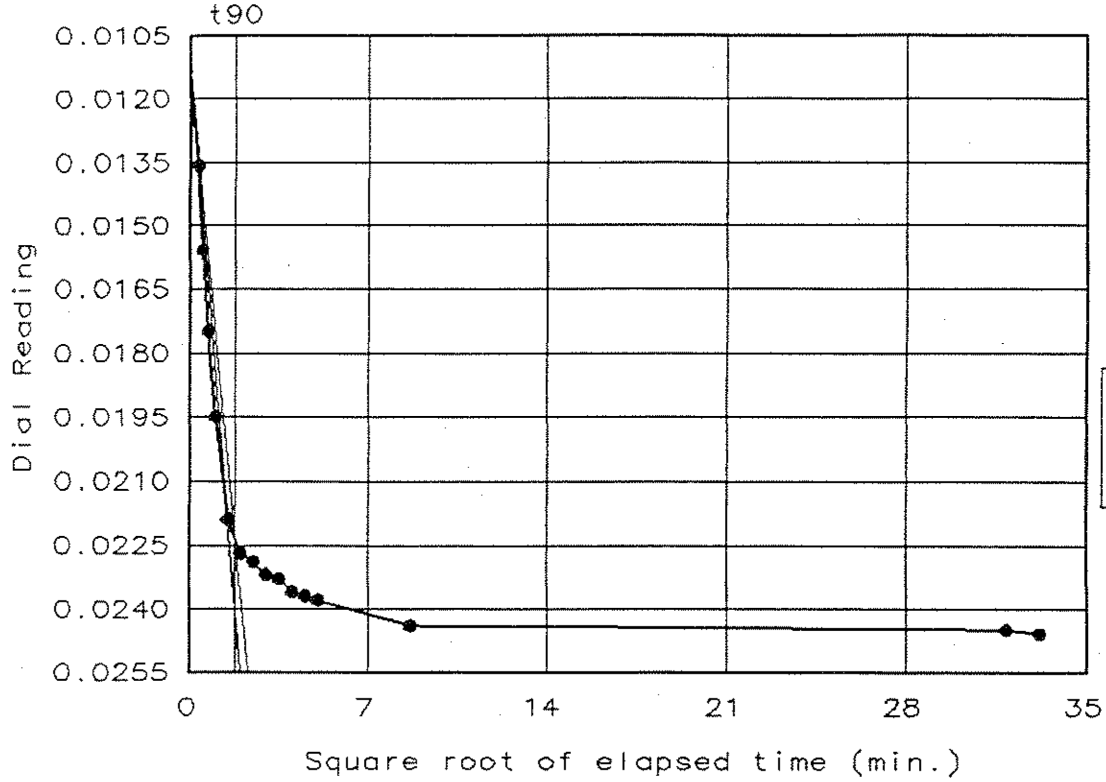
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No. ______

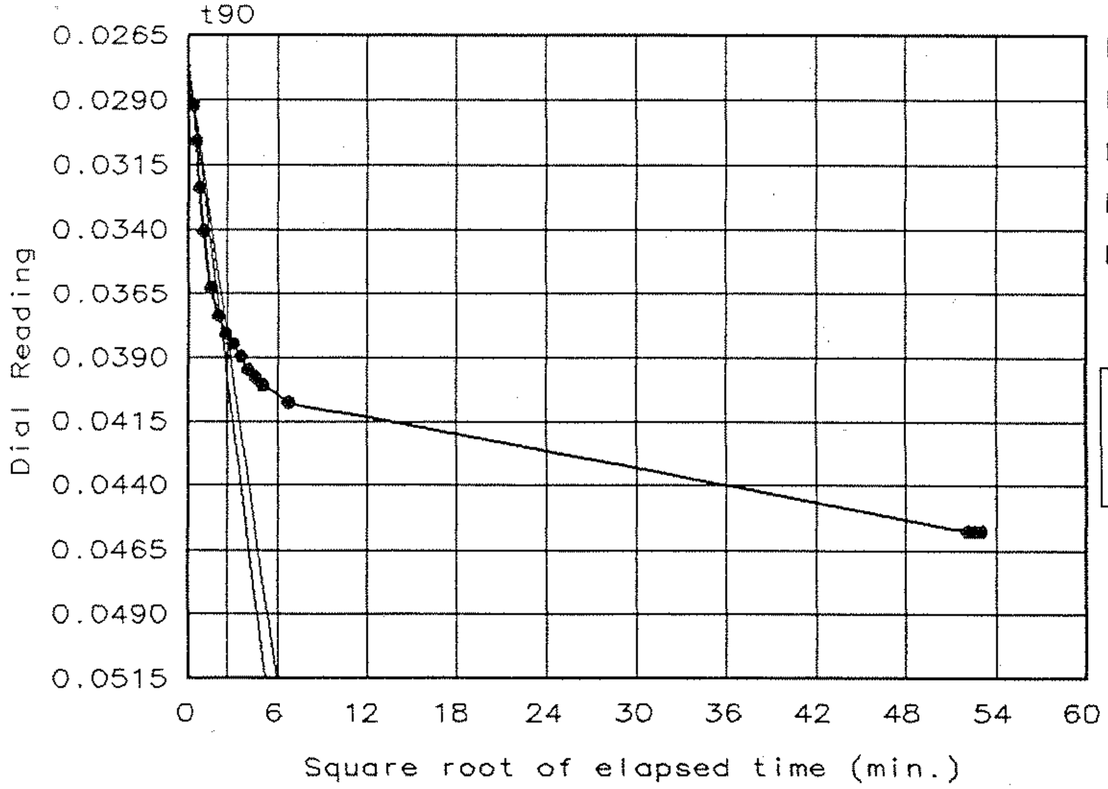
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7375
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/7/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0114
D_{90} = 0.0223
D_{100}= 0.0236
T_{90}= 3.16 min.

C_v @ T_{90} =
.064 in.^{2}/min.



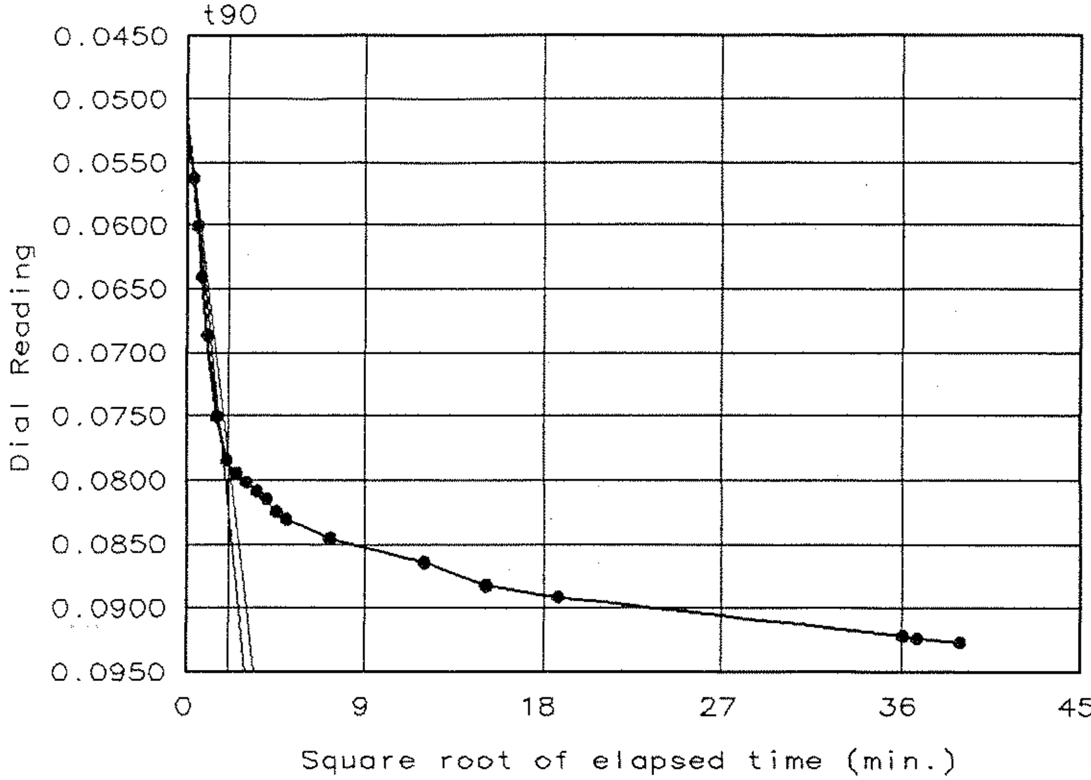
Load No.= 2
Load= 0.50 tsf
D_0 = 0.0277
D_{90} = 0.0382
D_{100}= 0.0393
T_{90}= 6.78 min.

C_v @ T_{90} =
.029 in.^{2}/min.

H.C. NUTTING COMPANY

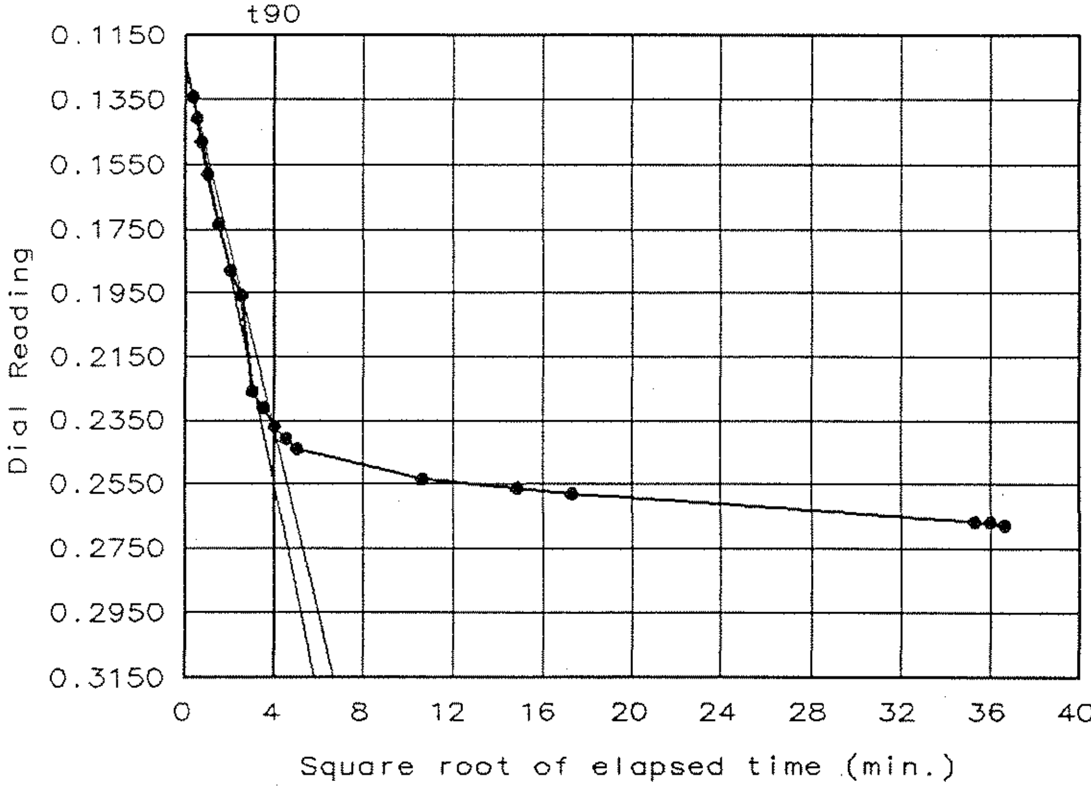
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7375
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/7/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.0516
D_{90} = 0.0787
D_{100}= 0.0817
T_{90}= 4.39 min.

C_v @ T_{90} =
.041 in.²/min.



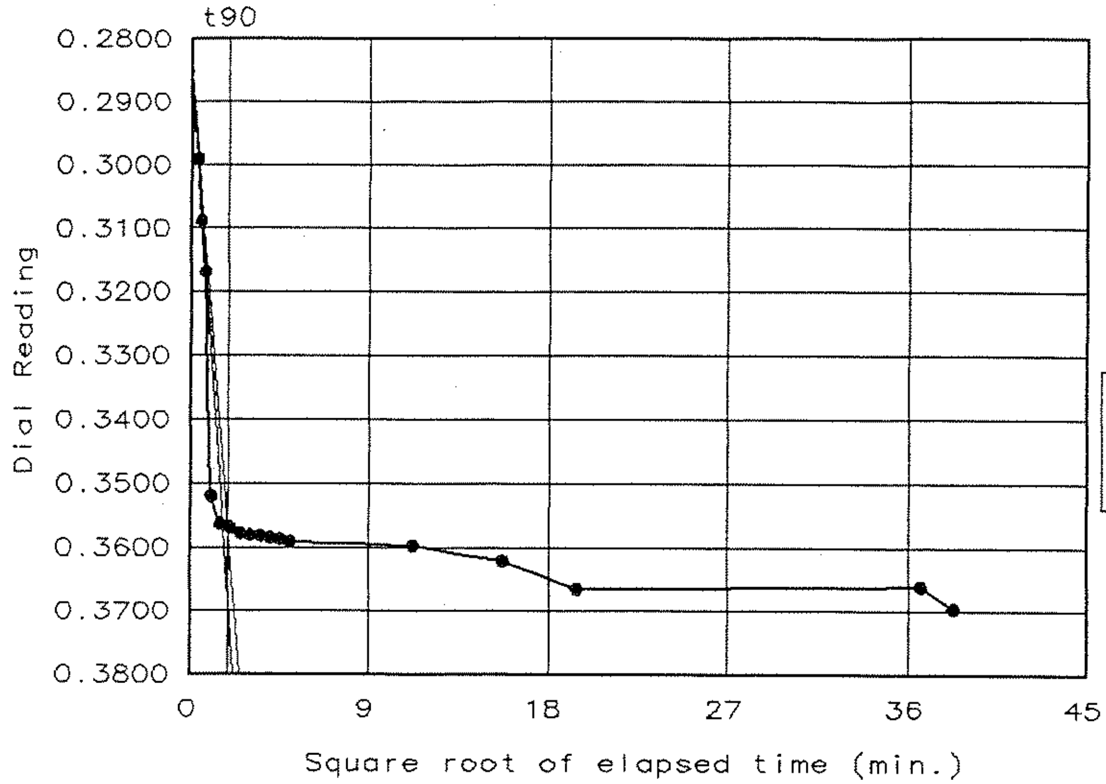
Load No.= 4
Load= 2.00 tsf
D_0 = 0.1239
D_{90} = 0.2365
D_{100}= 0.2490
T_{90}= 15.49 min.

C_v @ T_{90} =
.009 in.²/min.

H.C. NUTTING COMPANY

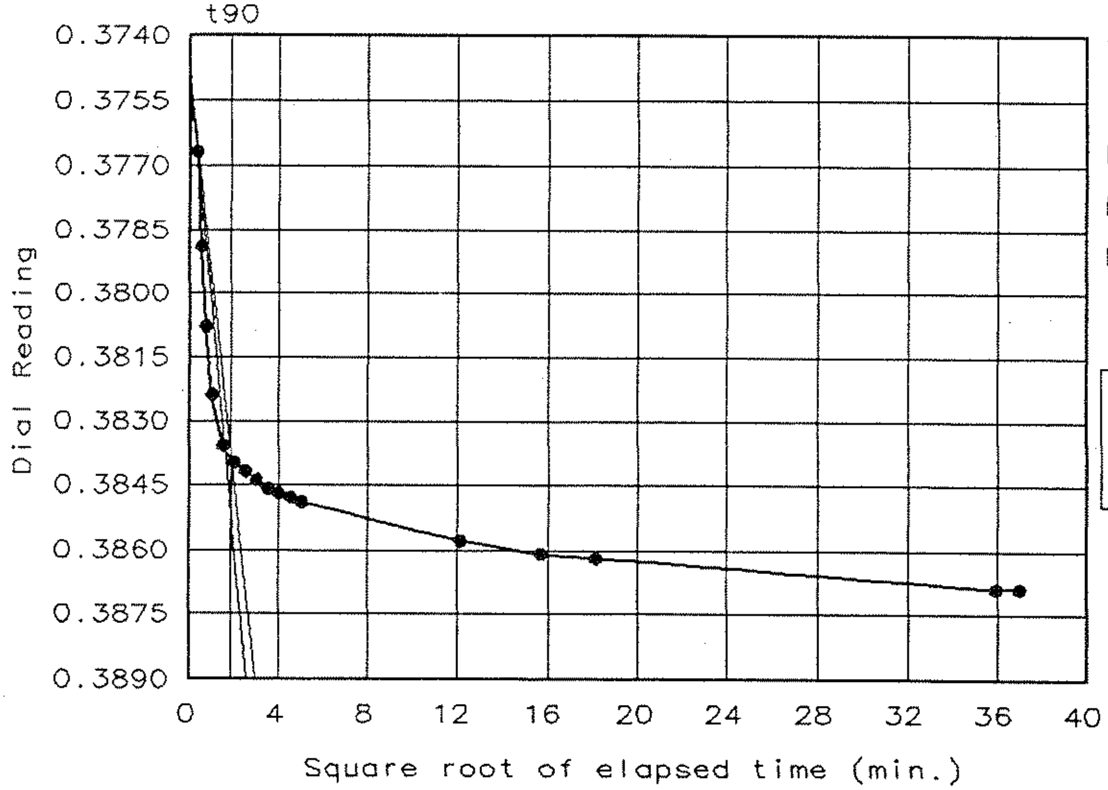
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7375
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/7/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.2852
D_{90} = 0.3569
D_{100}= 0.3648
T_{90}= 3.52 min.

C_v @ T_{90} =
.027 in.^{2}/min.

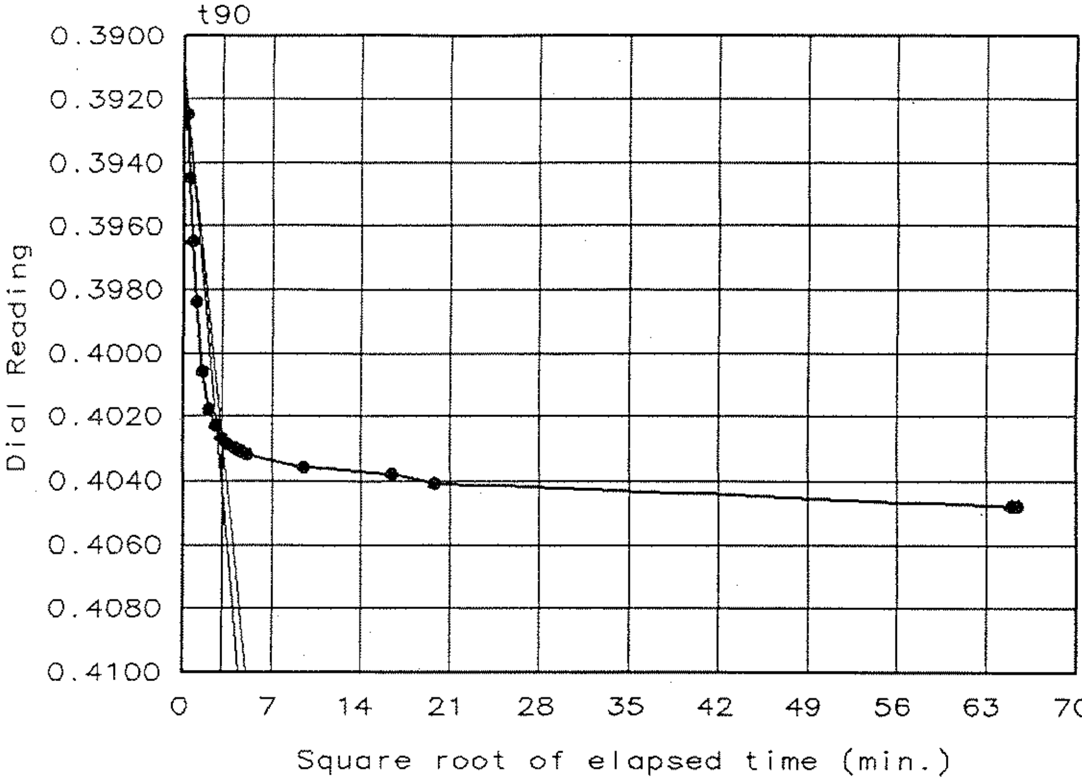


Load No.= 6
Load= 8.00 tsf
D_0 = 0.3750
D_{90} = 0.3839
D_{100}= 0.3849
T_{90}= 3.48 min.

C_v @ T_{90} =
.023 in.^{2}/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7375
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/7/99



Load No.= 7

Load= 16.00 tsf

D_0 = 0.3911

D_{90} = 0.4027

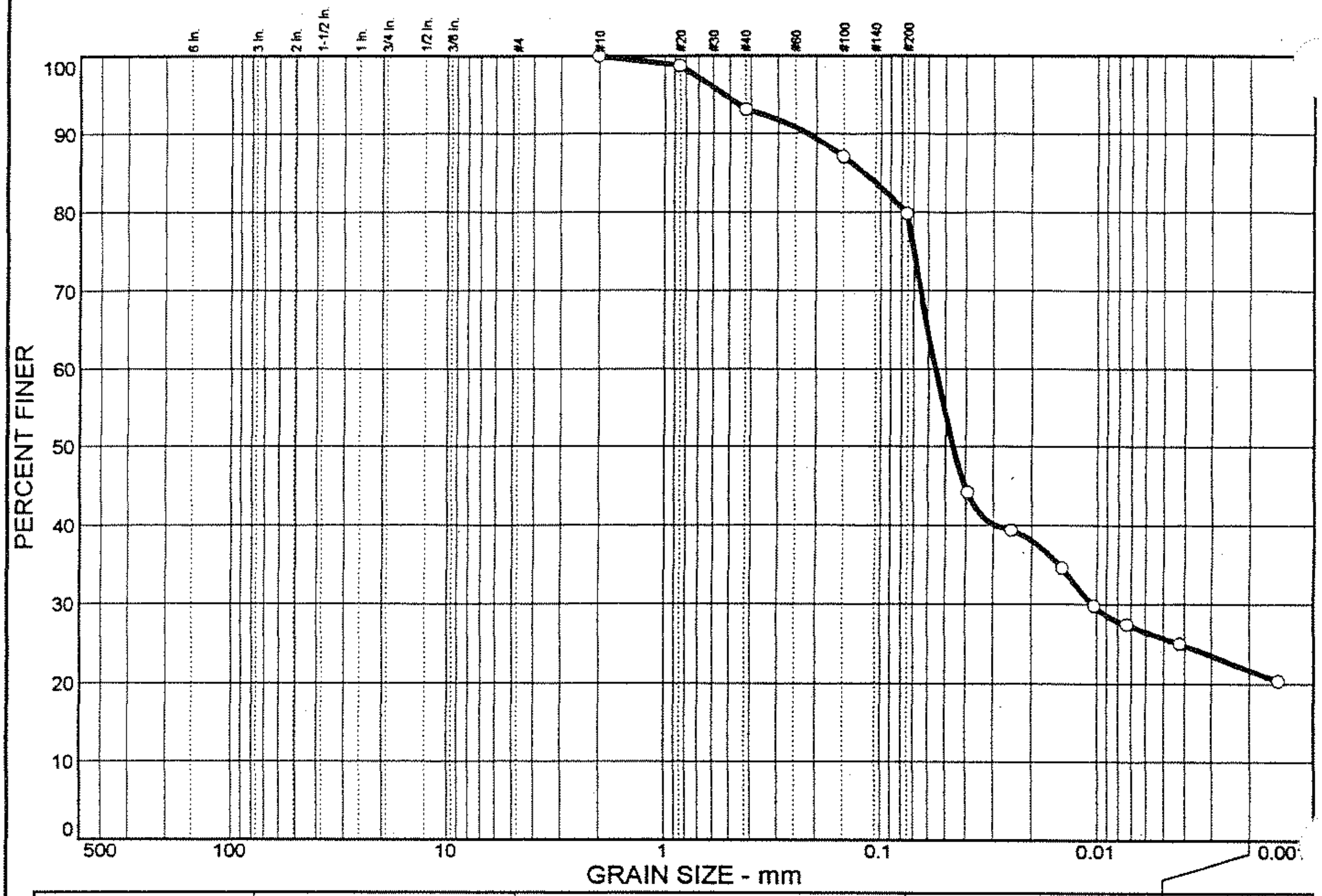
D_{100}= 0.4040

T_{90}= 9.26 min.

C_v @ T_{90} =
.008 in.^{2}/min.

H.C. NUTTING COMPANY

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	20.2	58.1	21.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.8		
#40	93.1		
#100	87.1		
#200	79.8		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 75 LL= 112 PI= 37

Coefficients

D_{85}= 0.120 D_{60}= 0.0553 D_{50}= 0.0458
D_{30}= 0.0105 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7376

Sample No.: ST-2 **Source of Sample:** L-7376 **Date:** 10/6/99
Location: BORING:BH-7 **Elev./Depth:** 5-7'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019 **Plate**

H.C. NUTTING COMPANY SOILS DEPARTMENT 103-0

CLASSIFICATION TESTS AND NATURAL MOISTURE CONTENT DETERMINATION Cincinnati, Oh

Client Conestoga Rovers		Boring No. BH-7	Sample No. ST
Project GmC Harrison Radiator		Depth 5-7'	Lab No. 7376

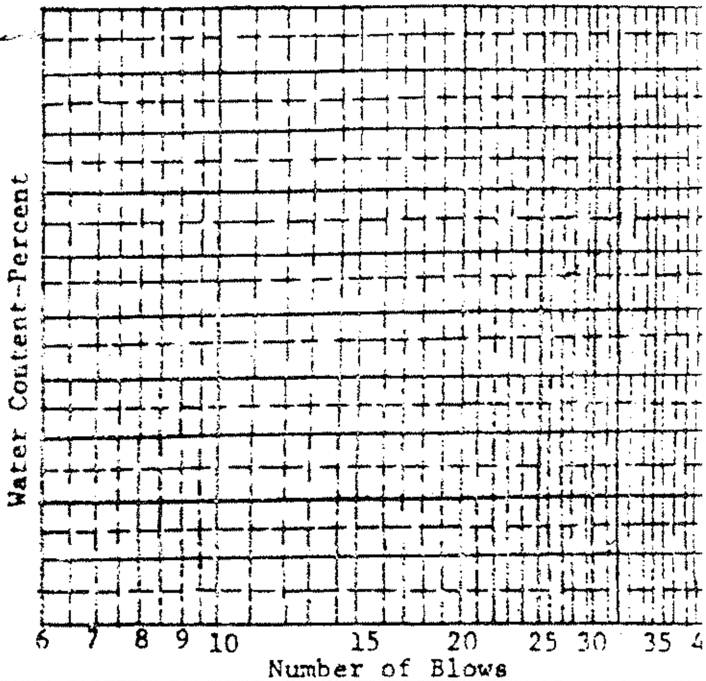
WATER CONTENT

Tare No.	Wet Wt. S+T	Dry Wt. S+T	Tare No.	Wt.of Solids	Wt.of Water	% Water

LIMITS

	Liquid			Plastic	
Tare No.	BA	BB	BC	BD	BE
Blows	33	19	10		
Wet Wt.S+T	27.02	27.61	28.22	19.45	19.63
Dry Wt.S+T	20.99	21.40	21.74	17.89	18.13
Wt. Water					
Wt. Tare	15.55	15.90	16.13	15.80	16.15
Wt. Dry Soil					
Water Content					
Dish No.					
Corrected&Average	☒	☒	112	75	☒
Plasticity Index				37	

Remarks:



SIEVE

Sieve No.	Open-ing MM	Wt. Ret.	% Ret.	Hygroscopic Moisture			Cum. % Pass.
2	50.8			Wet Wt.S+T	49.03		
1½	38.1			Dry Wt.S+T	45.90		
1	25.4			Wt. Tare	21.15		
3/4	19.1			Dry Wt.Sa.			
1/2	12.7			Wet Wt.Sa.			
3/8	9.52			Hygro M.F.			
4	4.76			Tare No.	AB-93		
10	2.00	—		Wt.Air Dry Sample			
				Color			
40	0.42			Hydrometer			
				Wt. Retained		%Pass	62.5
				20	0.3		
200	.074			40	1.4		
ap	☒	62.0	☒	100	1.5		
o an	☒		☒	200	1.8		
otal	☒		☒	270		☒	
actor	☒		☒	Total		☒	

HYDROMETER

Dry Wt.(W) of soil =

DIAMETER $D = K\sqrt{\frac{L}{T}}$

Percent FINER $P = \frac{Ra(100)}{W}$

For (L) see Table #1
For (K) see Table #2
For (R) seet Table #3
For S.G. = 2.75, (a) = 0.98

For Doodling

FOAMED BADLY

2470

Elap. Time T	Hyd. Read	Eff. Length L	Temp. °C	K	Diam. D	Corr. Hyd. Read.	Fir Tot Sar
1							
2	16.0						
5	15.0		18.5				
15	14.0						
30	13.0		18.6				
60	12.5		18.6				
180	12.0		18.6				
1440	10.5		21.1				

+4	+10	+40	+200	+.005	-.005	L.L.	P.I.	G.I.	Classification	Tested by Computed by

GRAIN SIZE DISTRIBUTION TEST DATA

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project Number: 11294.019

Sample Data

Source: L-7376
Sample No.: ST-2
Elev. or Depth: 5-7' **Sample Length (in./cm.):**
Location: BORING:BH-7
Description: Elastic silt with sand (SLUDGE)
Date: 10/6/99 **PL:** 75 **LL:** 112 **PI:** 37
USCS Classification: MH **AASHTO Classification:**
Testing Remarks: LAB NO. 7376

Mechanical Analysis Data

Initial
Dry sample and tare= 62.50
Tare = 0.00
Dry sample weight = 62.50
Sample split on number 10 sieve
Split sample data:
Sample and tare = 45.90 Tare = 21.15 Sample weight = 24.75

Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 10	0.00	0.00	100.0
# 20	0.30	0.00	98.8
# 40	1.40	0.00	93.1
# 100	1.50	0.00	87.1
# 200	1.80	0.00	79.8

Hydrometer Analysis Data

Separation sieve is #10
Percent -#10 based upon complete sample= 100.0
Weight of hydrometer sample: 24.75
Hygroscopic moisture correction:
Moist weight & tare = 49.03
Dry weight & tare = 45.90
Tare = 21.15
Hygroscopic moisture= 12.7 %
Calculated biased weight= 21.97
Automatic temperature correction
Composite correction at 20 deg C = -6.5

Meniscus correction only= 0
Specific gravity of solids= 2.42
Specific gravity correction factor= 1.061
Hydrometer type: 152H
Effective depth L= 16.294964 - 0.164 x Rm

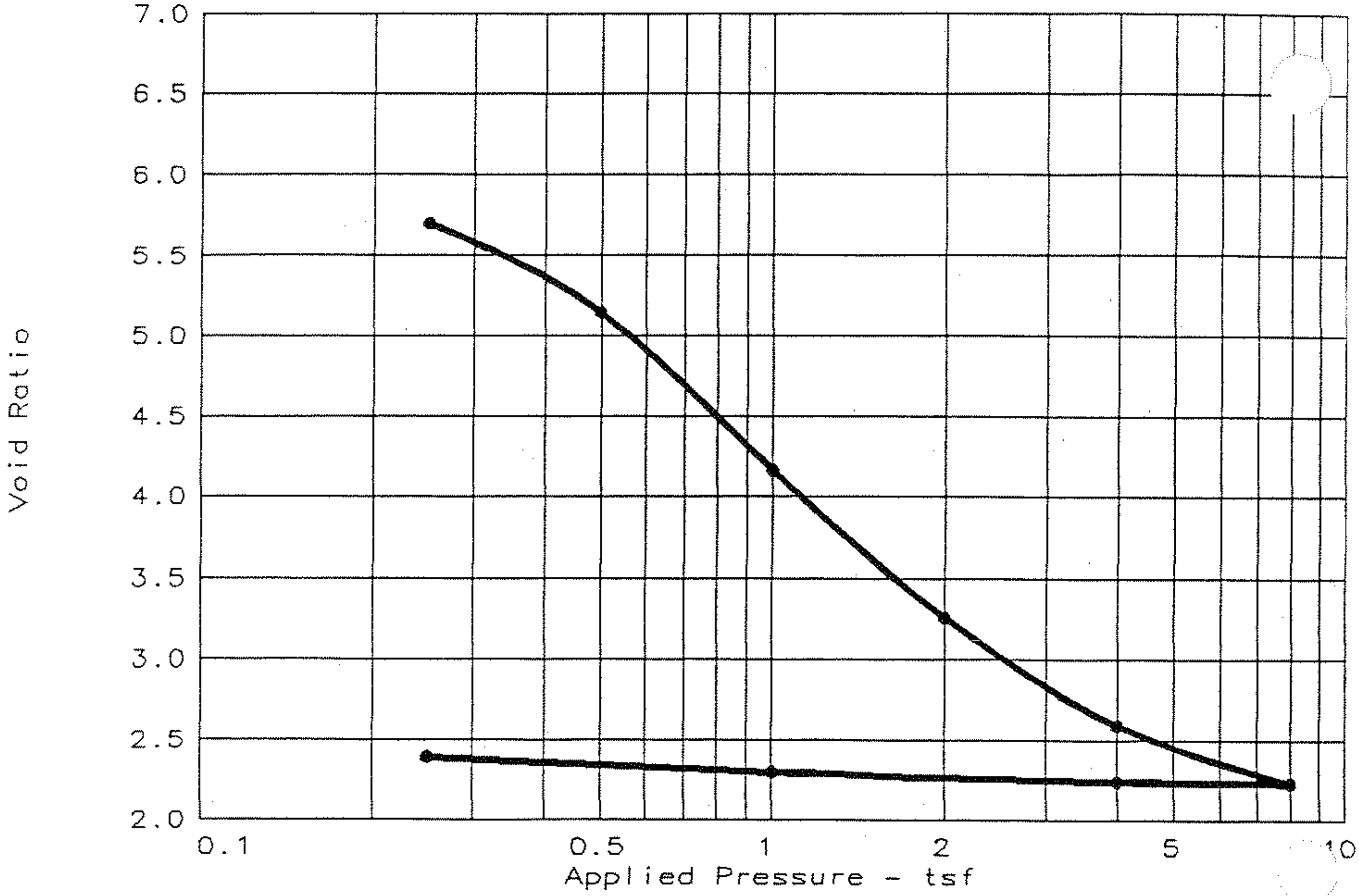
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.00	18.5	16.0	9.1	0.0150	16.0	13.7	0.0392	44.2
5.00	18.5	15.0	8.1	0.0150	15.0	13.8	0.0249	39.4
15.00	18.5	14.0	7.1	0.0150	14.0	14.0	0.0145	34.5
30.00	18.6	13.0	6.2	0.0150	13.0	14.2	0.0103	29.8
60.00	18.6	12.5	5.7	0.0150	12.5	14.2	0.0073	27.4
180.00	18.6	12.0	5.2	0.0150	12.0	14.3	0.0042	25.0
1440.00	21.1	10.5	4.2	0.0145	10.5	14.6	0.0015	20.3

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL = % SAND = 20.2
% SILT = 58.1 % CLAY = 21.7

D_{85}= 0.12 D_{60}= 0.06 D_{50}= 0.05
D_{30}= 0.01

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)					
No.	Load	No Cv	Load	No Cv	Load
1	0.25	0.062			
2	0.50	0.042			
3	1.00	0.019			
4	2.00	0.019			
5	4.00	0.007			
6	8.00	0.028			

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
97.3 %	240.9	21.6	112	37	2.420	5.9895

TEST RESULTS

MATERIAL DESCRIPTION

ELASTIC SILT W/SAND
(SLUDGE)

Class: MH

Remarks:

CLIENT:
CONESTOGA-ROVERS
& ASSOC. LTD

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7376
SAMPLE:ST-2 DEPTH:5-7'
Date: 10/7/99

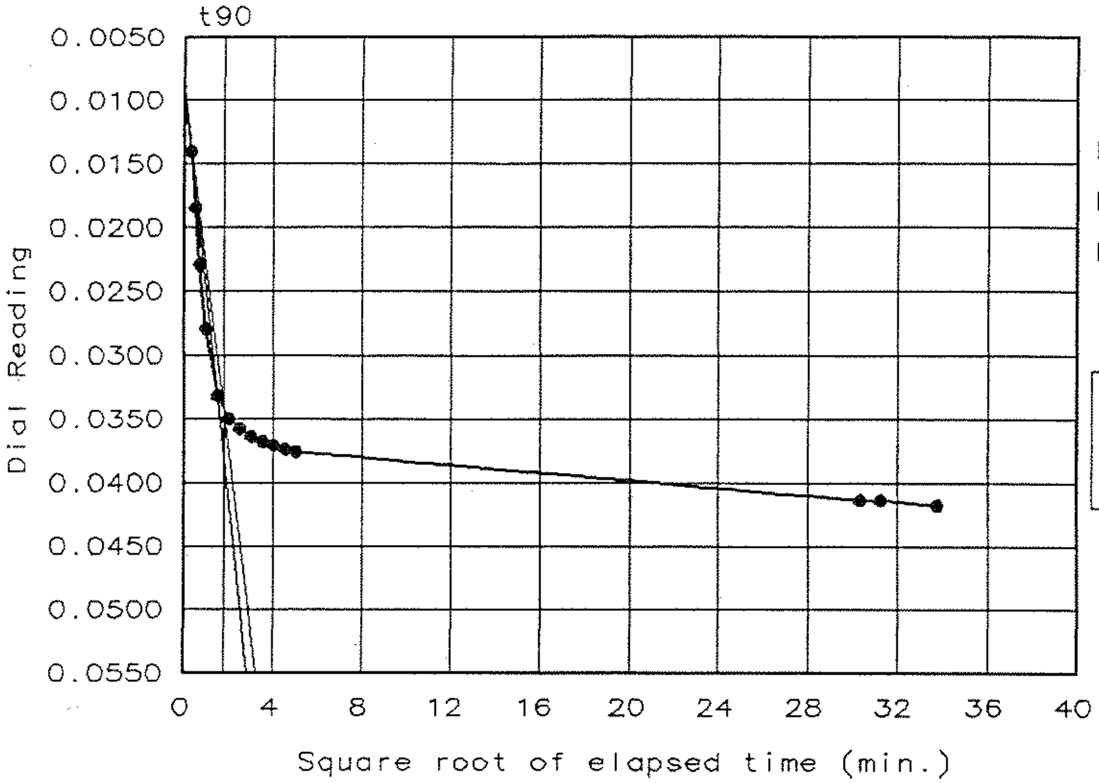
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

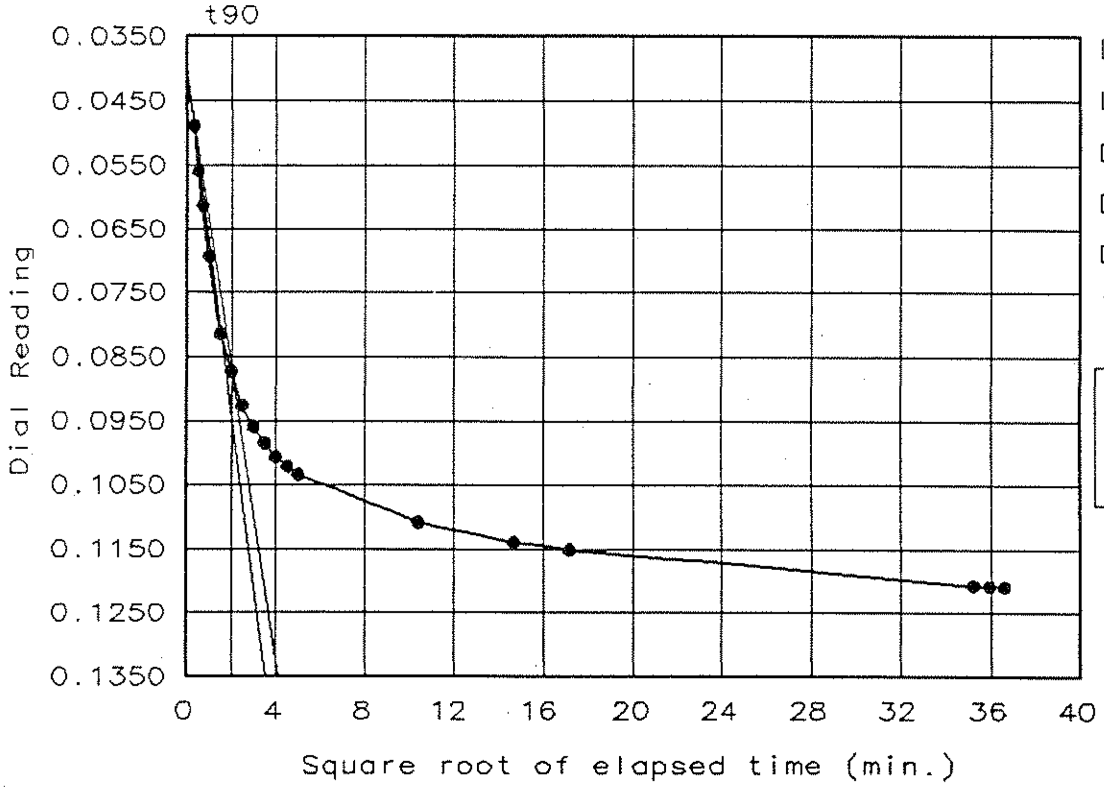
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7376
SAMPLE:ST-2 DEPTH:5-7'
Date: 10/7/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0090
D_{90} = 0.0342
D_{100}= 0.0370
T_{90}= 3.19 min.

C_v @ T_{90} =
.062 in.^{2}/min.



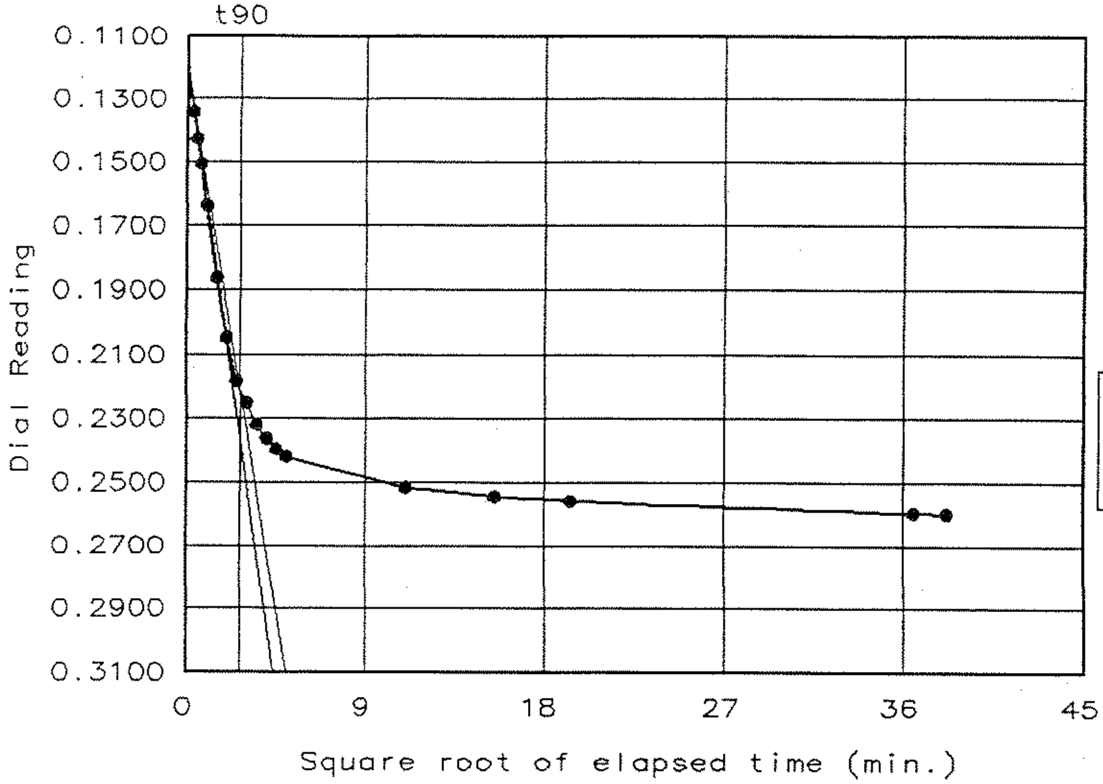
Load No.= 2
Load= 0.50 tsf
D_0 = 0.0406
D_{90} = 0.0878
D_{100}= 0.0931
T_{90}= 4.17 min.

C_v @ T_{90} =
.042 in.^{2}/min.

H.C. NUTTING COMPANY

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7376
SAMPLE:ST-2 DEPTH:5-7'
Date: 10/7/99



Load No.= 3

Load= 1.00 tsf

D_0 = 0.1208

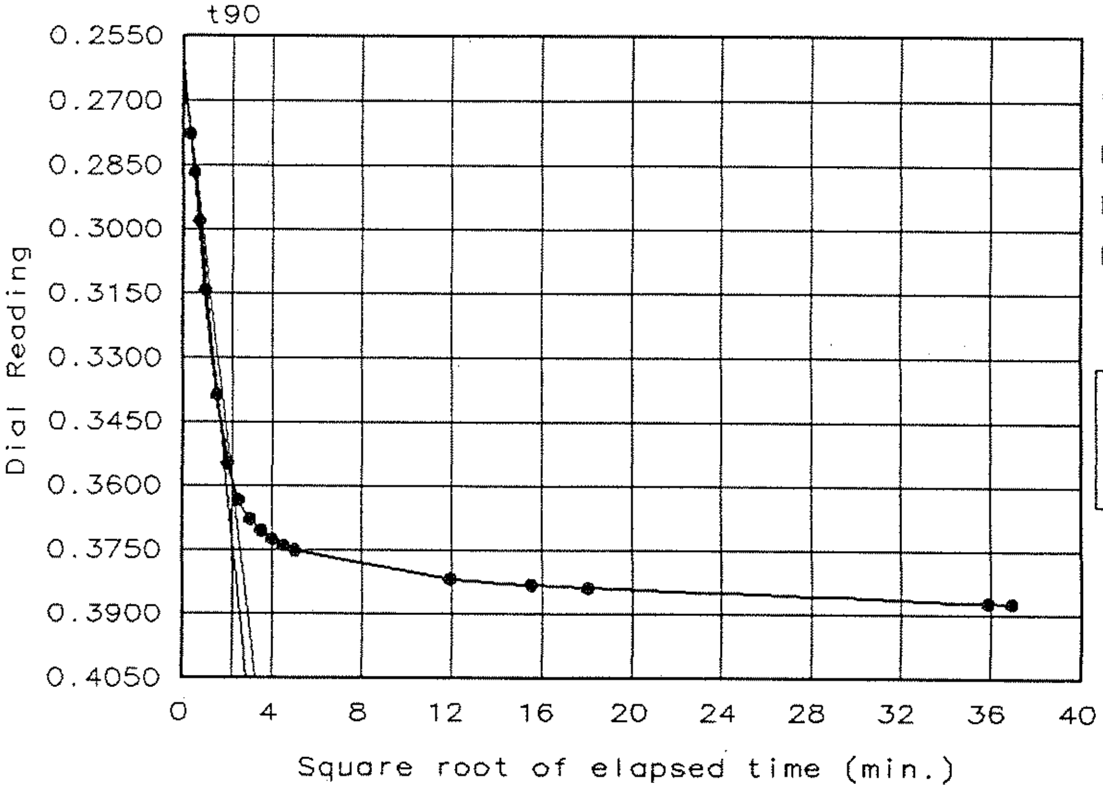
D_{90} = 0.2206

D_{100}= 0.2317

T_{90}= 7.03 min.

C_v @ T_{90} =

.019 in.^{2}/min.



Load No.= 4

Load= 2.00 tsf

D_0 = 0.2617

D_{90} = 0.3584

D_{100}= 0.3691

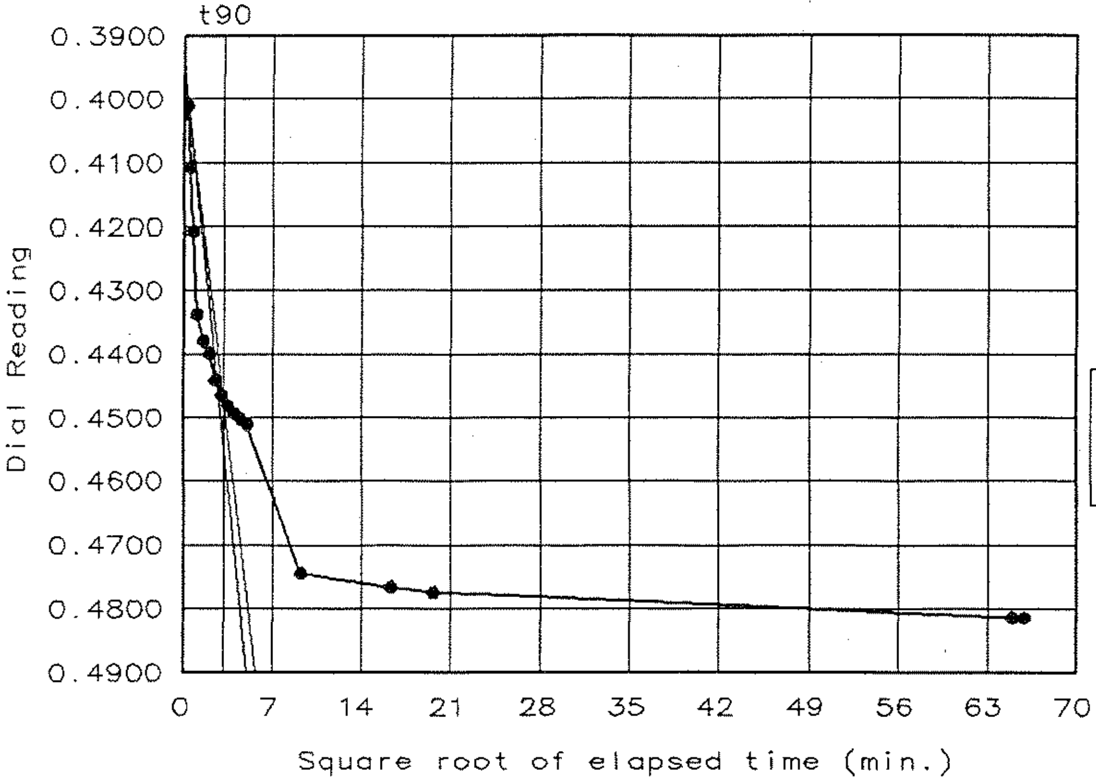
T_{90}= 4.85 min.

C_v @ T_{90} =

.019 in.^{2}/min.

