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GRAND CALUMET RIVER SEDIMENT REMEDIATION

CORRECTIVE ACTION MANAGEMENT UNIT CLOSURE AND POST-CLOSURE PLANS U.S. STEEL – GARY WORKS

Prepared for:

GARY WORKS

February 2003

GRAND CALUMET RIVER
SEDIMENT REMEDIATION

CAMU - CLOSURE PLAN
U.S. STEEL - GARY WORKS

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TABLE OF CONTENTS

LIST OF TABLES

(Tables are located at the end of each respective section)

LIST OF FIGURES

(Figures are located at the end of the text portion of the document)

LIST OF APPENDICES

1.0 INTRODUCTION

This document, entitled the Closure Plan for the Sediment Corrective Action Management Unit (CAMU), was prepared for United States Steel Corporation (USS) Gary Works (the facility) in Gary, Indiana.

This section, Section 1.0, provides a brief project description and describes the closure performance standard. Section 2.0 presents the Closure Plan, including a description of the conceptual cover design, how the cover will minimize liquid migration, maintenance needs, drainage and erosion control, settlement and subsidence, cover permeability, and freeze and thaw effects. Section 3.0 presents the schedule for the closure. Section 4.0 discusses the disposal or decontamination of equipment, structures, and soils. Section 5.0 discusses the notice in deed and certification. Section 6.0 presents the closure and post-closure cost estimate. Section 7.0 presents the financial test and corporate guarantee for closure.

1.1 Project Description

The U.S. Steel - Gary Works facility is located in Lake County, Indiana. The Gary Works facility covers almost 4,000 acres and is located at the northern end of the city of Gary, Indiana, approximately 25 miles southeast of downtown Chicago, Illinois. The Gary Works facility extends approximately 7 miles along the southern shore of Lake Michigan and is roughly one mile wide.

The CAMU at USS Gary Works will provide containment, passive dewatering and permanent disposal of dredged sediments as part of the Grand Calumet River Sediment Remediation Project. The non-native sediments are to be dredged from Transects 1 through 36 of the Grand Calumet River. The estimated volume of these sediments is approximately 746,700 cubic yards. The existing layout of the CAMU has a plan area of about 31.2 acres. The CAMU is divided into two units: Unit 1, which is for disposal of TSCA and RCRA-regulated dredge spoils; and Unit 2, for disposal of the remaining non-TSCA and non-hazardous dredge spoils. Unit 1 is approximately 8.6 acres and Unit 2 is approximately 22.6 acres. The available disposal capacity for dredged spoils is 269,000 cubic yards in Unit 1 and 878,100 cubic yards in Unit 2, excluding the volume needed for freeboard, water pool, and for the 2-foot thick drainage layer to be placed in the bottom of each unit. The total capacity for the dredge spoils in the two units is 1,147,900 cubic yards. USS may propose to use excess capacity in the CAMU to dispose of remediation waste resulting from implementation of an Interim Stabilization Measure, or Corrective Action Measure as set forth in the RCRA Corrective Action Order. Such use shall be subject to EPA approval.

The key elements of the CAMU design include a large perimeter berm, primary and secondary liner systems, leachate collection and leak detection systems, and a surface water management system. These design elements are described in the CAMU Construction/Operation Level Design Report (Earth Tech 2001). Once the CAMU is filled with the waste, an engineered cover will be installed. The conceptual design of the cover is presented in Section 2.0 of this plan.

1.2 Closure Performance Standard

This Closure Plan has been prepared to meet the requirements of 40 CFR 264.310 and 40 CFR 264.552(e). In doing so, this plan specifies the methods and procedures to:

- Minimize the need for further maintenance;
- Control, minimize or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and
- Comply with the closure requirements of subpart 40 CFR Subpart G.

2.0 CLOSURE OF CAMU

The CAMU at USS Gary Works will be closed following the landfill closure requirements of 40 CFR 264.310, which states that the owner or operator must cover the landfill or cell with a final cover designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfills;
- Function with minimum maintenance;
- Promote drainage and minimize erosion of the cover;
- Accommodate settling and subsidence so that the cover's integrity is maintained; and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

This section presents the conceptual design of the cover and demonstrates how the design of the CAMU minimizes liquid migration, minimizes maintenance, provides drainage and minimizes erosion, accommodates settling and subsidence, and has a cover permeability less than the liner permeability. In addition, this section discusses the effects of freeze/thaw on the cover.

2.1 Conceptual Cover Design

The CAMU Landfill final cover system will consist of:

- Grading the existing waste to the design contours,
- Placing and compacting a minimum of one-foot thick slag layer over the waste,
- Installing a gas collection system within the 1-foot slag layer above the graded waste;
- Installing a geosynthetic clay liner (GCL) on top of the slag;
- Installing a 40-mil high density polyethylene (HDPE) geomembrane liner over the GCL,
- Installing a synthetic geonet over the geomembrane liner,
- Installing a protective geotextile filter fabric over the geonet,
- Installing a one-foot thick sand cover over the geotextile fabric,
- Placing a two-foot thick slag cover over the sand,
- Harrowing a seed/organic matter mixture into the upper six (6) inches of slag to form a vegetative cover, and
- Installing a stormwater drain system inside the perimeter access road to divert surface water away from the landfill.

A typical cross-section of the CAMU cover identifying the main construction components listed above is shown in Figure 2-1.

2.1.1 Grading of Waste

The final cover construction on the CAMU will be performed after the CAMU is filled to specified grades with non-native sediments from the Grand Calumet River and any other EPA-approved materials from Gary Works. The outer slopes of the CAMU will range from 3 percent to 5 percent and will be dependent on the conformity of wastes within the cells. The sediment subgrade for the slag layer shall be final graded and proofrolled. Proofrolling shall consist of one pass with an approved non-vibrating smooth drum roller to ensure that the subgrade is free of loose materials, irregularities, protrusions, and abrupt changes in grade.

2.1.2 Gas Collection System and Slag Layer

Methane gas is expected to be generated due to the presence of organic matter in the sediments.[1] A passive gas collection system will be used to collect and vent the gas generated from the decomposition of organic matter in the CAMU. The gas collection system shall be installed in a 1-foot thick slag layer above the sediment subgrade. The gas collection system shall consist of horizontal 6inch diameter slotted HDPE pipes placed over the sediment subgrade on 200foot centers. The horizontal collection pipes shall be connected to vertical pipes that will extend a minimum of 8 feet above the top of the CAMU cover. These pipes shall passively vent any landfill gas. The horizontal collection pipes will be equipped with clean outs near the perimeter of the CAMU cover. A one-foot thick layer of slag will be placed over the sediment subgrade and around the horizontal collection pipes. The slag shall meet the Course Aggregate No. 2 standards specified in InDOT Standard Specification 904.02(e).

The area around the landfill gas vents, where they protrude through the cover, shall be sealed. Each vent will have a geomembrane boot installed around the base of the vent. The boot will be welded to the cover geomembrane and sealed around the pipe with a stainless steel band.

Differential settlement analysis of sediments and the design calculations for the gas collection system are presented in Appendix A and Appendix B, respectively. Based on the calculations provided in Appendix B, the landfill gas collection system described above will adequately vent, and thus minimize the build-up of, the gas expected to be produced from the CAMU. Figure 2-1 shows a typical cross-section of the gas collection system.

2.1.3 GCL layer

A reinforced geosynthetic clay liner (GCL) shall be placed on top of the slag layer. The GCL will consist of one pound per square foot bentonite sandwiched between geotextile. Specific type of GCL (e.g., Claymax, Bentofix, etc.) will be determined during the cover design phase.

2.1.4 HDPE Geomembrane Liner

USS will select a geomembrane manufacturer / installer with demonstrated ability to manufacture and install the geomembrane at the CAMU site.

[1] Total organic content of the sediments averaged 4.5 percent (Floyd-Brown)

The geomembrane liner will consist of 40-mil thick smooth high-density polyethylene panels. Each roll should be identified by a unique manufacturing number; with test results conducted by the producer of the raw material and the manufacturer to verify the quality of the raw material, including density, melt index, thickness, tensile force per unit width at yield and break, elongation at yield and break, tear resistance, and coefficient of thermal expansion-contraction. It should be delivered to the site in light-protected rolls. All rolls should be inspected upon delivery to the site for damage.