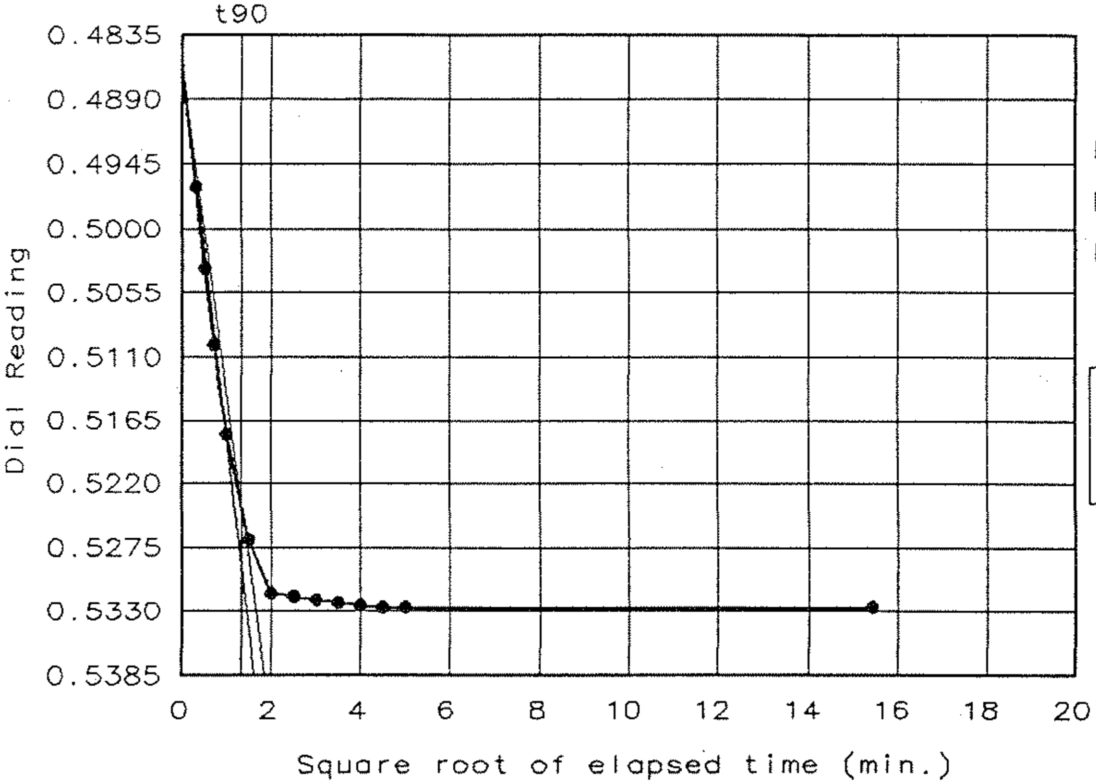
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-7 LAB NO. 7376
SAMPLE:ST-2 DEPTH:5-7'
Date: 10/7/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.3951
D_{90} = 0.4469
D_{100}= 0.4527
T_{90}= 9.65 min.

C_v @ T_{90} =
.007 in.^{2}/min.



Load No.= 6
Load= 8.00 tsf
D_0 = 0.4862
D_{90} = 0.5237
D_{100}= 0.5279
T_{90}= 1.75 min.

C_v @ T_{90} =
.028 in.^{2}/min.

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.1	23.5	64.2	12.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	99.9		
#10	99.5		
#20	97.6		
#40	92.7		
#100	82.6		
#200	76.4		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 61 LL= 93 PI= 32

Coefficients

D_{85}= 0.194 D_{60}= 0.0632 D_{50}= 0.0564

D_{30}= 0.0265 D_{15}= 0.0033 D_{10}=

C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7377

Sample No.: ST-1 **Source of Sample:** L-7377 **Date:** 10/6/99

Location: BORING:BH-8 **Elev./Depth:** 1-3'

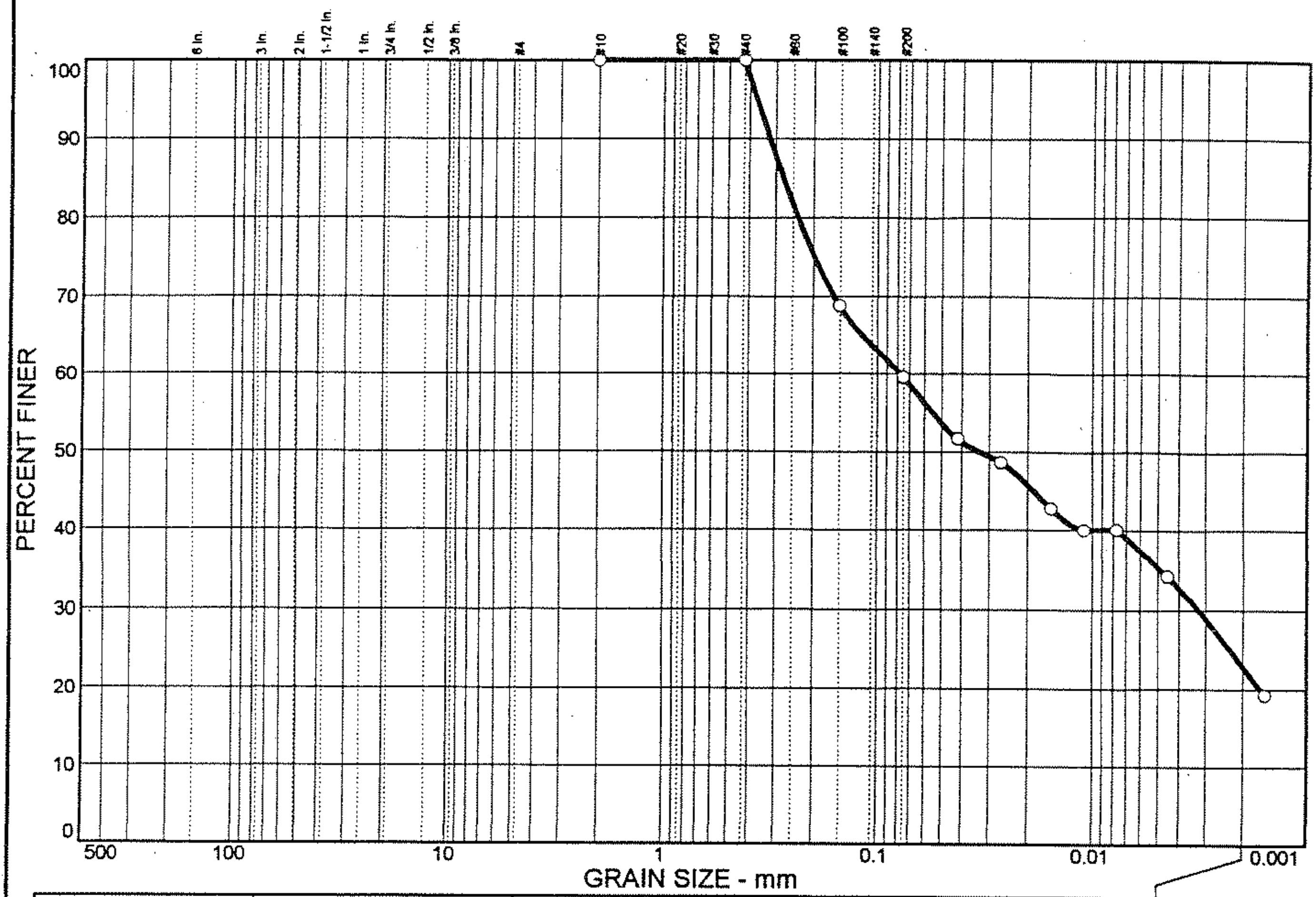
H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD

Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	40.4	36.7	22.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#40	100.0		
#100	68.8		
#200	59.6		

* (no specification provided)

Soil Description

Sandy elastic silt (SLUDGE)

Atterberg Limits

PL= 88
LL= 129
PI= 41

Coefficients

D_{85}= 0.275
D_{60}= 0.0773
D_{50}= 0.0329
D_{30}= 0.0033
D_{15}=
D_{10}=
C_u=
C_c=

Classification

USCS= MH
AASHTO=

Remarks

LAB NO. 7378

Sample No.: ST-1
Location: BORING:BH-9
Source of Sample: L-7378
Date: 10/6/99
Elev./Depth: 0-2'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019
Plate

Grain Size Distribution Test Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	19.3	76.3	4.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.4		
#40	91.8		
#100	85.4		
#200	80.7		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 36 LL= 61 PI= 25

Coefficients

D_{85}= 0.141 D_{60}= 0.0591 D_{50}= 0.0518

D_{30}= 0.0222 D_{15}= 0.0096 D_{10}= 0.0081

C_u= 7.34 C_c= 1.03

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7379

Sample No.: ST-1 **Source of Sample:** L-7379 **Date:** 10/6/99

Location: BORING:BH-10 **Elev./Depth:** 1-3'

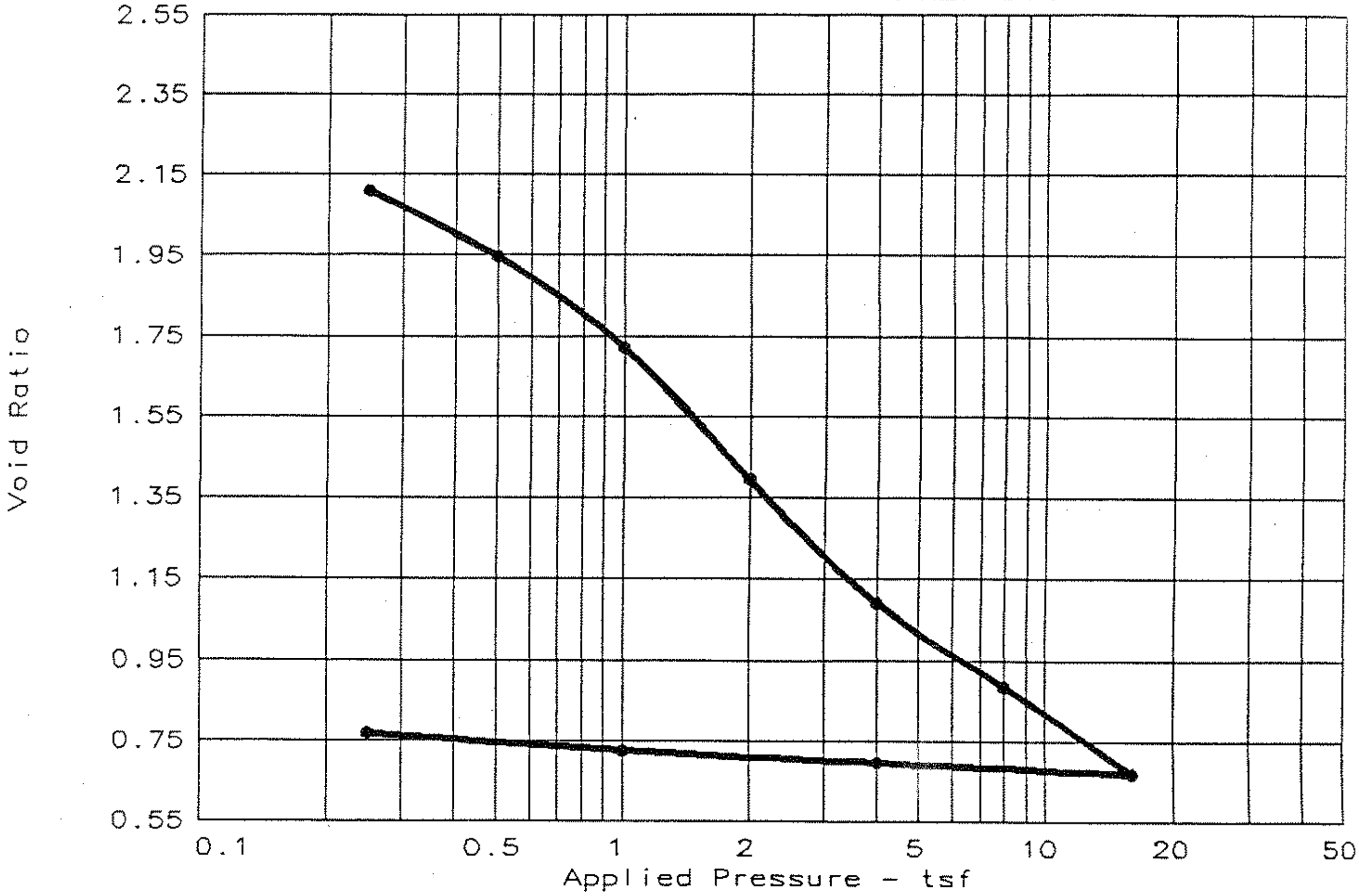
H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD

Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)						
No.	Load	No Cv	Load	No Cv	Load	
1	0.25	0.061				
2	0.50	0.041				
3	1.00	0.031				
4	2.00	0.028				
5	4.00	0.010				
6	8.00	0.014				
7	16.00	0.011				

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
95.1 %	95.2	43.0	61	25	2.230	2.2340

TEST RESULTS

MATERIAL DESCRIPTION

ELASTIC SILT W/SAND
(SLUDGE)

Class: MH

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7379
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/8/99

Remarks:

CLIENT:
CONESTOGA-ROVERS
& ASSOC LTD

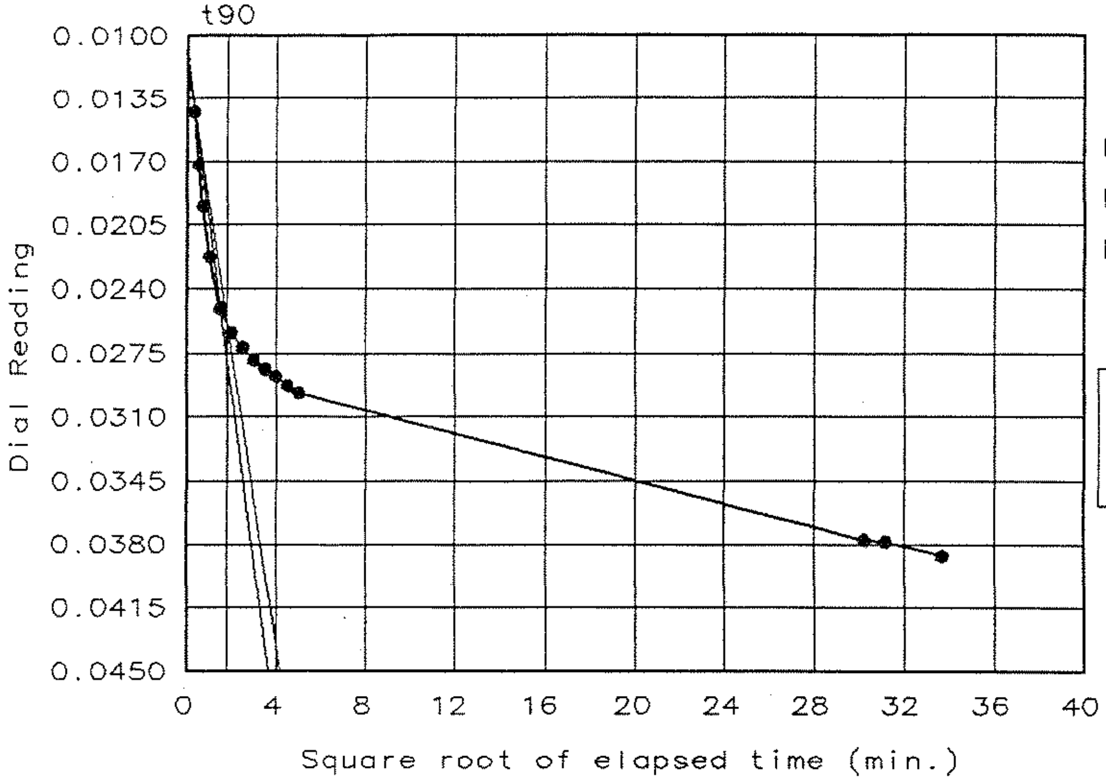
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

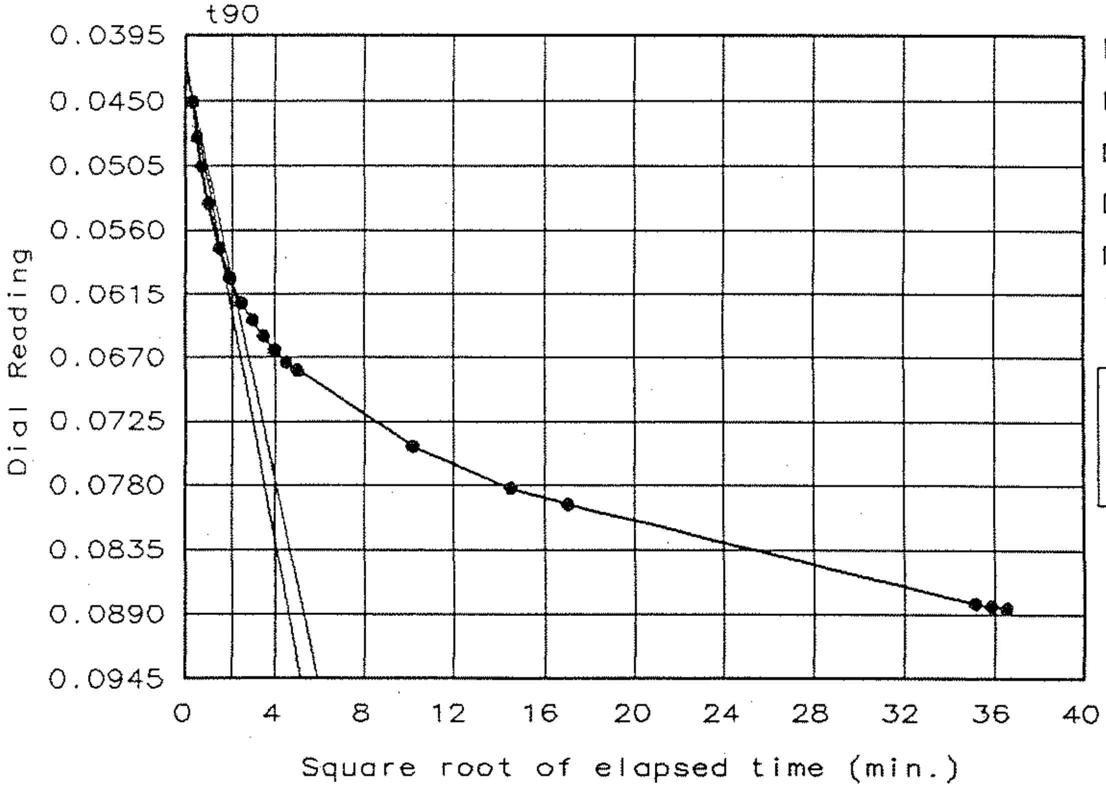
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7379
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/8/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0114
D_{90} = 0.0259
D_{100}= 0.0275
T_{90}= 3.28 min.

C_v @ T_{90} =
.061 in.^{2}/min.

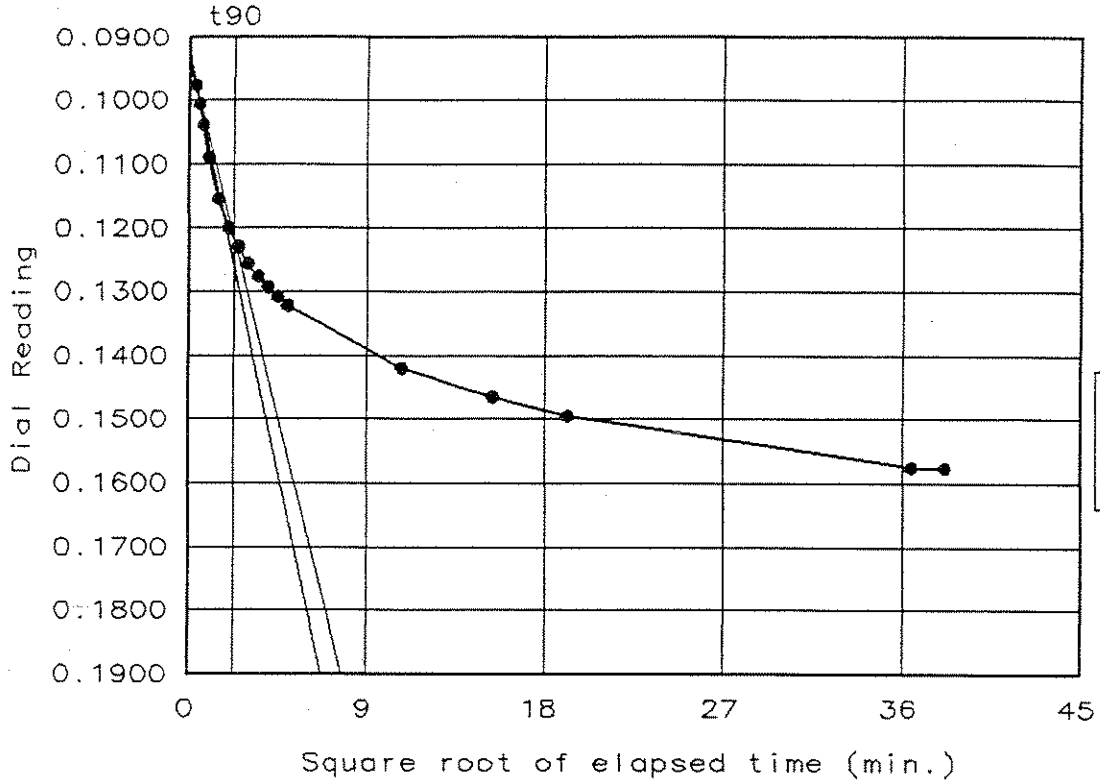


Load No.= 2
Load= 0.50 tsf
D_0 = 0.0418
D_{90} = 0.0606
D_{100}= 0.0627
T_{90}= 4.41 min.

C_v @ T_{90} =
.041 in.^{2}/min.

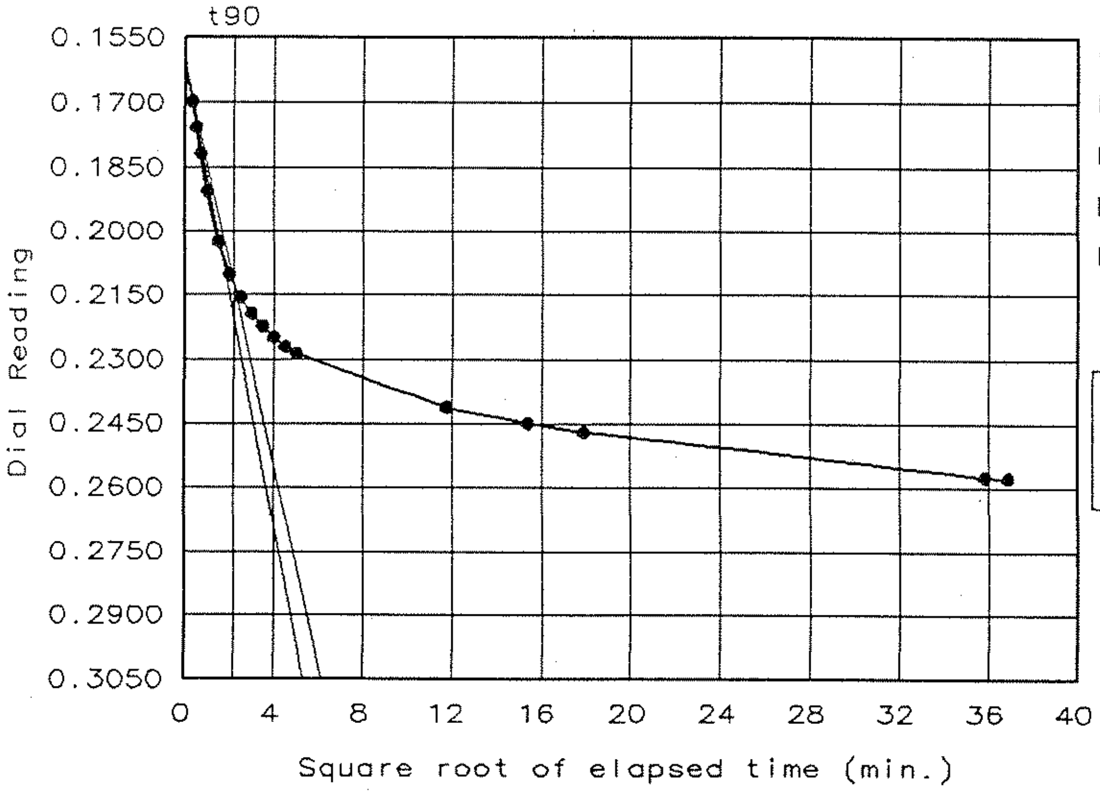
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7379
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/8/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.0932
D_{90} = 0.1216
D_{100}= 0.1247
T_{90}= 5.12 min.

C_v @ T_{90} =
.031 in.²/min.

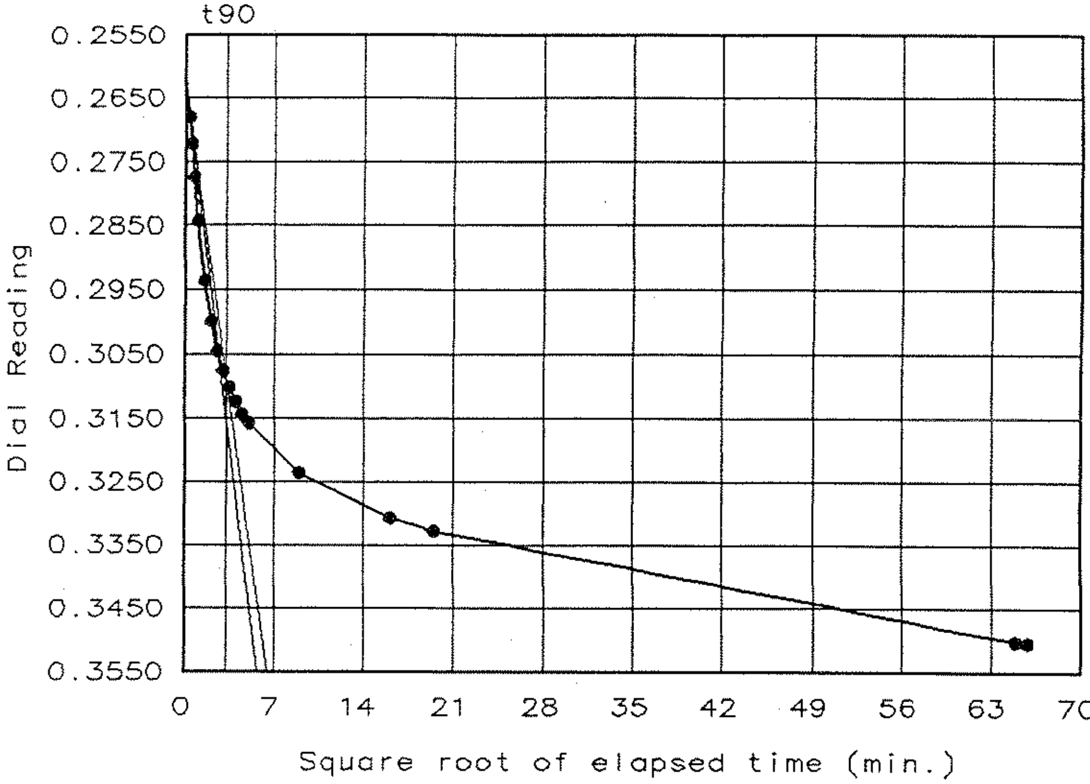


Load No.= 4
Load= 2.00 tsf
D_0 = 0.1612
D_{90} = 0.2123
D_{100}= 0.2179
T_{90}= 4.70 min.

C_v @ T_{90} =
.028 in.²/min.

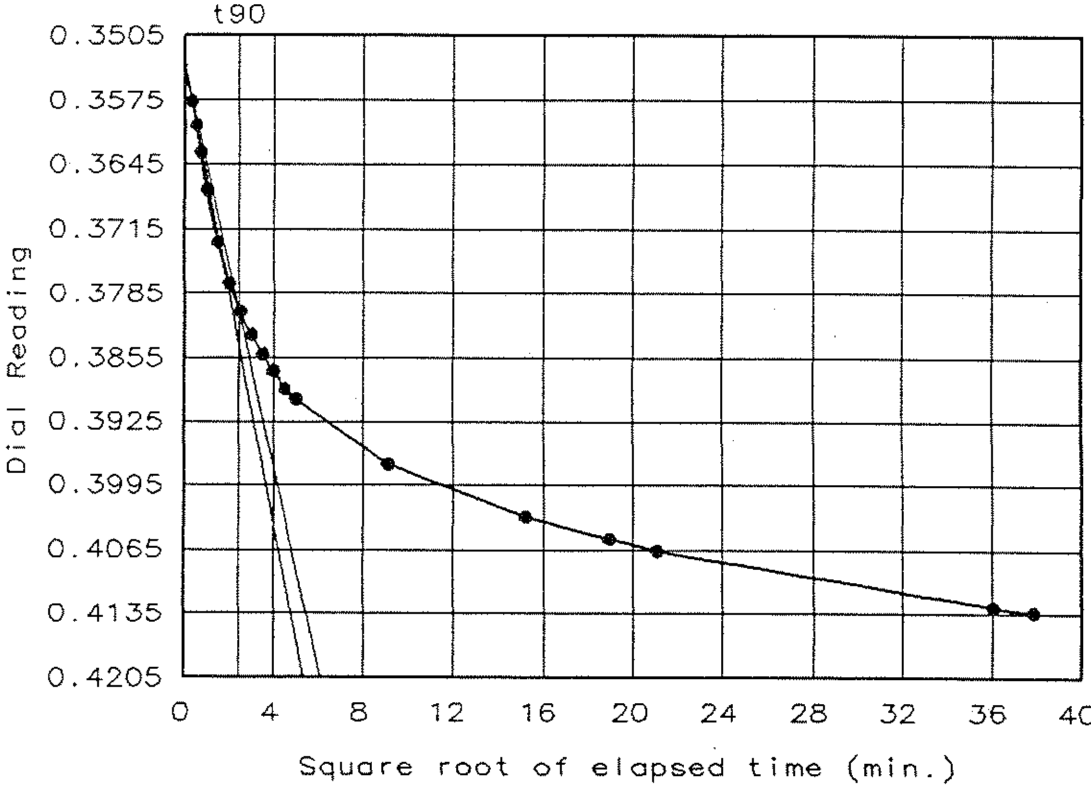
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7379
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/8/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.2629
D_{90} = 0.3088
D_{100}= 0.3139
T_{90}= 10.42 min.

C_v @ T_{90} =
.010 in.^{2}/min.



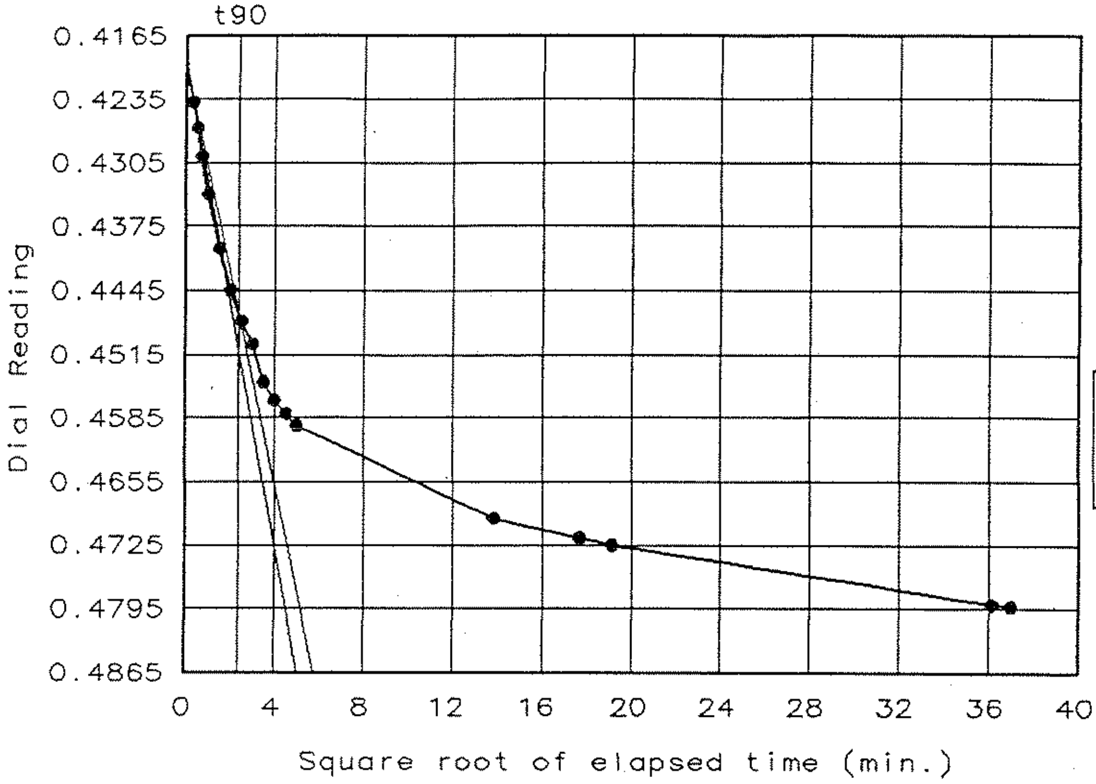
Load No.= 6
Load= 8.00 tsf
D_0 = 0.3537
D_{90} = 0.3800
D_{100}= 0.3829
T_{90}= 5.75 min.

C_v @ T_{90} =
.014 in.^{2}/min.

H.C. NUTTING COMPANY

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7379
SAMPLE:ST-1 DEPTH:1-3'
Date: 10/8/99

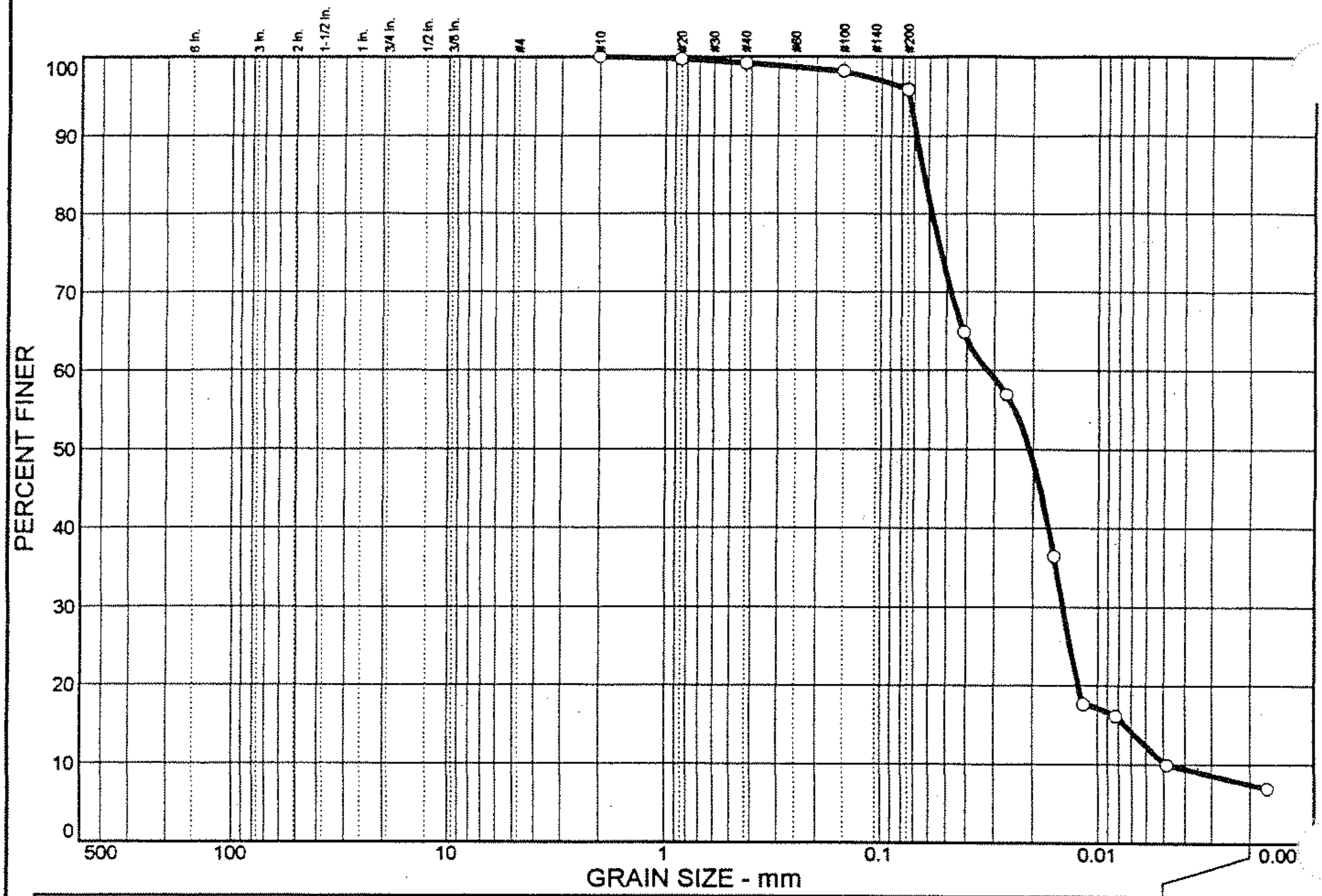


Load No.= 7
Load= 16.00 tsf
D_0 = 0.4197
D_{90} = 0.4469
D_{100}= 0.4499
T_{90}= 5.52 min.

C_v @ T_{90} =
.011 in.^{2}/min.

H.C. NUTTING COMPANY

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	4.1	88.5	7.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.7		
#40	99.2		
#100	98.2		
#200	95.9		

* (no specification provided)

Soil Description

Elastic silt (SLUDGE)

Atterberg Limits

PL= 39 LL= 68 PI= 29

Coefficients

D_{85}= 0.0628 D_{60}= 0.0322 D_{50}= 0.0208
D_{30}= 0.0145 D_{15}= 0.0075 D_{10}= 0.0048
C_u= 6.65 C_c= 1.34

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7380

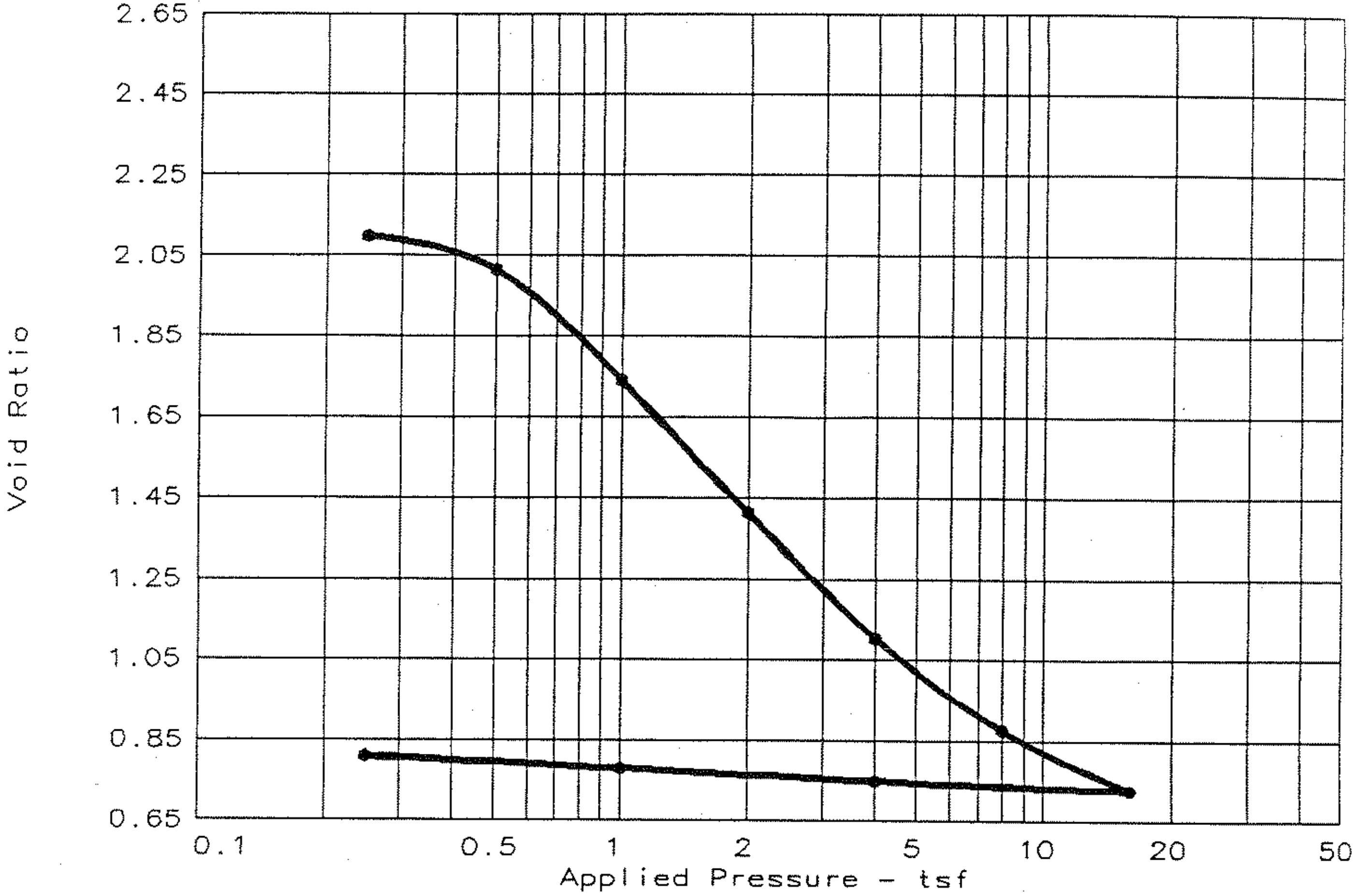
Sample No.: ST-2 **Source of Sample:** L-7380 **Date:** 10/6/99
Location: BORING:BH-10 **Elev./Depth:** 3.5-5.5'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)						
No.	Load	No Cv	Load	No Cv	Load	
1	0.25	0.066				
2	0.50	0.027				
3	1.00	0.029				
4	2.00	0.016				
5	4.00	0.016				
6	8.00	0.011				
7	16.00	0.006				

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
96.3 %	98.4	41.9	68	29	2.130	2.1770

TEST RESULTS	MATERIAL DESCRIPTION
	ELASTIC SILT (SLUDGE) Class: MH

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7380
SAMPLE:ST-2 DEPTH:3.5-5.5'
Date: 10/8/99

Remarks:
CLIENT:
CONESTOGA-ROVERS &
ASSOC. LTD

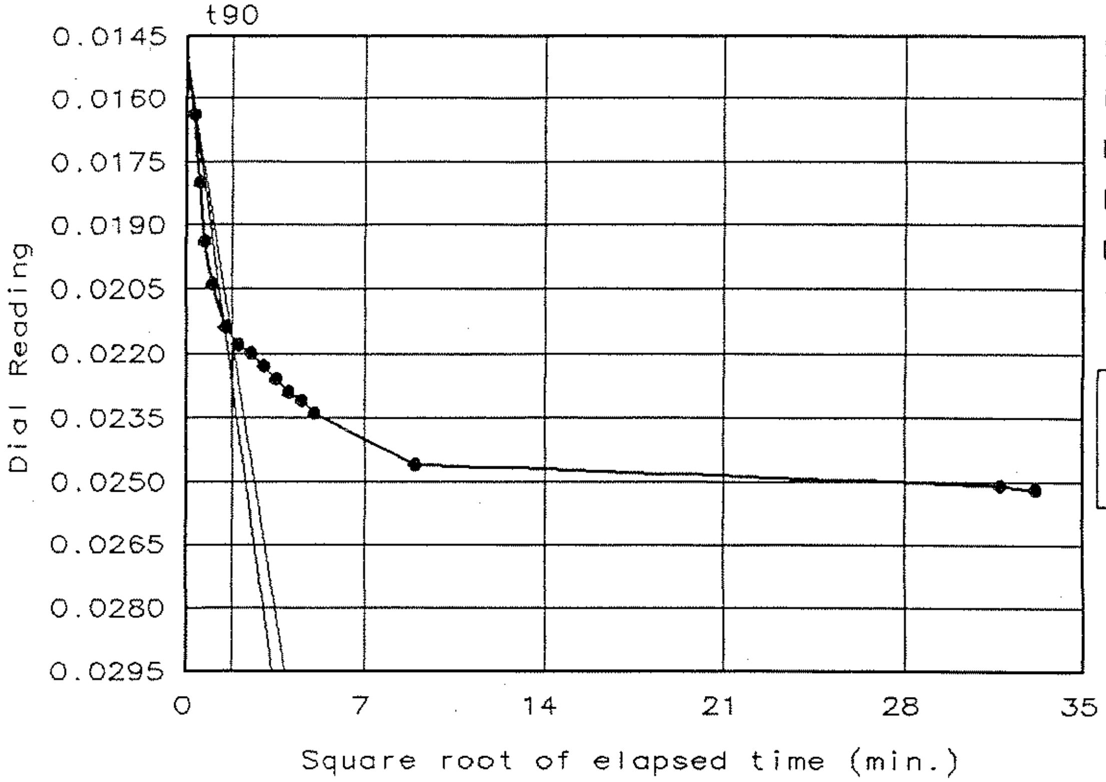
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

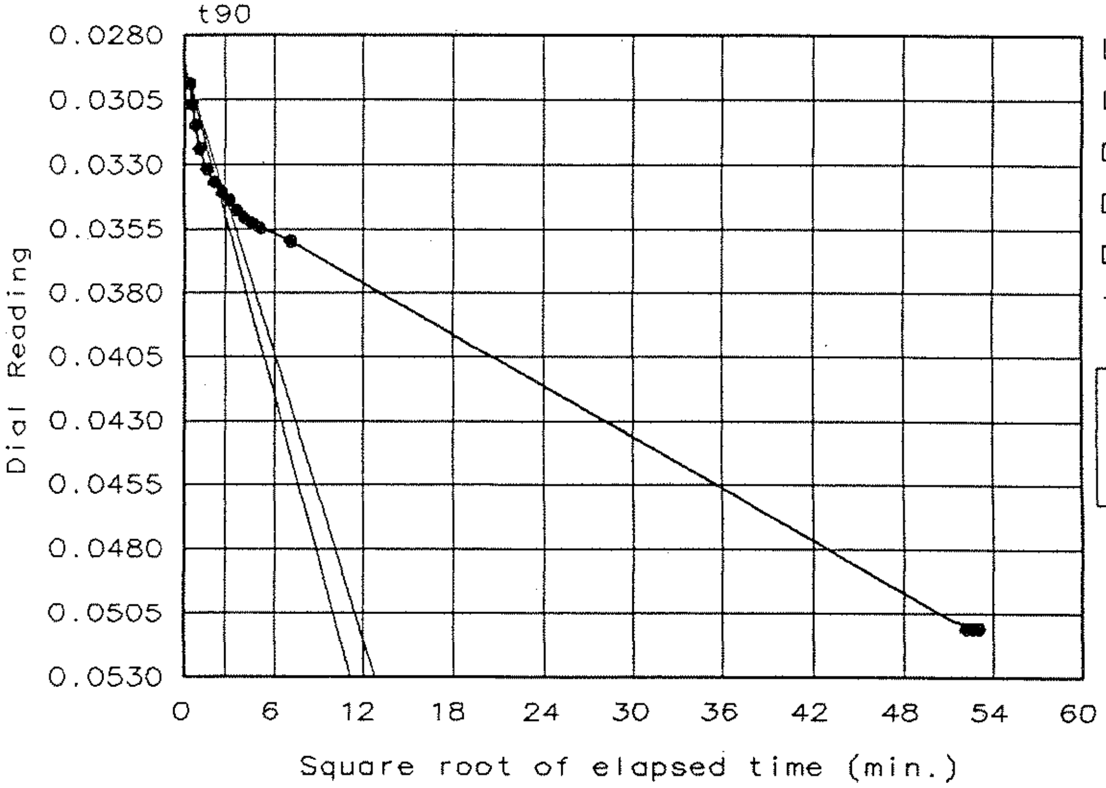
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7380
SAMPLE:ST-2 DEPTH:3.5-5.5'
Date: 10/8/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0150
D_{90} = 0.0216
D_{100}= 0.0223
T_{90}= 3.05 min.

C_v @ T_{90} =
.066 in.^{2}/min.



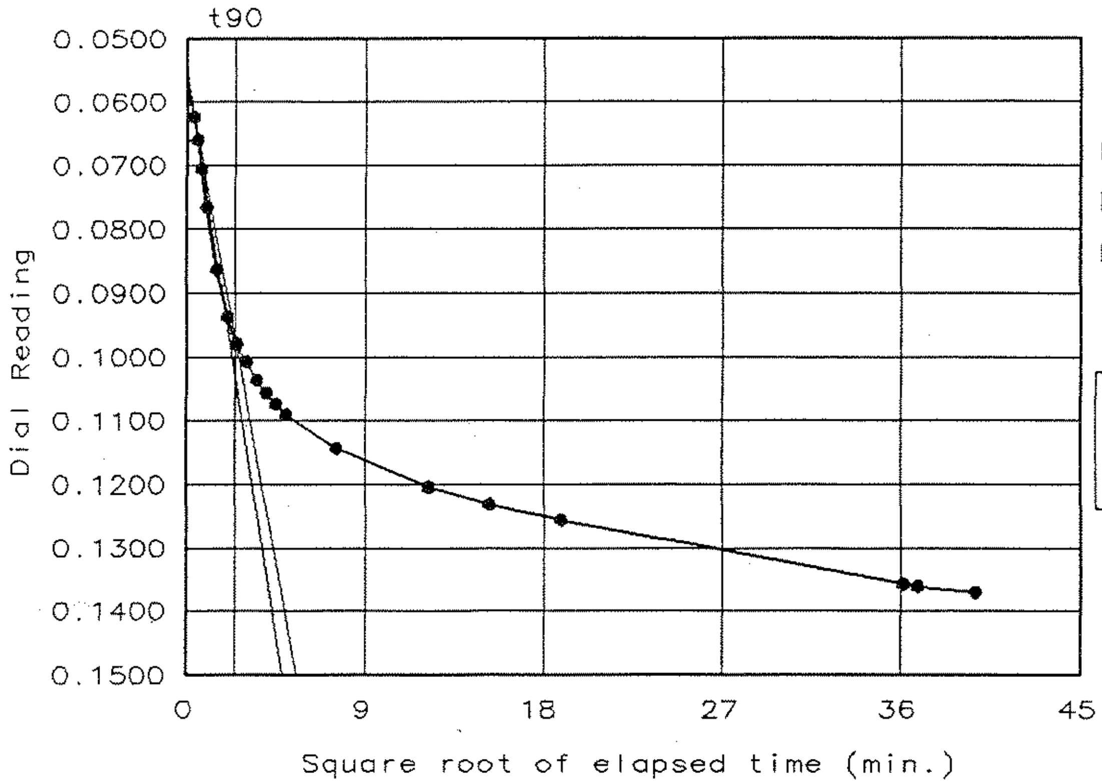
Load No.= 2
Load= 0.50 tsf
D_0 = 0.0292
D_{90} = 0.0342
D_{100}= 0.0348
T_{90}= 7.11 min.