The overall installation of the geomembrane and geonet should indicate that the materials were installed in accordance with the manufacturer's installation requirements and the Construction Specifications. The contracted installer should also provide guarantees that the cover will be free of defects at the completion of installation and that the installed geomembrane and field seams would remain free of defects for a period of two years after installation.

2.1.5 Synthetic Geonet

The installation of the geonet will require surface preparation consisting of observing the placement, the inspection of the geomembrane after installation, review and approval of the seaming data when appropriate, and a final walk-through inspection prior to installation of the geonet. The contractor should review and approve the manufacturer's QC data for all geosynthetics, including the geomembrane, geonet and the geotextile.

The approved Synthetic Geonet covering the geomembrane should be ¼-inch thick HDPE drainage netting. Placement of the geonet should begin from the highest points of the landfill extending to the perimeter toe drain. Adjacent geonet panels will overlap with a minimum of 2 inches (6 inches if at end of roll) and will fasten every 5 feet with the self-locking ties supplied by the geonet manufacturer.

2.1.6 Geotextile Filter

The purpose of the geotextile is to act as a separator layer and to filter soil particles, minimizing the potential for migration from the overlying protective slag cover into the infiltration collection geonet and consequently minimizing clogging potential.

The approved geotextile should be a non-woven needle-punched polypropylene fiber geotextile and should be resistant to commonly encountered soil chemicals, non-biodegradable, and stable within a pH range of 2 to13. Its Apparent Opening Size shall be less than a No. 100 sieve and should have a mass per unit area of 10 oz/yd^2. The geotextile properties shall meet the minimum design requirements as tested by ASTM D3776, ASTM D1777, and ASTM D3786. The certificates of geotextile physical property values reported shall be documented.

2.1.7 Sand Cover

A one-foot thick sand layer will cover the geotextile. The sand will have a hydraulic conductivity greater than 1 x 10^{-3}.

2.1.8 Slag Cover

A two-foot thick compacted layer of slag will be installed over the entire surface of the infiltration collection layer. The slag shall conform to INDOT 53 gradation standards.

2.1.9 Vegetative Cover

Once the slag cover has been placed over the CAMU, the upper surface of the slag shall receive an application of organic matter (e.g., compost, peat moss, or biosolids from a local publicly owned treatment works). The organic matter shall be applied to the surface at an application rate not less than one (1) part organic matter to four (4) parts protective cover by dry unit weight (20 percent organic matter: 80 percent slag) for a six (6) inch deep root zone. The layer of organic matter shall be blended into the slag cover to a depth of six (6) inches using agricultural methods.

A seed mix shall be applied using a hydroseeder. The seed mix shall consist of the following species that were successfully grown on another slag-covered landfill at USS:

- Annual rye (secale cereale)
- Tall wheat (agropyron clongatum)
- Alfalfa (medicago sativa)
- Alkali grass (puccinellia distans)

In addition, native shallow-rooted grasses and legumes such as Bromegrass, Tall Fescue, and various varieties of prairie grasses shall be used.

2.1.10 Perimeter Drain System

A perimeter drain, approximately 2 feet wide (at the base) and 3 feet deep, will be installed on the east and west perimeter of the CAMU cover. The drain will be located on the exterior of the perimeter berm/access road as shown on Figure 2-2. The drain will be sloped so that runoff will be conveyed to the two stormwater retention ponds located on the southeast and southwest corners of the CAMU: The runoff will be routed from the toe drain through culverts under the perimeter access road to the stormwater detention ponds. Water on the north and south sides of the CAMU cover will be routed to the east and west perimeter drains via diversion berms. Stormwater drainage calculations supporting this design are presented in Appendix C. These calculations demonstrate that the drainage system and detention ponds are designed to handle a 100-year, 24-hour storm event.

2.2 Construction Quality Control Program

Verification that construction of the landfill system is in accordance with the plans and specifications will be achieved by a two-step process. The first step is quality control monitoring performed in the field during the construction process. The second part consists of quality assurance monitoring before, during, and after construction is complete. Quality assurance procedures will be performed in the field and laboratory.

2.3 Minimization of Liquid Migration

Minimization of migration of liquids through the cover will be achieved by the design of the cover (described in detail in Section 2.1). The cover design includes a vegetative cover that will absorb and evapotranspire rainwater, a sloped cap that will encourage surface drainage, and low permeability layers (GCL and geomembrane) to prevent the infiltration of rainwater. In addition, a perimeter toe drain around the landfill will divert surface water away from the landfill.

2.4 Maintenance Needs

The protective cover system will function effectively with minimum maintenance needs. The only maintenance anticipated is the repair of slag cover because of erosion and the removal of any woody plants that take root.

2.5 Drainage and Erosion

The construction of the Infiltration Collection System (described in detail in Section 2.1.5) meets the applicable criteria for adequate drainage. To facilitate drainage, the minimum slope to be used will be three (3) percent, which is the minimum slope recommended in USEPA's Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments – USEPA 1989. The maximum slope will be five (5) percent. The use of slag in similar applications (i.e. a landfill cover in Northwest Indiana) have generally provided no movement of surface materials from a cover with a 25 percent slope during routine storm events and minimal movement of material beyond the perimeter during severe events.[2] The top layer of the cover will be stabilized with a vegetative cover.

2.6 Settlement and Subsidence

Appendix A presents an evaluation of the differential settlement due to consolidation of foundation soils and the dredge spoil (i.e., sediments) within the CAMU. This evaluation demonstrates that after the sediments have been dewatered, the differential settlement between the edge of the CAMU and the center of the CAMU (the peak of

[2] Using the Universal Soil Loss Equation (USLE) to calculate erosion for the CAMU cover is not applicable. The USLE is based on factors for topsoil, cropping, and conservation practices. The cover design specifies 2 ft of slag (similar to INDOT 53). The slag can not be correlated accurately to the soil erodibility factors given in tables or charts. Additionally, crops and conservation practices will not be used in the cover. Therefore, a calculation of erosion for the cover using USLE can not be determined.

the cover) will be about 2 feet. Based on this differential settlement, a cover that originally has a 5 percent slope will have a 4.65 percent slope after settlement. This amount of settlement should not impact the cover's integrity. The actual settlement and bearing capacity of the waste material will be evaluated prior to placing the cover on the CAMU. The construction of the cover will not begin until USS is assured that the underlying material has sufficient bearing capacity in order to minimize differential settlement and protect the integrity of the cover.

The sediment will consist primarily of fine-grained sands and silts. Some clay will be present. (Included in Appendix A is a summary of the material properties of the sediment.) USS will discharge the sediment into the CAMU through discharge pipe that will be located on a floating platform/raft. During daily operations, this raft will be moved via a winch system to spread the material evenly over the CAM (Earth Tech 2002). This procedure will minimize the potential for build-up of zones of fine and coarse-grained fractions, and thus reduce the potential for localized differential settlement within the CAMU.

A slope stability analysis was performed for the final build-out slopes after CAMU closure under long-term conditions. This analysis, which is presented in Appendix A, indicates that the CAM will be stable based on the proposed design.

The final CAMU cover will be sloped from 3 to 5 percent. This slope will be sufficient to maintain surface water drainage and minimize the formation of low spots with the anticipated differential settlement. In addition, as described in the Post-Closure Plan, the cap will be inspected for signs of differential settlement and water ponding in low spots. Inspections will be done on quarterly basis and after each precipitation event equal to or greater than a 24-hour, 25-year storm. USS will initiate corrective measures within 30 days from the date on which a problem is identified.

2.7 Cover Permeability

The closure requirements of 40 CFR Subpart G require the cover to have a permeability equal to or less than the bottom liner. This is achieved with the combined GCL/geomembrane cover materials.

The GCL shall achieve a hydraulic conductivity less than $1x10^{-7}$ cm/sec. The hydraulic conductivity of geomembranes is in the range of $1x10^{-10}$ to $1x10^{-13}$ cm/sec. The combined GCL/geomembrane cover provides a permeability that is less than or equal to the permeability of the CAMU liner.

2.8 Freeze/Thaw

The regional depth of frost penetration for northwest Indiana is between 30-35 inches [from Figure 6-4 of EPA Guidance Document on CFR 40 Chapter 6 Subpart F]. The cover system from top to bottom has a minimum of two feet (24 inches) of slag and one foot (12 inches) of sand above the geosynthetic liner for a total thickness of 36 inches. Frost will penetrate a maximum of 35 inches, which is less than the total thickness of the material above the geosynthetic cover.

3.0 SCHEDULE

This document is the final closure plan. The only modification anticipated by USS is the final configuration of the unit including the height and side slopes, which will be based on the actual amount of material placed in the CAMU. USS will submit the proposal to use native plants as the final vegetative cover for the CAMU, in addition to any other modification to the closure plan, to USEPA for review and approval at least 180 days prior to the expected closure date of the unit.

Within 90 days of receiving final volume of wastes, USS will begin closure activities. Closure will be completed within 180 days unless an extension is requested by USS and approved by USEPA. Within 60 days of completion of closure, the owner or operator will submit to the Regional Administrator a certification that the CAMU has been closed in accordance with the specifications in the approved closure plan.

4.0 DISPOSAL OR DECONTAMINATION OF EQUIPMENT STRUCTURES AND SOILS

The only decontamination anticipated at the closure is the cleaning of some of the tanks, piping and appurtenances at the Project Specific Wastewater Treatment Plant (PSWTP). A portion of the PSWTP (i.e., a scaled-down PSTP) will remain operational to treat decontamination water and leachate generated from the CAMU.

Decontamination will involve the scraping of waste from the structure / equipment, where accessible, followed by steam cleaning then by rinsing with a low volume, high pressure water wash. All fluids generated from the decontamination operation will be treated on-site at the scaled-down PSWTP.

Operations will be managed so that the fluids produced will be capable of being treated at on-site treatment facilities. Containerized fluids requiring off-site disposal are not anticipated. Any sludge removed from the PSWTP will meet the requirements for disposal and be disposed in an open cell or off-site, as appropriate.

5.0 NOTICE IN DEED AND CERTIFICATION

5.1 Certification Of Closure Report

All closure of hazardous waste management units must be certified in accordance with 40 CFR 264.115.

Within 60 days of completion of closure, the owner or operator will submit to the Regional Administrator a certification that the CAMU has been closed in accordance with the specifications in the approved closure plan. The certification will be signed by the owner or operator and by an independent registered professional engineer.

A copy of the certification will be submitted to the USEPA concurrently with IDEM. The independent engineer will be present at all critical, major activities during the closure including final cover placement. The frequency of inspection by the independent engineer will be sufficient to determine the adequacy of each critical activity.

A closure documentation report will be submitted with the certification statement. This report will include:

a) The volume or weight of waste and water residue removed;
b) The method of waste handing and transport;
c) Analytical methods used to characterize the waste, if necessary;
d) A chronological summary of closure activities;
e) Closure costs;
f) Photo documentation of closure;
g) Analytical results; if any; and
h) An as-built drawing of the closed CAMU.

5.2 Survey Plat

Survey plat of hazardous waste management units must be submitted in accordance with 40 CFR 264.115.

The survey plat will be prepared by a licensed surveyor and submitted with the certification of closure. The survey plat will include the location and dimensions of the landfill with respect to permanently surveyed benchmarks. This plat will be prepared by a professional land survey and submitted to the local zoning authority.

5.3 Notice In Deed

USS will submit to the local zoning authority and to the Regional Administrator a record of the type, location, and quantity of hazardous wastes disposed of within the CAMU no later than 60 days after certification of closure. Also, within 60 days after certification of closure, USS will submit a copy of the notation recorded in the deed to the facility property, or on some other instrument which is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that (1) the land has been used to manage hazardous wastes; (2) its use is restricted; and (3) the survey plat and record of the type, location, and quantity of hazardous wastes disposed of within each cell or area of the facility has been filed with the County

Recorder, to any local zoning authority or the authority with jurisdiction over local land use and with the Agency.

6.0 COST ESTIMATE FOR CLOSURE

For partial closures, revised cost estimates for remaining closures and any affected financial assurance instruments will be submitted with the closure certification documents. If the certification is for a final closure, the certification documents will also include a request for release from financial assurance.

Based on the site topography and the conceptual design of the proposed CAMU cover, USS has prepared an estimated cost for closure of the CAMU. Volumes and material quantities were obtained from the conceptual design drawings, details and our calculations. Unit prices were obtained from published sources, material suppliers and from industry experience.

Closure of the CAMU is estimated to cost \$4.93 million. A summary of the calculated quantities and estimated costs are presented in Table 6-1.

7.0 FINANCIAL ASSURANCE FOR CLOSURE

In accordance with the Indiana Administrative Code (329 IAC 3.1-14-8 and -18), the United States Steel Corporation will use environmental insurance to provide financial assurance for closure and post closure care costs at the CAMU. The policy will be issued by:

Grant Assurance Corporation
100 Bank Street
Suite 610
Burlington, VT 05401.

A certificate of insurance will be provided to U.S. EPA upon request.

8.0 REFERENCES

Earth Tech 2002. "Operation and Maintenance Plan for the Corrective Management Unit, Grand Calumet River, Sediment Remediation Project." July.

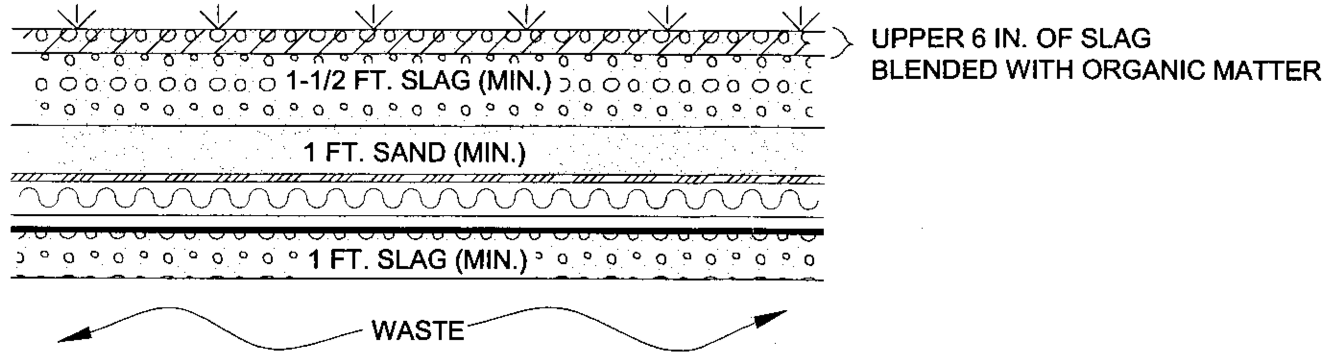
Floyd Browne Associates, Inc. 1993. "Sediment Characterization Study - U.S. Steel, Gary, Indiana." January.