C_v @ T_{90} =
.027 in.^{2}/min.

H.C. NUTTING COMPANY

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7380
SAMPLE:ST-2 DEPTH:3.5-5.5'
Date: 10/8/99



Load No.= 3

Load= 1.00 tsf

D_0 = 0.0563

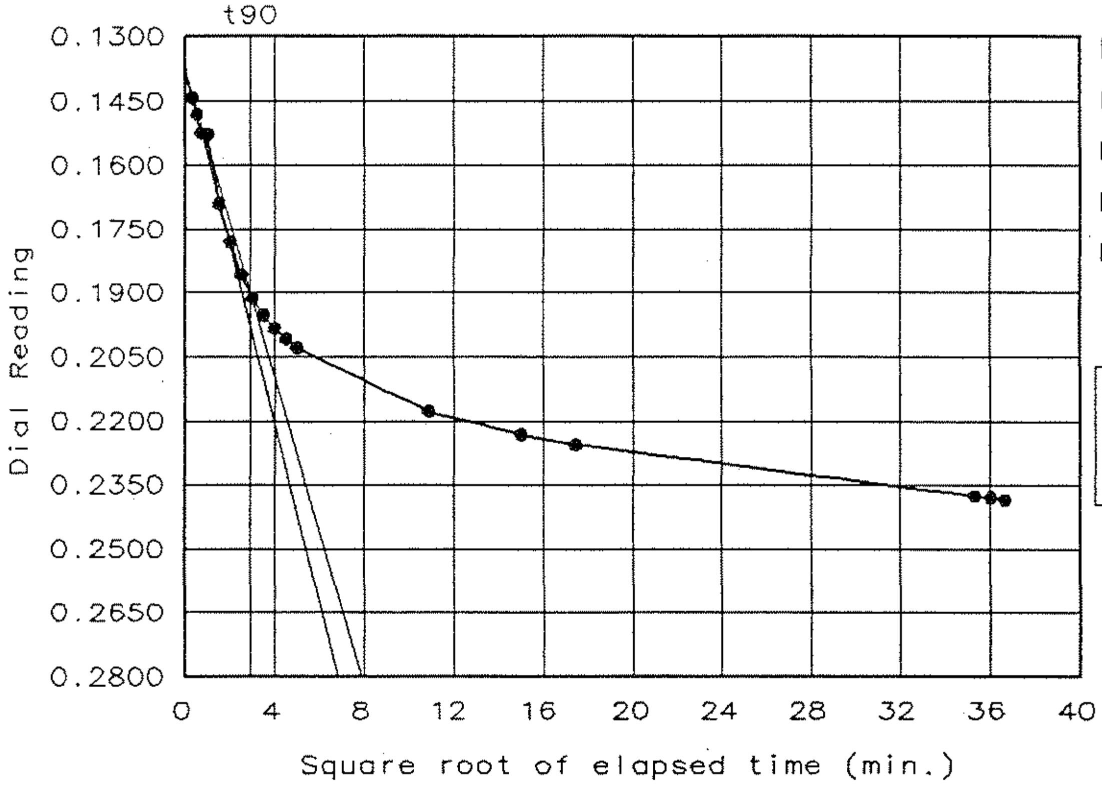
D_{90} = 0.0973

D_{100}= 0.1019

T_{90}= 5.84 min.

C_v @ T_{90} =

.029 in.^{2}/min.



Load No.= 4

Load= 2.00 tsf

D_0 = 0.1377

D_{90} = 0.1905

D_{100}= 0.1964

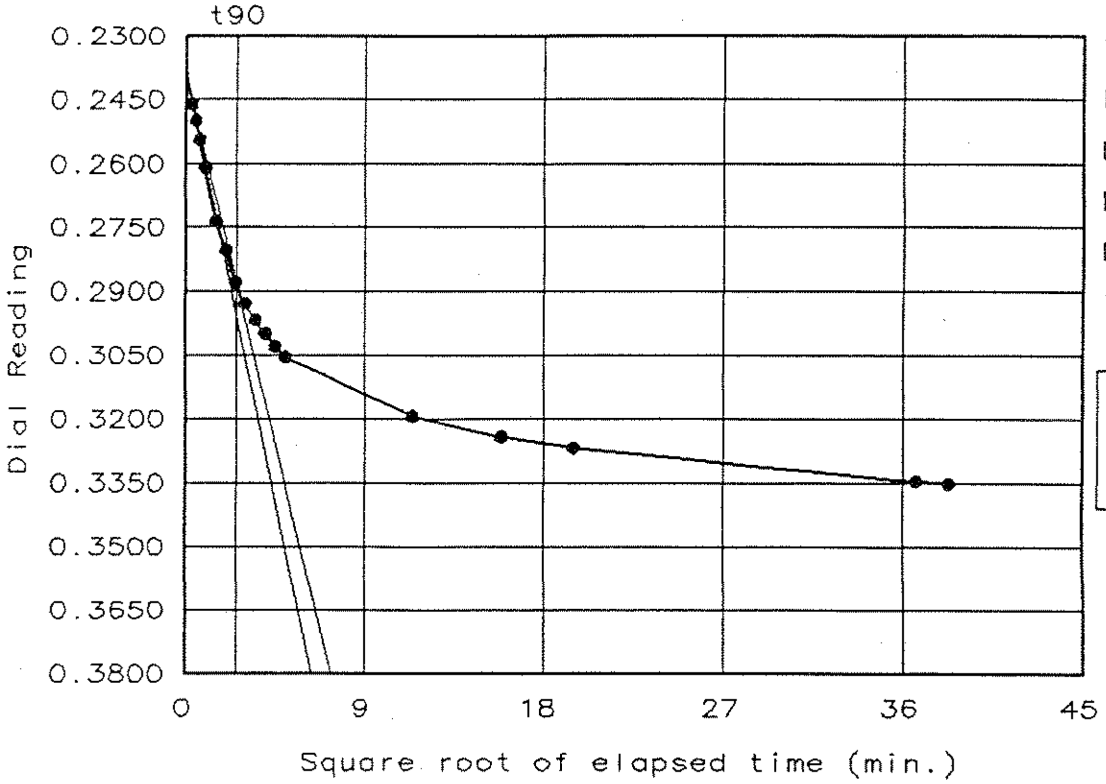
T_{90}= 8.48 min.

C_v @ T_{90} =

.016 in.^{2}/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7380
SAMPLE:ST-2 DEPTH:3.5-5.5'
Date: 10/8/99



Load No.= 5

Load= 4.00 tsf

D_0 = 0.2393

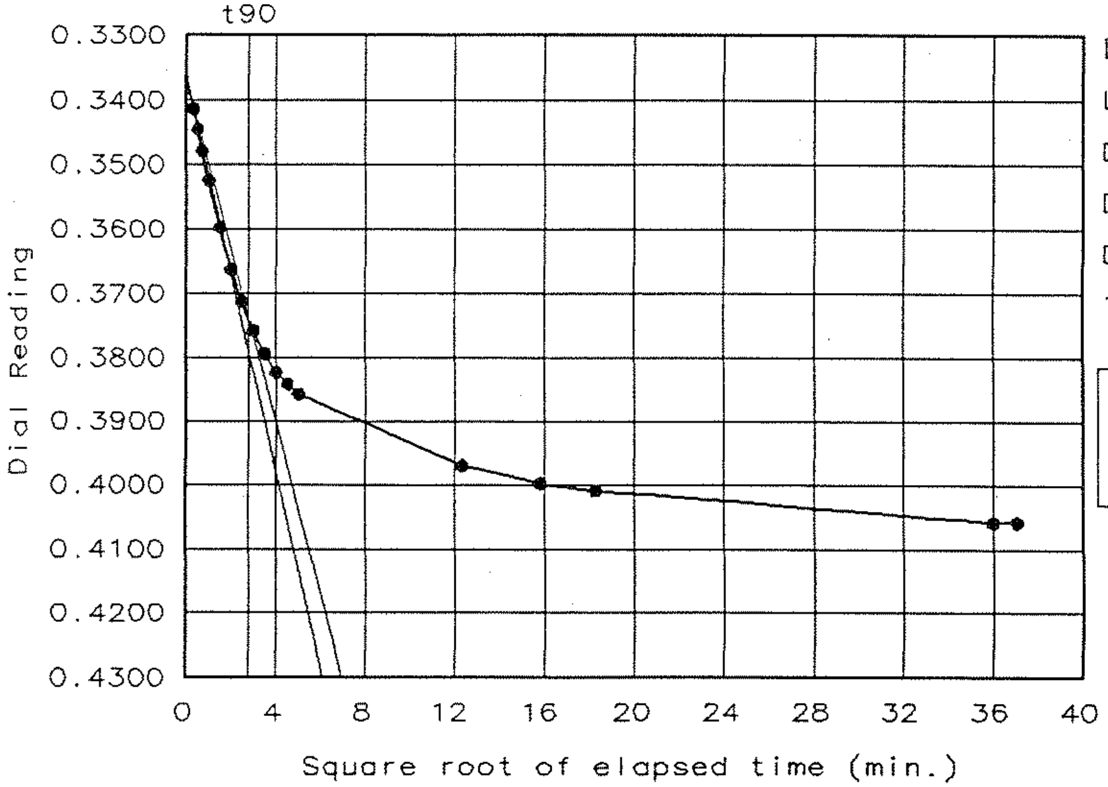
D_{90} = 0.2888

D_{100}= 0.2943

T_{90}= 6.55 min.

C_v @ T_{90} =

.016 in.^{2}/min.



Load No.= 6

Load= 8.00 tsf

D_0 = 0.3365

D_{90} = 0.3739

D_{100}= 0.3780

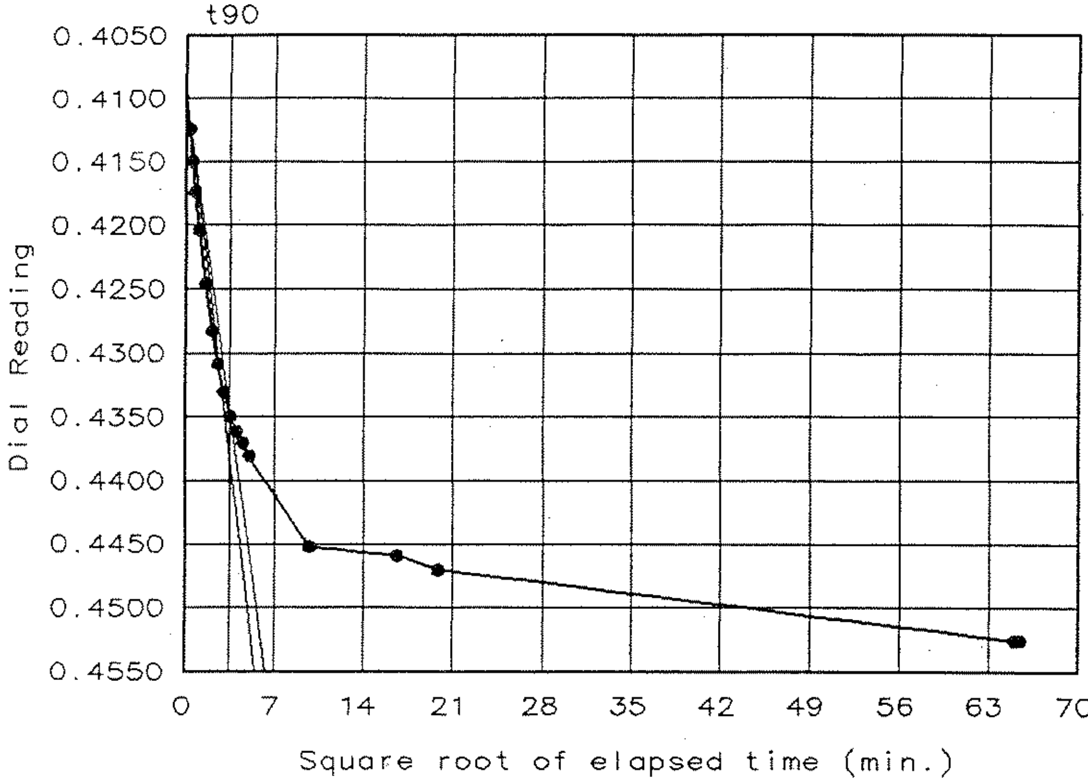
T_{90}= 7.74 min.

C_v @ T_{90} =

.011 in.^{2}/min.

Dial Reading vs. Time

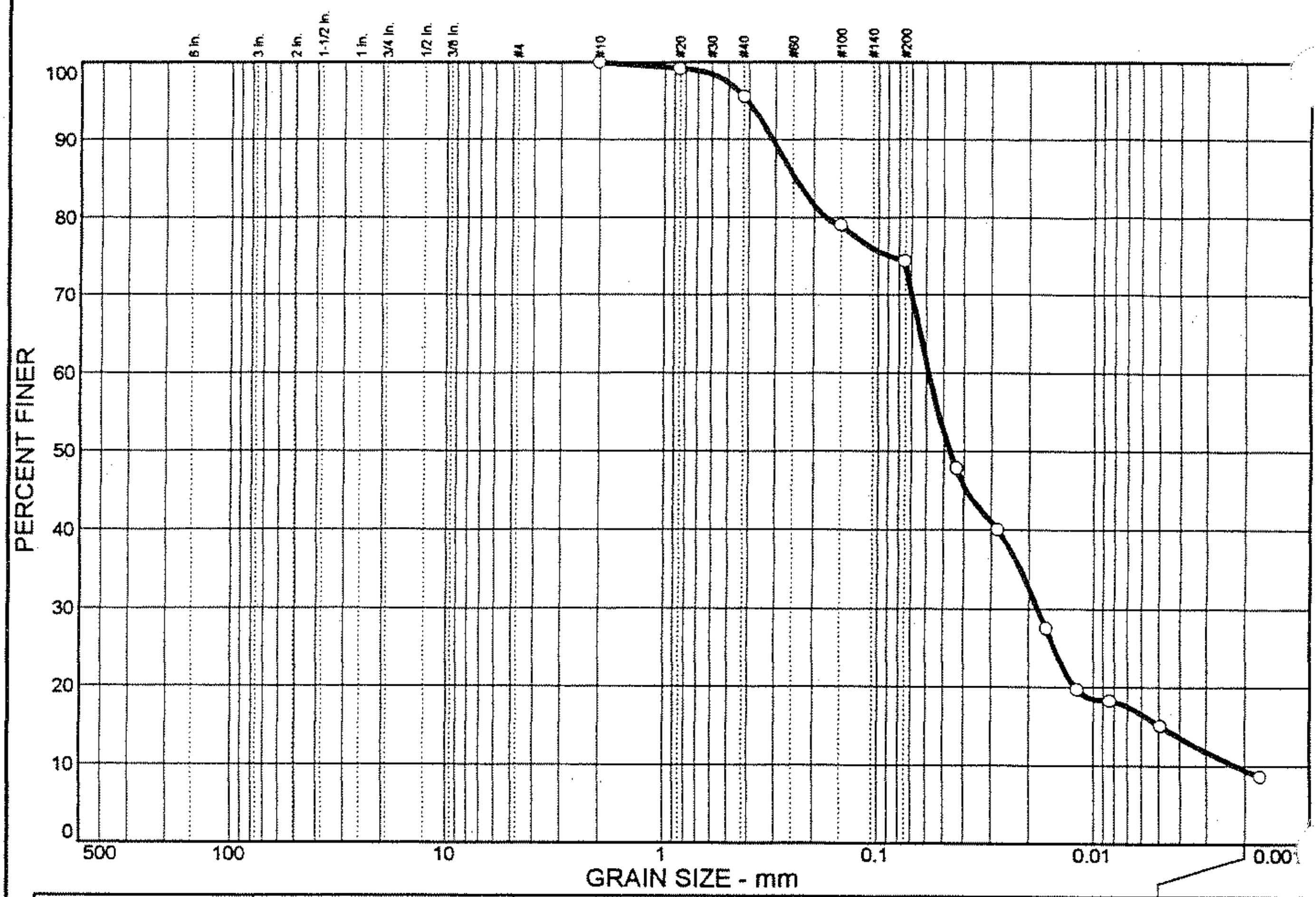
Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-10 LAB NO. 7380
SAMPLE:ST-2 DEPTH:3.5-5.5'
Date: 10/8/99



Load No.= 7
Load= 16.00 tsf
D_0 = 0.4099
D_{90} = 0.4348
D_{100}= 0.4376
T_{90}= 11.91 min.

C_v @ T_{90} =
.006 $in.^2/min.$

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	25.6	64.9	9.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.2		
#40	95.6		
#100	79.0		
#200	74.4		

* (no specification provided)

Soil Description

Lean clay with sand

Atterberg Limits

PL= 27
LL= 49
PI= 22

Coefficients

D_{85}= 0.242
D_{60}= 0.0583
D_{50}= 0.0466
D_{30}= 0.0182
D_{15}= 0.0049
D_{10}= 0.0022
C_u= 26.39
C_c= 2.56

Classification

USCS= CL
AASHTO=

Remarks

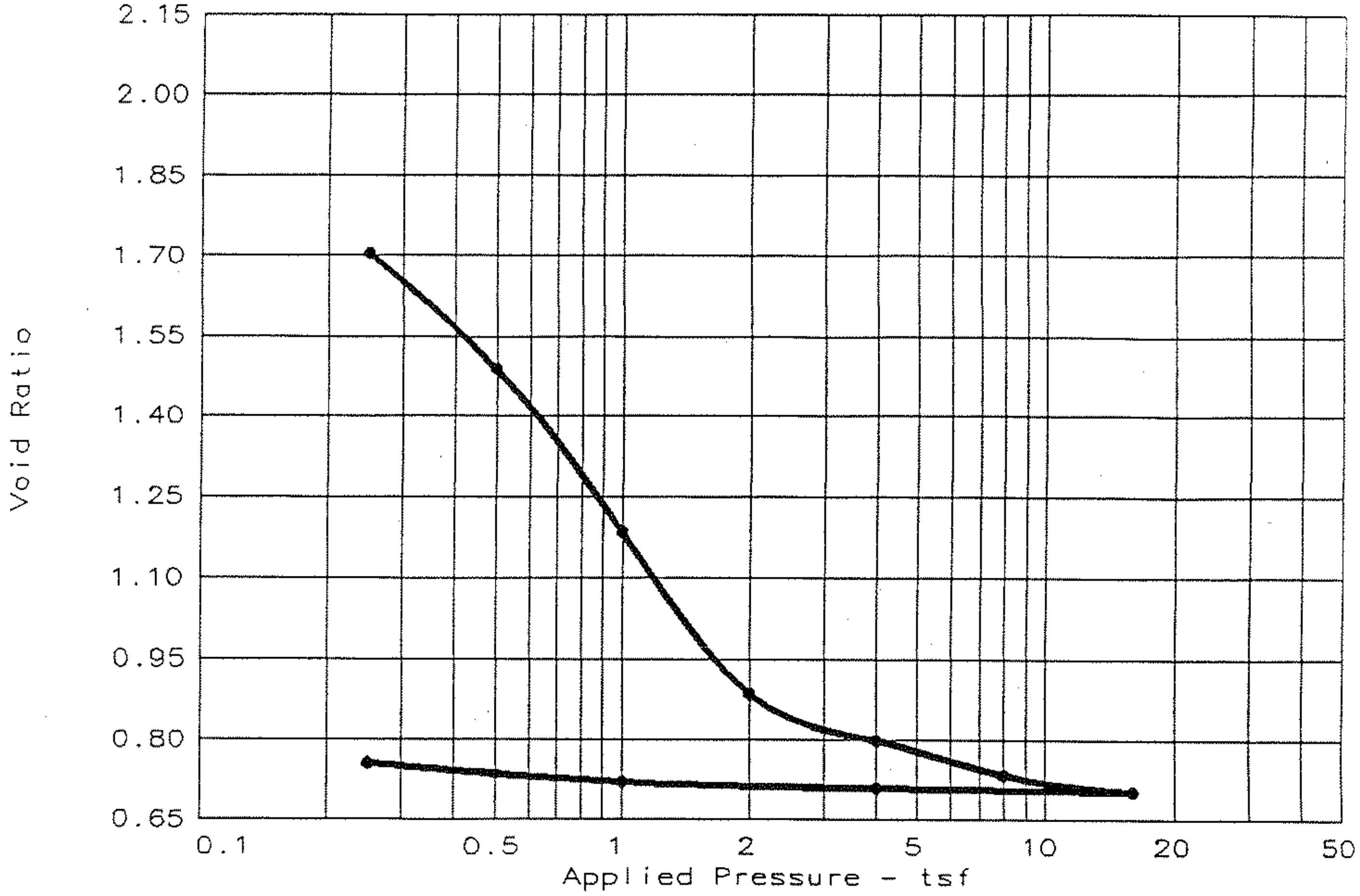
LAB NO. 7381

Sample No.: ST-1
Location: BORING:BH-12
Source of Sample: L-7381
Date: 10/7/99
Elev./Depth: 0-2'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site
Project No: 11294.019
Plate

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)

No.	Load	No Cv	Load	No Cv	Load
1	0.25	0.046			
2	0.50	0.034			
3	1.00	0.025			
4	2.00	0.007			
5	4.00	0.021			
6	8.00	0.017			
7	16.00	0.018			

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
86.4 %	80.4	44.0	49	22	2.050	1.9068

TEST RESULTS

MATERIAL DESCRIPTION

DK GR & LT GR LEAN
CLAY,V. MOSIT-STIFF

Class: CL

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:HB-12 LAB NO. 7381
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/19/99

Remarks:

CLIENT:
CONESTOGA-ROVERS &
ASSOC. LTD.

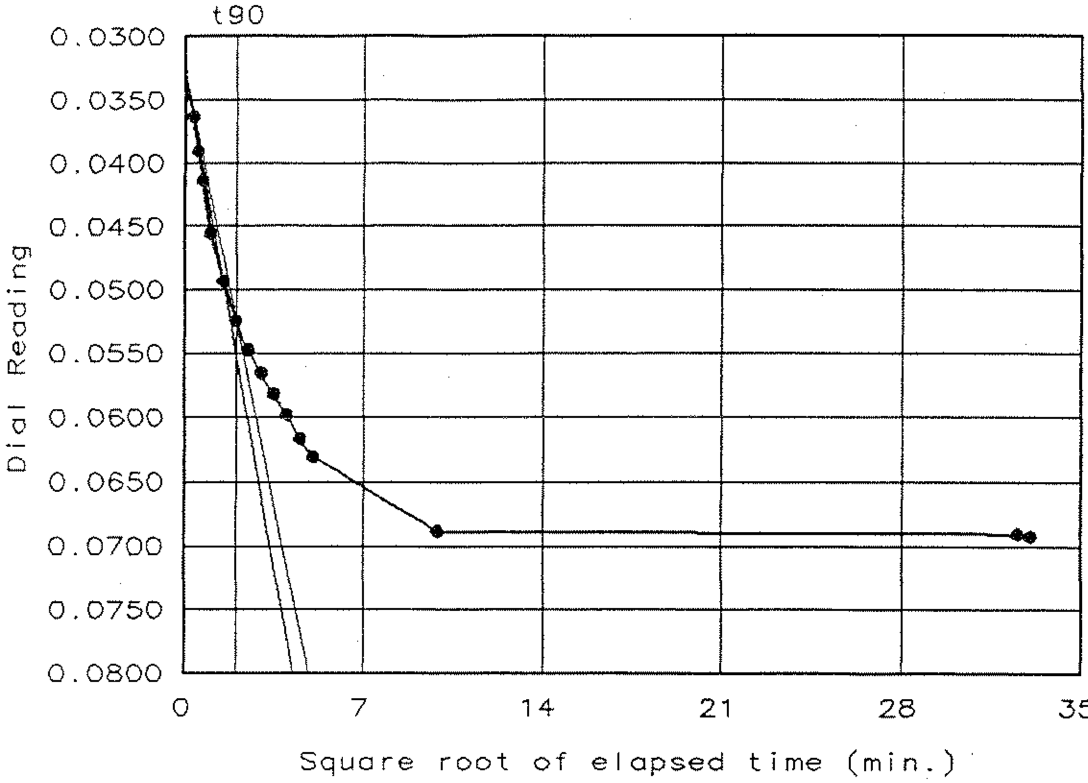
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

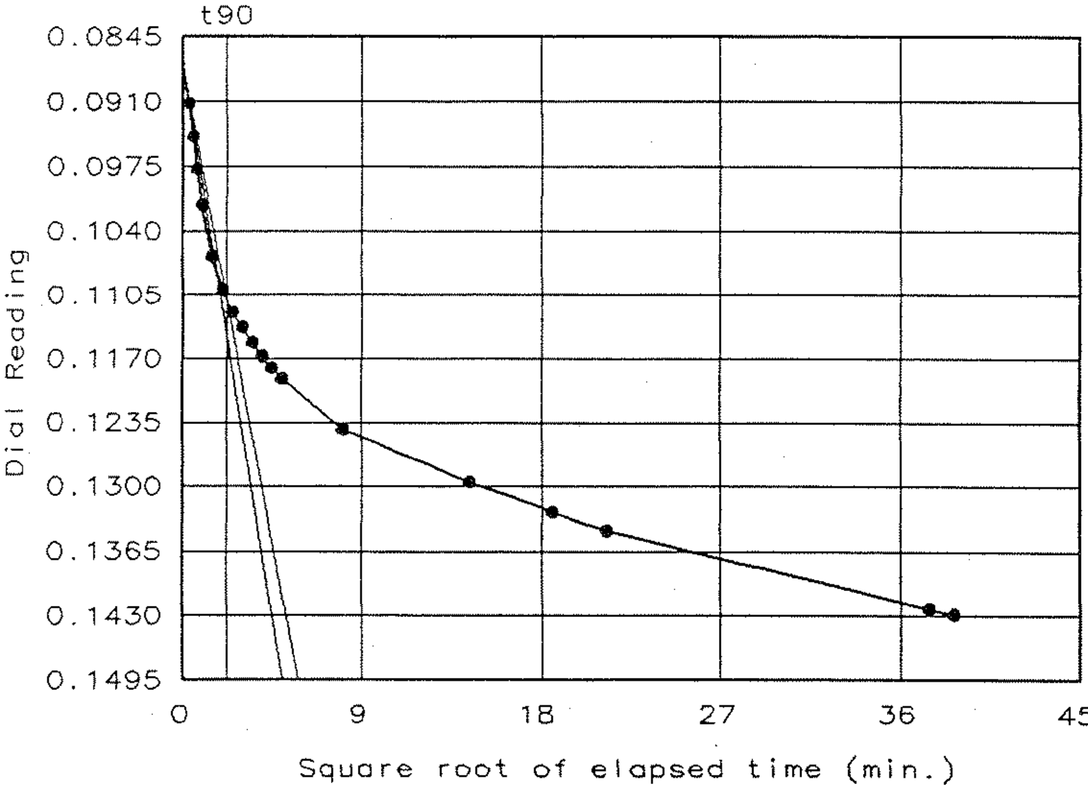
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:HB-12 LAB NO. 7381
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/19/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0329
D_{90} = 0.0527
D_{100}= 0.0549
T_{90}= 4.19 min.

C_v @ T_{90} =
.046 in.²/min.

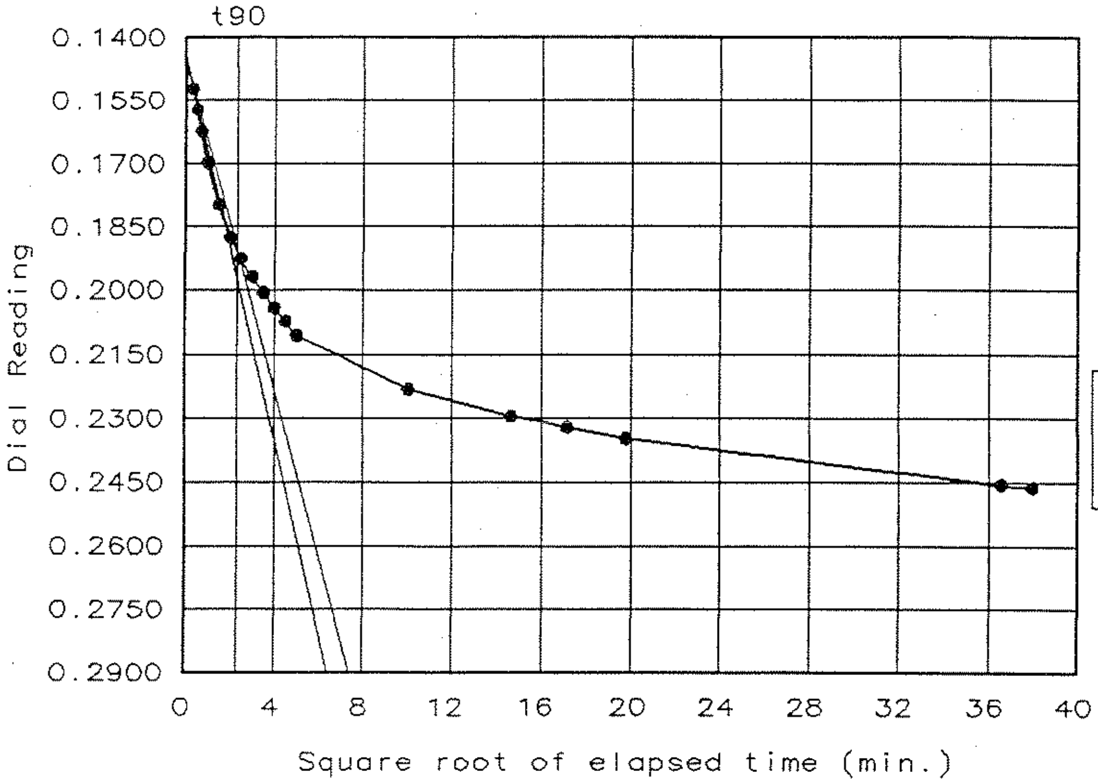


Load No.= 2
Load= 0.50 tsf
D_0 = 0.0873
D_{90} = 0.1109
D_{100}= 0.1135
T_{90}= 4.83 min.

C_v @ T_{90} =
.034 in.²/min.

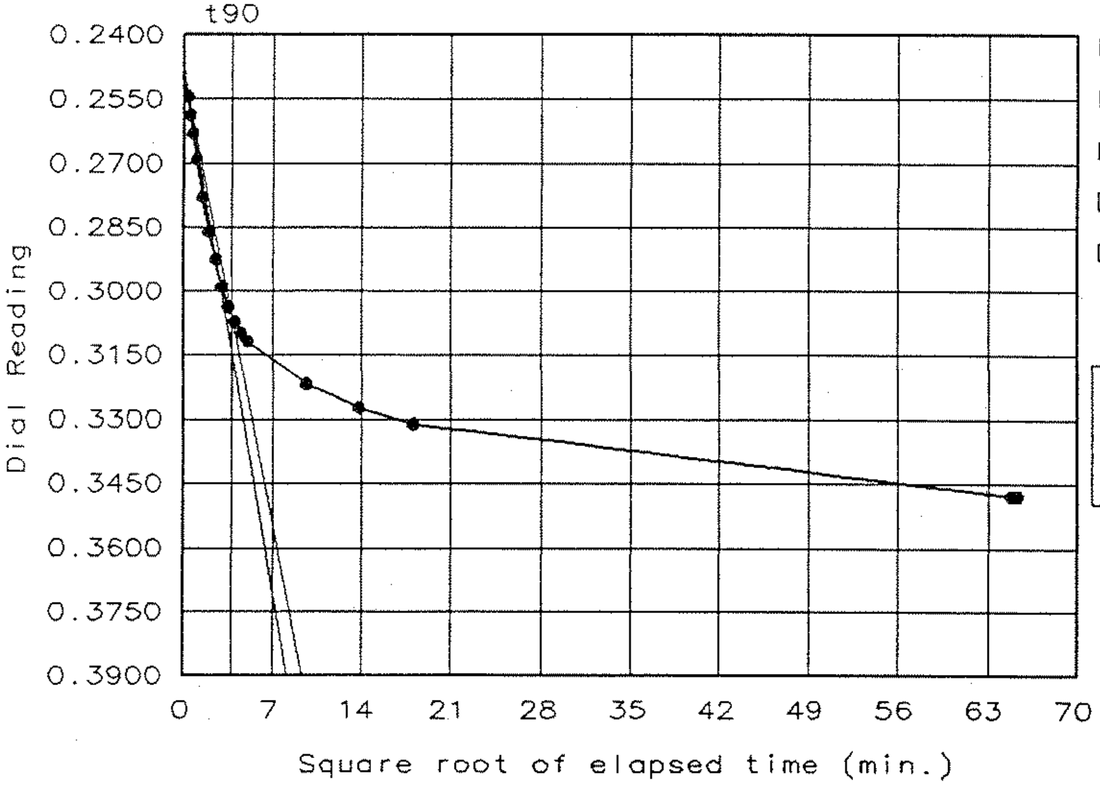
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:HB-12 LAB NO. 7381
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/19/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.1454
D_{90} = 0.1911
D_{100}= 0.1961
T_{90}= 5.46 min.

C_v @ T_{90} =
.025 in.^{2}/min.



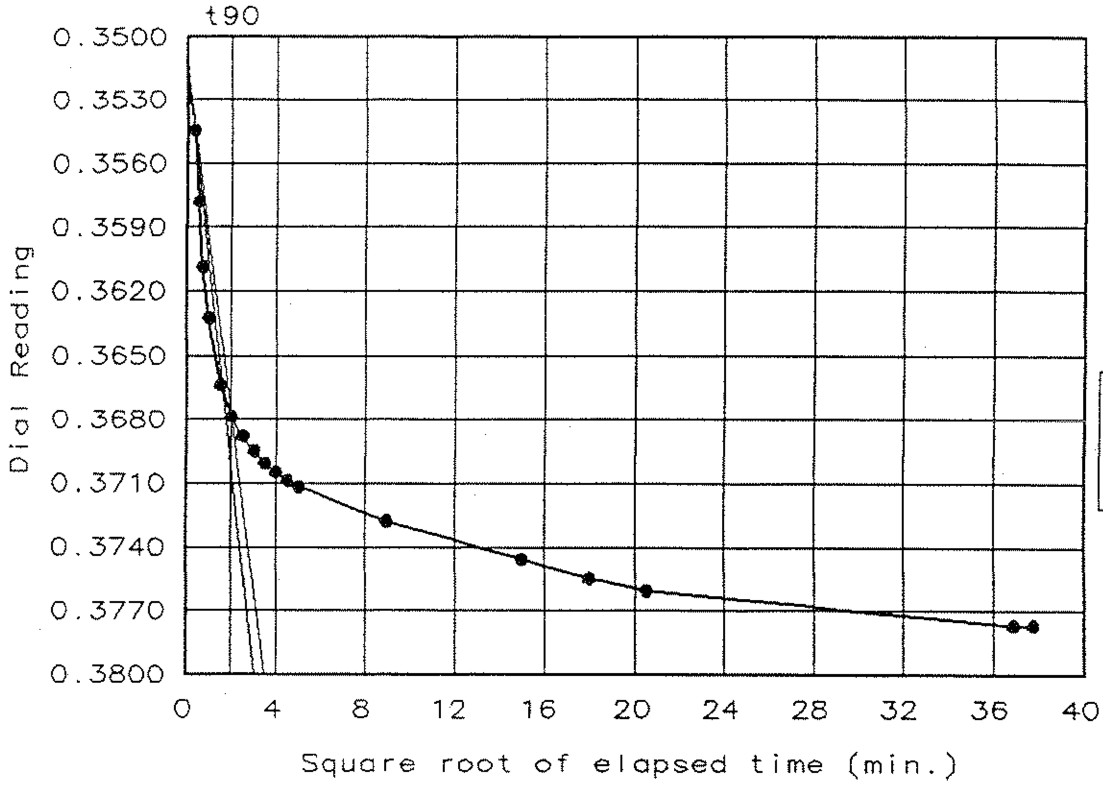
Load No.= 4
Load= 2.00 tsf
D_0 = 0.2490
D_{90} = 0.3056
D_{100}= 0.3119
T_{90}= 14.04 min.

C_v @ T_{90} =
.007 in.^{2}/min.

H.C. NUTTING COMPANY

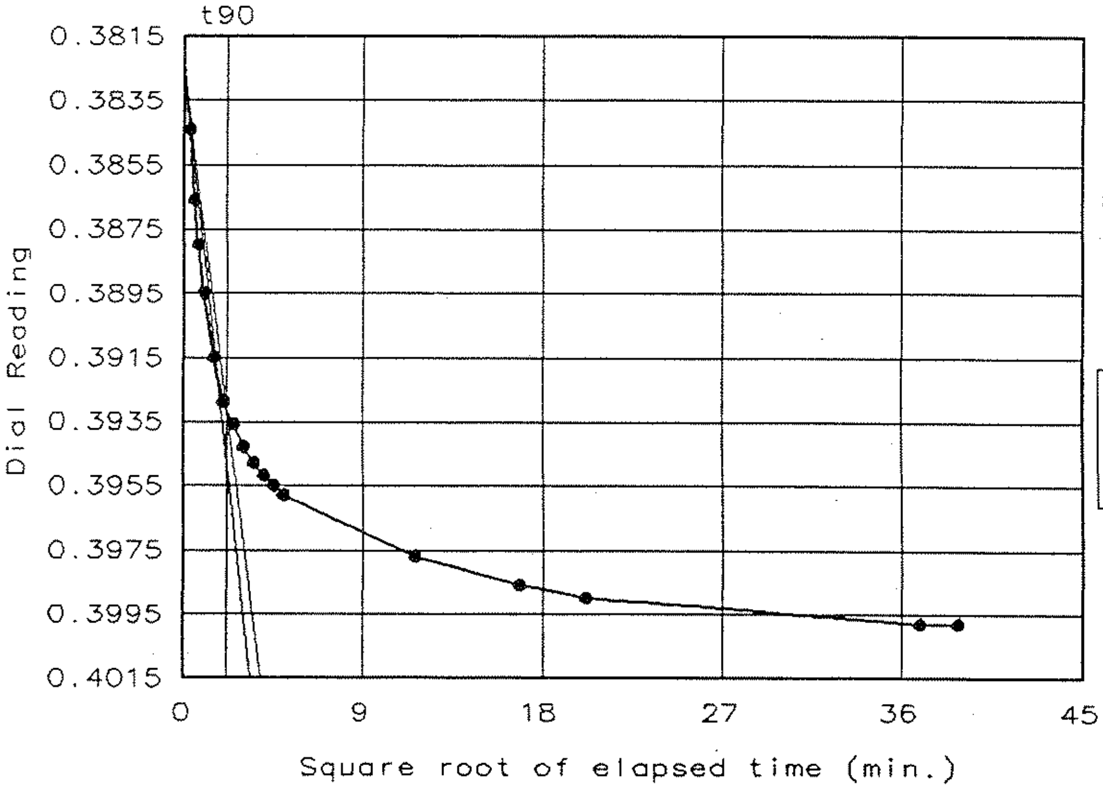
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:HB-12 LAB NO. 7381
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/19/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.3515
D_{90} = 0.3679
D_{100}= 0.3697
T_{90}= 3.95 min.

C_v @ T_{90} =
.021 in.²/min.

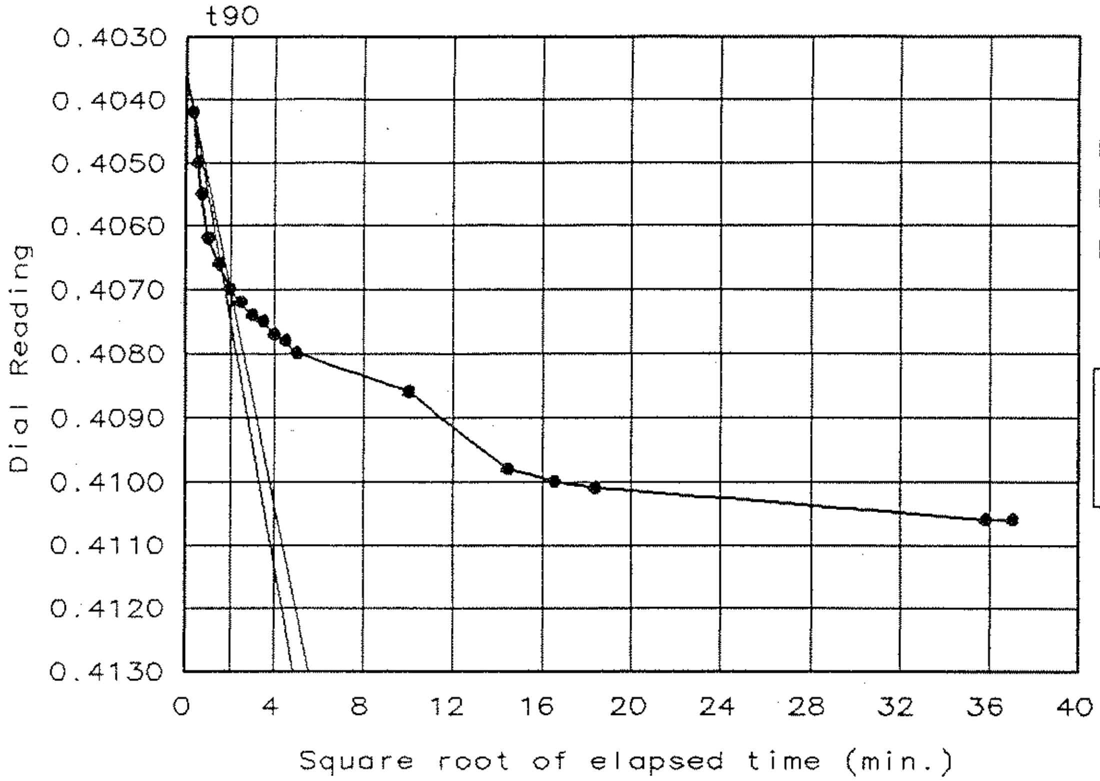


Load No.= 6
Load= 8.00 tsf
D_0 = 0.3826
D_{90} = 0.3931
D_{100}= 0.3942
T_{90}= 4.54 min.

C_v @ T_{90} =
.017 in.²/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:HB-12 LAB NO. 7381
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/19/99



Load No.= 7

Load= 16.00 tsf

D_0 = 0.4036

D_{90} = 0.4070

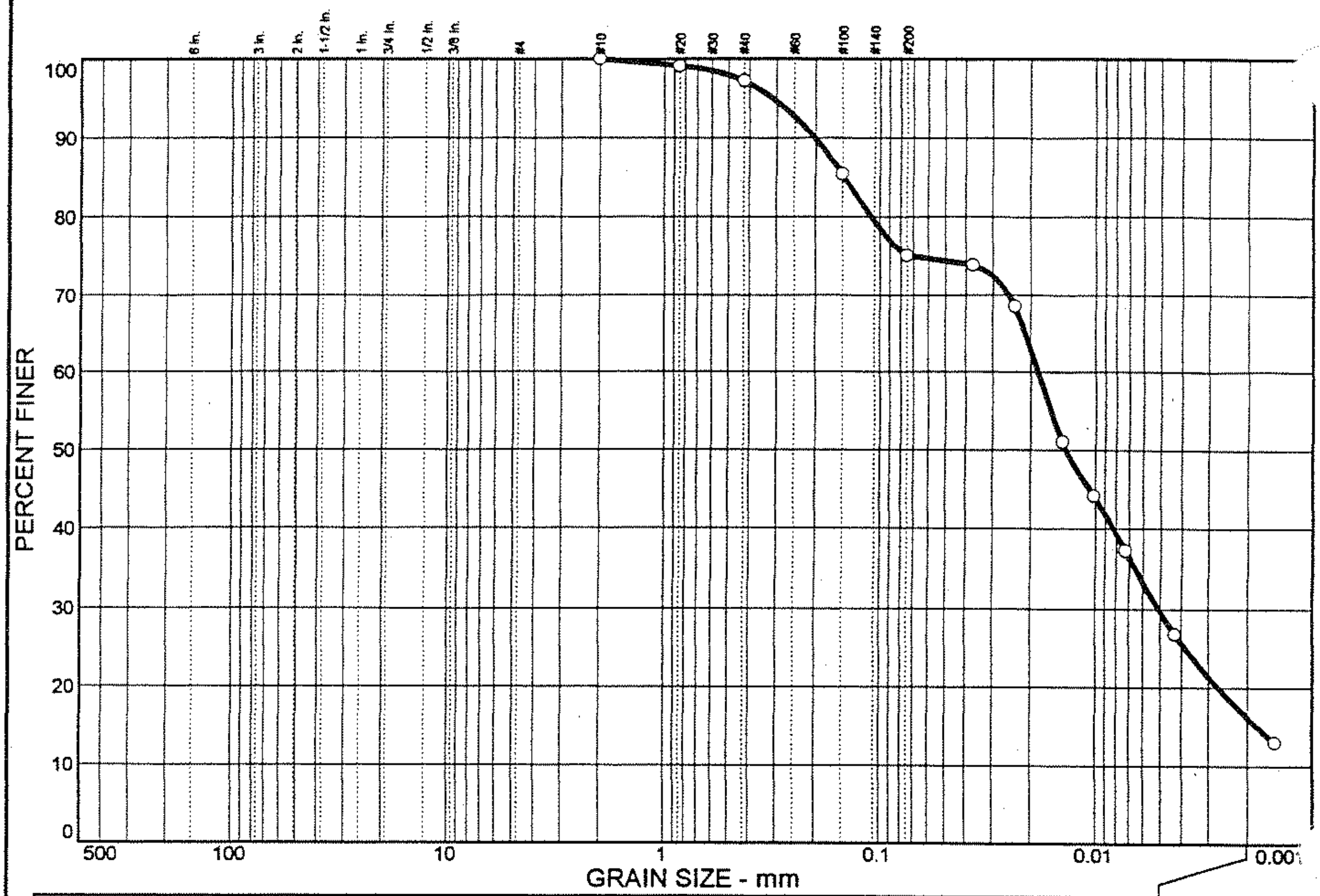
D_{100}= 0.4074

T_{90}= 4.09 min.

C_v @ T_{90} =

.018 in.^{2}/min.