Table 6-1
Closure Cost Estimate - CAMU
USS- Gary Works, Gary, Indiana
CAMU - Closure Plan

	Quantity	Units	Unit Cost		Cost
Grading	154,880	SY	$ 5.50	(1)	$ 851,840
Organic Matter	8,604	CY	$ 7.00	(1)	$ 60,231
Seeding/Harrowing	154,880	SY	$ 1.25	(1)	$ 193,600
Slag	154,880	CY	$ 5.15	(2)	$ 797,632
Sand	51,627	CY	$ 10.00	(1)	$ 516,267
Geotextile	1,393,920	SF	$ 0.16	(2)	$ 226,651
Geonet	1,393,920	SF	$ 0.34	(2)	$ 479,090
Geomembrane	1,393,920	SF	$ 0.50	(2)	$ 691,663
GCL	1,393,920	SF	$ 0.44	(2)	$ 615,137
Subtotal					*$ 4,432,111*
Engineering	1	each	$ 443,211		$ 443,211
Decontamination	1	each	$ 50,000		$ 50,000
Certification	1	each	$ 5,000		$ 5,000
Total					**$ 4,930,323**

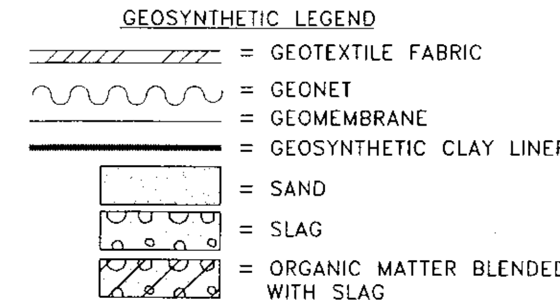
Calculations based on 32 acres (1 acre = 4,840 ft^2, 43,560 ft^2)

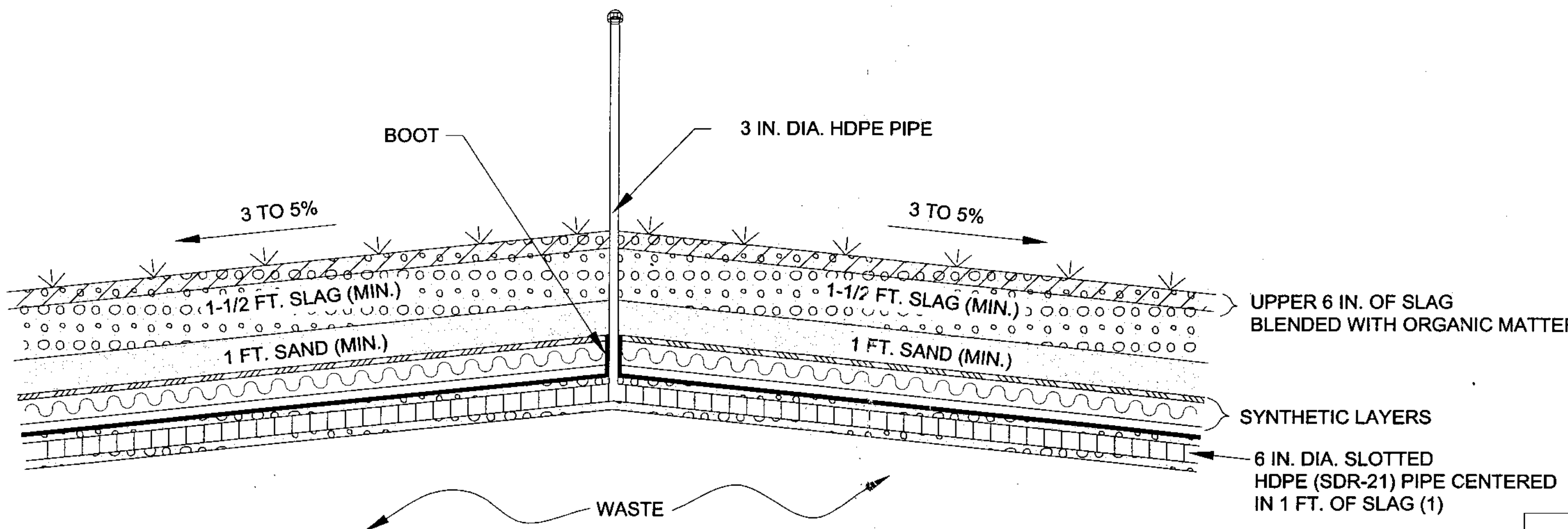
(1) Unit costs based on current URS project in Northwest Indiana (URS 2002).
(2) Unit costs from the construction of the CAMU liner (EarthTech 2002)



TYPICAL COVER SYSTEM

(N.T.S.)





TYPICAL CROSS-SECTION
OF THE LANDFILL GAS COLLECTION AND VENTING SYSTEM

(N.T.S.)

NOTES

1. HORIZONTAL COLLECTION PIPES WILL BE INSTALLED EVERY 200 FT. THE COLLECTION PIPES SHALL BE EQUIPPED WITH CLEANOUTS NEAR THE PERIMETER OF THE CAMU COVER.

Revision No.	Description	Date	By	App.

REVISIONS

US STEEL
GARY WORKS

CAMU FOR THE GCR SEDIMENT REMEDIATION PROJECT

TYPICAL COVER SYSTEM

Date: 8/12/02	Project Number: 2208USS213	Figure No. 2-1
Drawn by: LM	Design by: TCD	Chk'd By JVH

URS 122 South Michigan Ave. Suite 1920 Chicago, Illinois 60603

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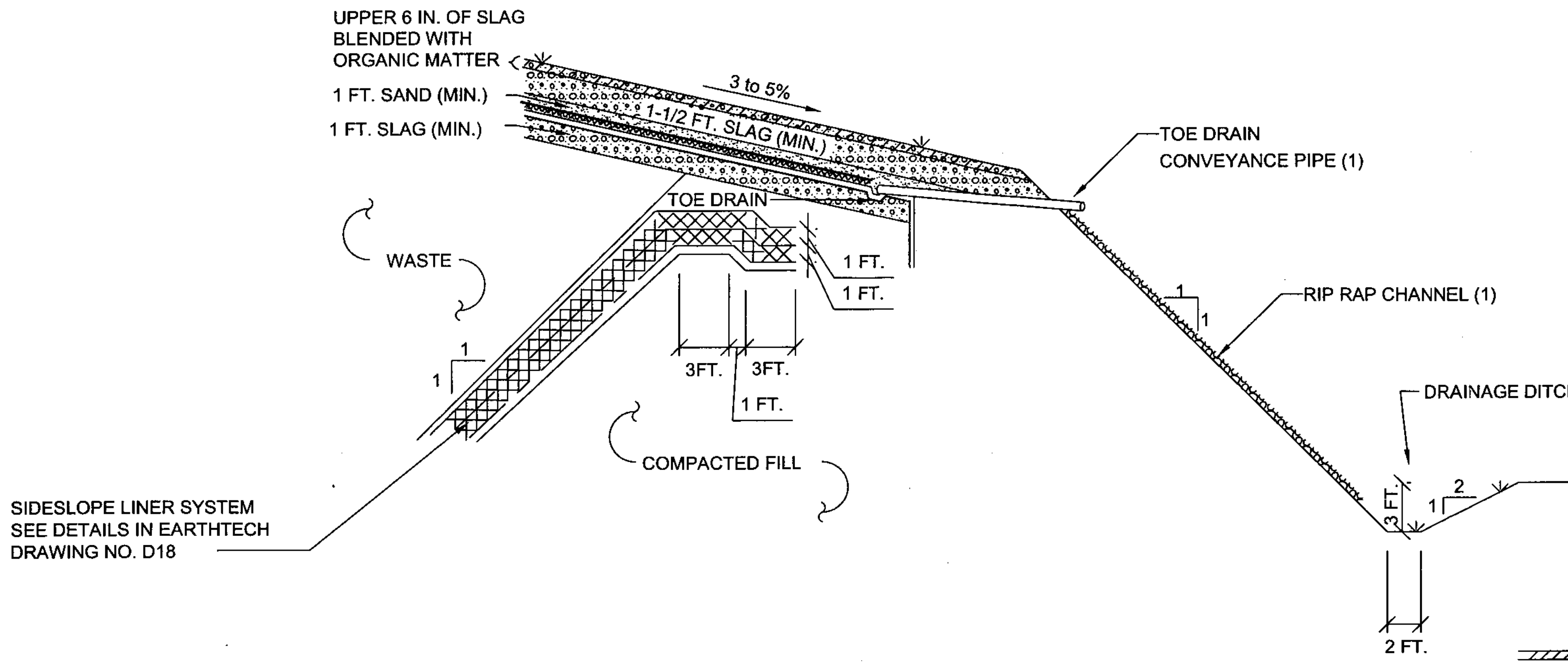

TYPICAL PERIMETER DRAIN AND BERM

GEOSYNTHETIC LEGEND

= GEOTEXTILE FABRIC
= GEONET
= GEOMEMBRANE
= GEOSYNTHETIC CLAY LINER
= SAND
= SLAG
= ORGANIC MATTER BLENDED WITH SLAG

NOTES

1. TOE DRAIN CONVEYANCE PIPES AND RIP RAP CHANNEL WILL BE INSTALLED EVERY 300 FT.

8 4 0 8 16

SCALE, FEET

Revision No.	Description	Date	By	App.

REVISIONS

US STEEL
GARY WORKS

CAMU FOR THE GCR SEDIMENT REMEDIATION PROJECT

TYPICAL PERIMETER DRAIN FOR COVER

Date: 8/8/02	Project Number: 2208USS213	Figure No. 2-2
Drawn by: LM	Design by: TCD	Chk'd By JVH

URS 122 South Michigan Ave. Suite 1920 Chicago, Illinois 60603

X:\8USS213\FIGURES\TYP_COV_SYS.dwg v:FIG2 s:1=1

APPENDIX A

SETTLEMENT ANALYSIS, SLOPE STABILITY ANALYSIS, AND MATERIAL PROPERTIES OF THE SEDIMENT

CLIENT USS SUBJECT Settlement Analysis Prepared By SYG Date 2/19/03

PROJECT CAMU Reviewed By TLB Date 2/20/03

Approved By TLB Date 2/20/03

SETTLEMENT ANALYSIS

Objective

Evaluate the differential settlement due to consolidation of foundation soils under the maximum loading condition and the dredge spoil within the landfill at its final configuration, and assess the impact of differential settlement on leachate collection system as well as on final cover performance.

Design Conditions and Assumptions

The design base grades vary from approximately elevation 588 feet to 596 feet. The final cover slope is 5% with a peak elevation of approximately 648 feet. The maximum waste depth is about 50 feet. The minimum design base slope along the leachate collection pipeline is 1.0 percent. The minimum design base slope perpendicular to the leachate collection pipeline is approximately 1.5 percent.

The dredge spoils will be placed within the landfill up to elevation 612.5 feet. The remaining airspace will be filled by waste materials which are unknown at this point.

Beneath the dredge spoils is a two-foot granular material for leachate collection. After the dredge spoil is placed in the landfill, it will be dewatered by gravity to its field capacity. Additional waste materials will eventually be placed above it and act as surcharge for the dredge spoil to consolidate. In the settlement calculations, it was assumed that the waste materials are placed simultaneously and only the primary settlement of dredge spoil was considered.

To be conservative, the waste material to be placed above the dredge spoil was assumed to have similar properties as the fine grained dredge spoil, the same density and consolidation parameters were used.

Five points were selected to estimate the settlement as shown on Figure 1. Points A and B are selected to estimate the leachate collection pipe line grade change due to differential settlement. Points C and D are selected to estimate the cross drain pipe line grade change due to differential settlement. Points A/C and B/D represent the locations of the maximum and minimum waste heights, respectively. In addition, Points C and E are used to estimate the final cover grade change due to differential settlement.

The foundation soil layers are generalized based on the site-specific geologic conditions. The sand layer immediately underlying the landfill extends to approximately elevation 545 feet MSL. The thickness of the soft clay layer, due to limited information from the boring logs, is assumed to be approximately 50 feet. The underlying geological units are considered to be incompressible in the calculations.

It is assumed that both sand and soft clay layers are considered saturated based on the Potentiometric Water Table Map shown on Drawing D3 of the COLDR report dated November 2001.

The settlements are calculated for waste materials within the landfill under the post-closure condition, sand and soft clay under the maximum loading condition. Consolidation tests were performed using the site-specific soil samples and reported in the Permit Level Design Report, Appendix D4 (Volume III of III), dated December 1997. Five consolidation tests were performed for the existing dredge spoils, one for sand and four for soft clay. All laboratory consolidation test results are provided in Attachment 1. The average compressibility characteristics of the materials obtained from the consolidation tests are summarized in Table 1.

Table 1
Summary of Consolidation Test Results

Soil Type	Average Initial Void Ratio (e)	Pre-consolidation Pressure (tsf)	Over-Consolidation Ratio (OCR)	Compression Index (Cc)	Recompression Index (Cr)
Dredge Spoil	0.721	-	-	0.0881	-
Sand	0.651	-	-	0.0317	-
Soft Clay	0.608	3.3	1.4	0.1779	0.0133

Review of Table 1 indicates that the soft clay is slightly over-consolidated with an average pre-consolidation pressure of 3.3 tsf (6,600 psf) and OCR of 1.4. Dredge spoil and foundation sand materials are normally consolidated.

The consolidation test results for the existing dredge spoil that overlies the native sand on the CAMU site were used to estimate settlement of the dewatered waste materials within the landfill since this material is also dredge spoil.

Density of the materials used in the settlement calculations are summarized as follows:

Final cover soil: $\gamma = 110\text{pcf}$

Leachate granular drainage layer: $\gamma = 110\text{pcf}$

Foundation sand: $\gamma = 105\text{ pcf}$

Soft clay: $\gamma = 105\text{ pcf}$

Dredge spoil & waste materials: $\gamma = 90\text{ pcf} \sim 115\text{ pcf}$

The settlement calculations were performed using the waste density of 115 pcf since it results in the maximum settlement of the waste materials.

Methodology

Terzaghi's one-dimensional consolidation theory is utilized. Terzaghi's Equations are:

Normal Consolidated Clay

$$S_c = \frac{C_c H}{1+e_0}\log\left(\frac{P_f}{P_c}\right) \qquad (1)$$

Over-Consolidated Clay

If $P_0 + \Delta P \le P_c$,

$$S_c = \frac{C_r H}{1+e_0}\log\left(\frac{P_f}{P_0}\right) \qquad (2)$$

If $P_0 + \Delta P > P_c$,

$$S_c = \frac{C_r H}{1+e_0}\log\left(\frac{P_c}{P_0}\right) + \frac{C_c H}{1+e_0}\log\left(\frac{P_f}{P_c}\right) \qquad (3)$$

where
C_c = Compression index
C_r = Recompression index
H = Layer thickness

e_0 = Initial void ratio
P_c = Pre-consolidation pressure
P_0 = Initial average effective overburden pressure for the layer of concern
P_f = Final average effective overburden pressure for the layer of concern

The differential settlement between point pairs can be calculated as:

$$\Delta h = (S_1 - S_2) \qquad (4)$$

where S_1 = total settlement at Point 1
S_2 = total settlement at Point 2

Grade change due to differential settlement:

$$\Delta i\% = \Delta h / D \times 100 \qquad (5)$$

where D = distance between the two points

Settlement Calculations

For settlement calculations, grade elevations and depths of the dredge spoil, foundation sand and soft clay at each point analyzed are summarized in Table 2.

Table 2
Summary of Design Data

Layers	A	B	C	D	E
Final Grade Elevation (ft)	644.5	624.5	642.5	622.5	620
Existing Ground Surface Elevation (ft)	594	592	596	594	594
Excavation Grade Elevation (ft)	589	585	591	590	618
Leachate Granular Drainage Layer Thickness (ft)	2	2	2	2	2
Total Waste Thickness (ft)	50.5	34.5	46.5	27.5	0
Foundation Sand Thickness (ft)	44	40	46	45	45
Foundation Soft Clay Thickness (ft)	50	50	50	50	50

An example of settlement calculations at Point A is given below:

For settlement calculations, the initial and final effective stresses are calculated at the mid-points of the layers of concern:

Waste @ Point A:

Settlement of waste materials within the landfill at ½ of the total waste thickness is calculated. The settlement of waste at the top ½ is conservatively assumed the same as the bottom ½.