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	24.9	58.8	16.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.1		
#40	97.2		
#100	85.5		
#200	75.1		

* (no specification provided)

Soil Description

Elastic silt with sand (SLUDGE)

Atterberg Limits

PL= 51 LL= 80 PI= 29

Coefficients

D_{85}= 0.146 D_{60}= 0.0184 D_{50}= 0.0136
D_{30}= 0.0051 D_{15}= 0.0018 D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7382

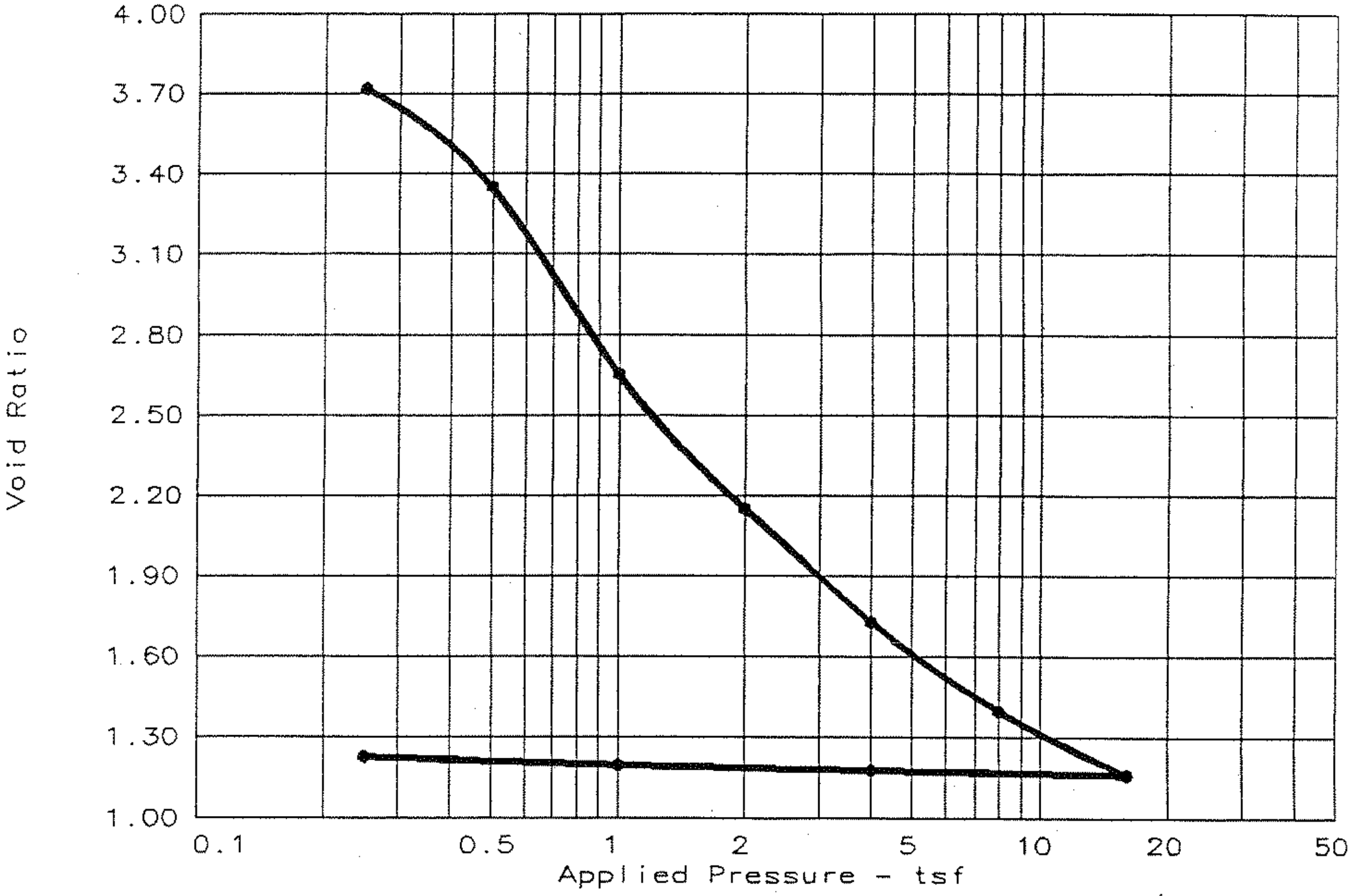
Sample No.: ST-2 **Source of Sample:** L-7382 **Date:** 10/6/99
Location: BORING:BH-12 **Elev./Depth:** 2-4'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)

No.	Load	No	Cv	Load	No	Cv	Load
1	0.25		0.048				
2	0.50		0.017				
3	1.00		0.024				
4	2.00		0.016				
5	4.00		0.014				
6	8.00		0.011				
7	16.00		0.005				

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
93.4 %	153.2	30.3	80	29	2.360	3.8698

TEST RESULTS

MATERIAL DESCRIPTION

ELASTIC SILT WITH SAND (SLUDGE)

Class: MH

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-12 LAB NO. 7382
SAMPLE:ST-2 DEPTH:2-4'
Date: 10/8/99

Remarks:

CLIENT:
CONESTOGA-ROVERS &
ASSOC. LTD

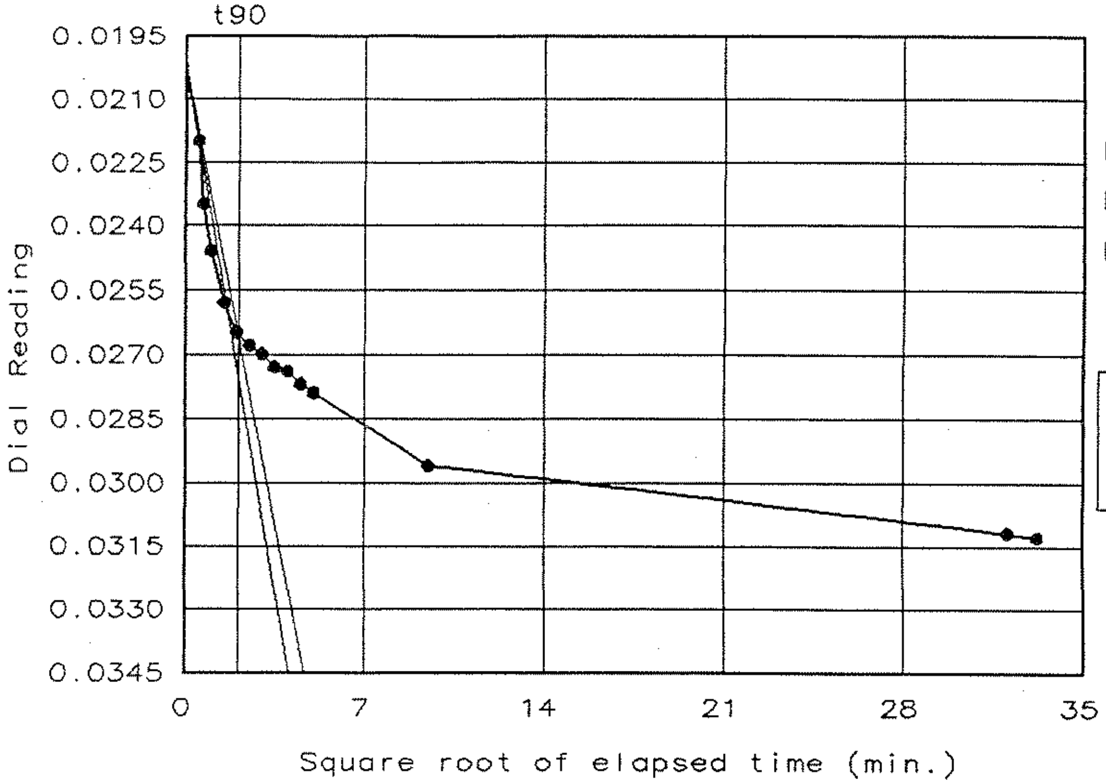
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

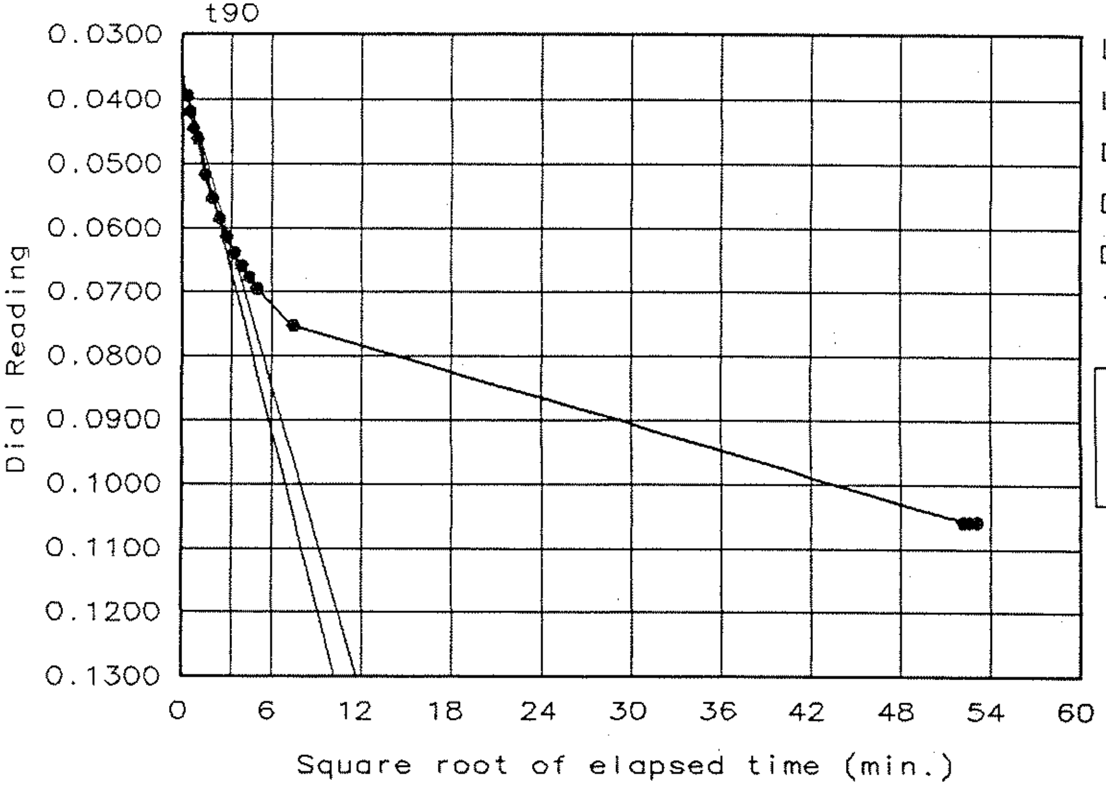
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-12 LAB NO. 7382
SAMPLE:ST-2 DEPTH:2-4'
Date: 10/8/99



Load No.= 1
Load= 0.25 tsf
D_0 = 0.0202
D_{90} = 0.0265
D_{100}= 0.0272
T_{90}= 4.22 min.

C_v @ T_{90} =
.048 in.²/min.



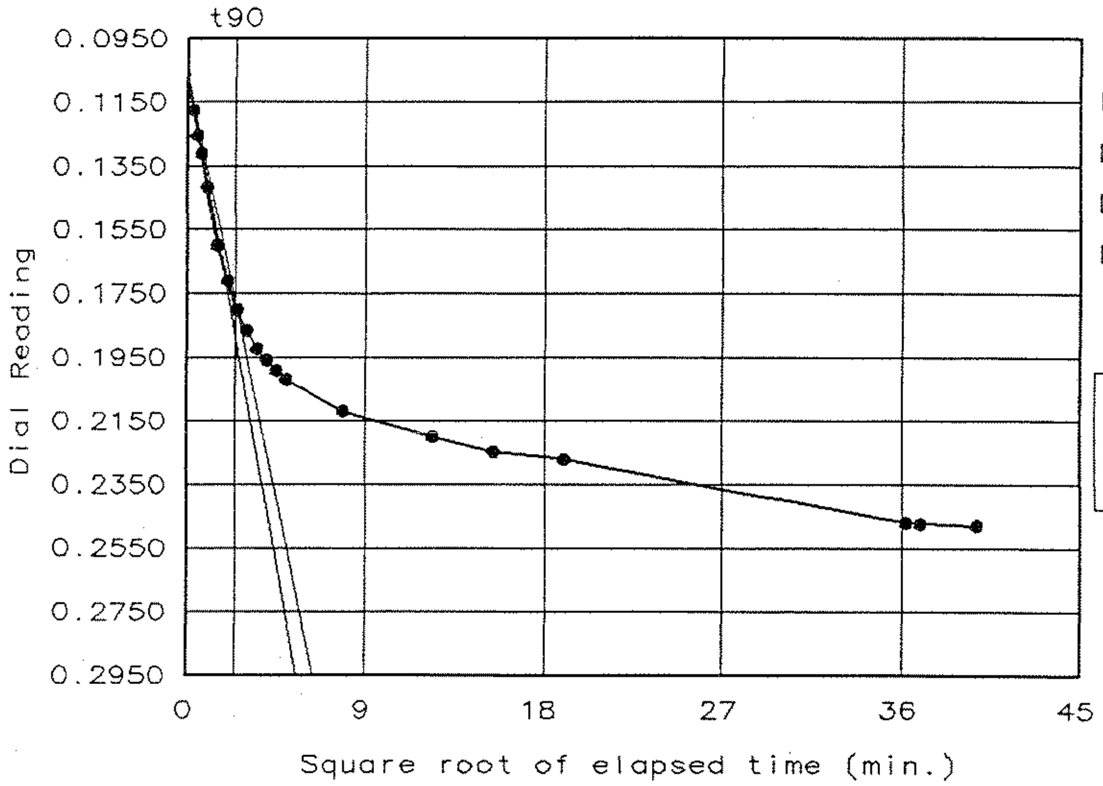
Load No.= 2
Load= 0.50 tsf
D_0 = 0.0366
D_{90} = 0.0630
D_{100}= 0.0659
T_{90}= 10.83 min.

C_v @ T_{90} =
.017 in.²/min.

H.C. NUTTING COMPANY

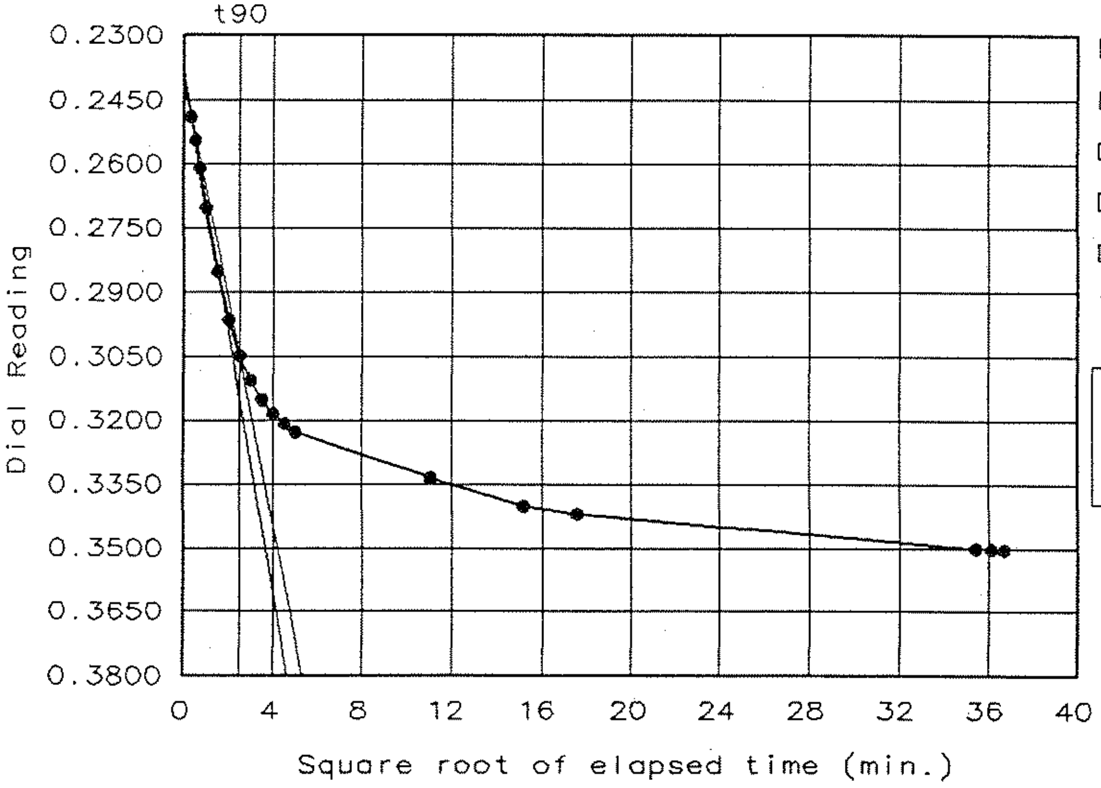
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-12 LAB NO. 7382
SAMPLE:ST-2 DEPTH:2-4'
Date: 10/8/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.1070
D_{90} = 0.1789
D_{100}= 0.1869
T_{90}= 5.89 min.

C_v @ T_{90} =
.024 in.^{2}/min.

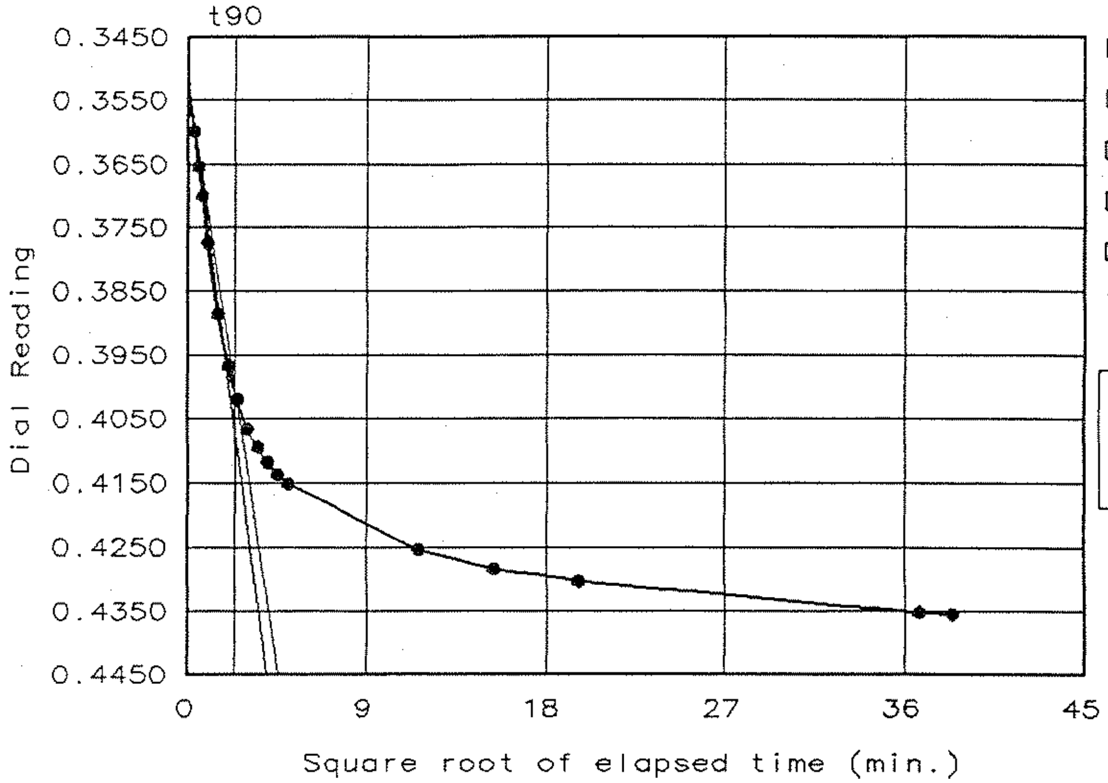


Load No.= 4
Load= 2.00 tsf
D_0 = 0.2394
D_{90} = 0.3050
D_{100}= 0.3123
T_{90}= 6.23 min.

C_v @ T_{90} =
.016 in.^{2}/min.

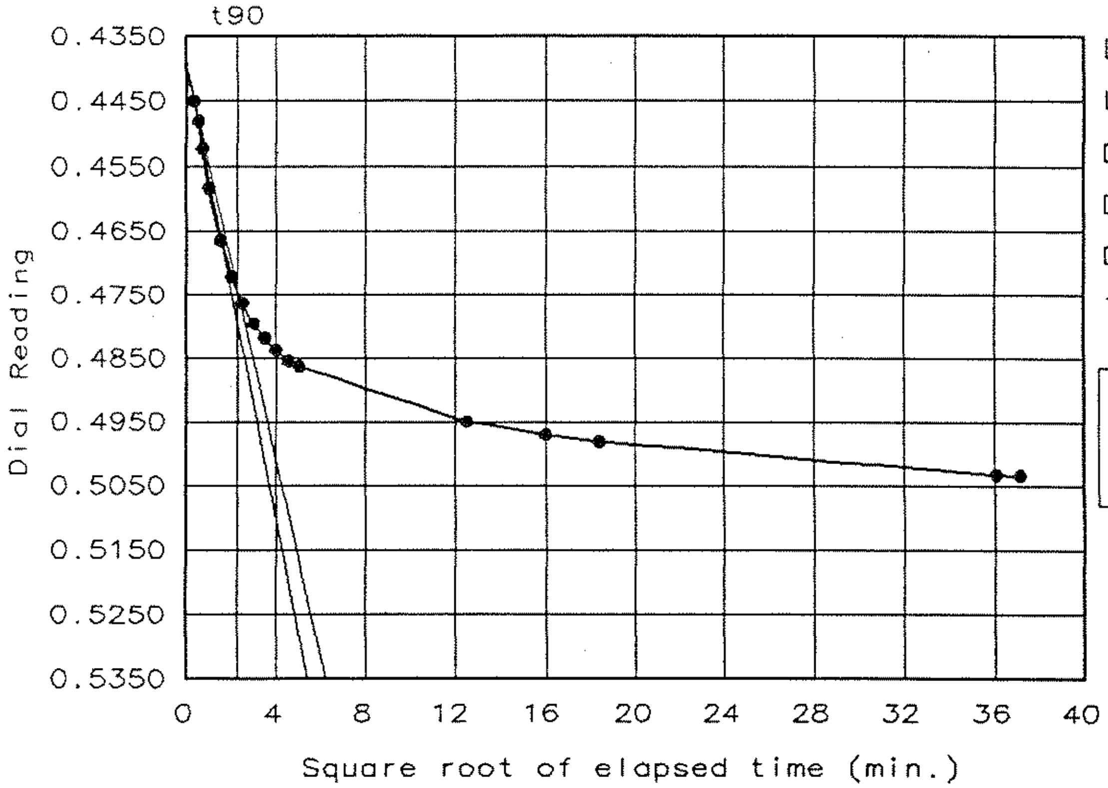
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-12 LAB NO. 7382
SAMPLE:ST-2 DEPTH:2-4'
Date: 10/8/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.3526
D_{90} = 0.4004
D_{100}= 0.4057
T_{90}= 5.49 min.

C_v @ T_{90} =
.014 in.²/min.

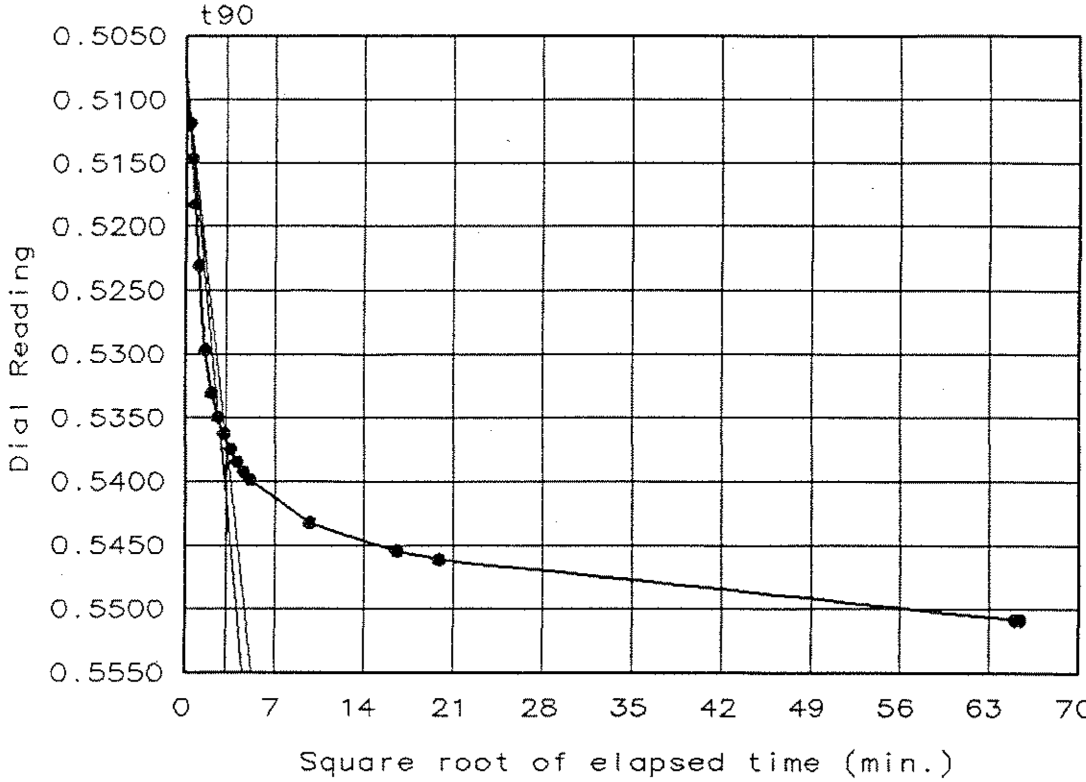


Load No.= 6
Load= 8.00 tsf
D_0 = 0.4395
D_{90} = 0.4746
D_{100}= 0.4785
T_{90}= 5.20 min.

C_v @ T_{90} =
.011 in.²/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING:BH-12 LAB NO. 7382
SAMPLE:ST-2 DEPTH:2-4'
Date: 10/8/99

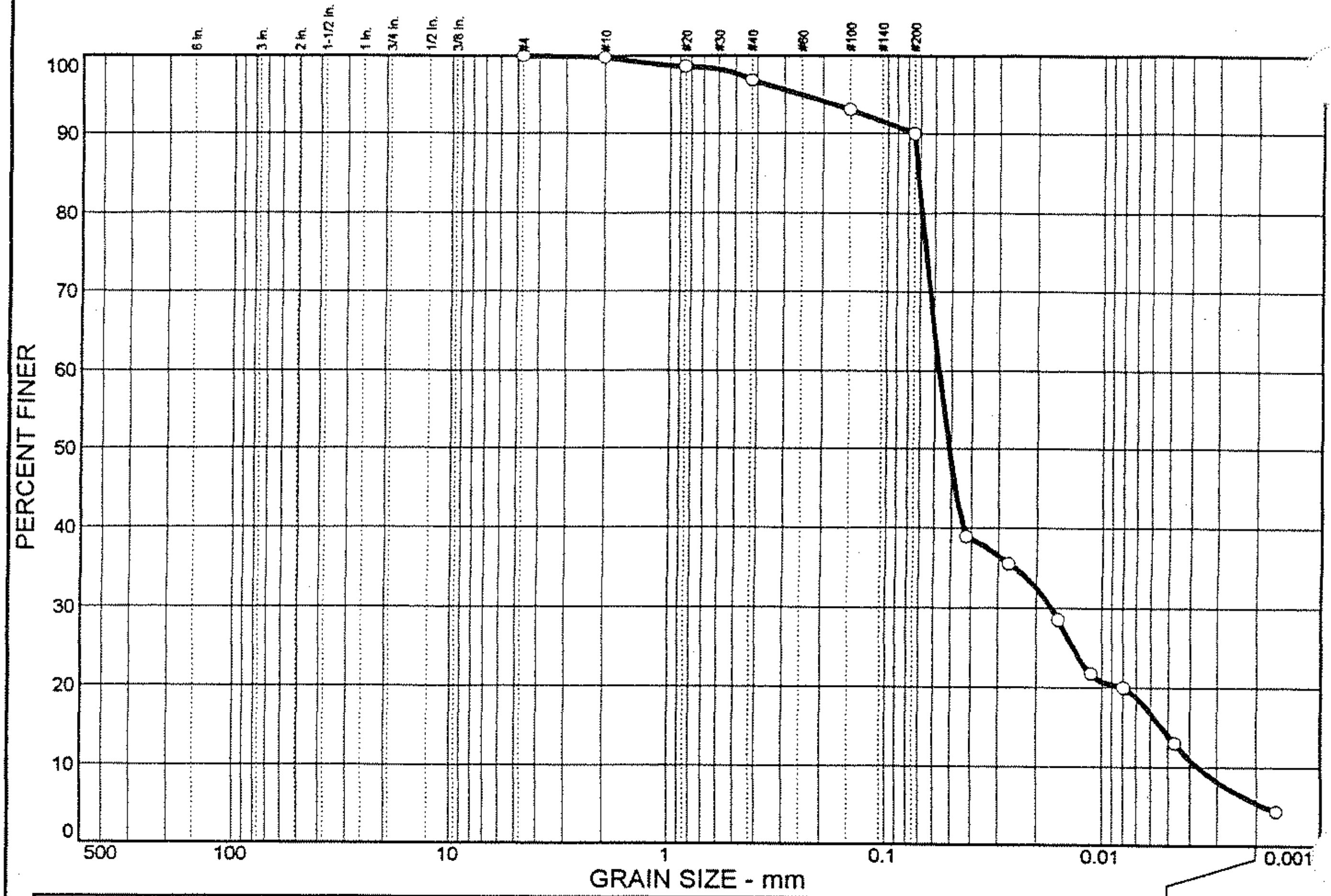


Load No.= 7
Load= 16.00 tsf
D_0 = 0.5086
D_{90} = 0.5365
D_{100}= 0.5396
T_{90}= 9.61 min.

C_v @ T_{90} =
.005 in.²/min.

H.C. NUTTING COMPANY

Grain Size Distribution Test Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	10.0	84.6	5.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.8		
#20	98.6		
#40	96.8		
#100	93.0		
#200	90.0		

* (no specification provided)

Soil Description

Elastic silt (SLUDGE)

Atterberg Limits

PL= 48 LL= 81 PI= 33

Coefficients

D_{85}= 0.0718 D_{60}= 0.0568 D_{50}= 0.0508
D_{30}= 0.0170 D_{15}= 0.0053 D_{10}= 0.0037
C_u= 15.56 C_c= 1.40

Classification

USCS= MH AASHTO=

Remarks

LAB NO. 7383

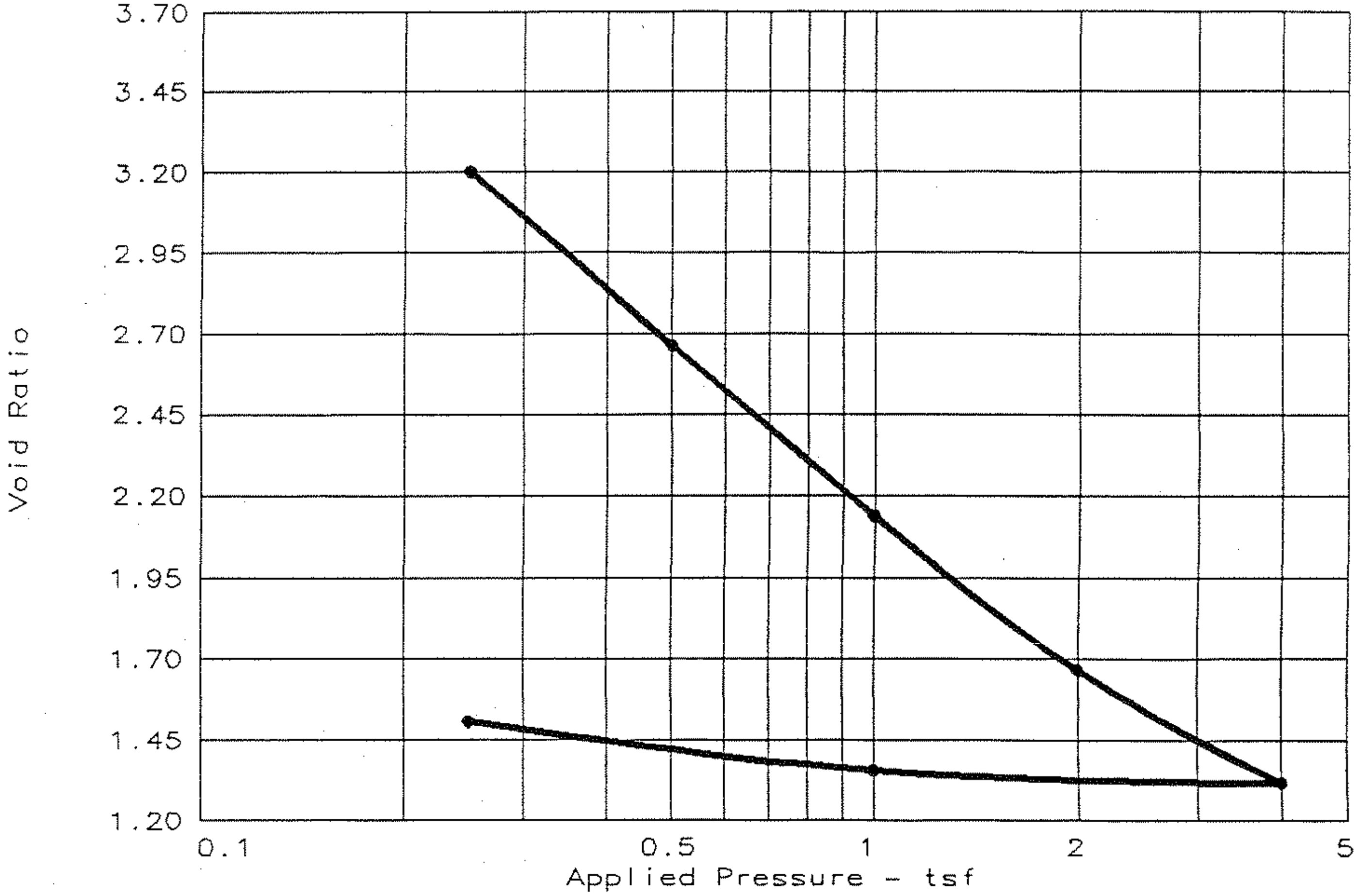
Sample No.: ST-1 **Source of Sample:** L-7383 **Date:** 10/6/99
Location: BORING:BH-13 **Elev./Depth:** 0-2'

H. C. NUTTING COMPANY

Client: Conestoga-Rovers & Assoc. LTD
Project: GMC-Harrison Radiator Site

Project No: 11294.019 **Plate**

CONSOLIDATION TEST REPORT



Cv

Coefficients of Consolidation (sq. in./min.)					
No.	Load	No Cv	Load	No Cv	Load
1	0.25	0.041			
2	0.50	0.012			
3	1.00	0.013			
4	2.00	0.010			
5	4.00	0.008			

Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
95.5 %	163.0	28.8	81	33	2.170	3.7054

TEST RESULTS

MATERIAL DESCRIPTION

ELASTIC SILT (SLUDGE)

Class: MH

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING: BH-13 LAB NO. 7383
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/15/99

Remarks:

CLIENT:
CONESTOGA-ROVERS &
ASSOC. LTD

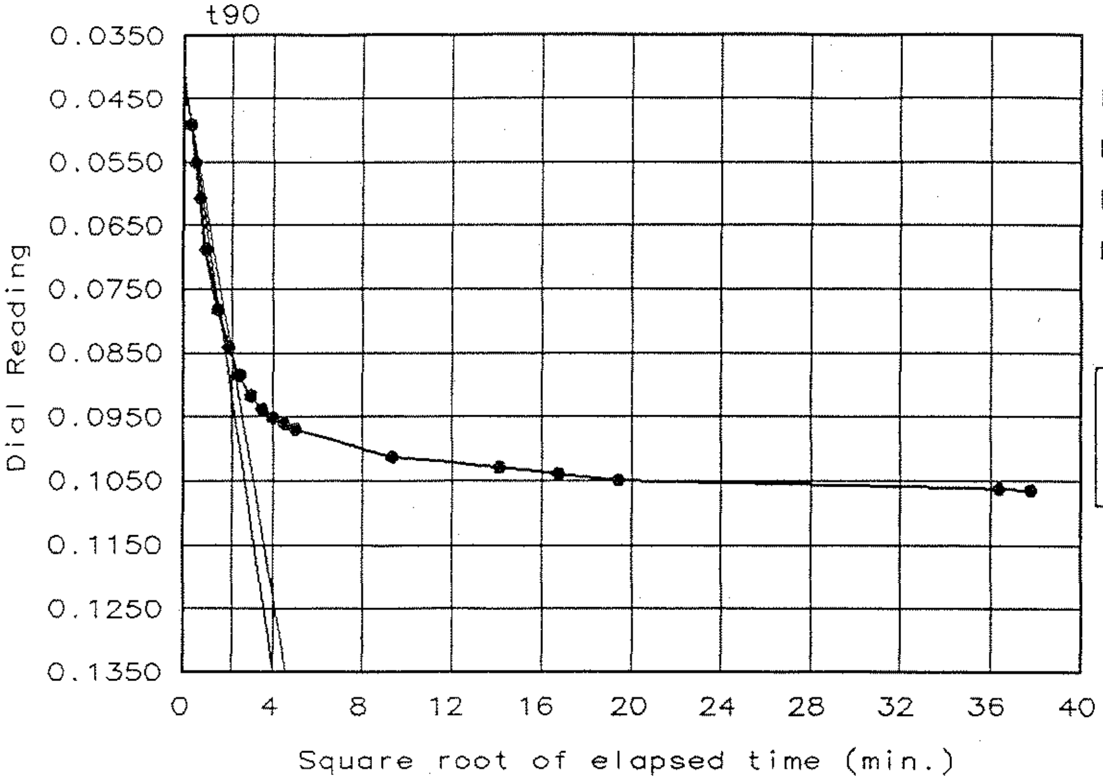
CONSOLIDATION TEST REPORT

H.C. NUTTING COMPANY

Fig. No.______

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING: BH-13 LAB NO. 7383
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/15/99



Load No.= 1

Load= 0.25 tsf

D_0 = 0.0419

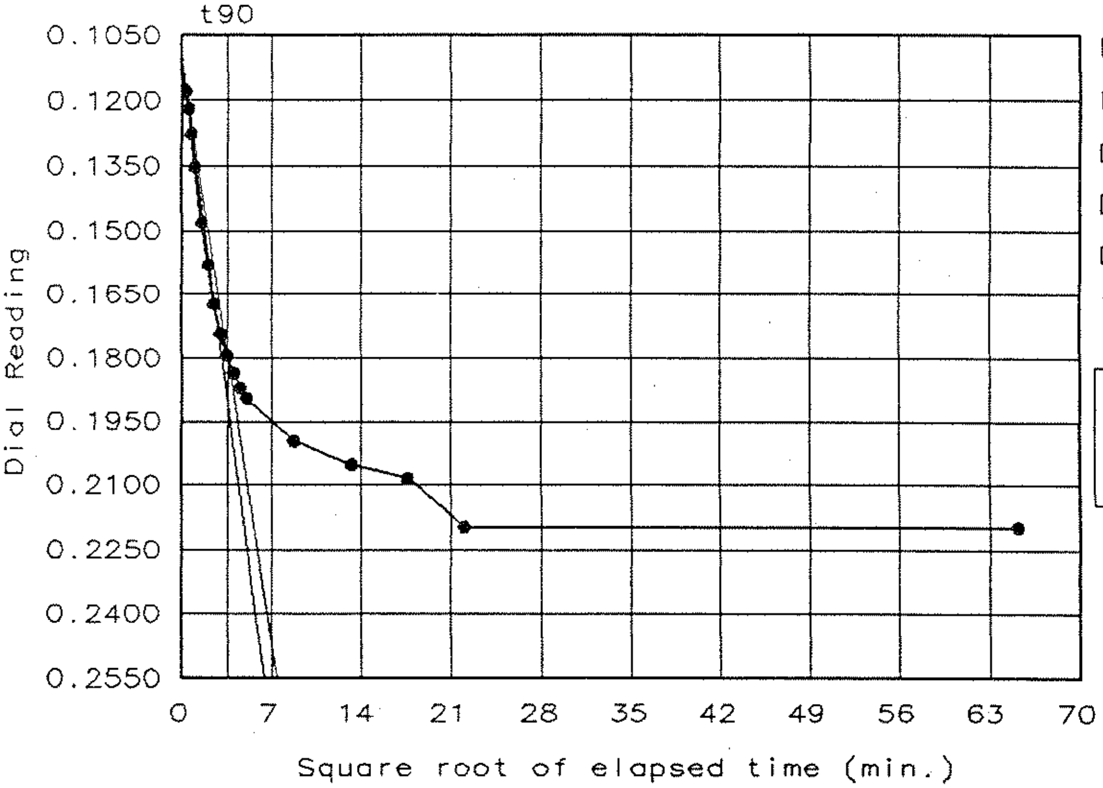
D_{90} = 0.0855

D_{100}= 0.0903

T_{90}= 4.57 min.

C_v @ T_{90} =

.041 in.²/min.



Load No.= 2

Load= 0.50 tsf

D_0 = 0.1109

D_{90} = 0.1799

D_{100}= 0.1875

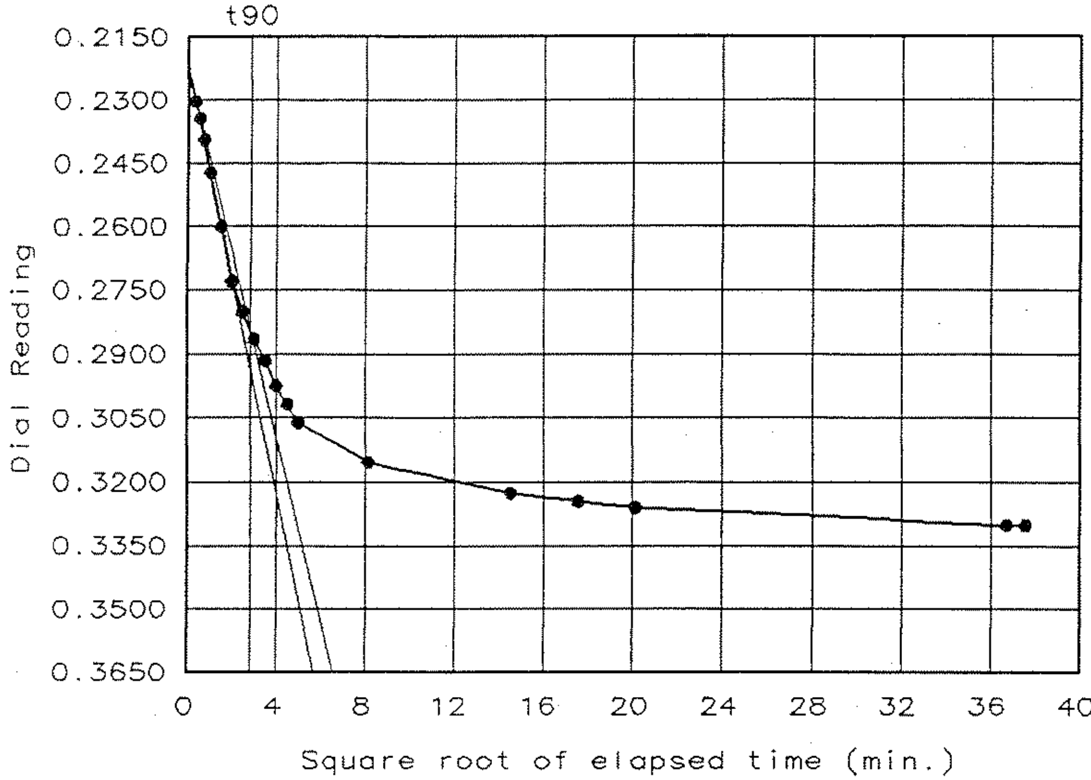
T_{90}= 12.47 min.

C_v @ T_{90} =

.012 in.²/min.

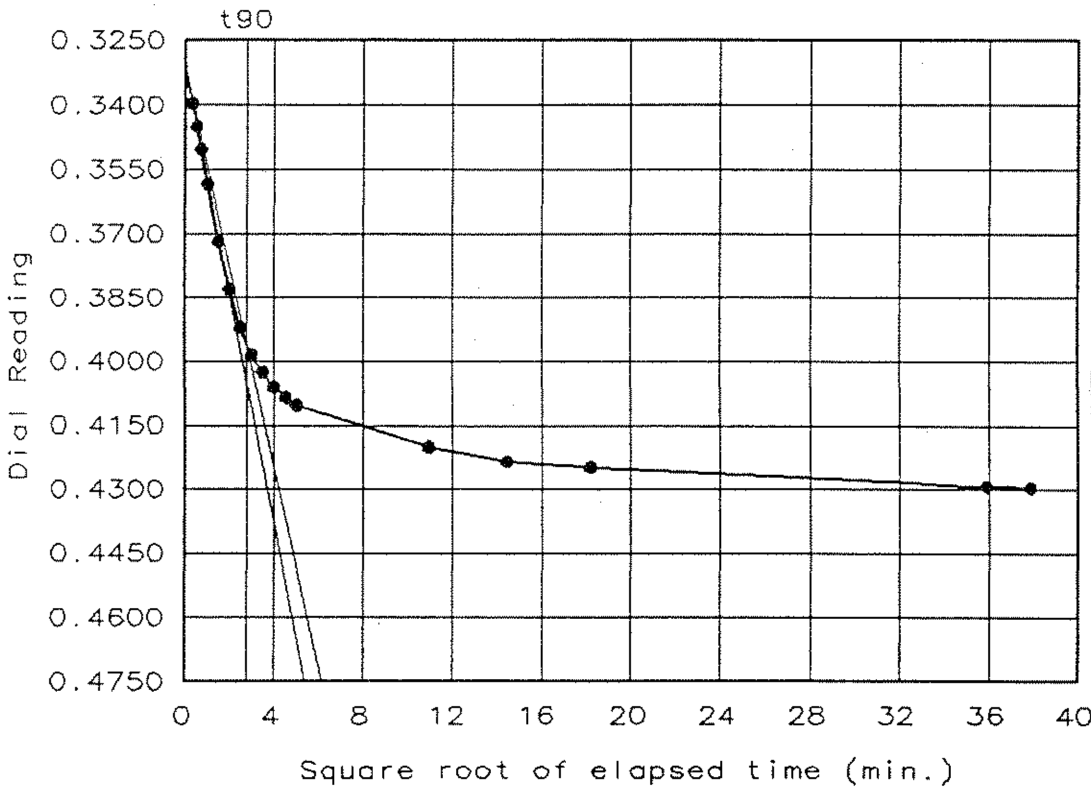
Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING: BH-13 LAB NO. 7383
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/15/99



Load No.= 3
Load= 1.00 tsf
D_0 = 0.2226
D_{90} = 0.2846
D_{100}= 0.2915
T_{90}= 8.09 min.

C_v @ T_{90} =
.013 in.^{2}/min.

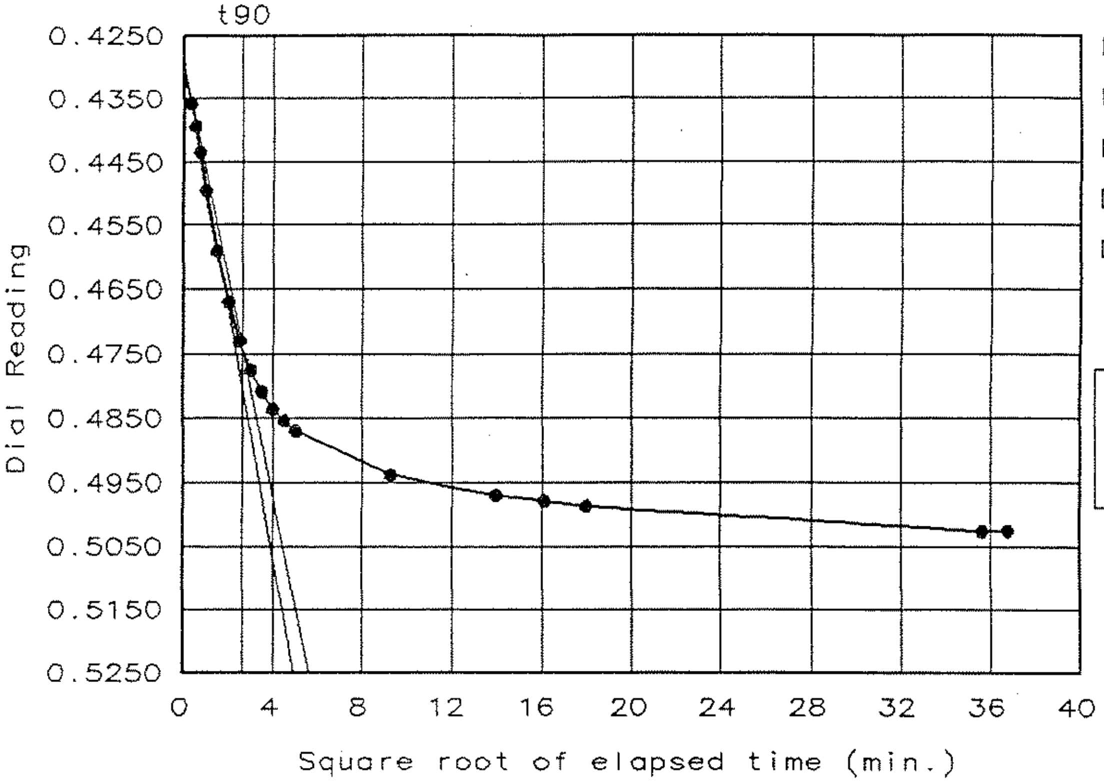


Load No.= 4
Load= 2.00 tsf
D_0 = 0.3312
D_{90} = 0.3954
D_{100}= 0.4025
T_{90}= 7.55 min.

C_v @ T_{90} =
.010 in.^{2}/min.

Dial Reading vs. Time

Project No.: 11294.019
Project: GMC-HARRISON RADIATOR SITE
Location: BORING: BH-13 LAB NO. 7383
SAMPLE:ST-1 DEPTH:0-2'
Date: 10/15/99



Load No.= 5
Load= 4.00 tsf
D_0 = 0.4298
D_{90} = 0.4742
D_{100}= 0.4791
T_{90}= 6.90 min.

C_v @ T_{90} =
.008 in.^{2}/min.

H.C. NUTTING COMPANY

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

10/28/99smo

Conestoga-Rovers & Assoc. LTD
GMC-Harrison Radiator Site
Moraine, OH
HCN W.O. # 11294.019

TABLE I
CLASSIFICATION TEST DATA

Boring No.	Sample No.	Depth (ft.)	Loss On Ignition (%)
1	1	1-3	13.21
	2	4.5-6.5	31.62
5	1	1-3	17.98
6	1	1-3	17.40
7	1	1-3	23.35
	2	5-7	18.47
8	1	1-3	23.53
9	1	0-2	26.40
10	1	1-3	27.81
	2	3.5-5.5	24.01
12	1	0-2	23.13
	2	2-4	18.36
13	1	0-2	38.78

1tb10-28

H.C. NUTTING COMPANY

Robert L. House,
Vice President/Lab. Director

TABLE 1

SLUDGE TREATABILITY STUDY
POCKET PANETROMETER RESULTS
HARRISON FACILITY
MORAINE, OHIO

Lagoon / Mix Ratio	COMPRESSIVE STRENGTH RESULTS: 14 (28) DAYS IN PSI			
	Control	25% CKD	50% CKD	100% CKD
South Primary Basin	<10(<10)	38(38)	>70(>70)	>70(>70)
South Secondary Basin	<10(<10)	21(24)	>70(>70)	>70(>70)
South Sludge Basin (Drying Basin)	<10(<10)	63(>70)	>70(>70)	>70(>70)
North Primary Basin	<10(<10)	13(14)	40(52)	>70(>70)
North Secondary Basin	<10(<10)	38(38)	56(59)	>70(>70)

Notes:

1. Unconfined strength measure by pocket panetrometer in pounds per square inch (psi).
2. Unconfined strength provided for sample following 14 and 28 days of curing time. Unconfined strength after 28 days noted in brackets.
3. Percent by volume cement kiln dust (CKD).
4. Closure Plan requirement of a minimum unconfined compressive strength of 25 psi.

TABLE 2

SLUDGE TREATABILITY STUDY
LABORATORY UNCONFINED COMPRESSIVE STRENGTH
HARRISON FACILITY
MORAINE, OHIO

	COMPRESSIVE STRENGTH RESULTS: 28 DAYS IN PSI								
Lagoon / Mix Ratio	10% CKD	15% CKD	20% CKD	25% CKD	30% CKD	35% CKD	40% CKD	45% CKD	50% CKD
South Primary Basin			14	32	139				
South Secondary Basin	AR	AR	76(4)	120.2	151(3)	225(3)			
South Sludge Basin (Drying Basin)		37		142					
North Primary Basin							22(3)(4)		73(3)
North Secondary Basin			9	14		34.7	43.7		

Notes:
1. Mix ratio of cement kiln dust (CKD) by volume.
2. Unconfined compressive strength in pounds per square inch (psi).
3. TCLP VOC analysis conducted.
4. TCLP Metal analysis conducted.
5. AR - Awaiting Results.

TABLE 3

SLUDGE PROPERTIES
HARRISON FACILITY
MORAINE, OHIO

Sample/Parameters	Moisture Content (%)	Bulk Density*** (lbs/ft³)	Observation
South Primary Basin*	48.9	87.4	Thick with hard lumps, hard to mix
South Secondary Basin**	69.5	68.7	Wet
South Sludge Basin**	44.5	56.2	light color, chunky
North Primary Basin*	54.0	81.2	Standing water, brown/gray
North Secondary Basin*	53.5	81.2	Thick, gray
Calcium Kiln Ash (Calciment)	<0.1	81.2	Beige color, fine powder

Note:
- * Sample received on 1/6/00.
- ** Sample received on 1/13/00.
- *** Determined by manual compacting of sample.

TCLP ANALYTICAL RESULTS
SOLIDIFIED SLUDGE SAMPLES

Columbia
Analytical
Services Inc.

1 Mustard St., Suite 250
Rochester, NY 14609

Date: March 29, 2000
Number of pages: ______

To:

Ms. Cynthia Lin
Conestoga Rovers & Associates
2055 Niagara Falls Blvd.
Suite Three
Niagara Falls, NY 14304

Phone: 716-297-6150

Fax: 716-297-6296

CC:

From:

Mark Wilson

Phone: (716) 288-5380

Fax: (716) 288-8475

RUSH REPORT

Submission #: R2001222
Project Reference: GMC-HARRISON RADIATOR #12611

IMPORTANT NOTICE:

COLUMBIA ANALYTICAL SERVICES

VOLATILE ORGANICS

METHOD 8260B TCLP
Reported: 03/29/00

Conestoga Rovers & Associates
Project Reference: GMC-HARRISON RADIATOR #12611
Client Sample ID : NORTH PRIMARY BASIN-40%

Date Sampled : 03/14/00 10:00 **Order #:** 364463 **Sample Matrix:** SOIL/SEDIME
Date Received: 03/14/00 **Submission #:** R2001222 **Analytical Run** 48834

ANALYTE	PQL	RESULT	UNITS
DATE ANALYZED : 03/22/00			
ANALYTICAL DILUTION: 10.00			
BENZENE	5.0	50 U	UG/L
2-BUTANONE (MEK)	10	100 U	UG/L
CARBON TETRACHLORIDE	5.0	50 U	UG/L
CHLOROBENZENE	5.0	50 U	UG/L
CHLOROFORM	5.0	50 U	UG/L
1,2-DICHLOROETHANE	5.0	50 U	UG/L
1,1-DICHLOROETHENE	5.0	50 U	UG/L
TETRACHLOROETHENE	5.0	50 U	UG/L
TRICHLOROETHENE	5.0	50 U	UG/L
VINYL CHLORIDE	5.0	50 U	UG/L

SURROGATE RECOVERIES	QC LIMITS		
BROMOFLUOROBENZENE	(86 - 115 %)	100	%
TOLUENE-D8	(88 - 110 %)	100	%
DIBROMOFLUOROMETHANE	(86 - 118 %)	12 *	%

Data Reported following TCLP Toxicity Characteristics Leaching Procedure. Federal Register, Part 261, Vol. 55, NO 126, June 29, 1990.