Thickness:	25.25 ft
Initial Effective Stress:	115 pcf x (25.25'/2) = 1,451.875 psf
Final Effective Stress:	110 pcf x 3' + 115 pcf x 25.25' + 115 pcf x (25.25'/2) = 4,685.625 psf

Settlement: $$S_c = \frac{C_c H}{1+e_0}\log\left(\frac{P_f}{P_c}\right) = \frac{0.0881}{1+0.721} x\ 25.75' x \log\left(\frac{4,685.625}{1,451.875}\right)$$

$$= 0.66'$$

For the bottom 25.25 feet of dredge spoils and waste materials, the settlement is about 0.66 feet. It was conservatively assumed that the same amount of settlement would occur in the top 25.25 feet of the waste. Then, the total settlement of waste is about 1.32 feet.

Foundation sand @ Point A:

Thickness:	44 ft
Initial Effective Stress:	105 pcf x (594' – 589') + (44'/2) x (105 pcf - 62.4 pcf) = 1,462.2 psf
Final Effective Stress:	110 pcf x 3' + 115 pcf x 50.5' + 110 pcf x 2' + (44'/2) x (105 pcf - 62.4 pcf) = 7,294.7 psf

Settlement: $$S_c = \frac{C_c H}{1+e_0}\log\left(\frac{P_f}{P_c}\right) = \frac{0.0317}{1+0.651} x\ 44' x \log\left(\frac{7,294.7}{1,462.2}\right)$$

$$= 0.59'$$

Foundation soft clay @ Point A:

Thickness:	50 ft
Initial Effective Stress:	105 pcf x (594' – 589') + 44' x (105 pcf - 62.4 pcf) + 50'/2 x (105 pcf - 62.4 pcf) = 3,464.4 psf
Final Effective Stress:	110 pcf x 3' + 115 pcf x 50.5' + 110 pcf x 2' + 44 x (105 pcf - 62.4 pcf) + 50'/2 x (105 pcf - 62.4 pcf) = 9,296.9 psf

Settlement:

$$S_c = \frac{C_r H}{1+e_0}\log\left(\frac{P_c}{P_0}\right) + \frac{C_c H}{1+e_0}\log\left(\frac{P_f}{P_c}\right)$$

$$= \frac{0.0133}{1+0.608}\ x\ 50'\ x\ \log\left(\frac{6{,}600}{3{,}464.4}\right) + \frac{0.1779}{1+0.608}\ x\ 50'\ x \log\left(\frac{9{,}296.9}{6{,}600}\right)$$

$$= 0.12' + 0.82' = 0.94'$$

The total foundation soils settlement = 0.59' + 0.94' = 1.53'.

Settlements for all points are calculated in Table 3.

Table 3
Summary of Settlement Calculations

Layers		A	B	C	D	E
Waste Materials	Initial effective stress (psf)	1451.875	991.875	1336.875	790.625	-
	Final effective stress (psf)	4685.625	3305.625	4340.625	2701.875	-
	Settlement (ft)	0.66	0.46	0.61	0.38	0.0
Total Settlement of Dredge Spoil:		**1.32**	**0.92**	**1.22**	**0.75**	**0.0**
Foundation Sand	Initial effective stress (psf)	1462.2	1587.0	1504.8	1378.5	1378.5
	Final effective stress (psf)	7294.7	5369.5	6877.3	4671.0	4958.5
	Settlement (ft)	0.59	0.41	0.58	0.46	0.48
Foundation Soft Clay	Initial effective stress (psf)	3464.4	3504.0	3549.6	3402.0	3402.0
	Final effective stress (psf)	9296.9	7286.5	8922.1	6694.5	6982
	Settlement (ft)	0.94	0.13	0.84	0.12	0.25
Total Settlement of Foundation Soils:		**1.53**	**0.54**	**1.42**	**0.58**	**0.73**

Differential Settlement Calculations

The differential settlement and slope change of the leachate collection layer and piping lines are calculated in Table 4. The differential settlement of the final cover are calculated in Table 5.

Conclusions

Review of Tables 4 and 5 indicates that the post-settlement slopes for the leachate collection layer and piping lines, and final cover will all remain positive.

References

1. B.M. Das, "Principles of Geotechnical Engineering," 1998.

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CALCULATION SHEET

PROJECT NO. 46860

CLIENT USS
PROJECT CAMU

SUBJECT Settlement Analysis

Prepared By SYG Date 2/19/03
Reviewed By TLB Date 2/20/03
Approved By TLB Date 2/20/03

Table 4
Differential Settlement and Slope Change Calculations
For Leachate Collection System

Point No.	Foundation Settlement (ft)	Distance (ft)	Differential Settlement (ft)	Slope Before Settlement (%)	Slope After Settlement (%)
A	1.53				
		400	0.99	1.0	0.75
B	0.54				
C	1.42				
		400	0.84	1.5	1.29
D	0.58				
E	0.73				
		50	0.15	56	55
D	0.58				

Table 5
Differential Settlement and Slope Change Calculations
For Final Cover

Point No.	Foundation Settlement (ft)	Waste Settlement (ft)	Distance (ft)	Differential Settlement (ft)	Slope Before Settlement (%)	Slope After Settlement (%)
C	1.42	1.22				
			550	1.91	5.0	1.65
E	0.73	0.0				

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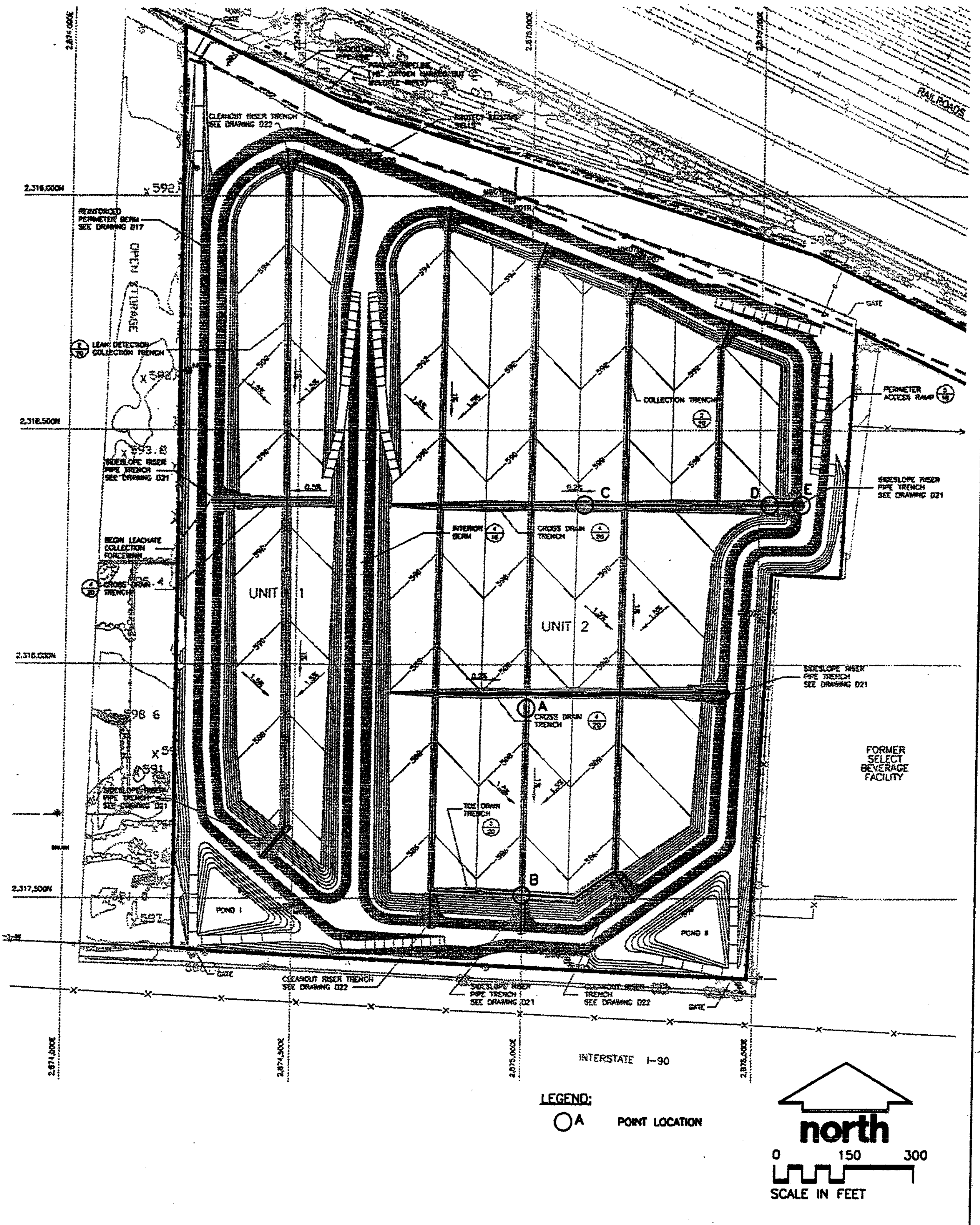

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3121 BUTTERFIELD ROAD, OAK BROOK, ILLINOIS 60523
PHONE: 630-574-2006 FAX: 630-574-2007

FIGURE 1
POINTS LOCATION MAP
SETTLEMENT ANALYSIS

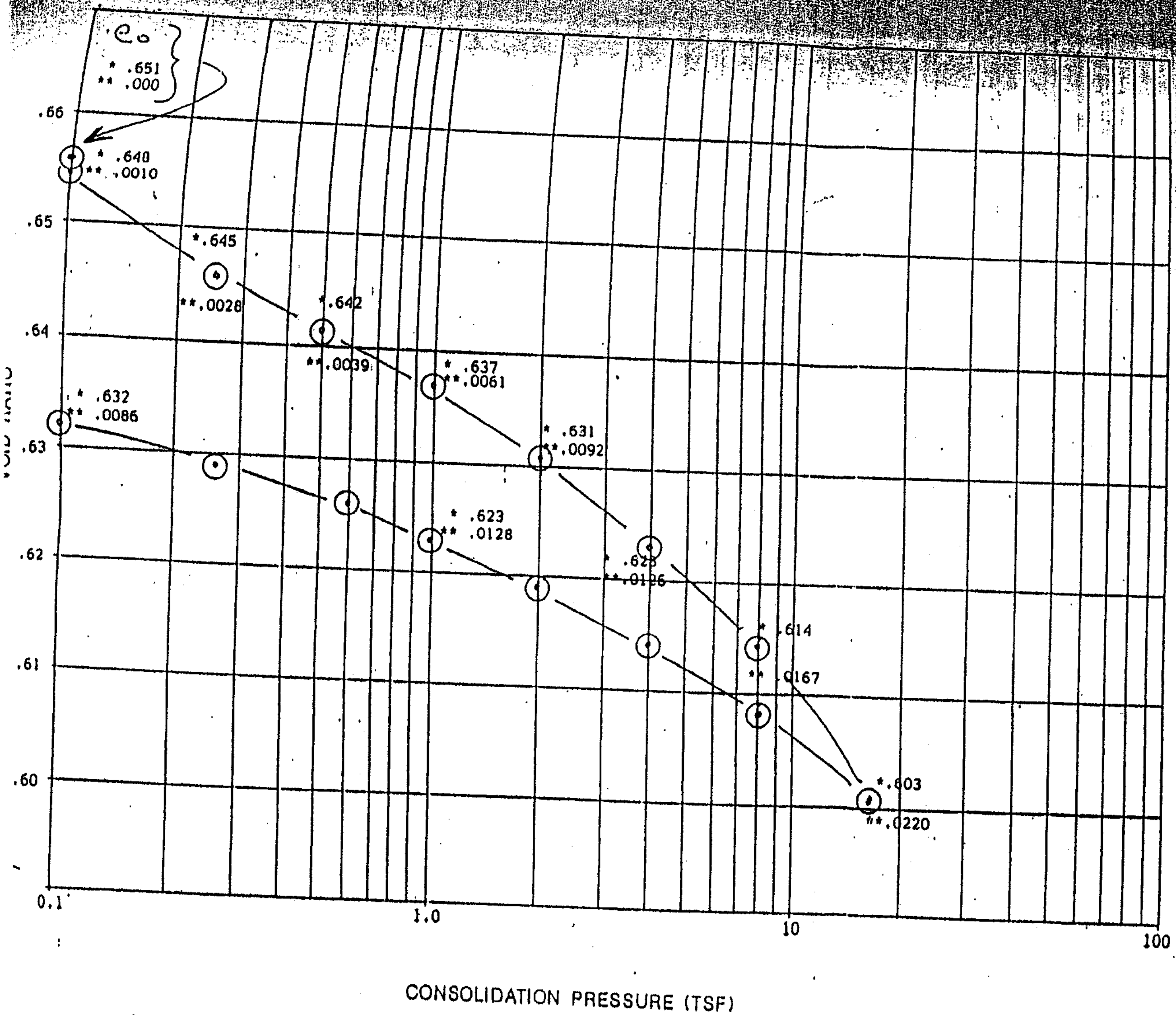
U.S. STEEL - GARY WORKS GCR SEDIMENT REMEDIATION PROJECT
GARY, INIDANA

APRIL 2002

46860

ATTACHMENT 1

LATORATORY CONSOLIDATION TEST RESULTS



SAMPLE PROPERTIES

(Visual)
DESCRIPTION: Brown Fine SAND, Some Silt Trace Clay U.S.C.S. SM

BORING NO. SB5 SAMPLE NO. – DEPTH 8-10 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 15.6 %
INITIAL DRY UNIT WEIGHT (Do)	= 98.3 PCF
INITIAL VOID RATIO (eo)	= .651
LIQUID LIMIT (LL)	= NP %
PLASTICITY INDEX (PI)	= NP %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= – TSF
POCKET PENETROMETER READING (qa)	= – TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= – TSF
EXISTING OVERBURDEN PRESSURE (Po)	= – TSF
OVERCONSOLIDATION RATIO (OCR)	= –
*** COMPRESSION INDEX (Cc)	= .0317
RECOMPRESSION INDEX (Cr)	= –
SWELL INDEX (Cs)	= –
Loss-on-Ignition	= 0.8%

* Void Ratio
** Change in Height (in.)
*** Based on 8 & 16 ton load only

This test was performed on a remolded material at it's natural moisture content at optimum compaction effort.