U - non-detected

COLUMBIA ANALYTICAL SERVICES

VOLATILE ORGANICS
METHOD 8260B TCLP
Reported: 03/29/00

Conestoga Rovers & Associates
Project Reference: GMC-HARRISON RADIATOR #12611
Client Sample ID : NORTH PRIMARY BASIN-50%

Date Sampled : 03/14/00 10:00 **Order #:** 364464 **Sample Matrix:** SOIL/SEDIMEN
Date Received: 03/14/00 **Submission #:** R2001222 **Analytical Run** 48834

DATE ANALYZED : 03/22/00
ANALYTICAL DILUTION: 10.00

ANALYTE	PQL	RESULT	UNITS
BENZENE	5.0	50 U	UG/L
2-BUTANONE (MEK)	10	100 U	UG/L
CARBON TETRACHLORIDE	5.0	50 U	UG/L
CHLOROBENZENE	5.0	50 U	UG/L
CHLOROFORM	5.0	50 U	UG/L
1,2-DICHLOROETHANE	5.0	50 U	UG/L
1,1-DICHLOROETHENE	5.0	50 U	UG/L
TETRACHLOROETHENE	5.0	50 U	UG/L
TRICHLOROETHENE	5.0	50 U	UG/L
VINYL CHLORIDE	5.0	50 U	UG/L

SURROGATE RECOVERIES	QC LIMITS		
ROMOFLUOROBENZENE	(86 - 115 %)	100	%
TOLUENE-D8	(88 - 110 %)	100	%
DIBROMOFLUOROMETHANE	(86 - 118 %)	6 *	%

Data Reported following TCLP Toxicity Characteristics Leaching Procedure. Federal Register, Part 261, Vol. 55, NO 126, June 29, 1990.

U - non - detected

COLUMBIA ANALYTICAL SERVICES

VOLATILE ORGANICS
METHOD 8260B TCLP
Reported: 03/29/00

Conestoga Rovers & Associates
Project Reference: GMC-HARRISON RADIATOR #12611
Client Sample ID : SOUTH SECONDARY BASIN-30%

Date Sampled : 03/14/00 10:00 **Order #:** 364465 **Sample Matrix:** SOIL/SEDIME
Date Received: 03/14/00 **Submission #:** R2001222 **Analytical Run** 48834

DATE ANALYZED : 03/23/00
ANALYTICAL DILUTION: 10.00

ANALYTE	PQL	RESULT	UNITS
BENZENE	5.0	50 U	UG/L
2-BUTANONE (MEK)	10	100 U	UG/L
CARBON TETRACHLORIDE	5.0	50 U	UG/L
CHLOROBENZENE	5.0	50 U	UG/L
CHLOROFORM	5.0	50 U	UG/L
1,2-DICHLOROETHANE	5.0	50 U	UG/L
1,1-DICHLOROETHENE	5.0	50 U	UG/L
TETRACHLOROETHENE	5.0	50 U	UG/L
TRICHLOROETHENE	5.0	50 U	UG/L
VINYL CHLORIDE	5.0	50 U	UG/L

SURROGATE RECOVERIES	QC LIMITS		
BROMOFLUOROBENZENE	(86 - 115 %)	101	%
TOLUENE-D8	(88 - 110 %)	101	%
DIBROMOFLUOROMETHANE	(86 - 118 %)	102	%

Data Reported following TCLP Toxicity Characteristics Leaching Procedure.
Federal Register, Part 261, Vol. 55, NO 126, June 29, 1990.

U- non- detected

COLUMBIA ANALYTICAL SERVICES

Reported: 04/07/00

Conestoga Rovers & Associates
Project Reference:GMC-HARRISON RADIATOR #12611
Client Sample ID :NORTH PRIMARY BASIN-403

Date Sampled : 03/14/00
Date Received: 03/31/00
Order #: 368668
Submission #: R2001464
Sample Matrix: SOIL/SEDIMENT

ANALYTE	PQL	RESULT	UNITS	DATE ANALYZED	ANALYTICAL DILUTION
METALS					
ARSENIC	0.500	0.500 U	MG/L	04/05/00	1.00
BARIUM	1.00	1.14	MG/L	04/05/00	1.00
CADMIUM	0.100	0.100 U	MG/L	04/05/00	1.00
CHROMIUM	0.100	0.100 U	MG/L	04/05/00	1.00
LEAD	0.100	0.100 U	MG/L	04/05/00	1.00
MERCURY	0.000300	0.00300 U	MG/L	04/07/00	10.0
SELENIUM	0.500	0.500 U	MG/L	04/05/00	1.00
SILVER	0.100	0.100 U	MG/L	04/05/00	1.00

Data reported following TCLP Toxicity Characteristic Leaching Procedure.
Federal Register, Part 261, Vol. 55, No. 126, June 29, 1990.

Columbia Analytical Services inc.

1 Mustard St., Suite 250
Rochester, NY 14609

Date: May 3, 2000
Number of pages: ______

To:

Ms. Cynthia Lin
Conestoga Rovers & Associates
2055 Niagara Falls Blvd.
Suite Three
Niagara Falls, NY 14304

Phone: 716-297-6150

Fax: 716-297-6296

CC:

From:

Mark Wilson

Phone: (716) 288-5380

Fax: (716) 288-8475

RUSH REPORT

Submission #: R2001751
Project Reference: GMC-HARRISON RADIATOR 12611

IMPORTANT NOTICE:

COLUMBIA ANALYTICAL SERVICES

VOLATILE ORGANICS
METHOD 8260B TCLP
Reported: 03/29/00

Conestoga Rovers & Associates
Project Reference: GMC-HARRISON RADIATOR #12611
Client Sample ID : SOUTH SECONDARY BASIN-35%

Date Sampled : 03/14/00 10:00 **Order #:** 364466 **Sample Matrix:** SOIL/SEDIMEN
Date Received: 03/14/00 **Submission #:** R2001222 **Analytical Run** 48834

DATE ANALYZED : 03/23/00
ANALYTICAL DILUTION: 10.00

ANALYTE	PQL	RESULT	UNITS
BENZENE	5.0	50 U	UG/L
2-BUTANONE (MEK)	10	100 U	UG/L
CARBON TETRACHLORIDE	5.0	50 U	UG/L
CHLOROBENZENE	5.0	50 U	UG/L
CHLOROFORM	5.0	50 U	UG/L
1,2-DICHLOROETHANE	5.0	50 U	UG/L
1,1-DICHLOROETHENE	5.0	50 U	UG/L
TETRACHLOROETHENE	5.0	50 U	UG/L
TRICHLOROETHENE	5.0	50 U	UG/L
VINYL CHLORIDE	5.0	50 U	UG/L

SURROGATE RECOVERIES	QC LIMITS		
ROMOFLUOROBENZENE	(86 - 115 %)	100	%
OLUENE-D8	(88 - 110 %)	99	%
DIBROMOFLUOROMETHANE	(86 - 118 %)	102	%

Data Reported following TCLP Toxicity Characteristics Leaching Procedure. Federal Register, Part 261, Vol. 55, NO 126, June 29, 1990.

U - non - detected

Columbia
Analytical
Services inc.

1 Mustard St., Suite 250
Rochester, NY 14609

Date: April 7, 2000
Number of pages: ______

To:

Ms. Cynthia Lin
Conestoga Rovers & Associates
2055 Niagara Falls Blvd.
Suite Three
Niagara Falls, NY 14304

Phone: 716-297-6150

Fax: 716-297-6296

CC:

From:

Mark Wilson

Phone: (716) 288-5380

Fax: (716) 288-8475

RUSH REPORT

Submission #: R2001464
Project Reference: GMC-HARRISON RADIATOR #12611

IMPORTANT NOTICE:

COLUMBIA ANALYTICAL SERVICES

Reported: 05/03/00

Conestoga Rovers & Associates
Project Reference:GMC-HARRISON RADIATOR 12611
Client Sample ID :SOUTH SECONDARY BASIN

Date Sampled : 04/18/00
Date Received: 04/19/00
Order #: 373167
Submission #: R2001751
Sample Matrix: SOIL/SEDIMENT

ANALYTE	PQL	RESULT	UNITS	DATE ANALYZED	ANALYTICAL DILUTION
METALS					
ARSENIC	0.500	0.500 U	MG/L	05/01/00	1.00
BARIUM	1.00	1.00 U	MG/L	05/01/00	1.00
CADMIUM	0.100	0.100 U	MG/L	05/01/00	1.00
CHROMIUM	0.100	0.100 U	MG/L	05/01/00	1.00
LEAD	0.100	0.100 U	MG/L	05/01/00	1.00
MERCURY	0.000300	0.00300 U	MG/L	05/01/00	10.0
SELENIUM	0.500	0.500 U	MG/L	05/01/00	1.00
SILVER	0.100	0.100 U	MG/L	05/01/00	1.00

Data reported following TCLP Toxicity Characteristic Leaching Procedure.
Federal Register, Part 261, Vol. 55, No. 126, June 29, 1990.

CRA
CONESTOGA-ROVERS & ASSOCIATES

PROJECT No.: 12611
PROJECT NAME: GMC Harrison Radiator
DATE: May 4/2000
DESIGNED BY: BP
CHECKED BY:
PAGE 1 OF 2

Load Bearing Capacity of Solidified Sludge

Specified unconfined compressive strength after solidification is: 25 psi

$25 \text{ psi} = 3600 \text{ psf}$

The shear strength at failure is:

$S_u = \frac{1}{2}(3600 \text{ psf}) = 1800 \text{ psf}$

Using Terzaghi's bearing capacity equation for continuous footings:

$q_{ult} = S_u N_c$

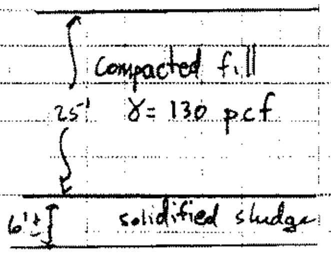
for undrained conditions, $N_c = 5.7$ (see attached reference)

$\therefore q_{ult} = 5.7 \times 1800 \text{ psf}$

$q_{ult} = 10260 \text{ psf}$

The solidified sludge will be covered by 10 to 25' of compacted fill.
Assuming the maximum surcharge load of 25', the load applied to the solidified sludge will be:

$q = 25 \text{ ft} \times 130 \text{ pcf}$
$= 3250 \text{ psf}$



Factor of safety, F.S

$F.S = \frac{q_{ult}}{q}$

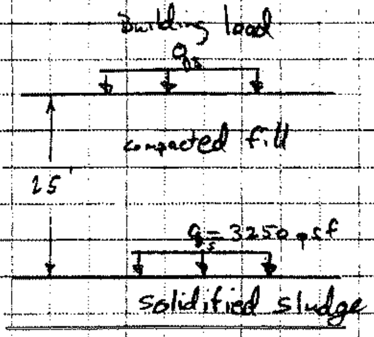
$= \frac{10260 \text{ psf}}{3250 \text{ psf}}$

$F.S = 3.2$ (o.k. since $F.S. > 2$)

CRA
CONESTOGA-ROVERS & ASSOCIATES

PROJECT No.: 12611
PROJECT NAME: GMC Harrison Radiator
DATE: May 4 /2000
DESIGNED BY: BP
CHECKED BY:
PAGE 2 OF 2

Additional Load Due to Future Building



To maintain a factor of safety, F.S > 2, the applied building load plus the compacted fill load must not exceed allowable bearing capacity

$$q_{all} = \frac{q_{ult}}{F.S}$$

$$= \frac{10260 \text{ psf}}{2}$$

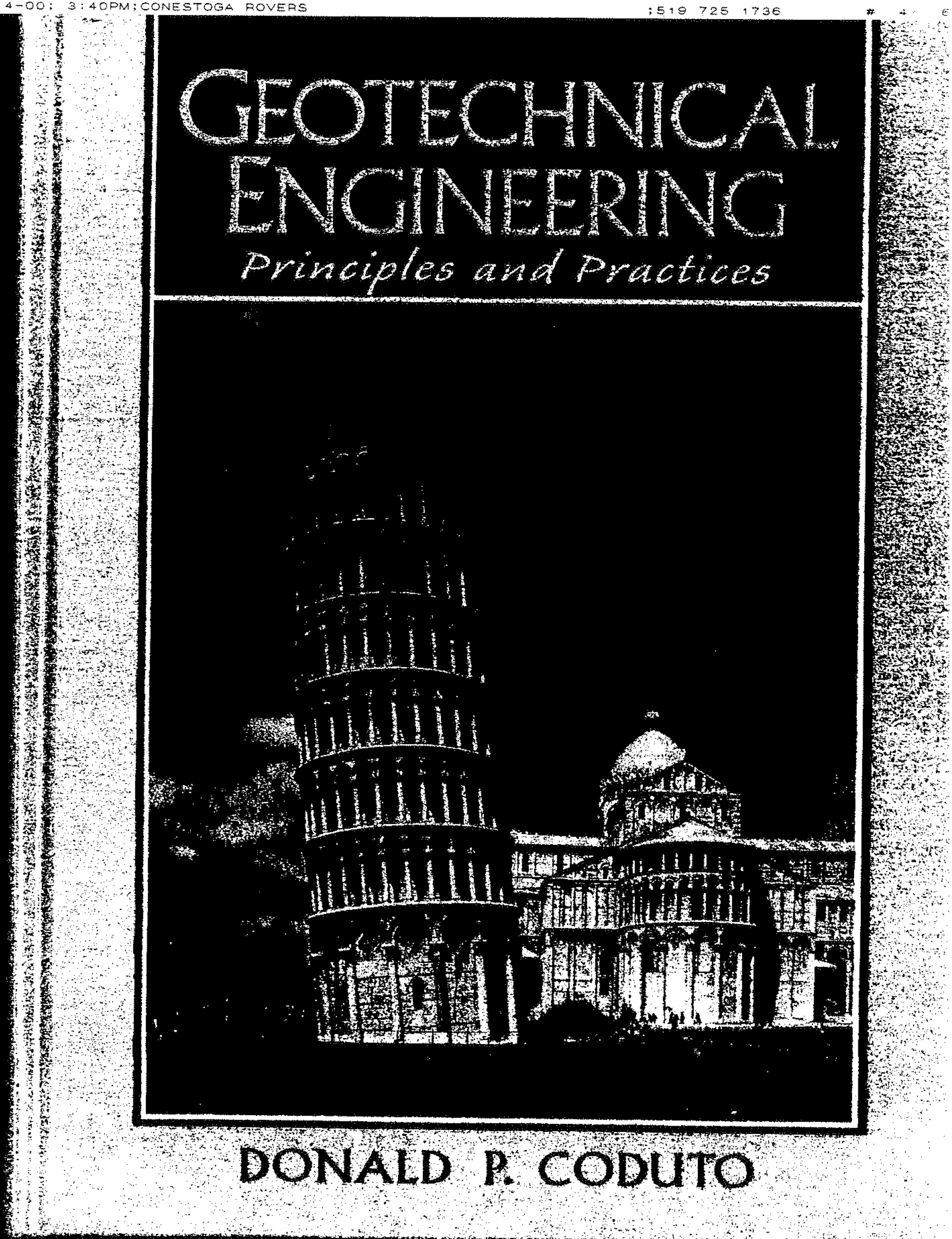
$$q_{all} = 5130 \text{ psf}$$

$$\therefore \quad q_B + q_s \leq 5130 \text{ psf}$$

$$q_B \leq (5130 - 3250) \text{ psf}$$

$$q_B \leq 1880 \text{ psf}$$

Therefore provided building loads do not exceed 1880 psf, the load bearing capacity of the sludge will not be exceeded and the factor of safety will be greater than 2.



GEOTECHNICAL ENGINEERING

Principles and Practices

DONALD P. CODUTO

the actual bearing pressure is sufficiently smaller than q_{ult} to provide an adequate factor of safety against a bearing capacity failure.

In 1943, Karl Terzaghi developed the first widely accepted formulas for computing ultimate bearing capacity. His analysis was based on a bearing capacity theory for continuous footings because this is a two dimensional problem, and thus is the simplest case. He evaluated the shear stress and shear strength along a failure surface with a certain geometry, then wrote an equation of equilibrium in terms of q_{ult}. He then extended this equation to square and circular footings by incorporating empirical coefficients. Terzaghi's formulas are as follows (Terzaghi, 1943):

For square footings:

$$\boxed{q_{ult} = 1.3c'N_c + \sigma'_D N_q + 0.4\gamma' B N_\gamma} \qquad (17.5)$$

For continuous footings:

$$\boxed{q_{ult} = c'N_c + \sigma'_D N_q + 0.5\gamma' B N_\gamma} \qquad (17.6)$$

For circular footings:

$$\boxed{q_{ult} = 1.3c'N_c + \sigma'_D N_q + 0.3\gamma' B N_\gamma} \qquad (17.7)$$

where:

q_{ult} = ultimate bearing capacity
c' = effective soil cohesion
σ_D' = vertical effective stress at depth D below the ground surface ($\sigma_D' = \gamma D$ if depth to groundwater table is greater than D)
γ' = effective unit weight of the soil ($\gamma' = \gamma$ if the groundwater table is very deep; see discussion later in this section for shallow groundwater conditions)
D = depth of footing below ground surface
B = width (or diameter) of footing
N_c, N_q, N_γ = bearing capacity factors = $f(\phi')$ — see Table 17.1

Terzaghi's equations also may be used in a total stress analysis. In that case, substitute c_T, ϕ_T, and σ_D for c', ϕ', and σ_D'. If saturated undrained conditions exist, we may conduct a total stress analysis with the shear strength defined as $c_T = s_u$ and $\phi_T = 0$. In this case, $N_c = 5.7$, $N_q = 1.0$, and $N_c = 0.0$.

TABLE 17.

ϕ' (deg)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
[illegible]
[illegible]
[illegible]
18
19

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:, we may conduct a
$_T = 0$. In this case,

TABLE 17.1 BEARING CAPACITY FACTORS FOR TERZAGHI'S EQUATIONS

ϕ' (deg)	N_c	N_q	N_γ
0	5.7	1.0	0.0
1	6.0	1.1	0.1
2	6.3	1.2	0.1
3	6.6	1.3	0.2
4	7.0	1.5	0.3
5	7.3	1.6	0.4
6	7.7	1.8	0.5
7	8.2	2.0	0.6
8	8.6	2.2	0.7
9	9.1	2.4	0.9
10	9.6	2.7	1.0
11	10.2	3.0	1.2
12	10.8	3.3	1.4
13	11.4	3.6	1.6
14	12.1	4.0	1.9
15	12.9	4.4	2.2
16	13.7	4.9	2.5
17	14.6	5.5	2.9
18	15.5	6.0	3.3
19	16.6	6.7	3.8
20	17.7	7.4	4.4
21	18.9	8.3	5.1
22	20.3	9.2	5.9
23	21.7	10.2	6.8
24	23.4	11.4	7.9
25	25.1	12.7	9.2
26	27.1	14.2	10.7
27	29.2	15.9	12.5
28	31.6	17.8	14.6
29	34.2	20.0	17.1
30	37.2	22.5	20.1
31	40.4	25.3	23.7
32	44.0	28.5	28.0
33	48.1	32.2	33.3
34	52.6	36.5	39.6
35	57.8	41.4	47.3
36	63.5	47.2	56.7
37	70.1	53.8	68.1
38	77.5	61.5	82.3
39	86.0	70.6	99.8

Although subsequent work has produced formulas that are more versatile and slightly more precise, Terzaghi's formulas are still widely used, and are adequate for many practical design problems.

Groundwater Effects

Apparent Cohesion

Sometimes soil samples obtained from the exploratory borings are not saturated, especially if the site is in an arid or semi-arid area. These soils have additional shear strength due to the presence of apparent cohesion, as discussed in Chapter 13. However, this additional strength will disappear if the moisture content increases. Water may come from landscape irrigation, rainwater infiltration, leaking pipes, rising groundwater, or other sources. Therefore, we do not rely on the strength due to apparent cohesion.

In order to remove the apparent cohesion effects and simulate the "worst case" condition, geotechnical engineers usually wet the samples in the lab prior to testing. This may be done by simply soaking the sample, or, in the case of the triaxial test, by backpressure saturation. However, even with these precautions, the cohesion measured in the laboratory test may still include some apparent cohesion. Therefore, we often perform bearing capacity computations using a cohesion value less than that measured in the laboratory.

APPENDIX G

LAGOON, PIPING HYDRAULICS, AND PAVEMENT/ COVER DESIGN CALCULATIONS

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM W.O. No.: 12 600-11
Project: Lagoon Closure Location: Moraine ,Ohio

CALCULATION IDENTIFICATION

Calculation Ref. No.: No. Pages:
(Including calculation cover sheet)

Calculation Description:

NORTH LAGOON STORMWATER MANAGEMENT

Design: A.Wesolowski Date: August 17/99
Checked: Date:
Supervised: Date:
Project Control: Date:

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

CRA	PROJECT No: 12600-11	DESIGNED BY: A.W.
	PROJECT NAME: Lagoon Closure	CHECKED BY:
	DATE : Aug 17/99	PAGE 1 OF 1

1. STORMWATER MANAGEMENT

1.1 Peak Discharge Calculations

1.1.1 Data Given :

- Method: TR-55 "Urban Hydrology for Small Watershed"
- Event; 25yr - 24 hr storm
- Location; Moraine, Ohio
- Catchment area: approx. 5.53 acres

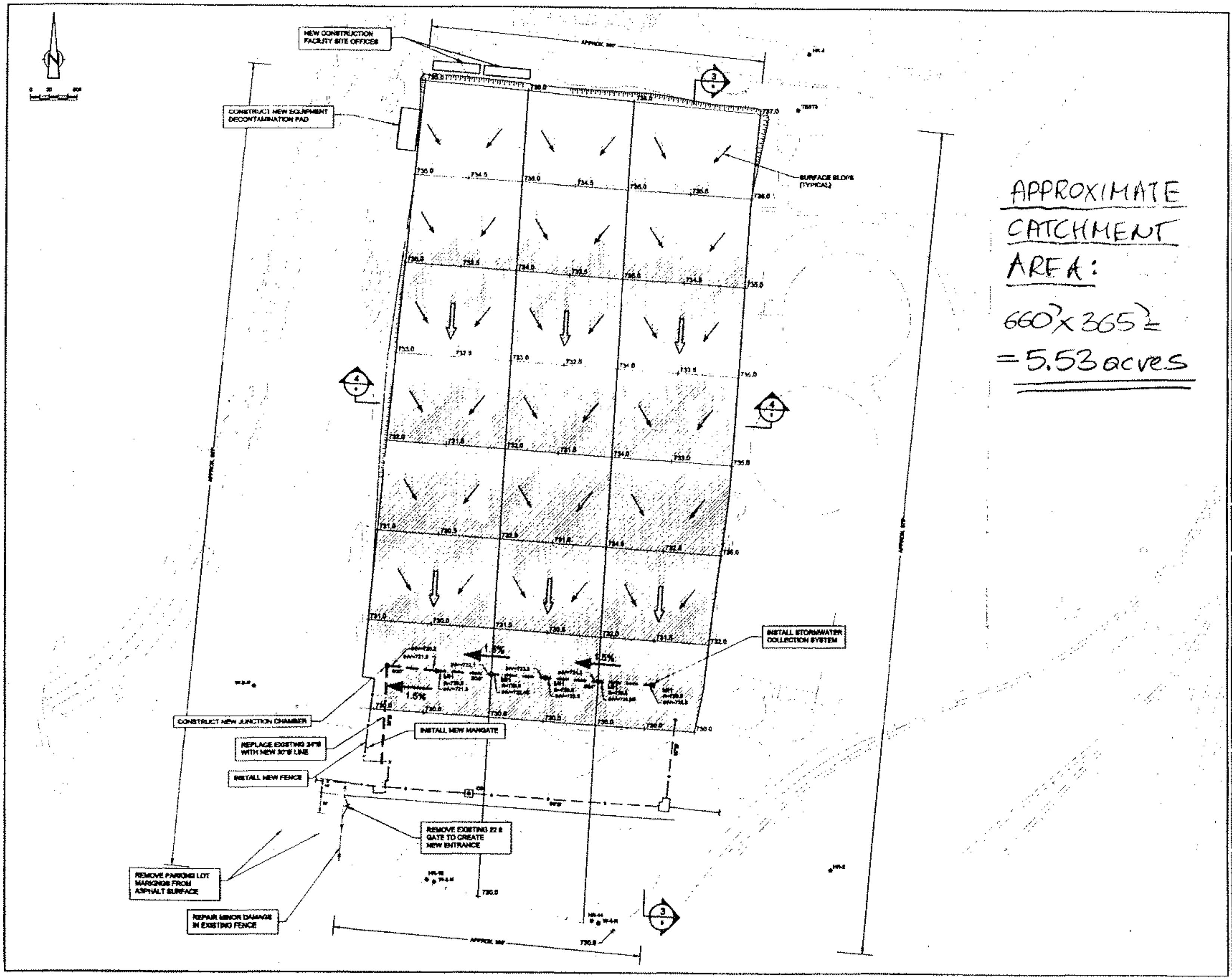
1.1.2 Detailed Calculations

Detailed calculations have been performed according to TR-55 document as shown in attached worksheet forms.

2. CONCLUSION

Estimated peak flow:

Q = 34.05 cfs



APPROXIMATE CATCHMENT AREA:

660'x 365' =

= 5.53 acres

LEGEND

NEW	EXISTING	
		FENCE
		TURN DIAL TYPE ENTRANCE
		ASPHALT PAVEMENT
		GRAVEL SURFACE
		EDGE OF WATER
		RAILROAD
		VEGETATION
		MARSH
		CONTOUR AND ELEVATION (ft.)
		STORMWATER SEWER
		OVERHEAD POWER LINE
		TREE
	● HR-4	MONITORING WELL
	◐ W-1-N	MONITORING WELL
● MH		MANHOLE/CATCH-BASIN
R=734.5		RIM ELEVATION
INV. = 730.0		PIPE INVERT ELEVATION
+ 734.5		SPOT ELEVATION
■ CB		CATCHBASIN
▨		LIMIT OF PROPOSED ASPHALT COVER
○		JUNCTION CHAMBER

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

DRAWING STATUS

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 7

ASPHALT PAVEMENT COVER
NORTH SETTLING LAGOON

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
WOOLPERT LLP DAYTON, OHIO JULY 1998

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1998	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
1"=80'	12611-00	003	PLAN 7

Worksheet 2: Runoff curve number and runoff

Project LAGOON CLOSURE By A.W. Date AUG 18/00

Location MORAINE OHIO Checked ____ Date ____

Circle one: Present [✓ Developed] ____________________

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
—	PAVED PARKING LOT	98			5.53	541.94
				Totals =		541.94

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = $\frac{541.94}{5.53}$ = 98 ; Use CN = 98

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency .... 24 hrs	yr	25	2	
Rainfall, P (24-hour)	in	4.5	2.75	
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	4.26		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project LAGOON CLOSURE By A.W. Date AUG 18/99

Location MORAINE OHIO Checked _____ Date _____

Circle one: Present [✓ Developed]

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID				
1. Surface description (table 3-1)		SMOOTH SURFACE		
2. Manning's roughness coeff., n (table 3-1) ..		0.011		
3. Flow length, L (total L ≤ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	2.75		
5. Land slope, s	ft/ft	0.005		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.038 +		= 0.038

Shallow concentrated flow

Segment ID				
7. Surface description (paved or unpaved)		PAVED		
8. Flow length, L	ft	525		
9. Watercourse slope, s (average)	ft/ft	0.008		
10. Average velocity, V (figure 3-1)	ft/s	1.4		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.104 +		= 0.104

Channel flow

Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_r	hr	+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.142

Worksheet 4: Graphical Peak Discharge method

Project LAGOON CLOSURE By ALW Date AUG 18/99

Location MORAINE OHIO Checked _____ Date _____

Circle one: Present [✓ Developed]

1. Data:

Drainage area .... A_m = 0.00864 mi^2 (acres/640)

Runoff curve number .... CN = 98 (From worksheet 2)

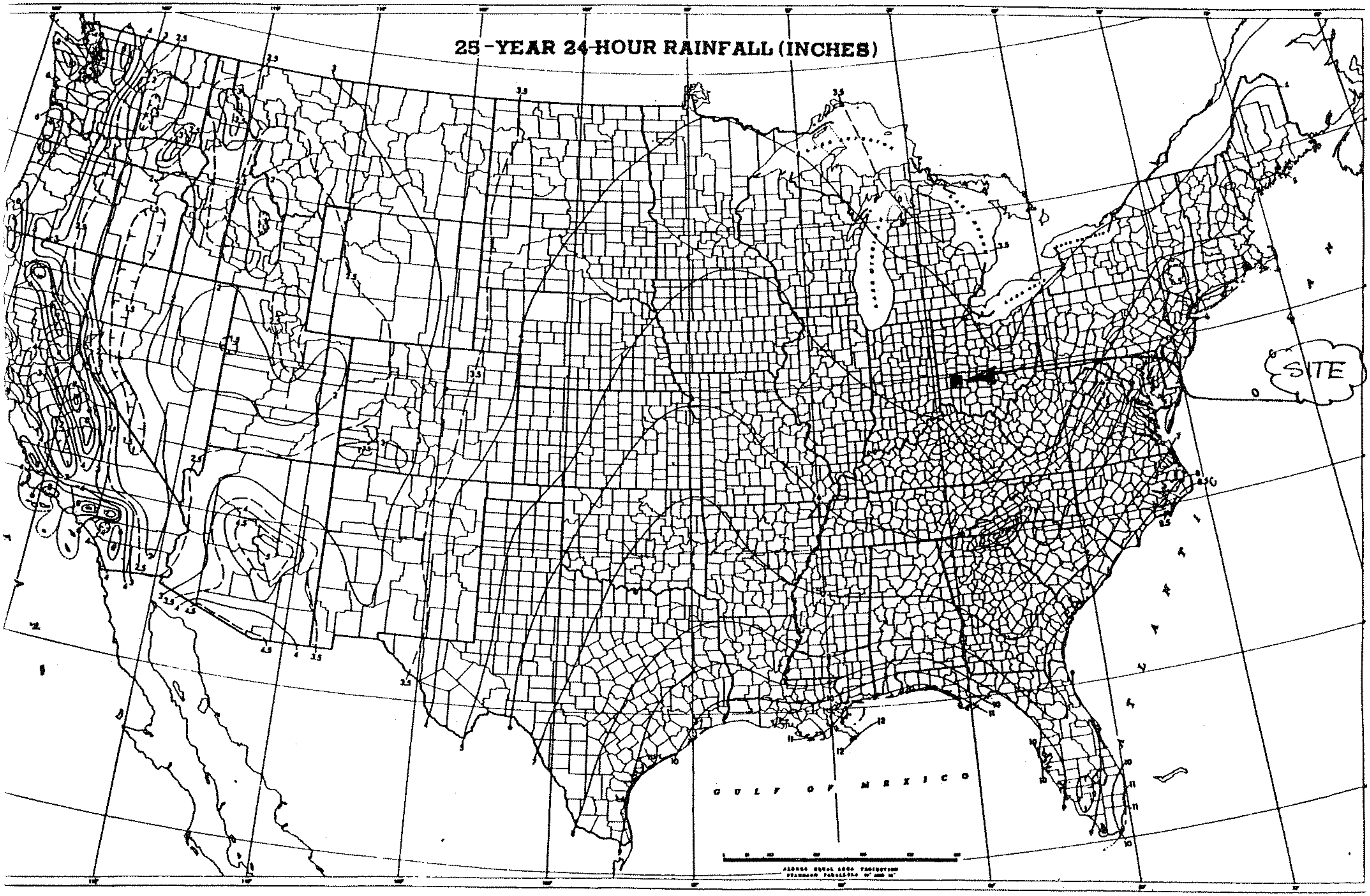
Time of concentration .. T_c = 0.142 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	4.5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.041		
5. Compute I_a/P		0.00911		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	925		
7. Runoff, Q .... (From worksheet 2).	in	4.26		
8. Pond and swamp adjustment factor, F_p 1.0 .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)				
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	34.05		

Chart



25-YEAR 24-HOUR RAINFALL (INCHES)

2-YEAR 24-HOUR RAINFALL (INCHES)

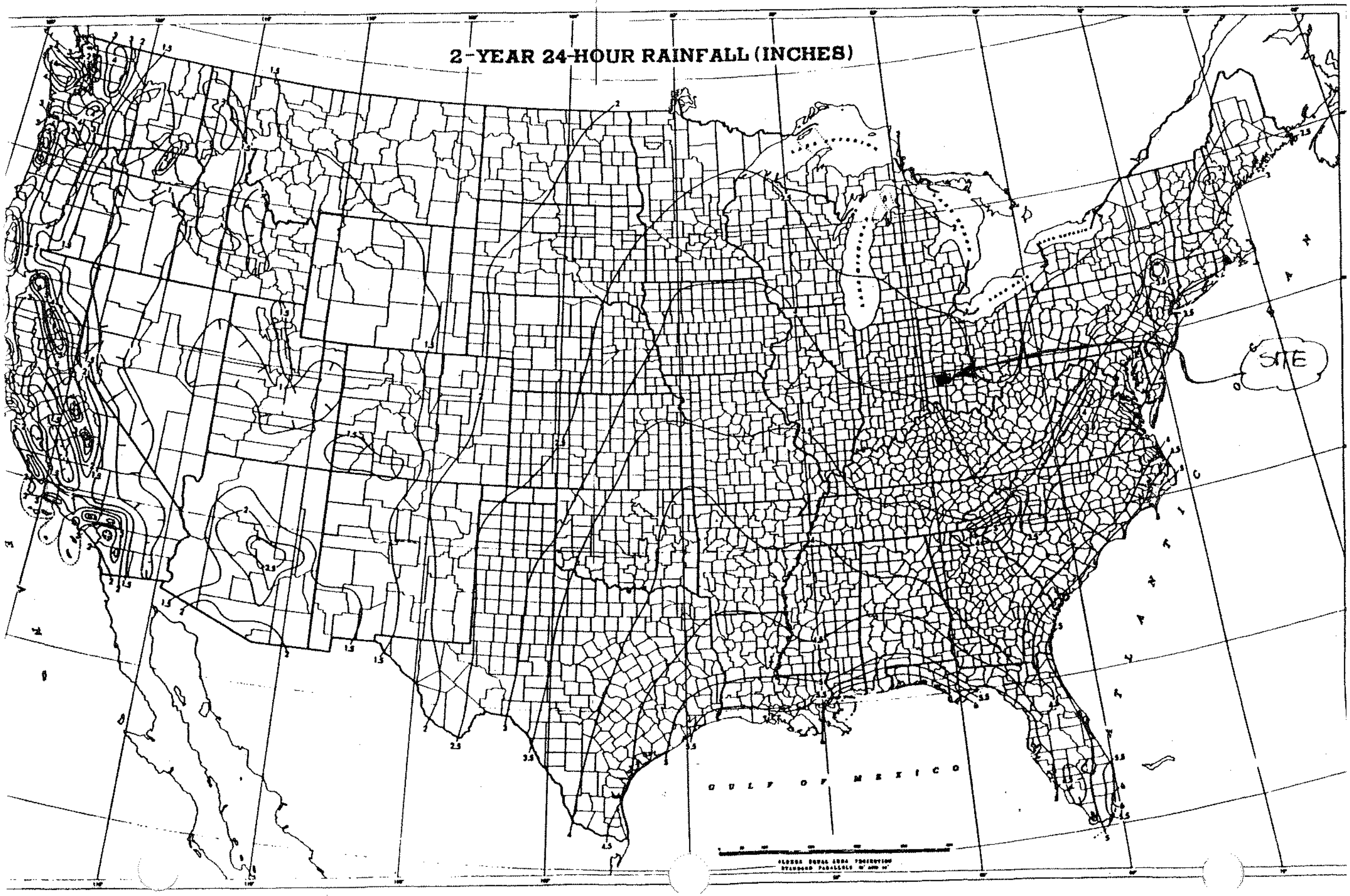


Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

---

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Chapter 4: Graphical Peak Discharge method

his chapter presents the Graphical Peak Discharge ethod for computing peak discharge from rural and rban areas. The Graphical method was developed om hydrograph analyses using TR-20, "Computer rogram for Project Formulation–Hydrology" (SCS 983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

here

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
A_m = drainage area (mi^2);
Q = runoff (in); and
F_p = pond and swamp adjustment factor.

he input requirements for the Graphical method are s follows: (1) T_c (hr), (2) drainage area (mi^2), (3) ppropriate rainfall distribution (I, IA, II, or III), (4) 4-hour rainfall (in), and (5) CN. If pond and swamp reas are spread throughout the watershed and are ot considered in the T_c computation, an adjustment or pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

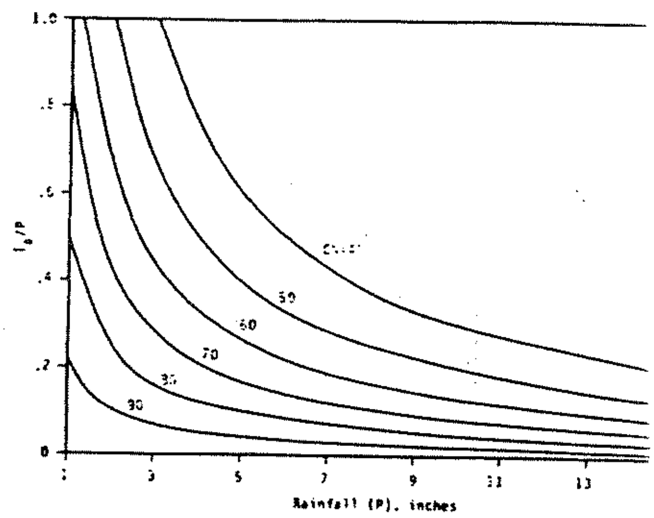


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.1[illegible]
65	1.077	95	0.[illegible]
66	1.030	96	0.08[illegible]
67	0.985	97	0.0[illegible]
68	0.941	98	0.041
69	0.899		

texture is given in appendix A for determining the HSG classification for disturbed soils.

Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and i generally estimated from density of plant and resi cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cov type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes i rotations; (d) percent of residue cover; and (e) degre of surface roughness.

Table 2-1.—Runoff depth for selected CN's and rainfall amounts[1]

Rainfall	Runoff depth for curve number of—												
	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from f[illegible]e 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

---

[1] The n values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

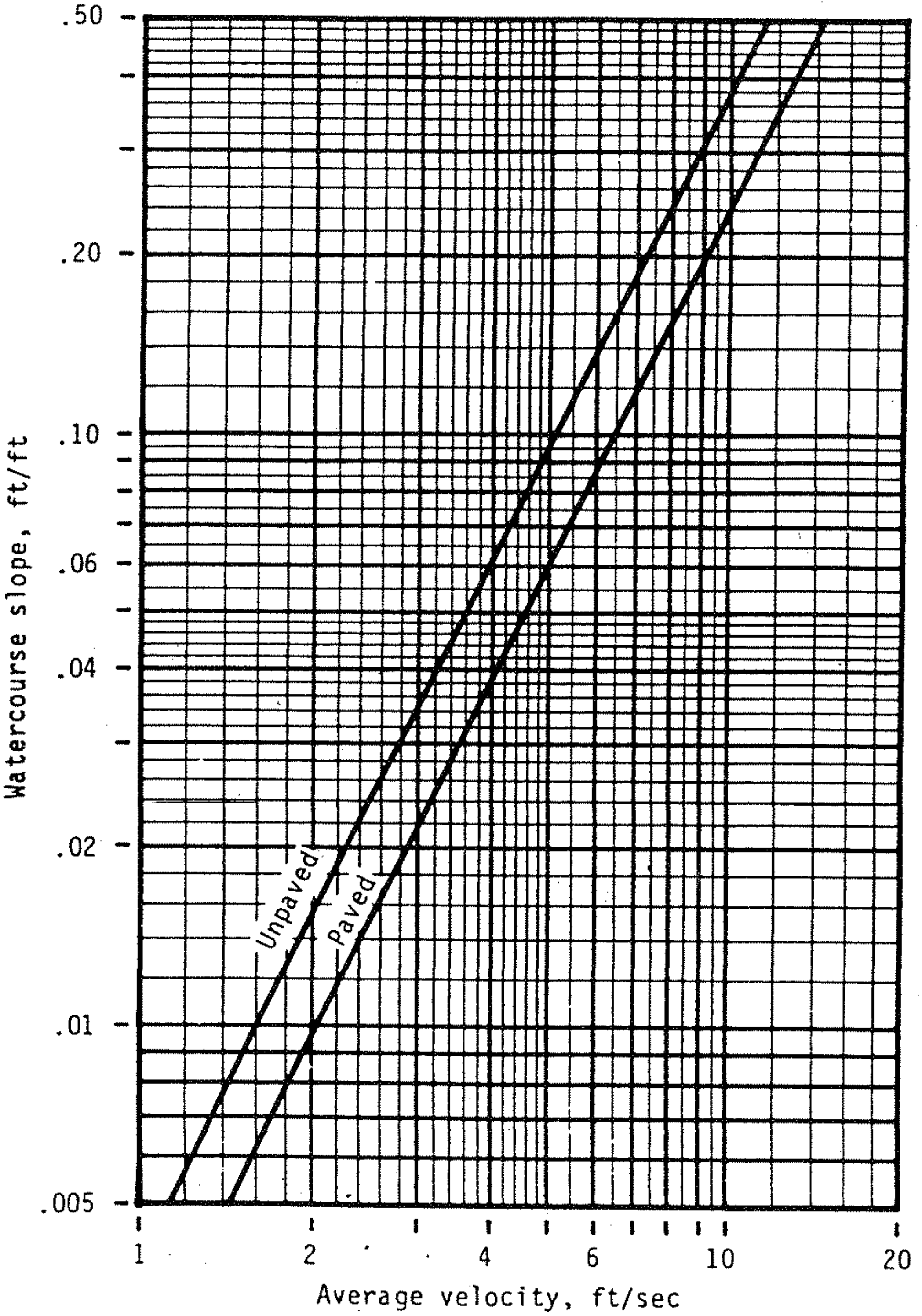
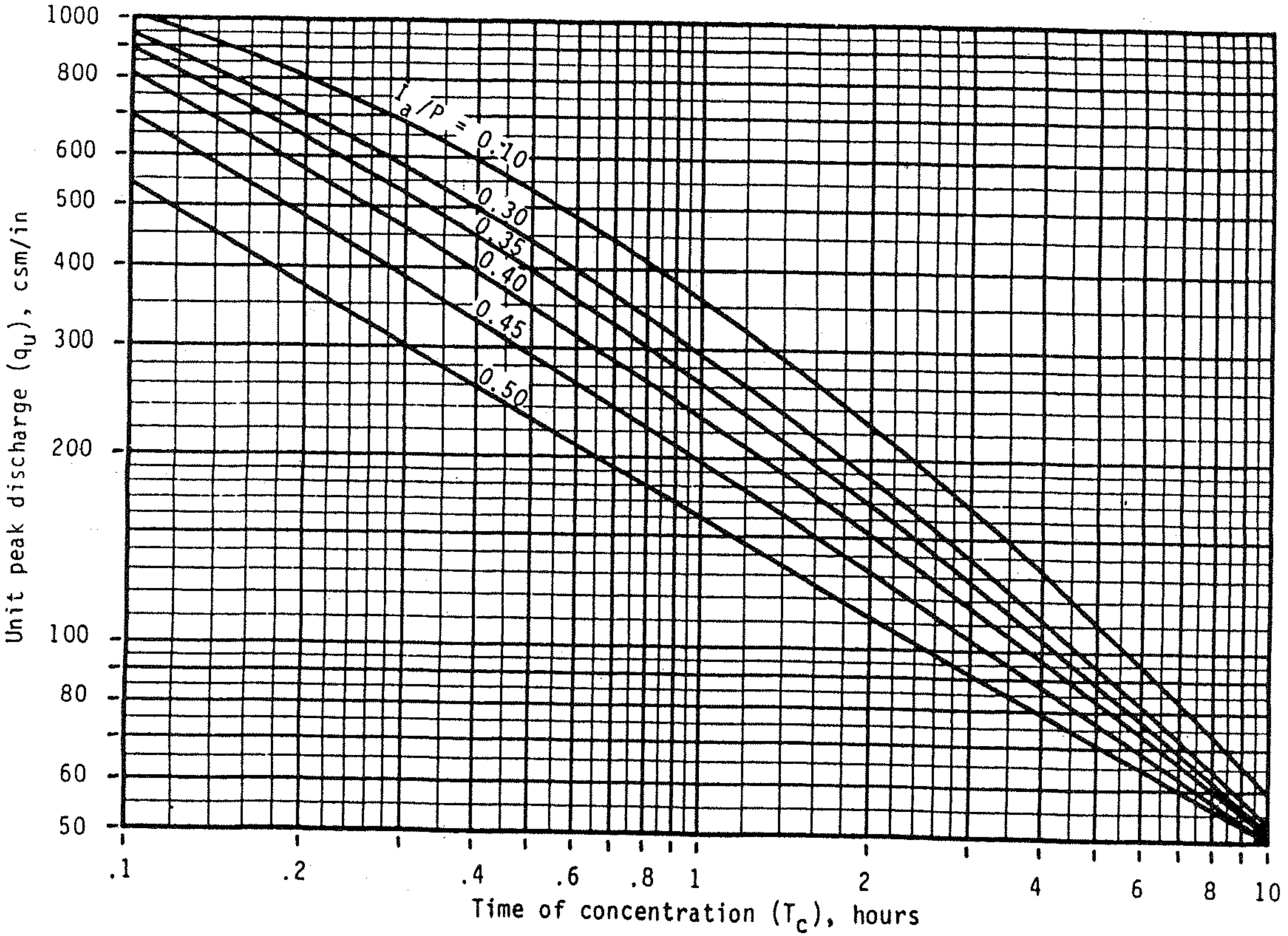


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution



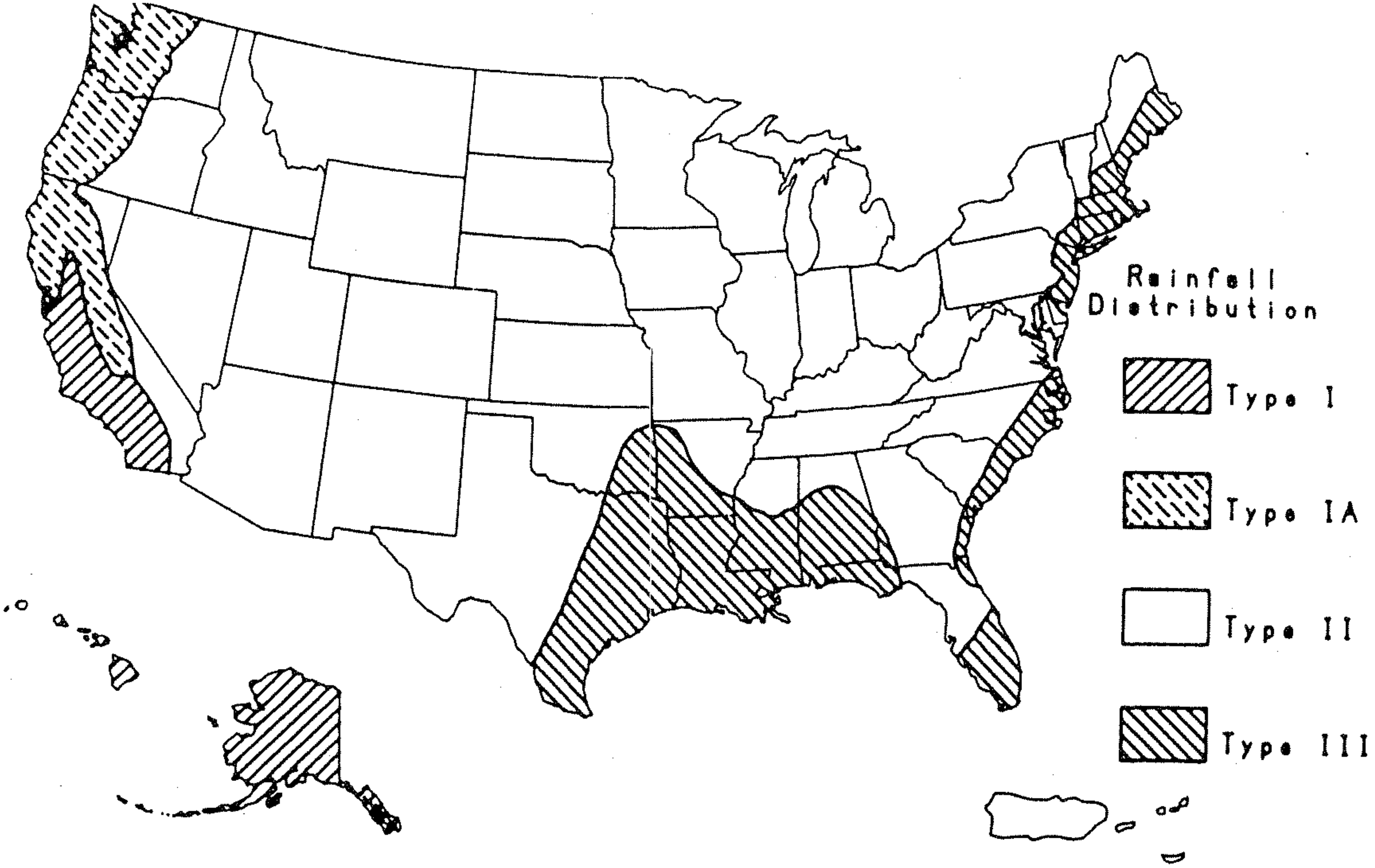


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM
W.O. No.: 12 611-00
Project: Lagoon Closure
Location: Morraine, Ohio

CALCULATION IDENTIFICATION

Calculation Ref. No.:
No. Pages:
(Including calculation cover sheet)

Calculation Description:

SOUTH LAGOON STORMWATER MANAGEMENT

Design: A.Wesolowski
Date: January 5/00
Checked:
Date:
Supervised:
Date:
Project Control:
Date:

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

CRA	PROJECT No: 12611-00	DESIGNED BY: A.W.
	PROJECT NAME: Lagoon Closure	CHECKED BY:
	DATE : Jan 6/00	PAGE 1 OF 2

1. STORMWATER MANAGEMENT

1.1 Peak Discharge Calculations

1.1.1 Data Given :

- Method: TR-55 "Urban Hydrology for Small Watershed"
- Event; 25yr - 24 hr storm
- Location; Moraine, Ohio
- Catchment areas: Area 1 = 1.5 ac
  Area 2 = 2.9 ac
  Area 3 = 4.9 ac
  Area 4 = 2.2 ac

1.1.2 Detailed Calculations

Detailed calculations have been performed according to TR-55 document as shown in attached worksheet forms.

2. CONCLUSION

Estimated peak flows:

Qarea1 = 2.15 cfs
Qarea2 = 4.13 cfs
Qarea3 = 6.74 cfs
Qarea4 = 3.10 cfs

Subsequently, discharge to:

CB 1= (4.13+6.74) = **10.87 cfs**
CB 2= (2.15+3.10) = **5.25 cfs**

CRA

PROJECT NO: 12611

DESIGNED BY:A.W.

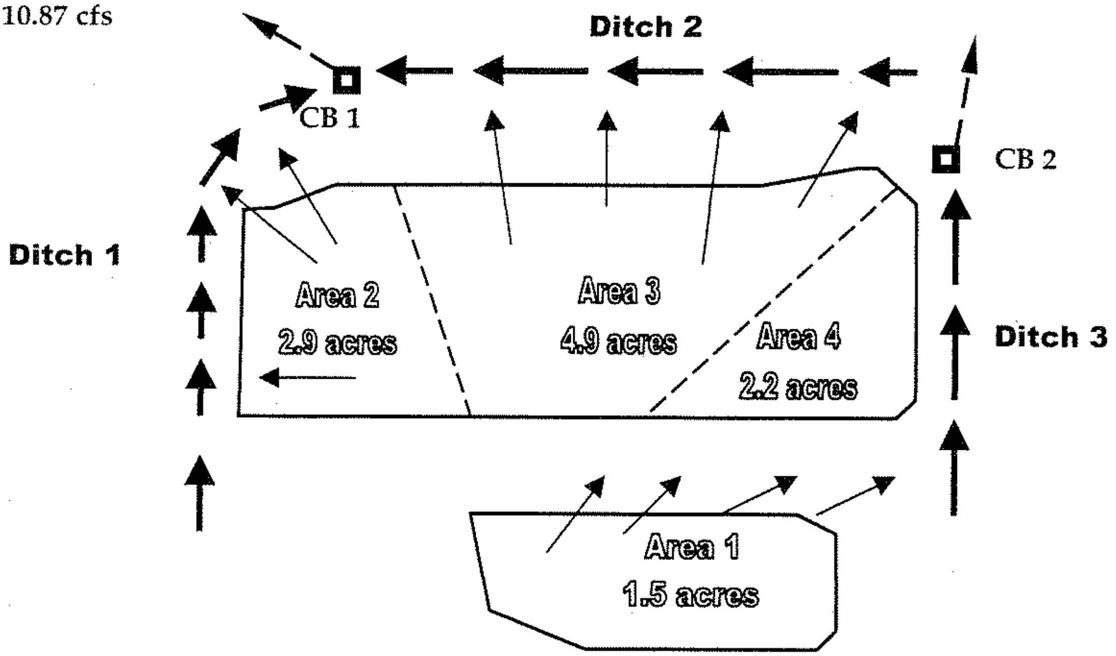
PROJECT NAME: Lagoon closure

CHECKED BY:

DATE : Jan6/00

PAGE 2 OF 2

SURFACE RUNOFF MANAGEMENT



Total piping discharge to public Stormsewer System, Q =10.87 cfs

Total piping discharge to public Stormsewer System, Q =5.25 cfs

Worksheet 2: Runoff curve number and runoff

Project LAGOON CLOSURE By A.W. Date JAN 6/00

Location MORAINE OHIO Checked ______ Date ______

Circle one: Present [✓ Developed] AREA 1

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4	☑ acres ☐ mi^2 ☐ %	
B	LANDFILL GRASS COVER,	69			1.5	103.5
				Totals =		103.5

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{103.5}{1.5} =$ 69 ; Use CN = 69

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency ......24 hrs...... yr	25	2	
Rainfall, P (24-hour) .... in	4.5	2.8	
Runoff, Q .... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	1.60		

Worksheet 2: Runoff curve number and runoff

Project LAGOON CLOSURE By A.W. Date JAN 6/00

Location MORAINE OHIO Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 2

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	Fig. 2-3	Fig. 2-4	Area ☑ acres ☐ mi² ☐ %	Product of CN x area
B	LANDFILL GRASS COVER,	69			2.9	200.1
				Totals =		200.1

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{200.1}{2.9} = 69$; Use CN = $\boxed{69}$

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency ....24 hrs........ yr	25	2	
Rainfall, P (24-hour) .... in	4.5	2.8	
Runoff, Q .... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	1.60		

Worksheet 2: Runoff curve number and runoff

Project LAGOON CLOSURE By A.W. Date JAN 6/00

Location MORAINE OHIO Checked ______ Date ______

Circle one: Present [✓ Developed] AREA 3

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1] Table 2-2	Fig. 2-3	Fig. 2-4	Area ☑ acres ☐ mi^2 ☐ %	Product of CN x area
B	LANDFILL GRASS COVER	69			4.9	338.1
				Totals =		338.1

[1] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{338.1}{4.9} =$ 69 ; Use CN = 69

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency ....24 hrs........	yr	25	2	
Rainfall, P (24-hour)	in	4.5	2.8	
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	1.60		

Worksheet 2: Runoff curve number and runoff

Project LAGOON CLOSURE By A.W. Date MAR1/00

Location MORAINE OHIO Checked ______ Date ______

Circle one: Present [✓ Developed] AREA 4

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4	☑ acres ☐ mi² ☐ %	
B	LANDFILL GRASS COVER	69			2.2	151.8
				Totals =		151.8

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{151.8}{2.2} = 69$; Use CN = 69

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency ....24........	yr	25	2	
Rainfall, P (24-hour)	in	4.5	2.8	
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	1.60		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project LAGOON CLOSURE By KW Date JAN 6/0[illegible]

Location MORAINE Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 1

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID		1		
1. Surface description (table 3-1)		DENSE GRASS		
2. Manning's roughness coeff., n (table 3-1)		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	2.9		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.34	+	= 0.34

Shallow concentrated flow

Segment ID		1		
7. Surface description (paved or unpaved)		UNPAVED		
8. Flow length, L	ft	80		
9. Watercourse slope, s	ft/ft	0.013		
10. Average velocity, V (figure 3-1)	ft/s	1.80		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.01	+	= 0.01

Channel flow

Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.35

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project LAGOON CLOSURE By AW Date JAN6/00

Location MORAINE Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 2

Circle one: T_c T_t through subarea ____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		2			
1. Surface description (table 3-1)		DENSE GRASS			
2. Manning's roughness coeff., n (table 3-1) ..		0.24			
3. Flow length, L (total $L \leq 300$ ft)	ft	100			
4. Two-yr 24-hr rainfall, P_2	in	2.8			
5. Land slope, s	ft/ft	0.01			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.34	+		= 0.34
Shallow concentrated flow Segment ID		2			
7. Surface description (paved or unpaved)		UNPAVED			
8. Flow length, L	ft	130			
9. Watercourse slope, s	ft/ft	0.01			
10. Average velocity, V (figure 3-1)	ft/s	1.6			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.02	+		= 0.02
Channel flow Segment ID					
12. Cross sectional flow area, a	ft^2				
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				0.36

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project LAGOON CLOSURE By LW Date JAN 6/00

Location MORAINE Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 3

Circle one: T_c T_t through subarea ____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		3		
1. Surface description (table 3-1)		DENSE GRASS		
2. Manning's roughness coeff., n (table 3-1) ..		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	2.3		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.34	+	= 0.34
Shallow concentrated flow Segment ID		3		
7. Surface description (paved or unpaved)		UNPAVED		
8. Flow length, L	ft	360		
9. Watercourse slope, s	ft/ft	0.01		
10. Average velocity, V (figure 3-1)	ft/s	1.6		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.06	+	= 0.06
Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_r	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.40

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project LAGOON CLOSURE By ACW Date MAR 1/00

Location MORAINE Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 4

Circle one: T_c T_t through subarea ____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		1		
1. Surface description (table 3-1)		DENSE GRASS		
2. Manning's roughness coeff., n (table 3-1) ..		0.24		
3. Flow length, L (total L $\leq$ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	2.8		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.34	+	= 0.34

Shallow concentrated flow Segment ID		1		
7. Surface description (paved or unpaved)		UNPAVED		
8. Flow length, L	ft	150		
9. Watercourse slope, s	ft/ft	0.01		
10. Average velocity, V (figure 3-1)	ft/s	1.60		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.03	+	= 0.03

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.37

Worksheet 4: Graphical Peak Discharge method

Project LAGOON CLOSURE By A-CW Date JAN13/00

Location MORAINE OHIO Checked ____ Date ______

Circle one: Present [✓ Developed] AREA 1

1. Data:

Drainage area .... A_m = 0.00234 mi^2 (acres/640)

Runoff curve number .... CN = 69 (From worksheet 2)

Time of concentration .. T_c = 0.35 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	4.5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.899		
5. Compute I_a/P		0.20		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	575		
7. Runoff, Q .... (From worksheet 2).	in	1.60		
8. Pond and swamp adjustment factor, F_p 1.0 .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		—		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	2.15		

Worksheet 4: Graphical Peak Discharge method

Project LAGOON CLOSURE By A.C.W. Date JAN13/00

Location MORAINE OHIO Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 2

1. Data:

Drainage area .... A_m = 0.00453 mi^2 (acres/640)

Runoff curve number .... CN = 69 (From worksheet 2)

Time of concentration .. T_c = 0.36 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	4.5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.899		
5. Compute I_a/P		0.20		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	570		
7. Runoff, Q .... (From worksheet 2).	in	1.60		
8. Pond and swamp adjustment factor, F_p 1.0 .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		—		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	4.13		

Worksheet 4: Graphical Peak Discharge method

Project LAGOON CLOSURE By A.CW. Date JAN13/00

Location MORAINE OHIO Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 3

1. Data:

Drainage area .... A_m = 0.00766 mi^2 (acres/640)

Runoff curve number .... CN = 69 (From worksheet 2)

Time of concentration .. T_c = 0.40 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	4.5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.899		
5. Compute I_a/P		0.20		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	550		
7. Runoff, Q .... (From worksheet 2).	in	1.60		
8. Pond and swamp adjustment factor, F_p 1.0 .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		—		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	6.74		

Worksheet 4: Graphical Peak Discharge method

Project LAGOON CLOSURE By ACW. Date MAR1/00

Location MORAINE OHIO Checked ____ Date ____

Circle one: Present [✓ Developed] AREA 4

1. Data:

Drainage area .... A_m = 0.00344 mi^2 (acres/640)

Runoff curve number .... CN = 69 (From worksheet 2)

Time of concentration .. T_c = 0.37 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	4.5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.899		
5. Compute I_a/P		0.20		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	565		
7. Runoff, Q .... (From worksheet 2).	in	1.60		
8. Pond and swamp adjustment factor, F_p 1.0 .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		—		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	3.10		

25-YEAR 24-HOUR RAINFALL (INCHES)

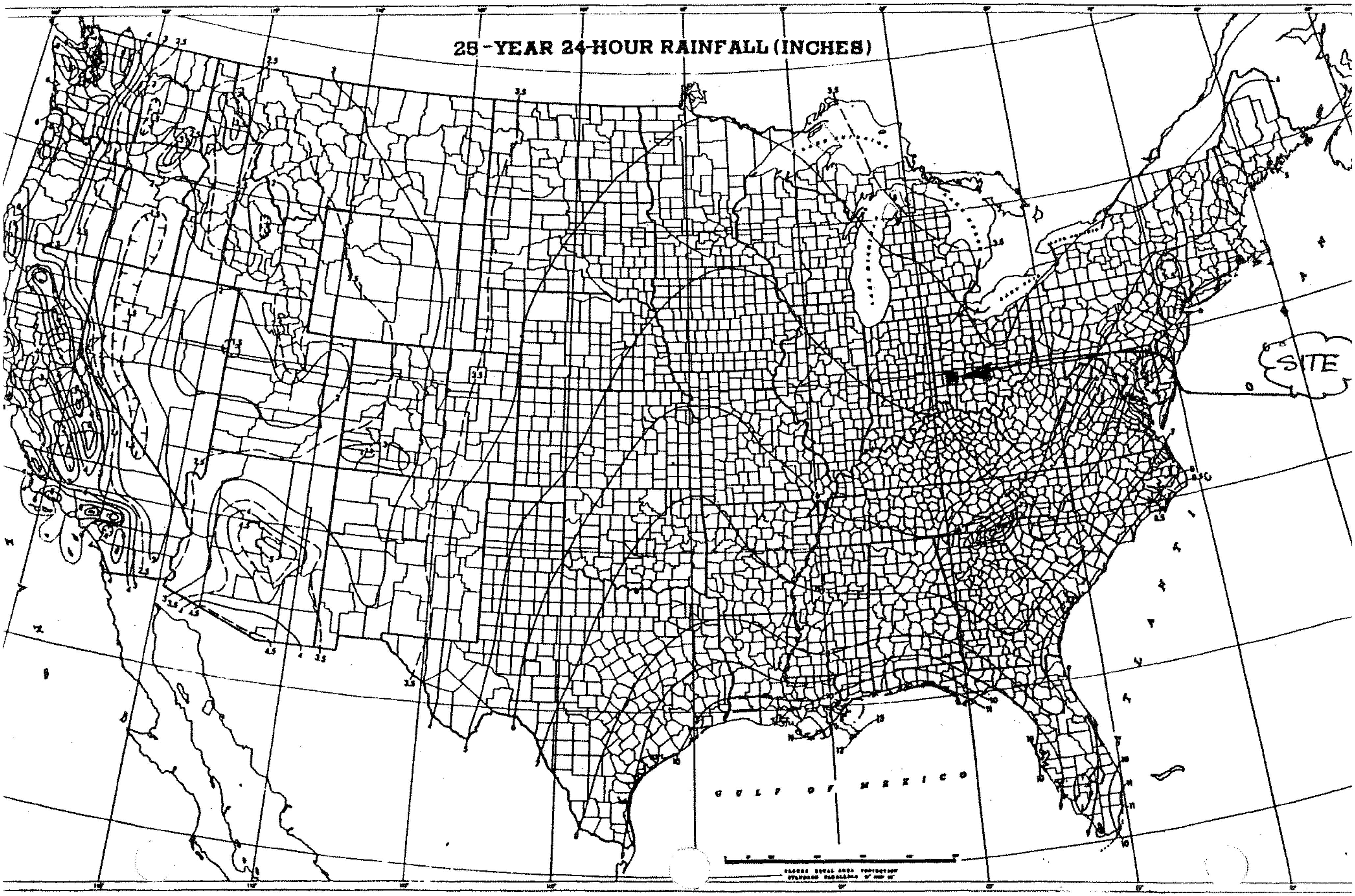
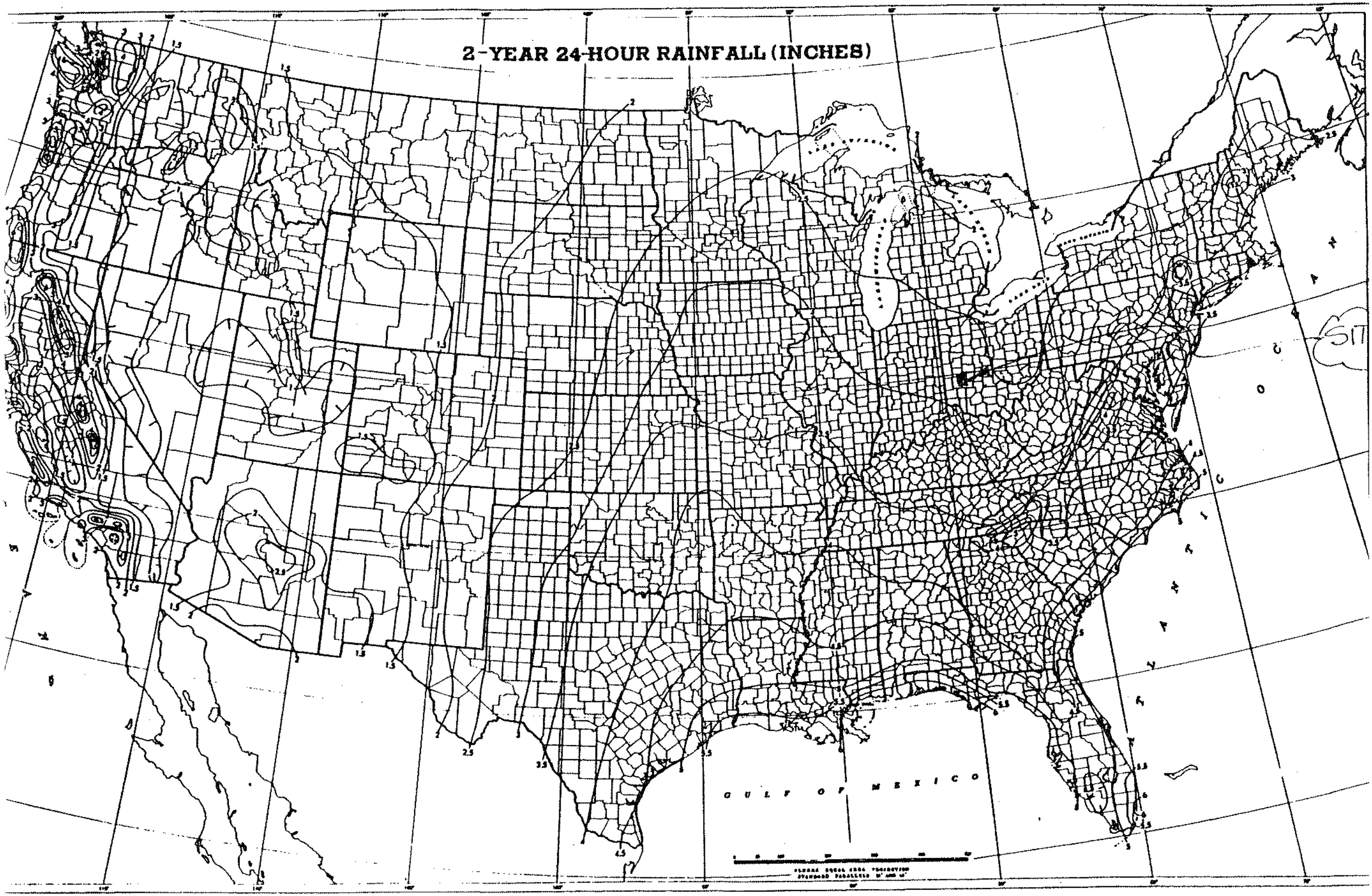


Chart 4



2-YEAR 24-HOUR RAINFALL (INCHES)

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	[illegible]
	Good	[4]30	55	70	[illegible]
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

texture is given in appendix A for determining the HSG classification for disturbed soils.

Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and i generally estimated from density of plant and resi cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, co type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes rotations; (d) percent of residue cover; and (e) degr of surface roughness.

Table 2-1.—Runoff depth for selected CN's and rainfall amounts[1]

	Runoff depth for curve number of—												
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
						inches							
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's *n* values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\ (nL)^{0.8}}{(P_2)^{0.5}\ s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow stead uniform flow, (2) constant intensity of rainfall exces (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

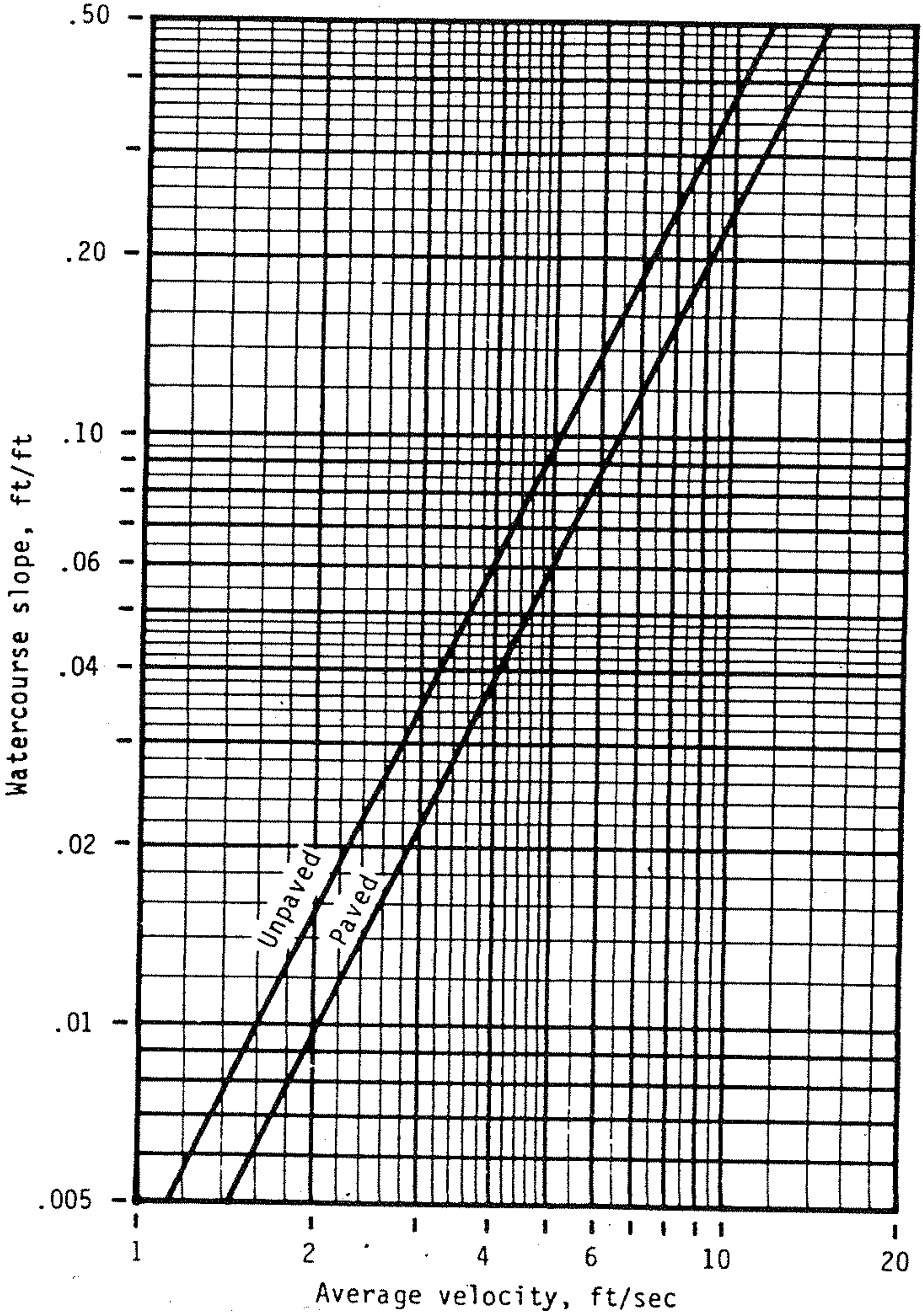


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Chapter 4: Graphical Peak Discharge method

his chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and rban areas. The Graphical method was developed rom hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

where

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
A_m = drainage area (mi^2);
Q = runoff (in); and
F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

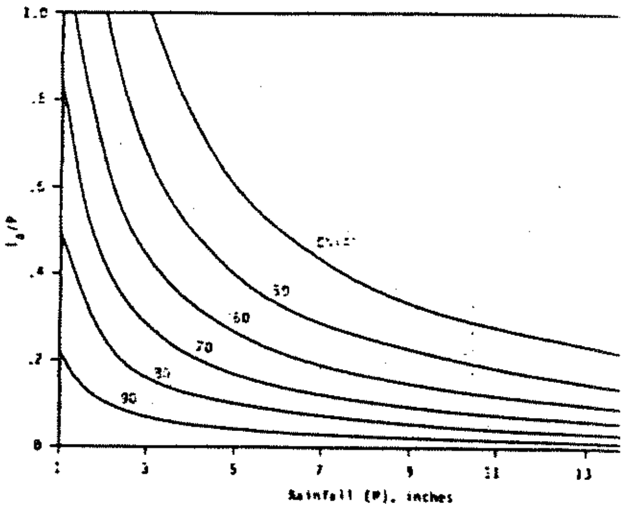
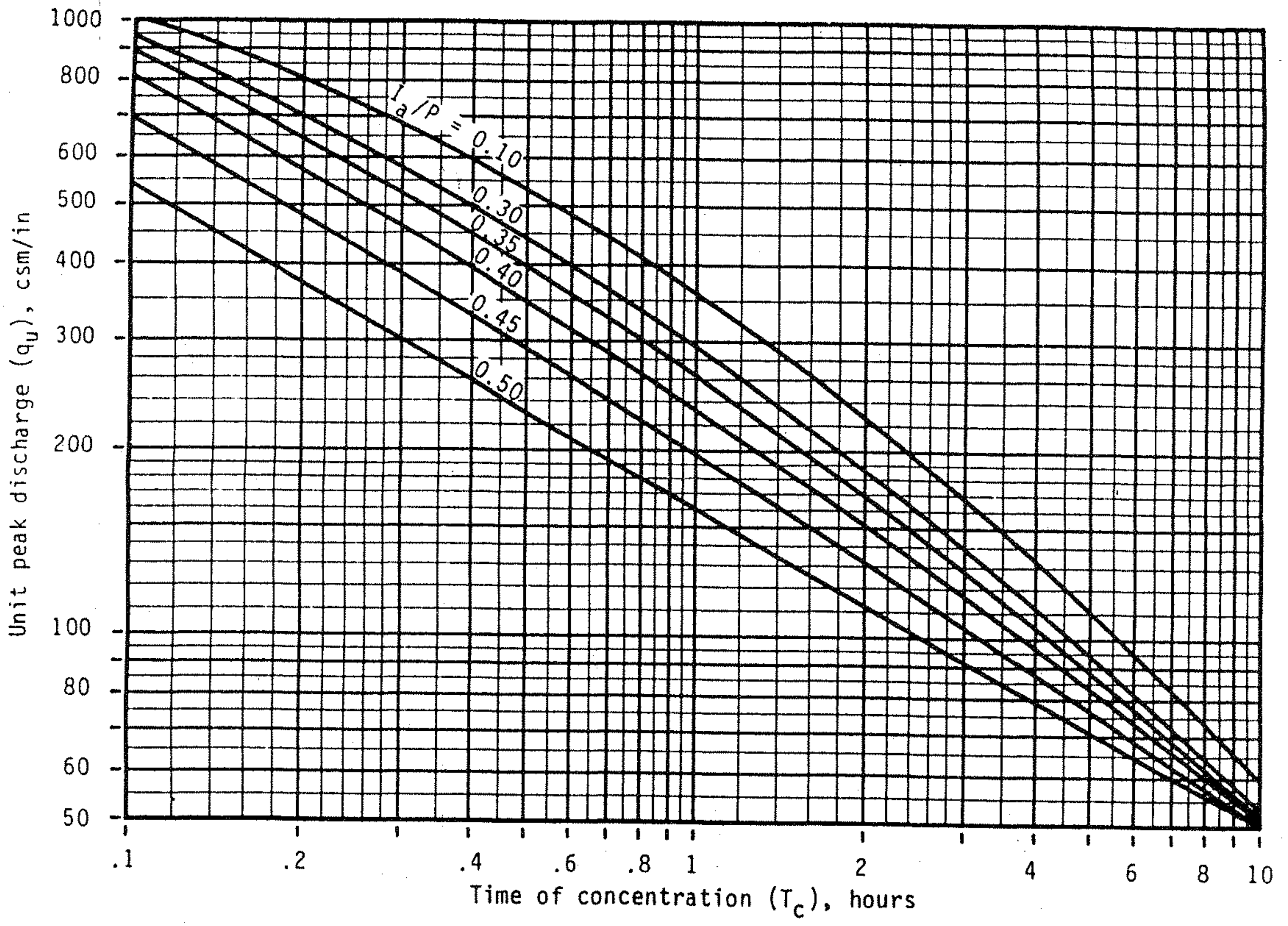


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	[illegible]
66	1.030	96	[illegible]
67	0.985	97	[illegible]
68	0.941	98	0.041
69	0.899		

Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution



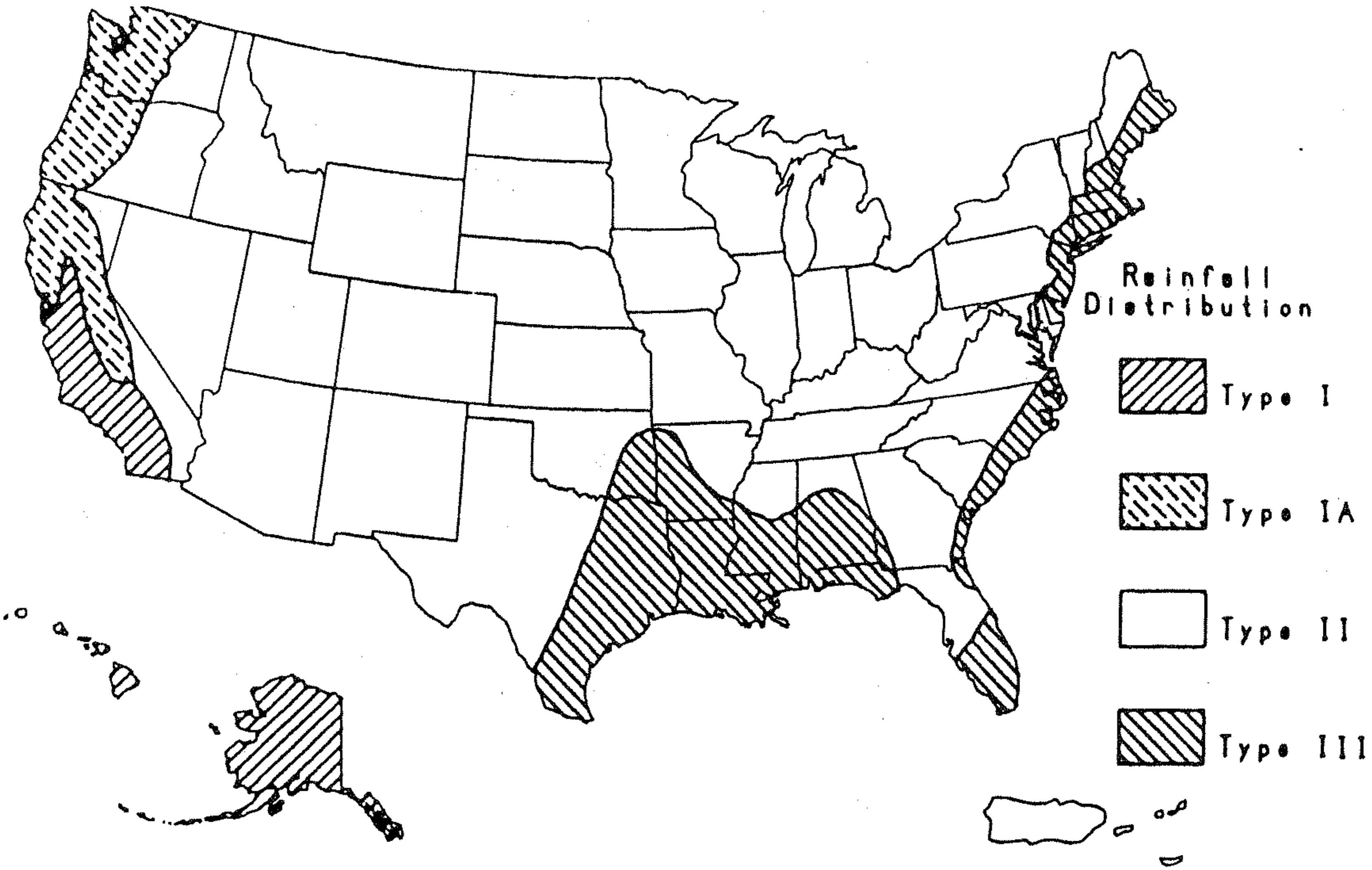


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

CRA

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM
W.O. No.: 12 600-11
Project: Lagoon Closure
Location: Moraine ,Ohio

CALCULATION IDENTIFICATION

Calculation Ref. No.:
No. Pages:
(Including calculation cover sheet)

Calculation Description:
STORMWATER DISCHARGE PIPING HYDRAULICS

Design: A.Wesolowski
Date: August 17/99
Checked:
Date:
Supervised:
Date:
Project Control:
Date:

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

TABLE 1
PIPING HYDRAULICS

Design Flow cfs	Design Slope %	Selected Pipe Diameter Inches	Actual Pipe Capacity Flowing Full cfs
13.5	1.5	24	35.0
37.9	1.5	30	65.0

STORM WATER SYSTEM HYDRAULICS

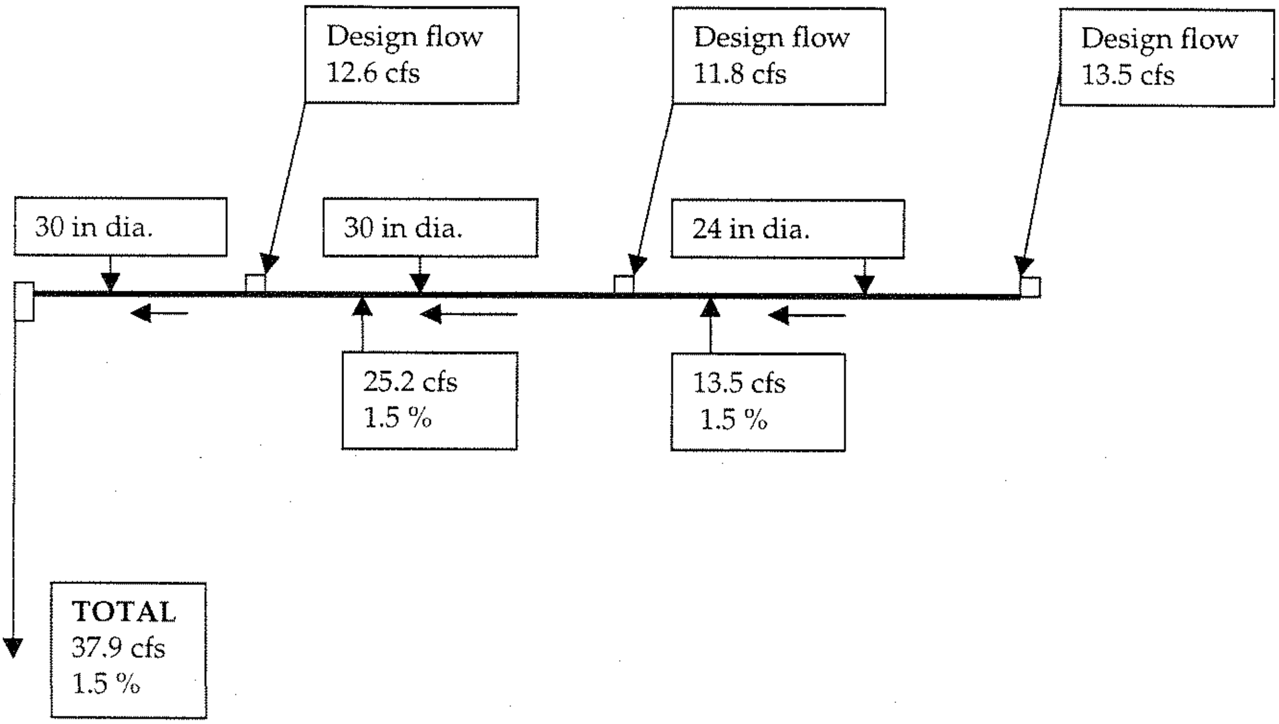
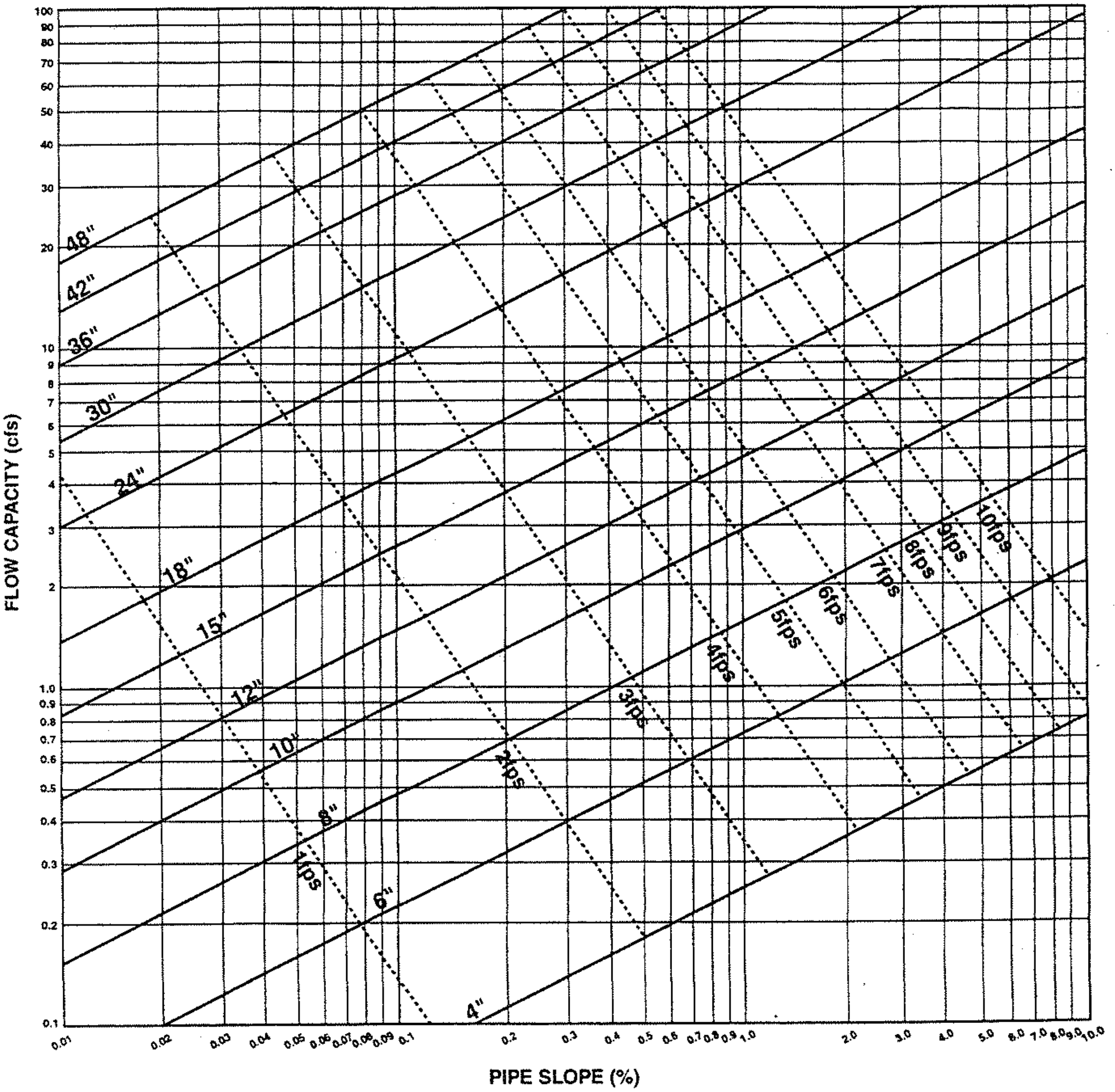


Figure 3-1
Discharge Rates for Hancor Hi-Q® and Hi-Q® Sure-Lok™ Pipes (SMOOTH WALL)



Note: Based on a design Manning's "n" of 0.010.
Hi-Q® Sure-Lok™ may not be available in all diameters shown.
Solid lines indicate pipe diameters. Dashed lines indicate approximate flow velocity.

CRA

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM

W.O. No.: 12 600-11

Project: Lagoon Closure

Location: Moraine ,Ohio

CALCULATION IDENTIFICATION

Calculation Ref. No.:

No. Pages:
(Including calculation cover sheet)

Calculation Description:

FLEXIBLE PAVEMENT/COVER DESIGN

Design: A.Wesolowski

Date: August 17/99

Checked:

Date:

Supervised:

Date:

Project Control:

Date:

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

1. FLEXIBLE PAVEMENT DESIGN

1.1 Design criteria

- traffic: H-20 highway loading
- subgrade allowable bearing pressure: 3 tsf

1.2 FHWA Design Procedure (Steward et al)

Determine minimum depth of aggregate base like for "unpaved" road, unreinforced case:

- loading case for very little rutting , unreinforced subgrade:

  $N_{c1} = 2.8$

- shear strength "C" value:

  use Table 6.1 for SW, SP type of material, medium to compact allowable bearing pressure P = 3 tsf = 41.7 Psi

  Than

  C = 1/2 P = 20.85 Psi

  And CBR = C/4.33 = 4.82

Calculate stress value

$C \times N_{c1} = 20.85 \times 2.8 = 58.28$ Psi

Use Fig.3 for CN $_{c1}$ product = 58.28 Psi and dual wheel load of 16,000 lbs
required depth of aggregate will be approx. 5 inches.

1.3 Simplified Asphalt Institute Method

Use CBR = 4.82
Resilient Modulus:

$M_r = 1500 \times CBR = 7230$ Psi

Use Traffic Class II, ESAL 1×10^4 (see Table 3-4)

Use Fig.3-7, for ESAL = 1×10^4 and $M_r = 7230$ Psi for aggregate base course of 6-in, asphalt design thickness = 3 in. minimum.

CRA

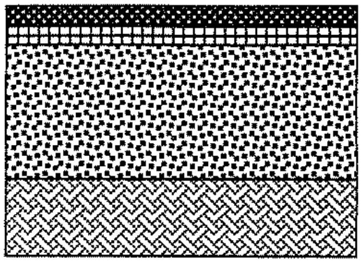
PROJECT NO: 12600-11 **DESIGNED BY: A.W.**

PROJECT NAME: Lagoon closure **CHECKED BY:**

DATE : Aug 24/99 **PAGE 3 OF 3**

2. CONCLUSION:

The following asphalt structure will apply:



1 1/2-in surface course
ODOT No.404
1 1/2-in leveling course
ODOT No.403
5-in coarse aggregate ODOT. No.703-1
Size No.68
Subgrade - imported fill

TABLE 6.1
NOMINAL VALUES FOR ALLOWABLE BEARING PRESSURE FOR SPREAD FOUNDATIONS*

Type of bearing material	Consistency in place	Allowable bearing pressure, tsf	
		Ordinary range	Recommended value for use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks)	Hard, sound rock	60 to 100	80
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks)	Medium hard sound rock	30 to 40	35
Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities	Medium hard sound rock	15 to 25	20
Weathered or broken bedrock of any kind except highly argillaceous rock (shale)	Soft rock	8 to 12	10
Compaction shale or other highly argillaceous rock in sound condition	Soft rock	8 to 12	10
Well-graded mixture of fine and coarse-grained soil: glacial till, hardspan, boulder clay (GW-GC, GC, SC)	Very compact	8 to 12	10
Gravel, gravel-sand mixtures, boulder-gravel mixtures (GW, GP, SW, SP)	Very compact	6 to 10	7
	Medium to compact	4 to 7	5
	Loose	2 to 6	3
Coarse to medium sand, sand with little gravel (SW, SP)	Very compact	4 to 6	4
	Medium to compact	2 to 4	3
	Loose	1 to 3	1.5
Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC)	Very compact	3 to 5	3
	Medium to compact	2 to 4	2.5
	Loose	1 to 2	1.5
Fine sand, silty or clayey medium to fine sand (SP, SM, SC)	Very compact	3 to 5	3
	Medium to compact	2 to 4	2.5
	Loose	1 to 2	1.5
Homogeneous inorganic clay, sandy or silty clay (CL, CH)	Very stiff to hard	3 to 6	4
	Medium to stiff	1 to 3	2
	Soft	0.5 to 1	0.5
Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML, MH)	Very stiff to hard	2 to 4	3
	Medium to stiff	1 to 3	1.5
	Soft	0.5 to 1	0.5

*From NAVFAC (1982).[13]

NOTES:

1. Variations of allowable bearing pressure for size, depth, and arrangement of footings are given in the text.
2. Compacted fill, placed with control of moisture, density, and lift thickness, has allowable bearing pressure of equivalent natural soil.
3. Allowable bearing pressure on compressible fine grained soils is generally limited by considerations of overall settlement of structure (Fig. 6.9).
4. Allowable bearing pressure on organic soils or uncompacted fills is determined by investigation of individual case.
5. Allowable bearing pressure for rock is not to exceed the unconfined compressive strength.

Synthetic Industries

SMART SOLUTIONS® Technical Note

Geotextile Selection and Design In Paved and Unpaved Road Construction—An Engineering Approach

February 1997 **SM-107**

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Geotextile Selection and Design in Paved and Unpaved Road Construction

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FORWARD

The most common use of geotextiles is in the construction of paved and unpaved roadways. Geotextiles used in paved and unpaved roadways provide several benefits through primarily three geotextile functions: Separation, Reinforcement, and Filtration.

The benefits derived from these three geotextile functions are most significant when subgrade soils are weak, i.e., CBR <3. These benefits are well documented in the literature. However, long-term benefits (improved pavement performance over time) from separation in application's where the subgrade is competent, (i.e., CBR >3), are just now beginning to surface. Additionally , the National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board (TRB) approved the funding of an extensive research program aimed at quantifying the benefits of geotextiles as separators in pavement systems. Clearly, the benefits of geotextiles as separators are widely recognized. However, they have yet to be documented satisfactorily.

This *SMART SOLUTIONS*™ will present design procedures for paved and unpaved roadways with geotextiles based on the FHWA Geotextile Engineering Manual and the current state-of-the-practice. Additionally, this *SMART SOLUTIONS*™ will guide the designer through the geotextile selection process, also based on the FHWA Geotextile Engineering Manual.

SEPARATION

Geotextile separation is defined as the introduction of a flexible, porous textile placed between dissimilar materials so that the integrity and functioning of both materials can remain intact or be improved (Koerner, 1994).

In paved and unpaved roadways where granular aggregate is placed on fine-grained soils, two detrimental mechanisms tend to occur over time without the use of a geotextile separator:

1. The fine-grained soils enter into the voids of the granular aggregate, preventing it from draining properly and (Figure 1);

2. The granular aggregate punches into the fine-grained soil, thereby decreasing the aggregates' strength (Figure 1).

Properly selected woven and nonwoven geotextiles prevent these failure mechanisms from occurring, thereby greatly improving pavement performance. Additionally, by providing subgrade restraint, i.e. preventing fine-grained soil from migrating up into the granular aggregate, the detrimental effects of aggregate contamination are prevented. Therefore, separation is considered to be the most important of the three geotextile functions provided.

REINFORCEMENT

Geotextile reinforcement is defined as the synergistic improvement of a total system's strength created by the introduction of a geotextile (good in tension) into a soil (good in compression but poor in tension) or other disjointed and separated material (Koerner, 1994).

In paved and unpaved roadway applications, geotextiles provide tensile reinforcement through frictional interaction with base course materials, thereby reducing applied stresses on the subgrade and preventing rutting caused by subgrade overstress.

Properly selected woven and nonwoven geotextiles provide reinforcement in roadways. However, woven geotextiles typically have a higher tensile modulus than a comparable nonwoven. By providing high tensile strength at low strains (i.e., high modulus) woven geotextiles generally are considered better reinforcement materials than nonwoven geotextiles which typically provide high strength at high elongations (low modulus). Therefore, benefits derived from the reinforcement function are dependent on the amount of system deformation allowed. In unpaved roads, typically a large amount of deformation is allowed and the reinforcement function of a geotextile provides significant benefits. In paved roads, allowable system deformation is usually very low and therefore it is questionable whether the geotextile can provide reinforcement. As a result, reinforcement is considered to be the second most important geotextile function in roadways.

FILTRATION

Geotextile filtration is defined as the equilibrium geotextile-to-soil system that allows for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration (Koerner, 1994).

In paved and unpaved roadway applications, geotextiles provide filtration through their defined openings that retain soil particles but allow the flow of water. This results in a free draining pavement system. In paved and unpaved roadways, filtration is similar to separation. However a geotextile that is a good separator (a barrier) will not always be a able to provide adequate filtration (retain particles and allow water flow). Properly selected, woven and nonwoven geotextiles can provide filtration in paved and unpaved roadway applications, thereby improving pavement performance. Depending on site conditions (e.g. if the subgrade is extremely wet) the filtration function may be as important as the separation function.

UNPAVED ROAD DESIGN

An "unpaved road" is an aggregate surfaced road that is required to support less than 10,000 vehicles during its life. This definition is consistent with the definition of "temporary road" by FHWA (FHWA, 1985).

Examples of unpaved roads are:

- * Construction Roads
- * Haul Roads
- * Access Roads
- * Industrial Yards
- * Detours
- * Oil Exploration Roads

The design approach presented here is adapted from the Steward, et al method presented in the FHWA (FHWA, 1985).

The assumptions included in this design approach are as follows:

1. The aggregate layer above the geotextile must be a cohesionless, nonplastic material compacted to CBR 80.
2. Vehicle passes are limited to 10,000.
3. Geotextile survivability criteria must be considered in geotextile selection.

The design method is based on theoretical analysis and empirical test results. *Very little rutting* (Less than 2 inches) will occur under even a relatively large number of load applications if stress levels in the subgrade are held to *2.8 or less times the undrained shear strength of the* unreinforced *subgrade* and *5.0 or less times the undrained shear strength of a* geotextile reinforced *subgrade*. Additionally, a *great amount of surface rutting* (greater than 4 inches) will occur at *3.3 times the undrained shear strength of the subgrade in the* unreinforced case and *6.0 times the undrained shear strength of the subgrade* in the geotextile reinforced case, under a small number of load applications. The design procedure is as follows (FHWA, 1985):

1. Determine the undrained shear strength in psi of the subgrade under consideration from accepted geotechnical methods. This value is "c".

2. Determine the maximum single wheel load, maximum dual wheel load, and the maximum dual tandem wheel load anticipated.

3. From Figures 2, 3, and 4, determine the required aggregate thickness for each loading case. Enter the curves with stresses equal to $Nc_1 = 2.8$; $Nc_2 = 3.3$; $Nc_3 = 5.0$; $Nc_4 = 6.0$ times the subgrade undrained shear strength that is $cNc_1 = c \times 2.8$; $cNc_2 = c \times 3.3$; $cNc_3 = c \times 5.0$; and $cNc_4 = c \times 6.0$. The dashed lines shown on Figures 2,3 and 4 are for a c = 4.5 psi; therefore, the cNc values in Figure 2 are 12.6, 14.8, 22.5, and 27.0, respectively.

UNPAVED ROAD DESIGN (cont)

4. If *very little rutting* is desired in the unreinforced case, the appropriate aggregate thickness corresponds to the cNc_1 reading. If a *greater amount of rutting* is acceptable (i.e. greater than 4 inches) in the unreinforced case, the appropriate thickness corresponds to the cNc_2 reading.

5. If *very little rutting* is desired in the geotextile reinforced case, the appropriate aggregate thickness corresponds to the cNc_3 reading. If a *greater amount of rutting* is acceptable (i.e. greater than 4 inches) in the geotextile reinforced case, the appropriate thickness corresponds to the cNc_4 reading.

6. If more rutting occurs during construction than was designed for, increase the thickness by at least as much as the difference between 2.8c and 3.3c, or 5.0c and 6.0c as appropriate.

7. Geotextiles shall be selected based on the survivability criteria in Table 1 and 2. From Table 1 the Construction Survivability Level (CSL) required is determined. As shown in Table 1, the CSL is dependent on subgrade CBR, ground contact pressure of the construction equipment to be used and the required aggregate thickness determined in steps 4 and 5. Once the CSL is determined, Table 2 is entered to determine the specific physical properties required for the geotextile, or Table 3 can be entered to determine the specific Synthetic Industries geotextile that meets the requirements of Table 2.

8. Geotextiles shall be installed with proper overlaps as shown in Table 4.

PAVED ROAD DESIGN

A "paved road" is a bituminous and/or concrete surfaced road that is required to remain in service over a number of years, usually ten or more, and is expected to handle over 1,000,000 vehicles during its design life (FHWA , 1985).

Examples of paved roads are:

- * Flexible Pavement Roads
- * Rigid Pavement Roads
- * Airport Runways
- * Parking Lots
- * Driveways

Quantitative design procedures that incorporate the benefits of geotextiles in paved roads have yet to be developed. As a result, with soft subgrades, i.e. CBR <3, the current state-of-the-practice for incorporating geotextiles into paved roads is to initially design a stabilizer lift for the construction traffic conditions using the approach outlined in this paper for unpaved roads, then design it for service conditions by an acceptable traditional paved road design method, i.e., AASHTO, Asphalt Institute, Corps of Engineers without having to increase the aggregate design thickness in anticipation of aggregate loss from soft conditions. This approach allows for paved roads to be economically constructed in soft conditions and for increased performance of the pavement system.

In more competent subgrade conditions, i.e. CBR >3, the current state-of-the-practice is to design the roadway using acceptable traditional methods and incorporate the geotextile for its separation benefits only. In these conditions, increased pavement life and performance can be expected.

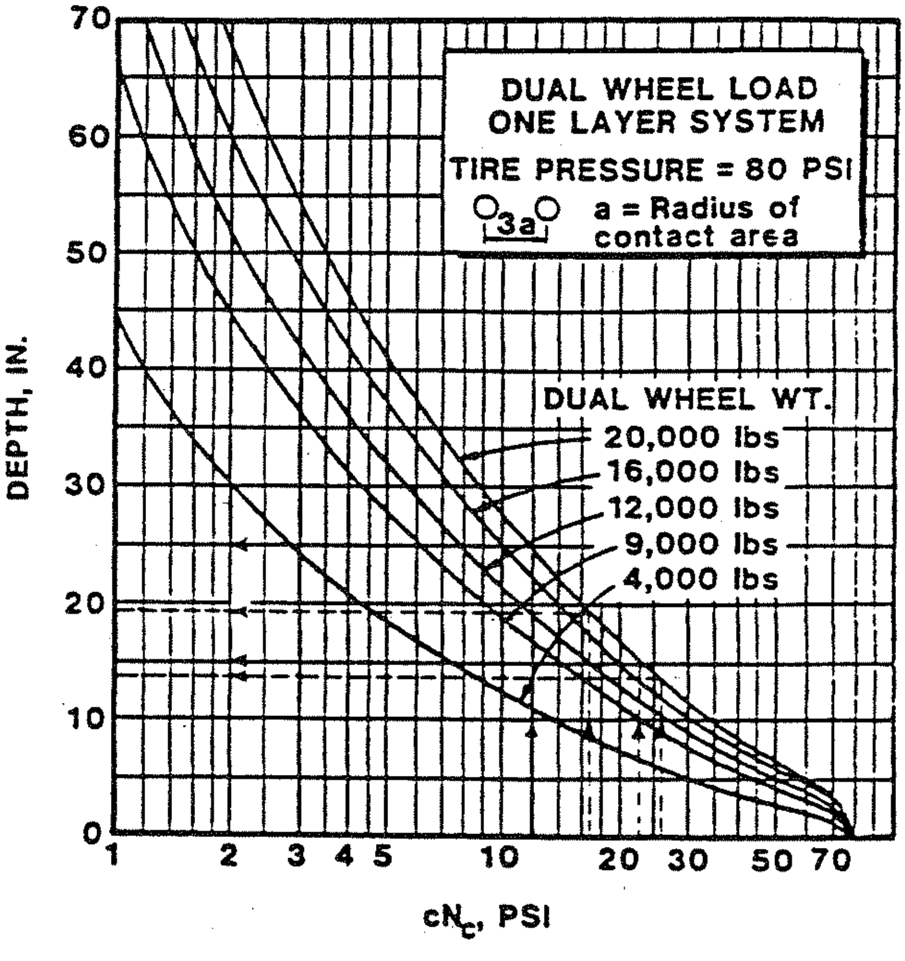

FIGURE 3.
Dual wheel load, one layer system.
From FHWA Geotextile Engineering Manual, Christopher & Holtz, 1984.

Geotextiles in Transportation Applications

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AMOCO GEOTEXTILES

AMOCO

Amoco Fabrics and Fibers Company

Design of Flexible Pavement Sections

The properties of geotextiles that improve the performance of an unpaved road also contribute to the performance of a paved road. For weak subgrades (CBR<3%), the geotextile acts to stabilize the section during construction of the aggregate base course and provide long term separation of the base course from the subgrade. However, for subgrades with moderate strength (3% < CBR < 7%), the geotextile acts primarily as a separator.

The effectiveness of a geotextile in stabilization and separation roles with flexible pavement sections has been extensively researched at Virginia Tech. (Smith et al., 1995; Lacina, 1995; Valentine, 1996). During their investigation of geotextile stabilization of weak subgrades (CBR = 2%), the researchers found that a geotextile extends the service life of a flexible pavement section by a factor of 2.5 to 3.2 compared to a non-stabilized section. Further, the researchers found that a geotextile effectively increased the pavement section's total AASHTO structural number by approximately 19 percent.

The researchers also investigated the effect of a geotextile in pavement sections constructed over subgrades with a CBR value which ranged from 4.2 to 4.5 percent. Given these moderate subgrade strengths, the researchers found that the geotextile increased the service life of the pavement section by a factor of 2.0 to 3.3 and increased the pavement section's total AASHTO structural number by 13 to 22 percent.

The design of flexible pavement sections which incorporate geotextiles can be performed using many of the prevalent design methodologies already in use. The AASHTO (1986) design method has been modified to partially account for the contribution of geotextiles and can be found in the recent FHWA publication *Geosynthetic Design and Construction Guidelines* (Holtz et al., 1995). This design method has been adapted to a computer software program called *Amospec*, and is available from Amoco Fabrics and Fibers Company.

This design manual presents a simplified approach to flexible pavement design with geotextiles that is based on the Asphalt Institute method (Asphalt Institute, 1991). This procedure is especially suitable for the design of secondary roads and parking lots and is useful for typical municipal and county projects. However, for a more rigorous design, it is recommended that the FHWA method be used.

Simplified Asphalt Institute Method

The simplified Asphalt Institute Method is a three step procedure. It requires an assessment of the subgrade resilient modulus, determination of traffic loading during the structure's service life, and calculation of the required base course and hot mix asphalt (HMA) thickness in the pavement cross-section design.

Subgrade Resilient Modulus - The resilient modulus (M_R) of representative laboratory subgrade soil samples can be measured using cyclic triaxial test methods. Alternatively, it can be estimated from other soil strength data, including the CBR value using the following relationship:

$$M_R = 1500 \times \text{CBR}$$

in which M_R is expressed in units of lb/in^2 and CBR is in percent. As with unpaved roads, the CBR used for design should represent soaked conditions to account for the most environmentally detrimental periods of the year. If measured or estimated CBR data is unavailable, the resilient modulus values suggested for design of low-volume roads by AASHTO (1986) may be used (Figure 3-5 and Table 3-3).

Traffic Loading - The traffic loadings that will be experienced by the roadway can be based on either a rigorous analysis of traffic count data and growth projections (refer to AASHTO, 1986), or they may be estimated using the guidelines in Table [redacted] 3-4.

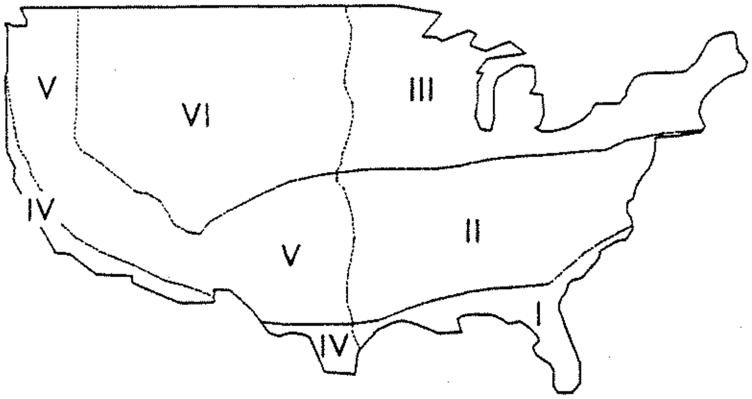


Figure 3-5 The six climatic regions in the United States (after Lister, 1972)

Table 3-3 Suggested subgrade resilient modulus (lb/in^2) values based on US climatic region and relative subgrade quality (AASHTO, 1986).

Climatic Region	Relative Quality of Roadbed Soil				
	Very Poor	Poor	Fair	Good	Very Good
I	2,800	3,700	5,000	6,800	9,500
II	2,700	3,400	4,500	5,500	7,300
III	2,700	3,000	4,000	4,400	5,700
IV	3,200	4,100	5,600	7,900	11,700
V	3,100	3,700	5,000	6,000	8,200
VI	2,800	3,100	4,100	4,500	5,700

Cross Section Design - The approach taken to the design of the pavement cross section depends on weather the subgrade consists of a weak or a moderate strength soil. If the soil is weak (CBR<3%), it must first be stabilized to the extent that it can support construction traffic. Thus, the pavement section is initially designed as a temporary road using the *Modified Bearing Capacity Method.*

Next, it is assumed that stabilization has effectively increased the subgrade CBR value to 3 percent. Therefore, the CBR value of the subgrade used in the simplified Asphalt Institute method for the pavement cross section is 3 percent. For example, assume that a subgrade has a CBR value of 2 percent and that it is necessary to install a geotextile followed by 6 inches of aggregate in order to support construction traffic of 10 yd^3 dump trucks. The use of the geotextile and the 6 in of aggregate has effectively increased the CBR of the road section to 3 percent. Thus, the pavement section is then designed assuming there exists a subgrade with a CBR value of 3%. The aggregate required by this pavement design is placed in addition to the 6 in of aggregate already used in site stabilization.

If the original CBR value of the subgrade is greater than 3 percent, stabilization is typically not required and the pavement section can be designed based on the actual subgrade CBR value.

The Asphalt Institute method relies on a series of charts to relate HMA thickness, base course thickness and subgrade strength. These charts are shown in Figures 3-6 through 3-10.

Table 3-4 Guidelines for estimation of traffic loadings (after Asphalt Institute, 1981).

Traffic Class	Type of Roadway	Range of Heavy Trucks Expected in Design Period	ESAL
I	Parking lots, driveways, Light traffic residential streets Light traffic farm roads	Less than 7,000	$5x10^3$
II	Residential streets Rural farm and residential streets	7,000 to 15,000	$1x10^4$
III	Urban minor collector streets Rural minor collector roads	70,000 to 150,000	$1x10^5$
IV	Urban minor arterial and light industrial streets Rural major collector and minor arterial highways	700,000 to 1,500,000	$1x10^6$
V	Urban freeways, expressways, and other principal arterial highways Rural interstate and other principal arterial highways	2,000,000 to 4,500,000	$3x10^6$
VI	Urban interstate highways Some industrial roads	7,000,000 to 15,000,000	$1x10^7$

Note: Whenever possible, more rigorous traffic analysis should be used for roads and streets in traffic category IV or higher.

The step-by-step process of using the simplified Asphalt Institute method with geotextiles is given below.

Step 1 Determine the soaked CBR of the subgrade. If CBR>3%, use a separation geotextile and design the paved road using Method A (steps 2a through 5a). If CBR<3%, use a stabilization geotextile and design the paved road using Method B steps 2b through 5b).

Method A, CBR > 3%

Step 2a For subgrade CBR > 3%: Estimate subgrade resilient modulus from subgrade CBR where:

M_R (psi) = CBR (%) x 1500

If CBR data is unavailable, use Figure 3-5 with Table 3-3 to estimate M_R.

Step 3a If a separator geotextile is used, proceed to Step 4a.

To perform a comparative design without a geotextile separator, a correction to the value of M_R is required to account for the base course contamination mechanisms which result in decreased base course performance.

Referring to Table 3-3, a locate the value of M_R which corresponds to the value selected in Step 2a. Reduce this value by one to two relative quality classes (i.e. "Good" becomes "Fair" or "Poor"). Identify the reduced value of M_R use it in the subsequent design steps.

Step 4a Determine the required thickness of the base course and HMA layer using Figure 3-6 through 3-10.

Step 5a Select either a woven or nonwoven separation geotextile based on the following AASHTO M 288-96 criteria:

• Survivability	Class 2
• Minimum Permittivity	0.02 sec^{-1}
• Maximum AOS	0.60 mm

Method B, CBR < 3%

If CBR<3%, the pavement section is initially designed as an unpaved road. A stabilization fabric is used and the aggregate thickness required for initial subgrade stabilization is determined using the Modified Bearing Capacity

Method (see page 3-5), but with one difference: the bearing capacity factor, N_c, is set to 5.0 This is done to reduce the amount of rutting permissible at the end of construction of the stabilization aggregate course. After the stabilization aggregate is compacted over the geotextile and subgrade, the flexible pavement section is designed for a subgrade having a CBR=3% (M_R=4500 psi).

The steps for a flexible pavement design over a subgrade with CBR<3% is described in Method B as follows:

Step 2b Determine the stabilization aggregate required to support construction equipment with little or no rutting using the Modified Bearing Capacity Method with $N_c = 5.0$.

For comparison to a section constructed without a geotextile, use $N_c = 2.8$ with the Modified Bearing Capacity Method.

Step 3b Determine the aggregate and HMA thickness required using Figure 3-6 through 3-10 for a subgrade CBR=3% (M_R = 4,500 psi).

Step 4b Select either a woven or nonwoven stabilization geotextile based on the following AASHTO M 288-96 criteria and the stabilization aggregate properties shown in Table 3-2.

• Survivability	Class 1
• Minimum Permittivity	0.05 sec^{-1}
• Maximum AOS	0.43 mm

Design Example 3-2

Design the most cost-effective flexible pavement section for a rural county road in northern Georgia. Based on studies of projected growth in the area, the ESAL is estimated at 850,000 over a 20-year service life. Available soil test data indicates that the subgrade has a soaked CBR of about 4. Installed aggregate and HMA costs are $10/ton and $28/ton, respectively. In-place aggregate and HMA densities are 135 and 145 pcf, respectively.

Step 1 The CBR value of 4% indicates that a separation geotextile is sufficient, and that stabilization is not necessary. Therefore, use of Method A will provide an adequate design.

Step 2a Estimate subgrade resilient modulus (M_R) from subgrade CBR.

M_R (psi) = 1500 x CBR (%)
M_R = 1500 x 4
M_R = 6,000 psi

At this point, compare the design value for M_R to the value indicated based on Figure 3-5 and Table 3-3. Figure 3-5 shows that northern Georgia is in Climatic Region II. Table 3-3 indicates that the relative quality of roadbed soil with M_R = 6,000 psi is close to range for "good".

Step 3a The design calls for use of a separator geotextile, so Step 3a may be skipped. However, an assessment of the design value for M_R may be made. If a separator geotextile is not used, the relative quality of the subgrade soil in Table 3-3 should be reduced one to two classes to compensate for aggregate contamination and degradation. Therefore, the relative quality of the subgrade decreased from "good" to "fair" or "poor." These classes correspond to an effective M_R between 3,400 psi and 4,500 psi.

Step 4a Determine the required thickness of aggregate base and HMA using Figures 3-6 through 3-10.

Figure 3-7 is used to show that if the aggregate base course is 6 in thick, the HMA layer is approximately 9 in thick.

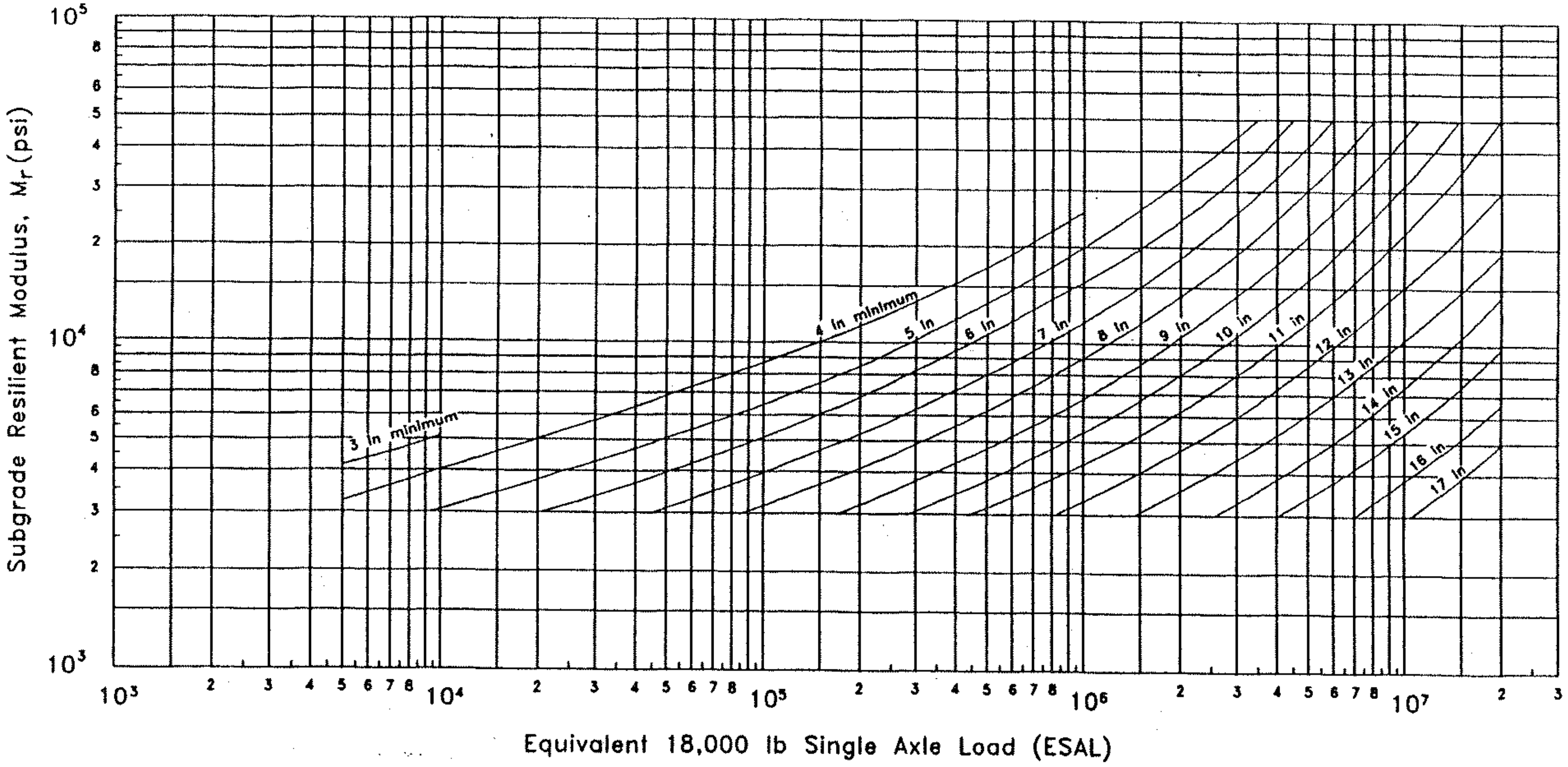
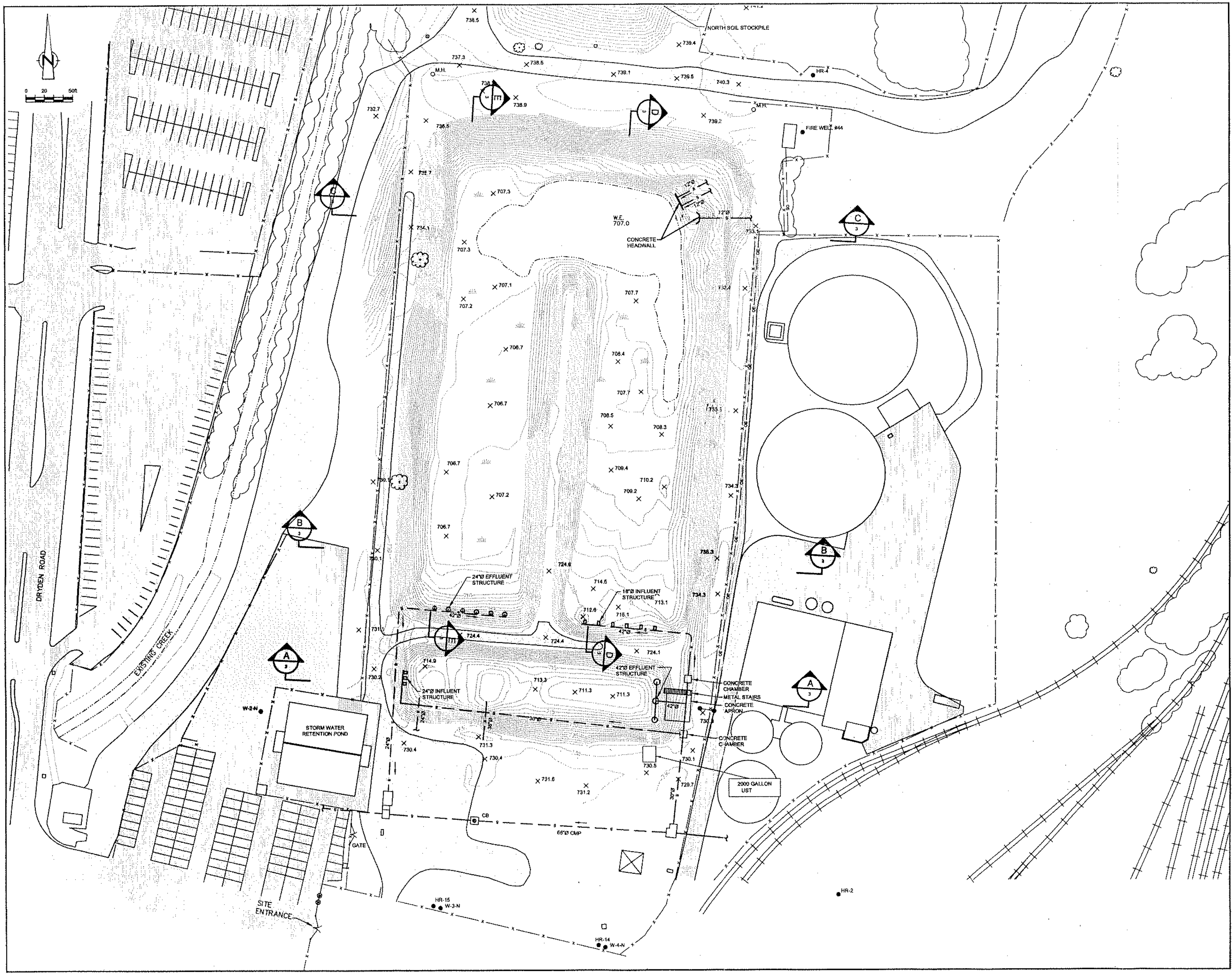


Figure 3-7 Design curves for HMA thickness given a 6-in untreated aggregate base course (after Asphalt Institute, 1981).



Nº	Revision	Date	Initial

LEGEND

— x —	FENCE
▨	ASPHALT PAVEMENT
☐	GRAVEL SURFACE
— · · —	EDGE OF WATER
┼┼┼	RAILROAD
⌒⌒⌒	VEGETATION
⁂	MARSH
···· 725 ····	CONTOUR AND ELEVATION (ft.)
× 705.4	GRADE SPOT ELEVATION (ft.)
— — s —	STORM SEWER
— — OE —	OVERHEAD POWER LINE
✿	TREE
● HR-4	MONITORING WELL
● W-3-N	MONITORING WELL

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 1

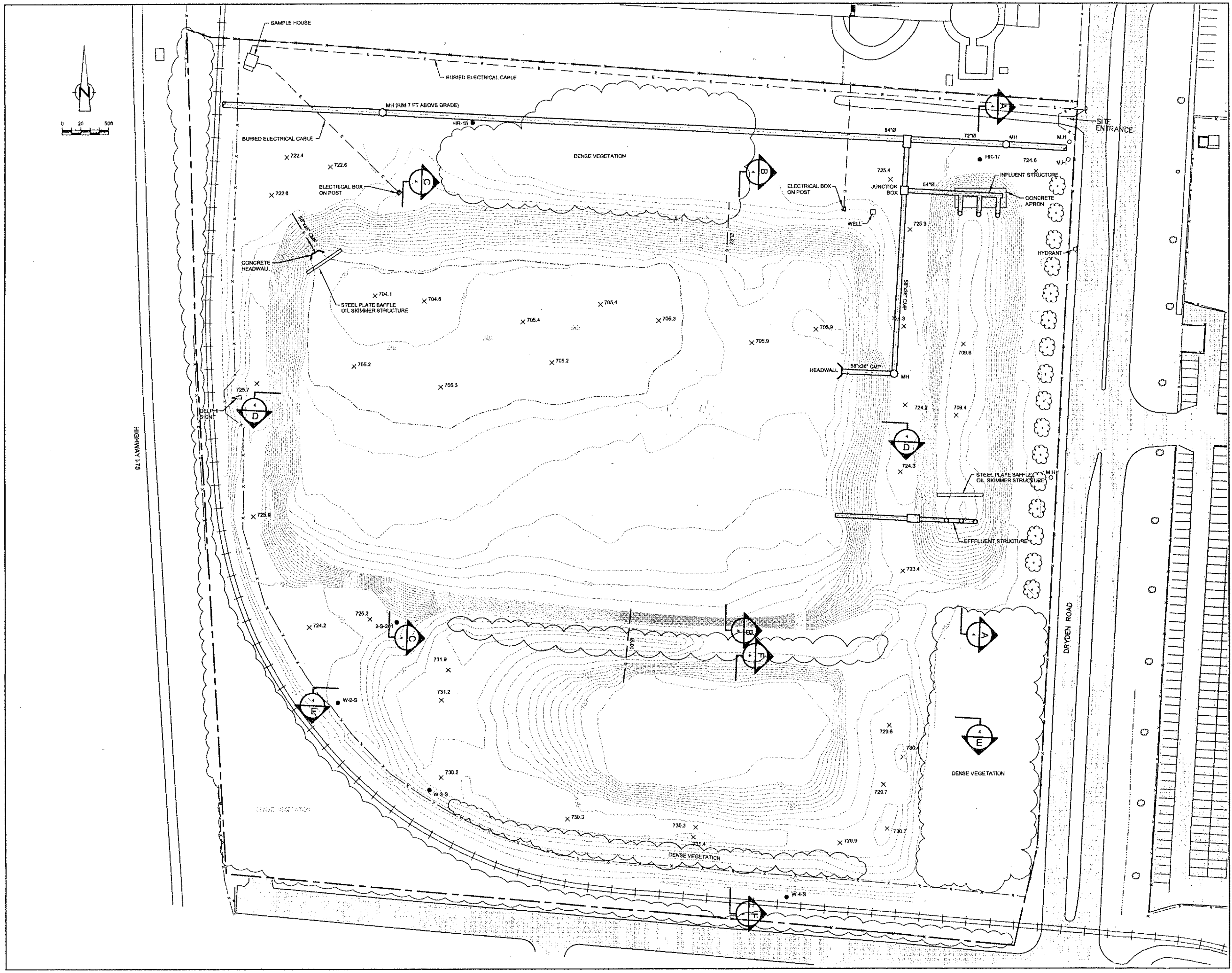
EXISTING CONDITIONS
NORTH SETTLING LAGOON - 1999

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
1"=50'	12611-00	003	PLAN 1

12611-00(003)GN-WA010 JUN 05/2000



Nº	Revision	Date	Initial

LEGEND

— — —	APPROXIMATE LOT LINE
—— x ——	FENCE
▨	ASPHALT PAVEMENT
☐	GRAVEL SURFACE
---·---·---	EDGE OF WATER
┼┼┼	RAILROAD
⌒⌒⌒	VEGETATION
⁂	MARSH
········	CONTOUR AND ELEVATION (ft.)
× 705.4	GRADE SPOT ELEVATION (ft.)
— — — S —	STORM SEWER
▭	UNDERGROUND PIPING
— — — E —	ELECTRICAL CABLE
✿	TREE
● W-2-S	MONITORING WELL
● HR-17	MONITORING WELL
● 2-S-281	MONITORING WELL

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HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 2

EXISTING CONDITIONS
SOUTH SETTLING LAGOON - 1999

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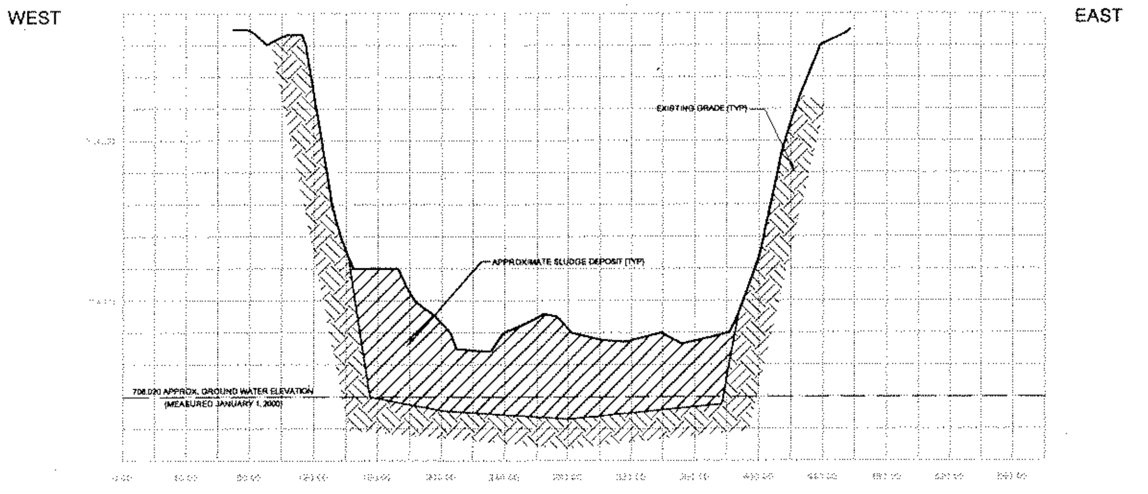
Source Reference:
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale: 1"=50'	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 2

12611-00(003)GN-WA011 JUN 05/2000



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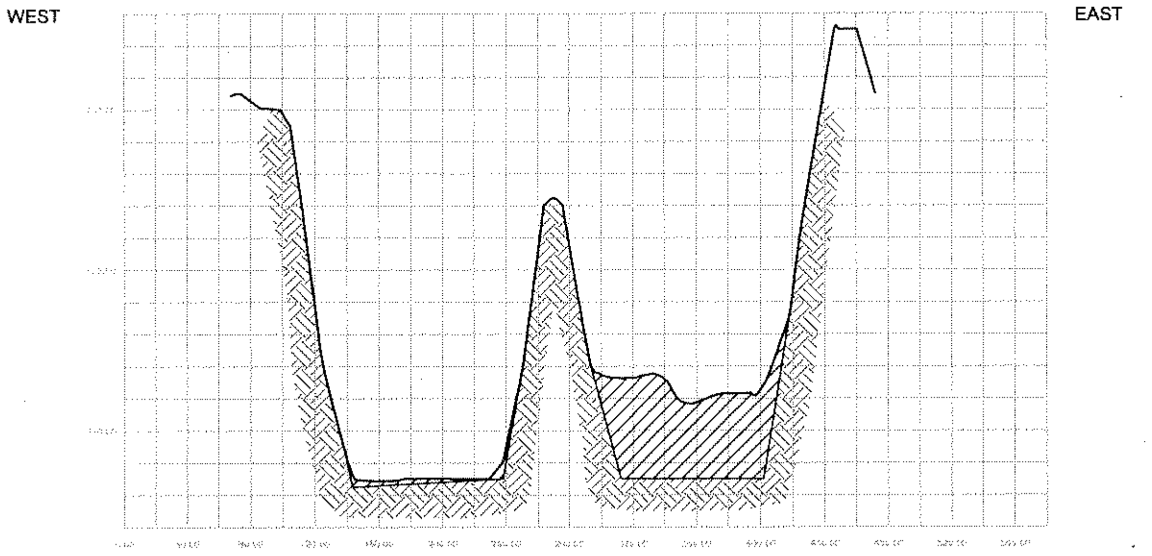

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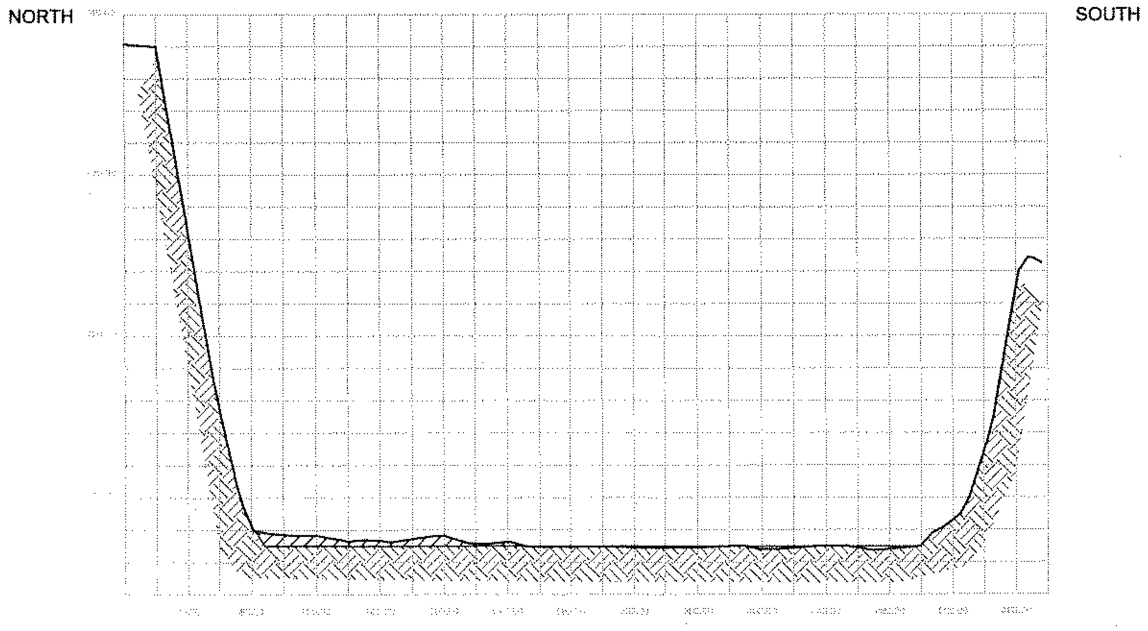

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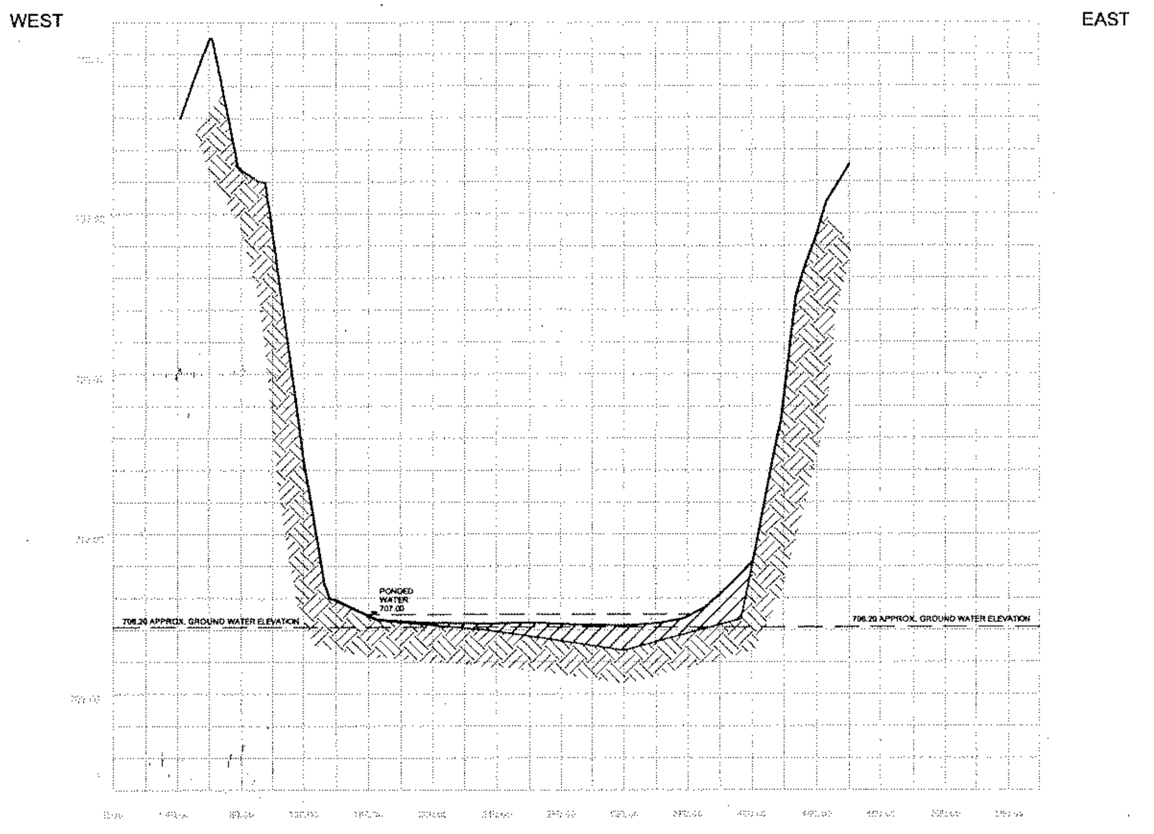

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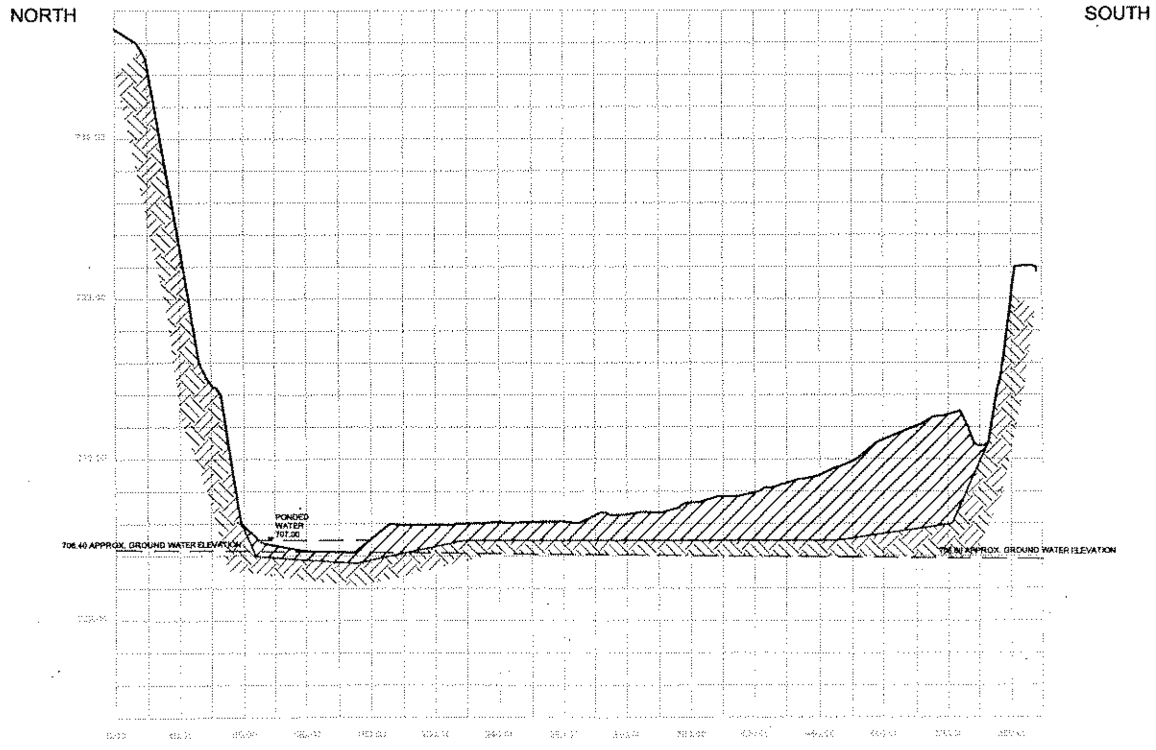

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Nº	Revision	Date	Initial

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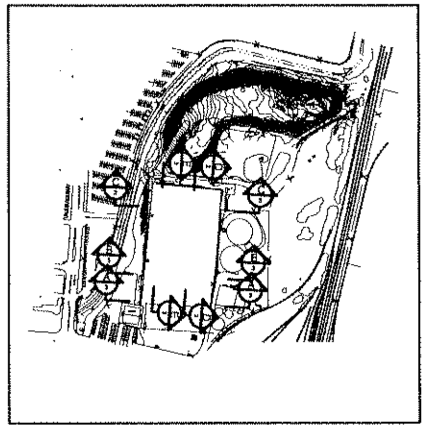
▨ EXISTING GRADE

▨ LIMIT OF SLUDGE



KEY PLAN
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LAGOON CLOSURE PLAN # 3

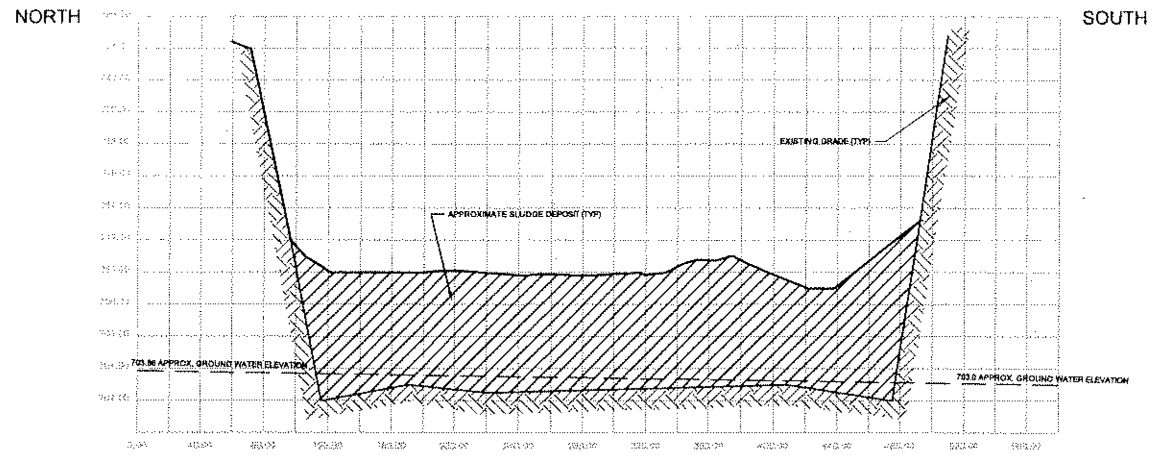
CROSS-SECTIONS - EXISTING CONDITIONS
NORTH SETTLING LAGOON - 1999

CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
HOR 1"=60' VERT 1"=6'	12611-00	003	PLAN 3

12611-00(003)GN-WA017 JUN 05/2000



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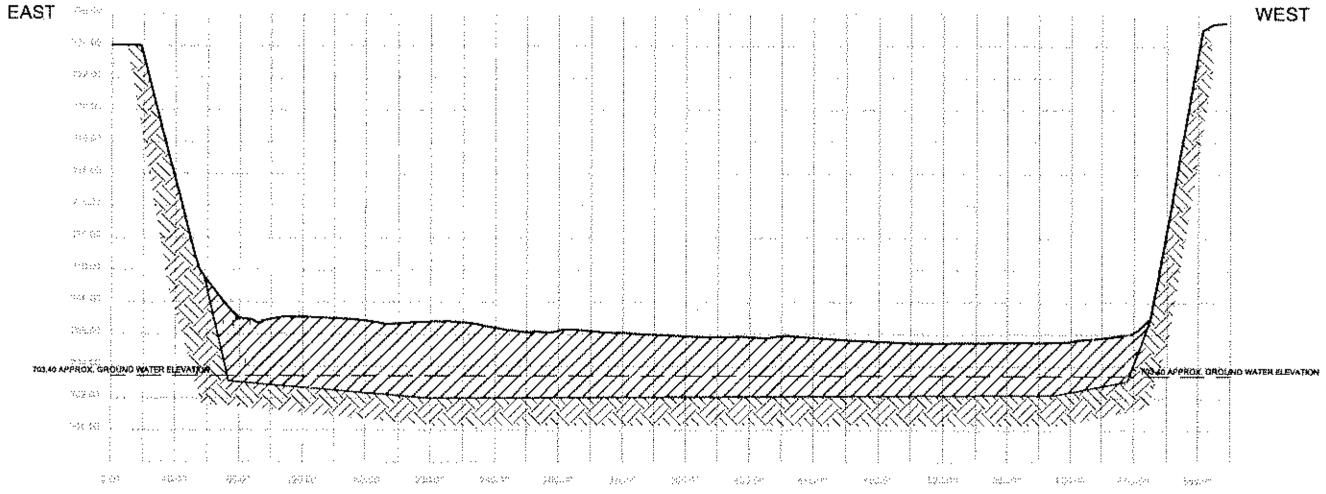

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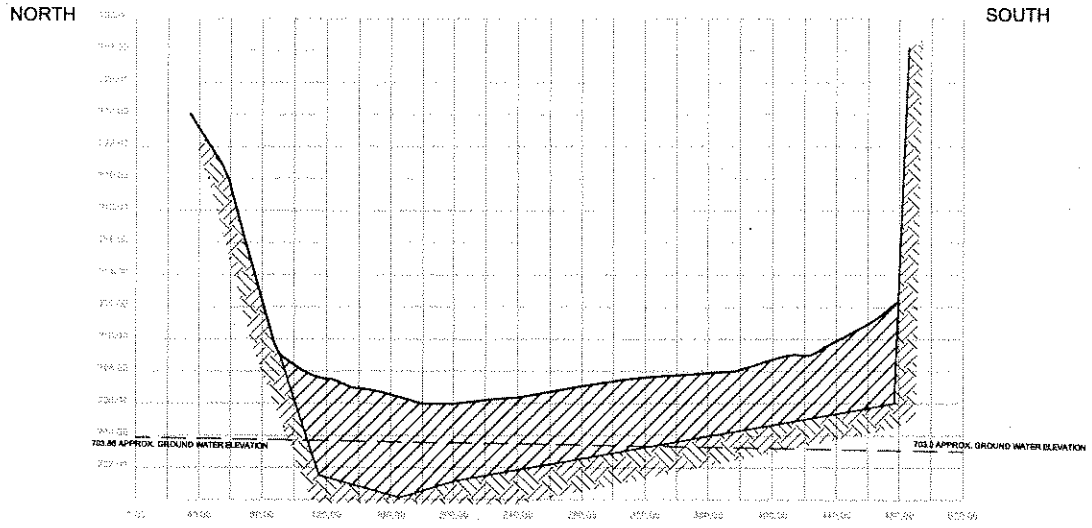

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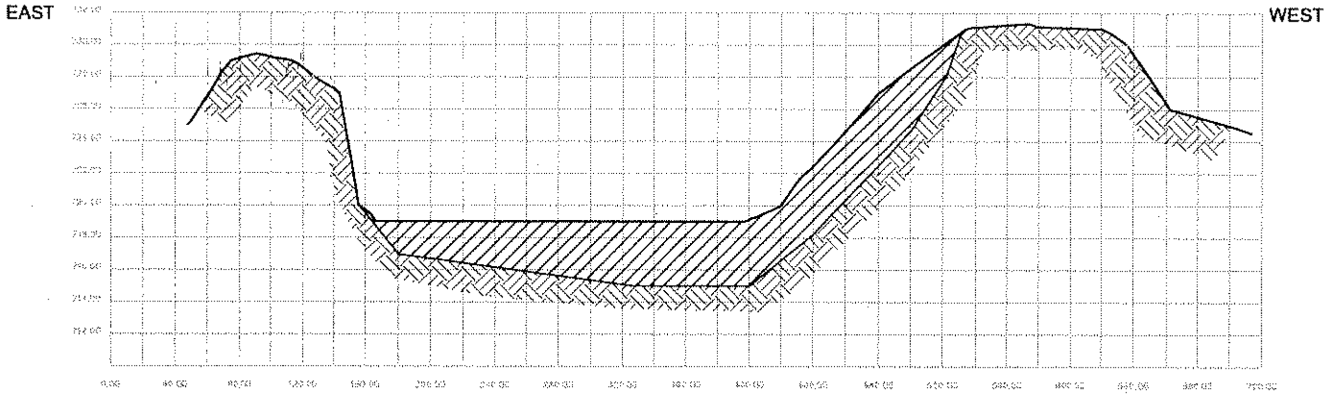

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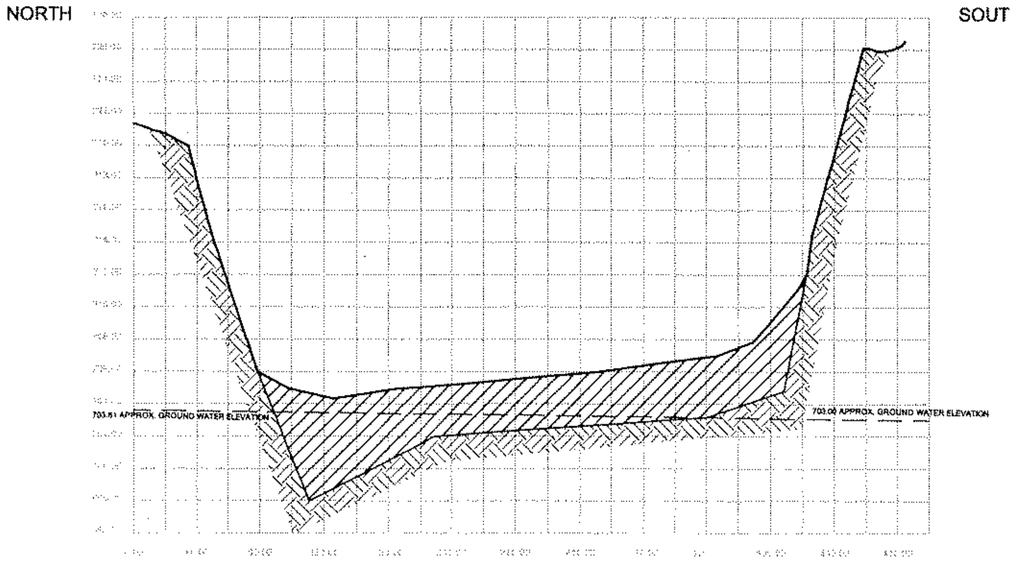

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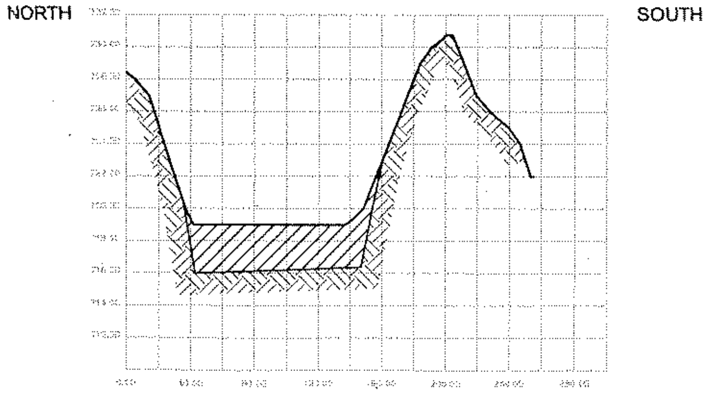

SECTION F
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Nº	Revision	Date	Initial

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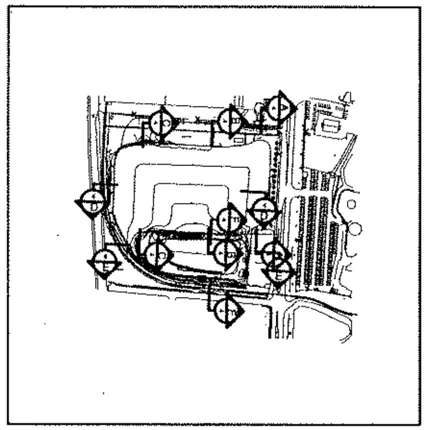
▨ LIMIT OF SLUDGE



KEY PLAN
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LAGOON CLOSURE PLAN # 4

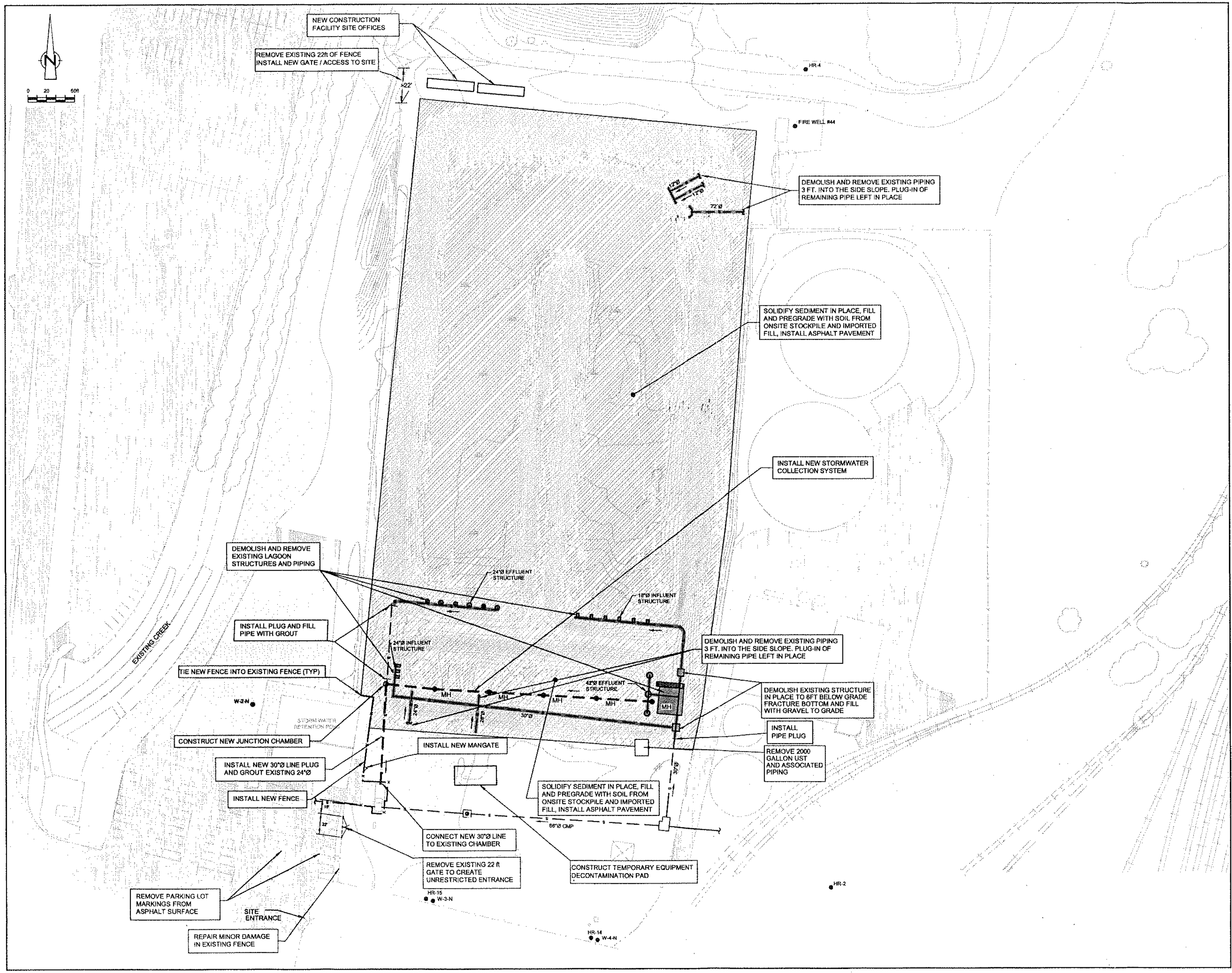
CROSS-SECTIONS - EXISTING CONDITIONS
SOUTH SETTLING LAGOON - 1999

CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager: I. RICHARDSON	Reviewed By: H. COOKE	Date: SEPTEMBER 1999	
Scale: HOR 1"=60' VERT 1"=30"	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 4

12611-00(003)GN-WA016 JUN 05/2000



Nº	Revision	Date	Initial

LEGEND

NEW	EXISTING	
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		TURN DIAL TYPE ENTRANCE
		ASPHALT PAVEMENT
		GRAVEL SURFACE
		EDGE OF WATER
		RAILROAD
		VEGETATION
		MARSH
	··· 725 ···	CONTOUR AND ELEVATION (ft.)
▬ ▬ ▬ ▬	— — — s —	STORMWATER SEWER
		OVERHEAD POWER LINE
		TREE
	● HR-4	MONITORING WELL
	● W-3-N	MONITORING WELL
● MH		MANHOLE/CATCHBASIN
▨		LIMIT OF PROPOSED ASPHALT COVER
		EXTENT OF PIPING AND LAGOON STRUCTURES TO BE DEMOLISHED AND REMOVED
○		JUNCTION CHAMBER

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LAGOON CLOSURE PLAN # 5

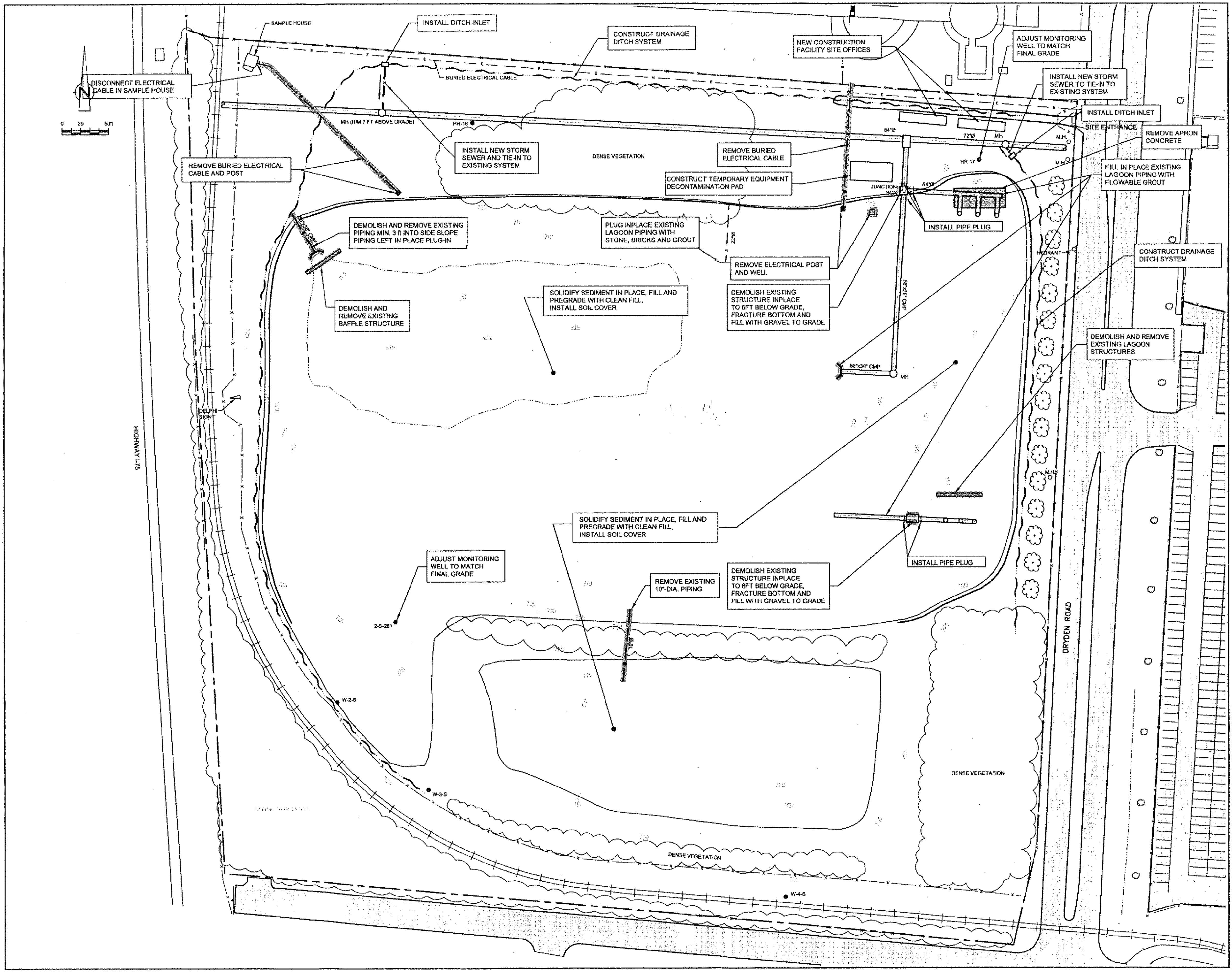
SITE WORK
NORTH SETTLING LAGOON

CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale: 1"=50'	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 5

12611-00(003)GN-WA012 MAY 31/2000



Nº	Revision	Date	Initial

LEGEND

NEW	EXISTING	
	— — —	APPROXIMATE LOT LINE
	—— x ——	FENCE
	▨	ASPHALT PAVEMENT
	☐	GRAVEL SURFACE
	— ·· — ·· —	EDGE OF WATER
	┼┼┼	RAILROAD
— — s —	— — — s —	STORMWATER SEWER
	⊂⊃	UNDERGROUND PIPING
	— — E —	ELECTRICAL CABLE
	✿	TREE
	● W-2-S	MONITORING WELL
	● HR-17	MONITORING WELL
	● 2-S-281	MONITORING WELL
● MH	○ MH	ACCESS MANHOLE
■ CB		CATCHBASIN
▨		LIMIT OF PROPOSED SOIL COVER
▩		EXTENT OF PIPING AND LAGOON STRUCTURES TO BE DEMOLISHED AND REMOVED
~		DRAINAGE DITCH

NOTE:

REGRADE AND RESEED FOLLOWING CONSTRUCTION OF THE CAP IN ALL NON-CAPPED AREAS EXCLUDED AREAS DESIGNATED AS DENSE VEGETATION.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 6

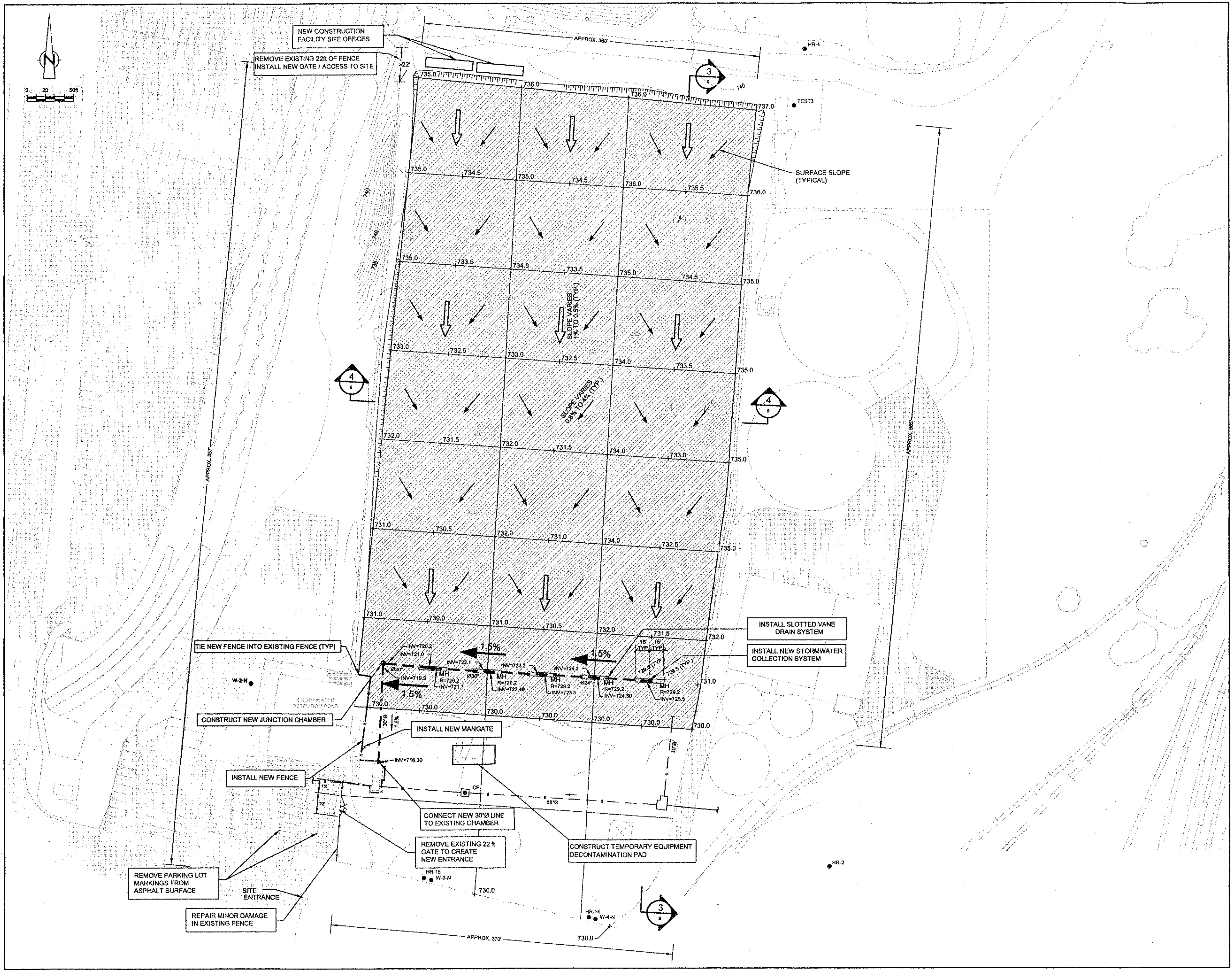
SITE WORK
SOUTH SETTLING LAGOON

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale: 1"=50'	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 6

12611-00(003)GN-WA013 JUN 05/2000



Nº	Revision	Date	Initial

LEGEND

NEW	EXISTING	
—x—		FENCE
		TURN DIAL TYPE ENTRANCE
		ASPHALT PAVEMENT
		GRAVEL SURFACE
		EDGE OF WATER
		RAILROAD
		VEGETATION
		MARSH
		CONTOUR AND ELEVATION (ft.)
	— s —	STORMWATER SEWER
	OE	OVERHEAD POWER LINE
		TREE
	● HR-4	MONITORING WELL
	● W-3-N	MONITORING WELL
● MH		MANHOLE/CATCHBASIN
R=734.5		RIM ELEVATION
INV. = 730.0		PIPE INVERT ELEVATION
+ 734.5		SPOT ELEVATION
■ CB		CATCHBASIN
▨		LIMIT OF PROPOSED ASPHALT COVER
○		JUNCTION CHAMBER

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 7

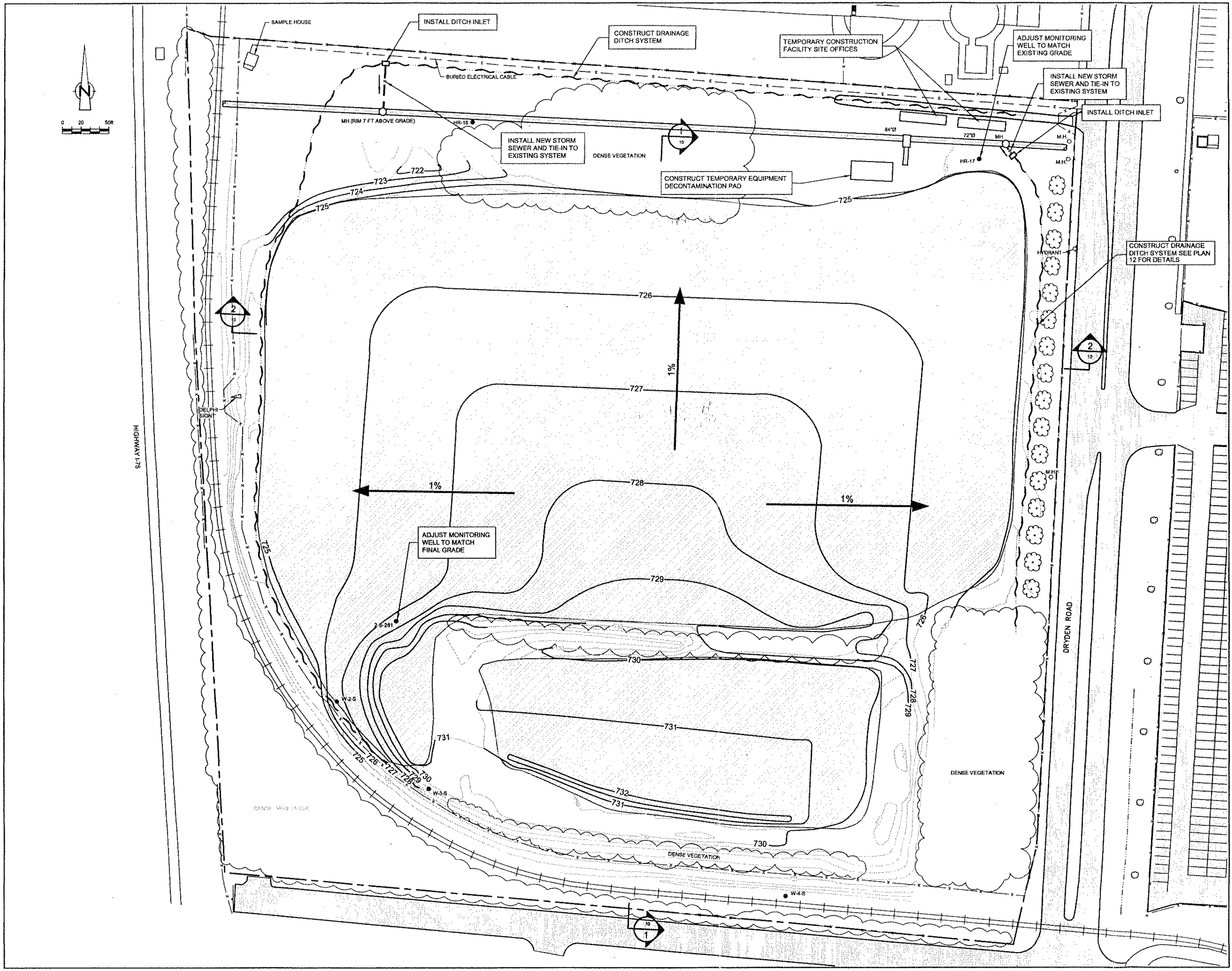
ASPHALT PAVEMENT COVER
NORTH SETTLING LAGOON

CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale: 1"=50'	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 7

12611-00(003)GN-WA020 JUN 05/2000



Nº	Revision	Date	Initial

LEGEND

NEW	EXISTING	
	— — —	APPROXIMATE LOT LINE
	—— x ——	FENCE
	▨	ASPHALT PAVEMENT
	☐	GRAVEL SURFACE
	- - - -	EDGE OF WATER
	┼┼┼┼	RAILROAD
	⌒⌒⌒	VEGETATION
	▭	UNDERGROUND PIPING
	— — E —	ELECTRICAL CABLE
	● W-2-S	MONITORING WELL
	● HR-17	MONITORING WELL
	● 2-S-281	MONITORING WELL
	○ MH	ACCESS MANHOLE
	·····	EXISTING CONTOUR AND ELEVATION (ft.)
——725——		PROPOSED CONTOUR AND ELEVATION (ft.)
~		DRAINAGE DITCH
— — S —		PROPOSED STORMWATER SEWER
☐		PROPOSED LIMIT OF SOIL COVER

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 8

SOIL COVER SOUTH SETTLING
LAGOON CLOSURE

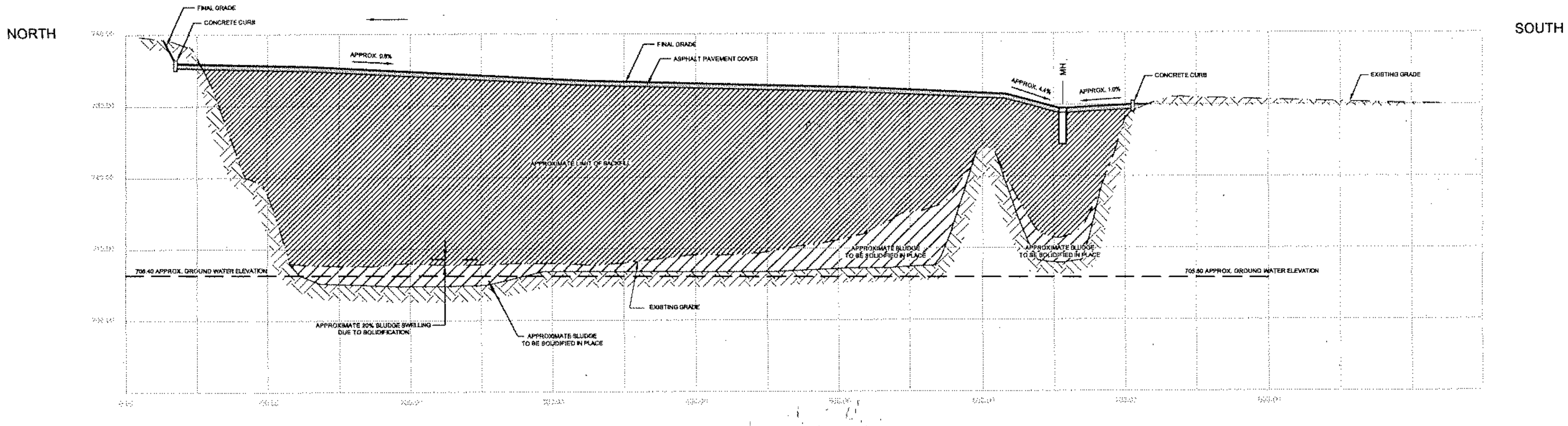
CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

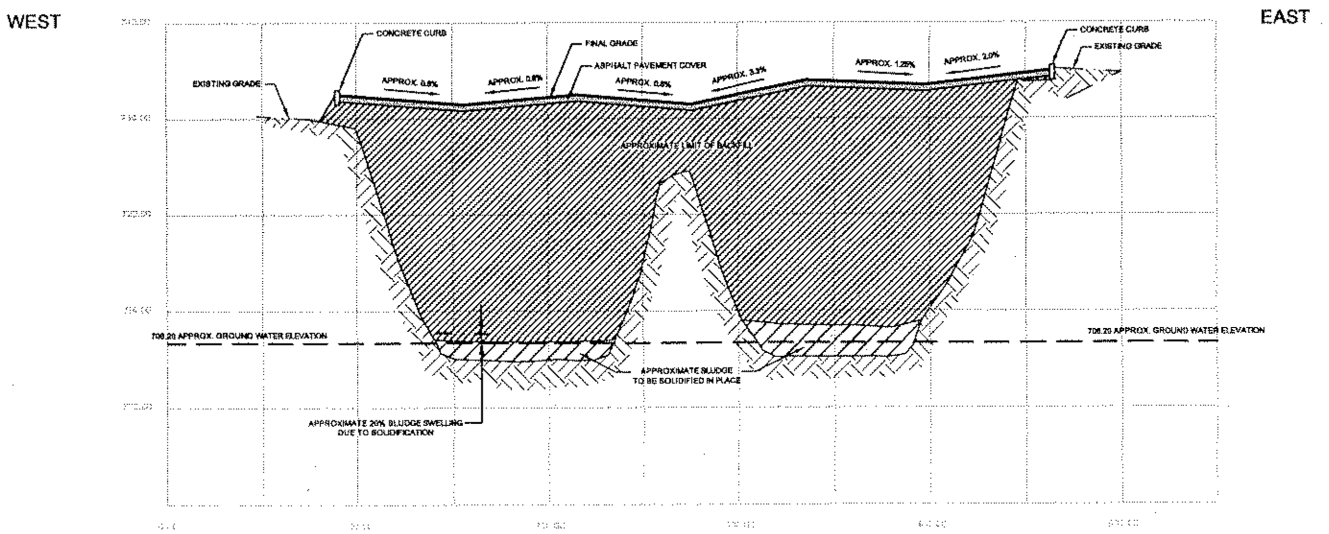
WOOLPERT LLP - DAYTON, OHIO JULY 1999

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
1"=50'	12611-00	003	PLAN 8

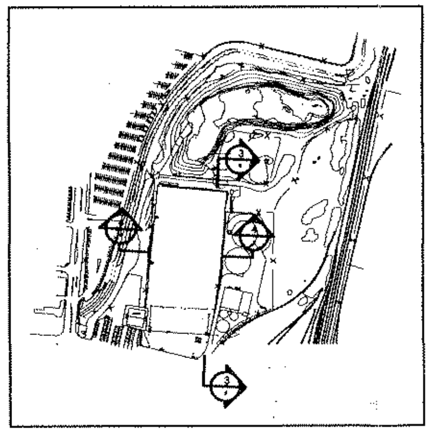
12611-00(003)GN-WA021 JUN 05/2000



SECTION 3/7



SECTION 4/7



KEY PLAN
N.T.S.

Nº	Revision	Date	Initial

LEGEND

▨	EXISTING GRADE
▨	LIMIT OF SLUDGE
▨	LIMIT OF BACKFILL

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN #9

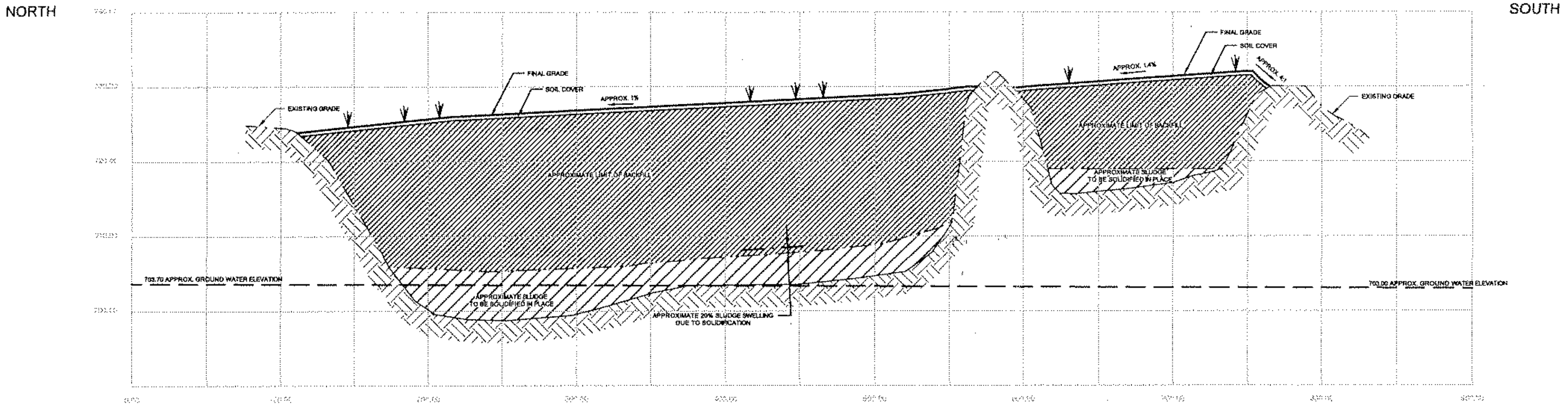
CROSS-SECTIONS
NORTH SETTLING LAGOON

CRA CONESTOGA-ROVERS & ASSOCIATES

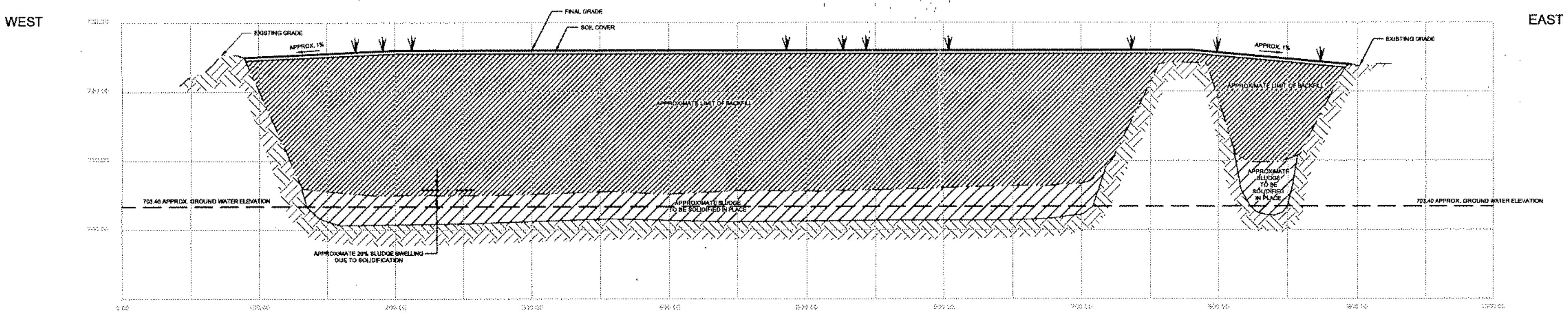
Source Reference:

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
HOR 1"=50' VERT 1"=10'	12611-00	003	PLAN 9

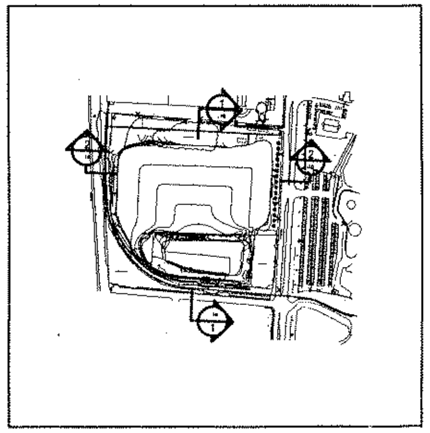
12611-00(003)GN-WA015 JUN 05/2000



SECTION 1/6



SECTION 2/6



KEY PLAN

N.T.S.

Nº	Revision	Date	Initial

LEGEND

- ▨ EXISTING GRADE
- ▨ LIMIT OF SLUDGE
- ▨ LIMIT OF BACKFILL

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 10

CROSS-SECTIONS
SOUTH SETTLING LAGOON

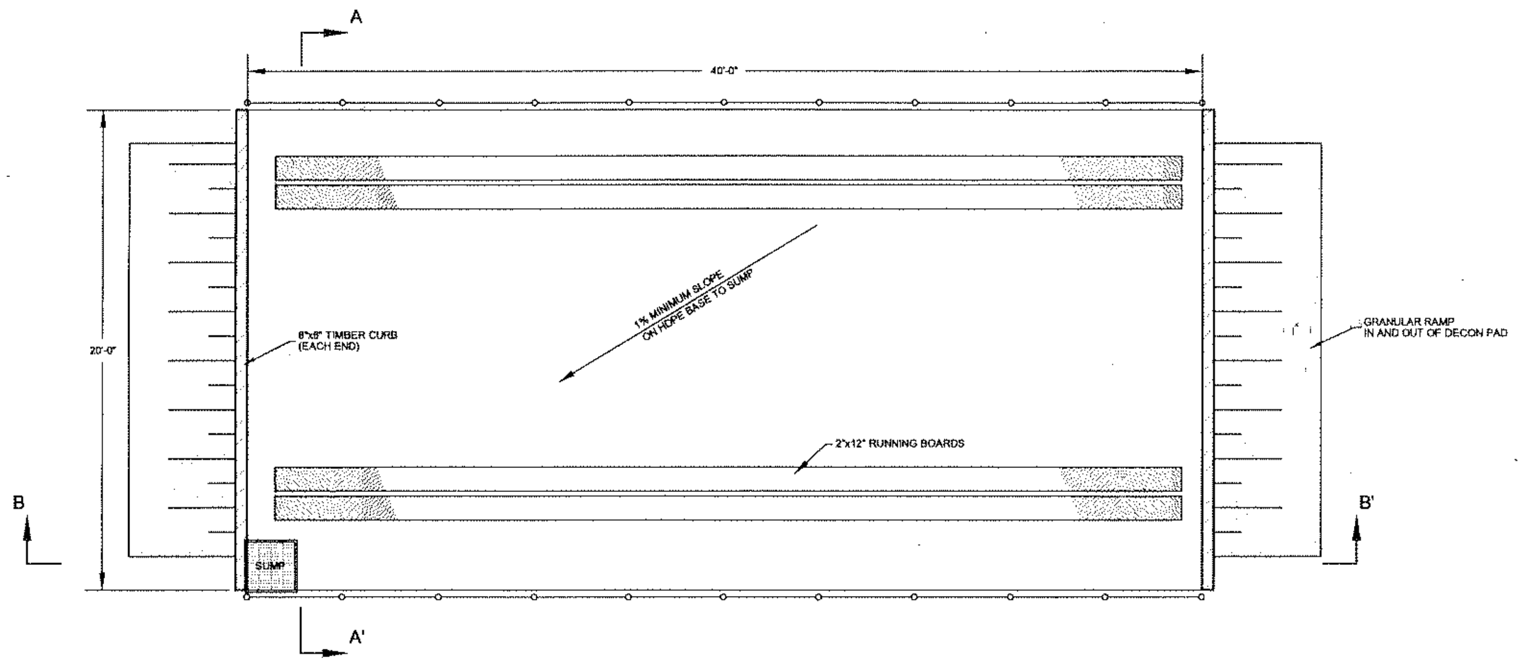
CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

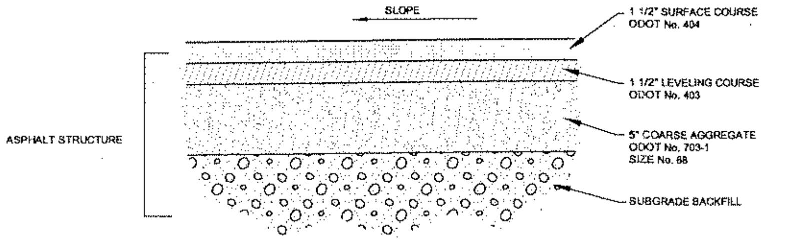
Project Manager: I. RICHARDSON	Reviewed By: H. COOKE	Date: SEPTEMBER 1999	
Scale: HOR 1"=50' VERT 1"=10'	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 10

12611-00(003)GN-WA014 JUN 05/2000

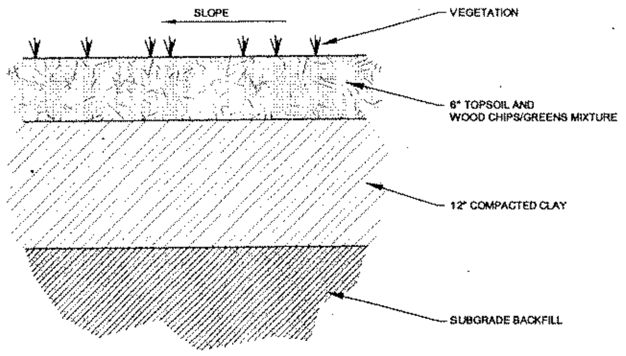
Nº	Revision	Date	Initial



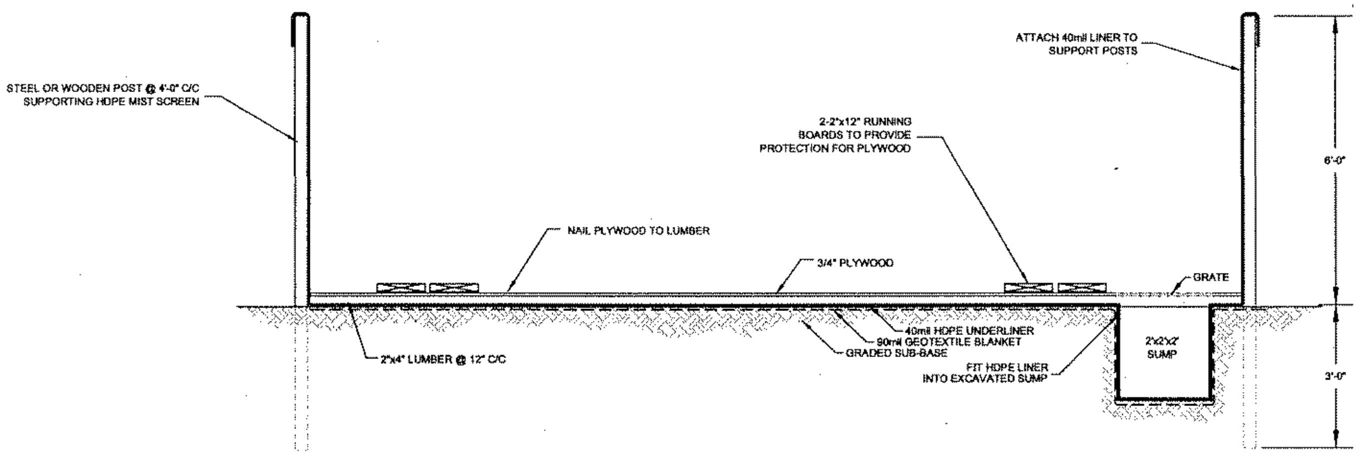
TEMPORARY EQUIPMENT
DECONTAMINATION PAD



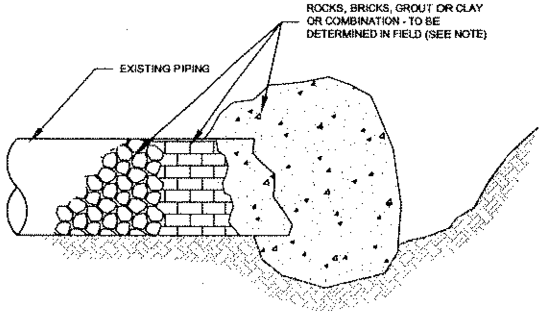
ASPHALT PAVEMENT COVER DETAIL



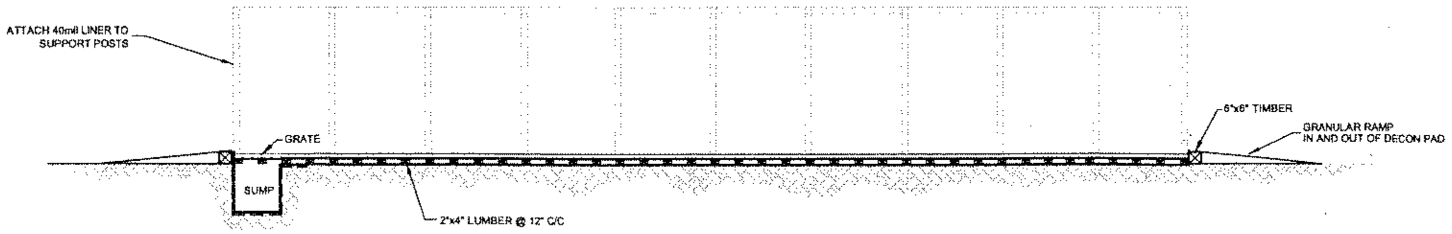
SOIL COVER DETAIL



SECTION A-A'



PIPE PLUG DETAIL
N.T.S.



SECTION B-B'

NOTE:

PIPE DIAMETER	PIPE PLUG MATERIAL
2" TO 6"	ROCKS AND GROUT OR CLAY
6" TO 12"	BRICKS AND GROUT
ABOVE 12"	BRICKS AND GROUT

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

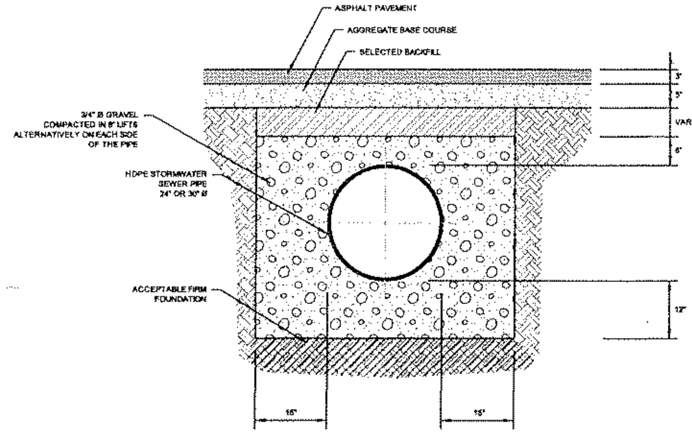
LAGOON CLOSURE PLAN # 11

DETAILS

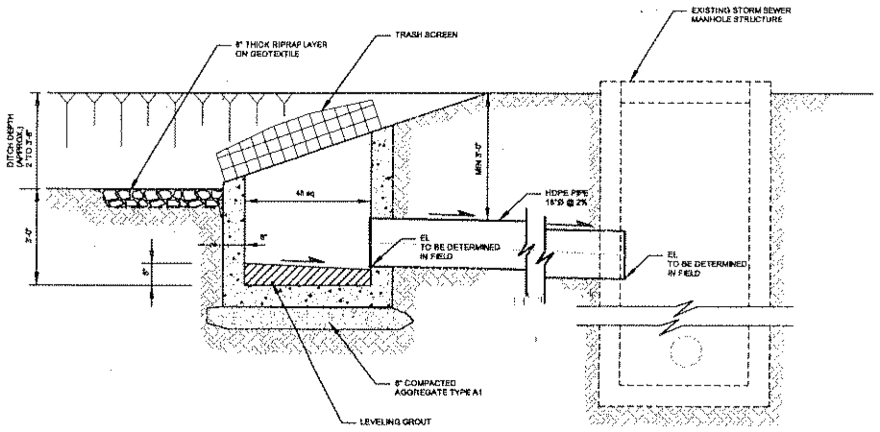
CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

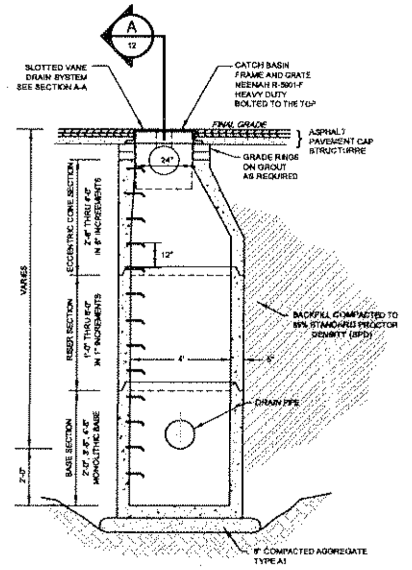
Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale: N.T.S.	Project Nº: 12611-00	Report Nº: 003	Drawing Nº: PLAN 11



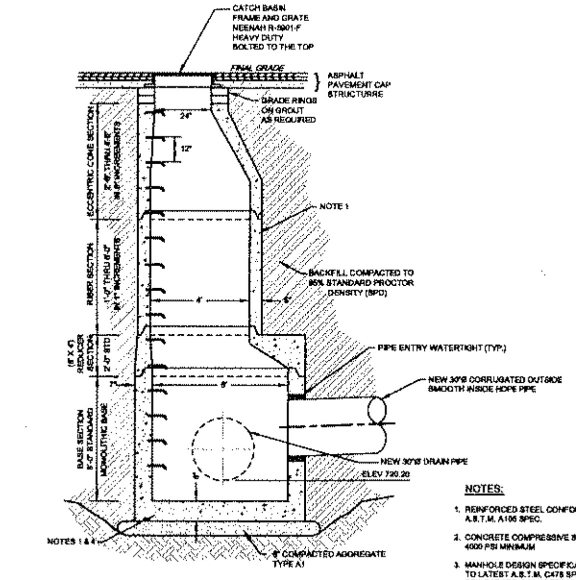
STORMWATER SEWER BEDDING DETAIL
N.T.S.



DITCH INLET STRUCTURE DETAIL
N.T.S.



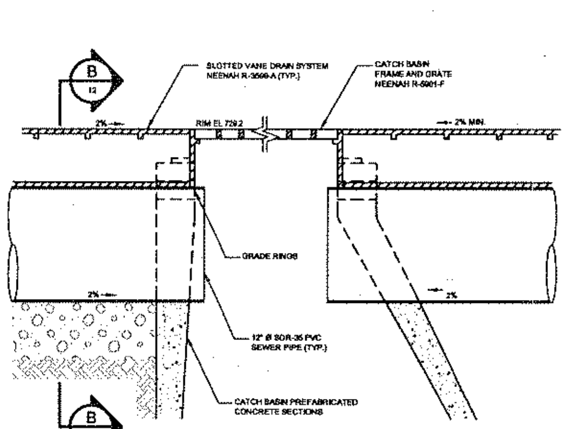
NEW MANHOLE CATCH BASIN DETAIL
N.T.S.



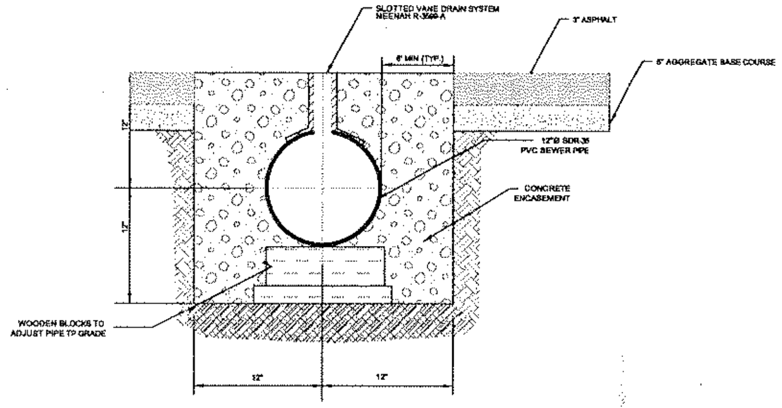
NEW JUNCTION CHAMBER DETAIL
N.T.S.

NOTES:

1. REINFORCED STEEL CONFORMES TO LATEST A.S.T.M. A106 SPEC.
2. CONCRETE COMPRESSIVE STRENGTH - 4000 PSI MINIMUM
3. MANHOLE DESIGN SPECIFICATIONS CONFORM TO LATEST A.S.T.M. C478 SPEC. FOR PRECAST REINFORCED CONCRETE MANHOLE SECTIONS
4. ONE POUR MONOLITHIC BASE SECTION
5. O-RING SECTION JOINT CONFORMED TO LATEST A.S.T.M. C443 SPEC. AND FEDERAL SPEC. SS-S-210A

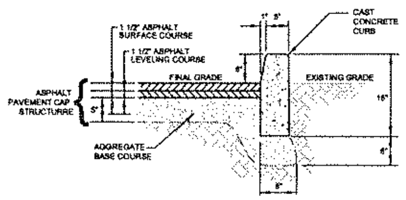


SECTION A-A
N.T.S.

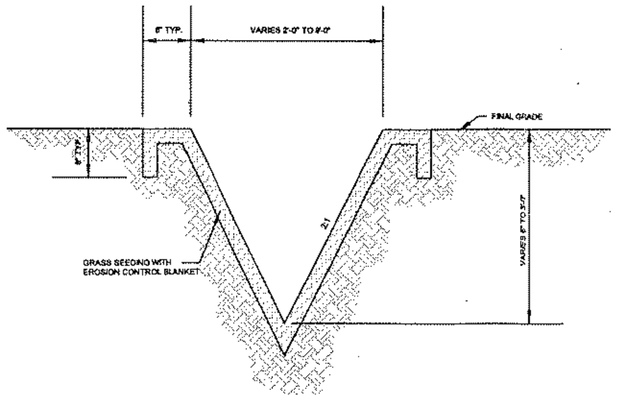


NOTE: INSTALL SLOTTED VANE DRAIN SYSTEM ACCORDING TO NEENAH FOUNDRY CO. RECOMMENDATIONS

SECTION B-B
N.T.S.



CONCRETE CURB DETAIL
N.T.S.



DRAINAGE DITCH DETAIL
N.T.S.

GENERAL NOTES

1. ADD 600 FT. TO ELEVATIONS SHOWN FOR USGS DATUM.
2. THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND, WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES, AND SHALL ASSUME ALL LIABILITY FOR DAMAGE TO THEM

Nº	Revision	Date	Initial

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

HARRISON FACILITY
MORAINE, OHIO

LAGOON CLOSURE PLAN # 12

DETAILS

CRA CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
I. RICHARDSON	H. COOKE	SEPTEMBER 1999	
Scale:	Project Nº:	Report Nº:	Drawing Nº:
N.T.S.	12611-00	003	PLAN 12

12611-00(003)GN-WA019 JUN 05/2000