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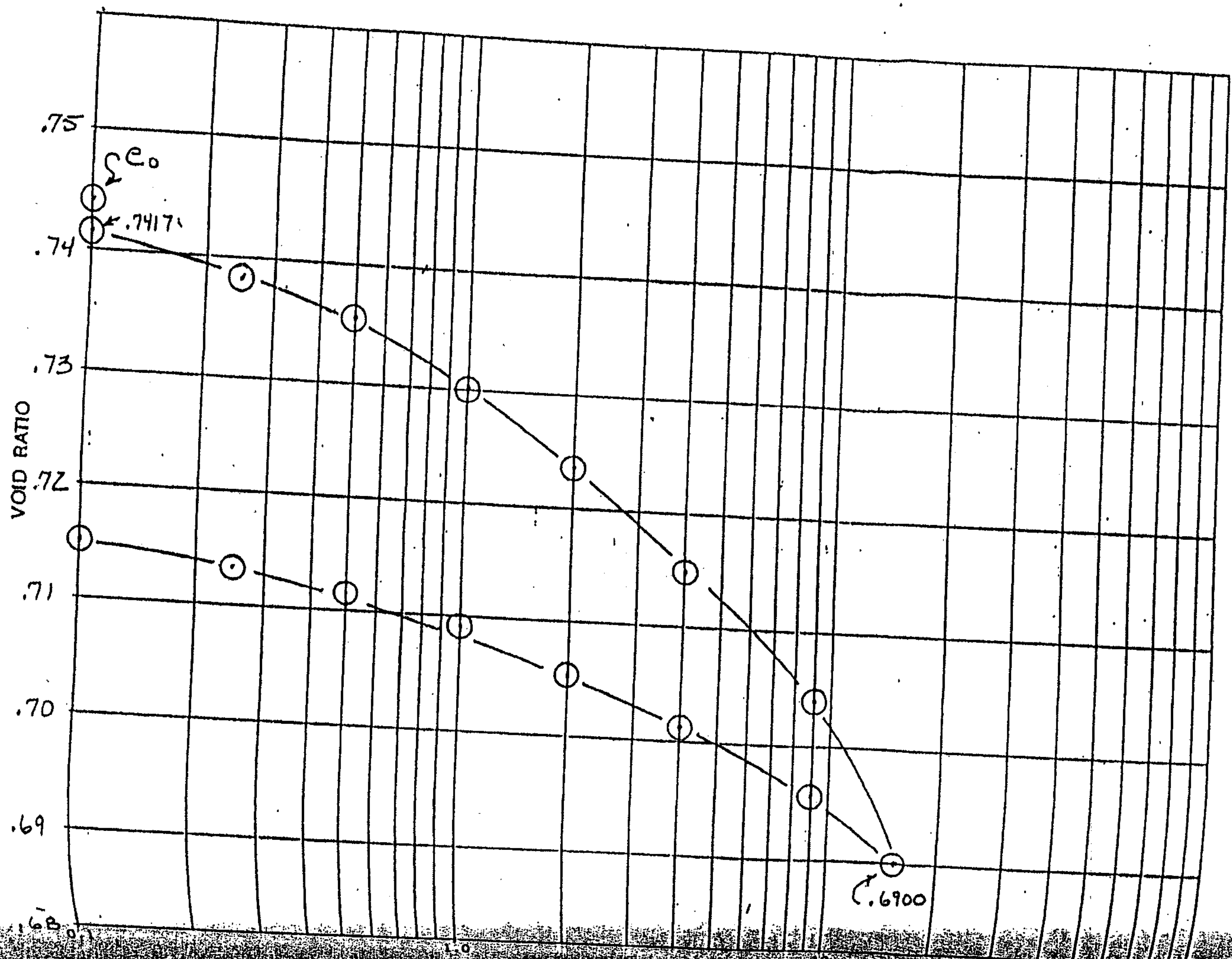
CONSOLIDATION TEST
Montgomery Watson
US Steel 0819.0070

Sheet Number: 1 OF 1
Report Number: C95164-2



SAMPLE PROPERTIES

DESCRIPTION: Brown Fine Sand, Some Silt, Trace Clay U.S.C.S. SM

Pail

BORING NO. SB 06 (Dredge Spoils) SAMPLE NO. — DEPTH 0-4 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 13.1 %
INITIAL DRY UNIT WEIGHT (Do)	= 94.8 PCF
INITIAL VOID RATIO (eo)	= .773
LIQUID LIMIT (LL)	= NP %
PLASTICITY INDEX (PI)	= NP %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= NA TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 1.00 IN.

PRECONSOLIDATION PRESSURE (Pc)	= — TSF
EXISTING OVERBURDEN PRESSURE (Po)	= — TSF
OVERCONSOLIDATION RATIO (OCR)	= —
COMPRESSION INDEX (Cc)	= 0.0324
RECOMPRESSION INDEX (Cr)	= —
SWELL INDEX (Cs)	= 0.0149

THIS TEST WAS PERFORMED ON REMOLDED MATERIAL

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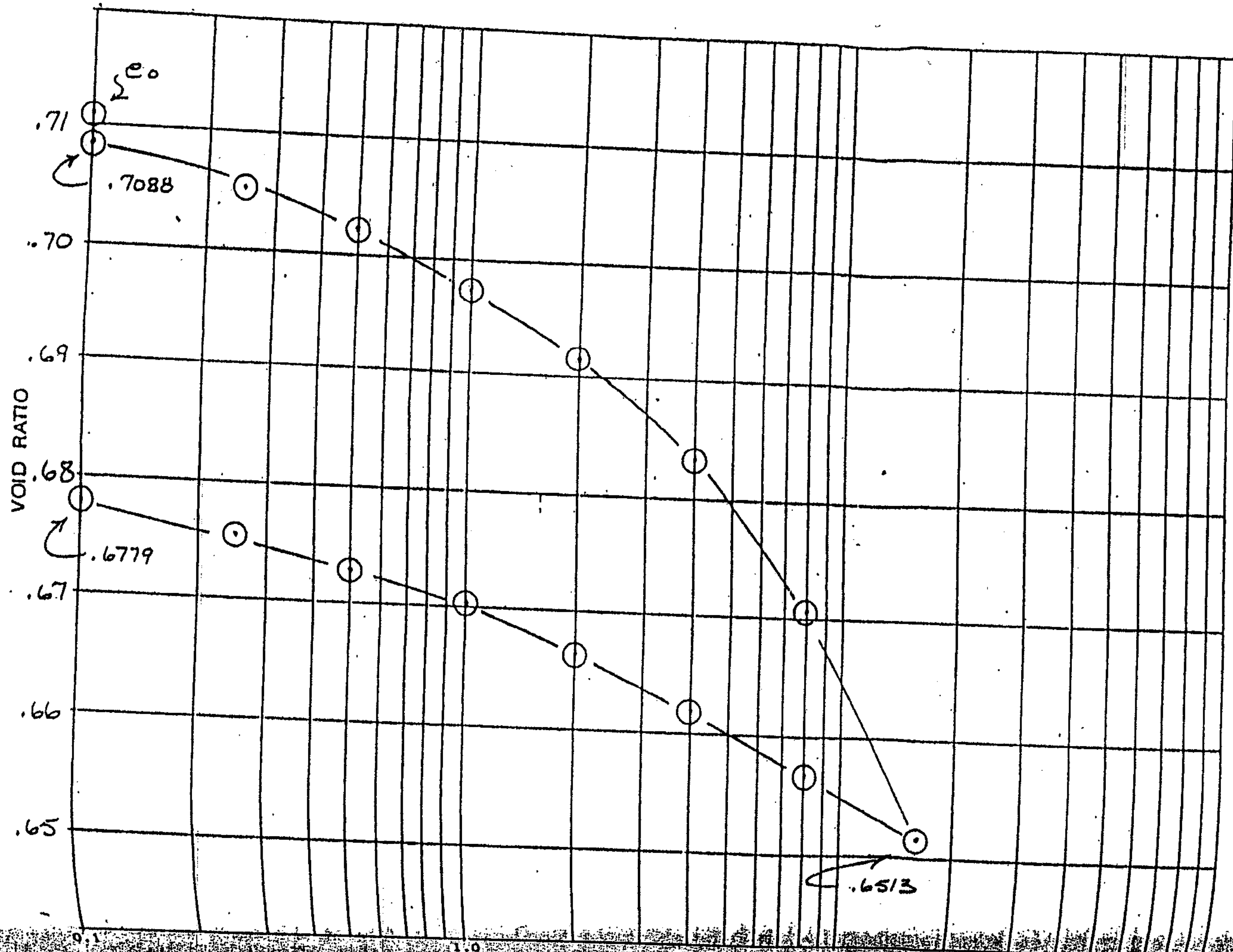

SAMPLE PROPERTIES

DESCRIPTION: BROWN FINE SAND, SOME SILT, TRACE CLAY U.S.C.S. SM

BORING NO. PAIL SB 07 (DREDGE SPOILS) SAMPLE NO. — DEPTH 0-4 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 11.2 %
INITIAL DRY UNIT WEIGHT (Do)	= 96.7 PCF
INITIAL VOID RATIO (eo)	= .711
LIQUID LIMIT (LL)	= NP %
PLASTICITY INDEX (PI)	= NP %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= NA TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 1.00 IN.

PRECONSOLIDATION PRESSURE (Pc)	= — TSF
EXISTING OVERBURDEN PRESSURE (Po)	= — TSF
OVERCONSOLIDATION RATIO (OCR)	= —
COMPRESSION INDEX (Cc)	= 0.0432
RECOMPRESSION INDEX (Cr)	= —
SWELL INDEX (Cs)	= 0.0149

THIS TEST WAS PERFORMED ON REMOLDED MATERIAL

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Geotechnical Consulting/Foundation Engineering

Drawn by DWA Checked by MWS
Approved [signature]
Date 3-17-97

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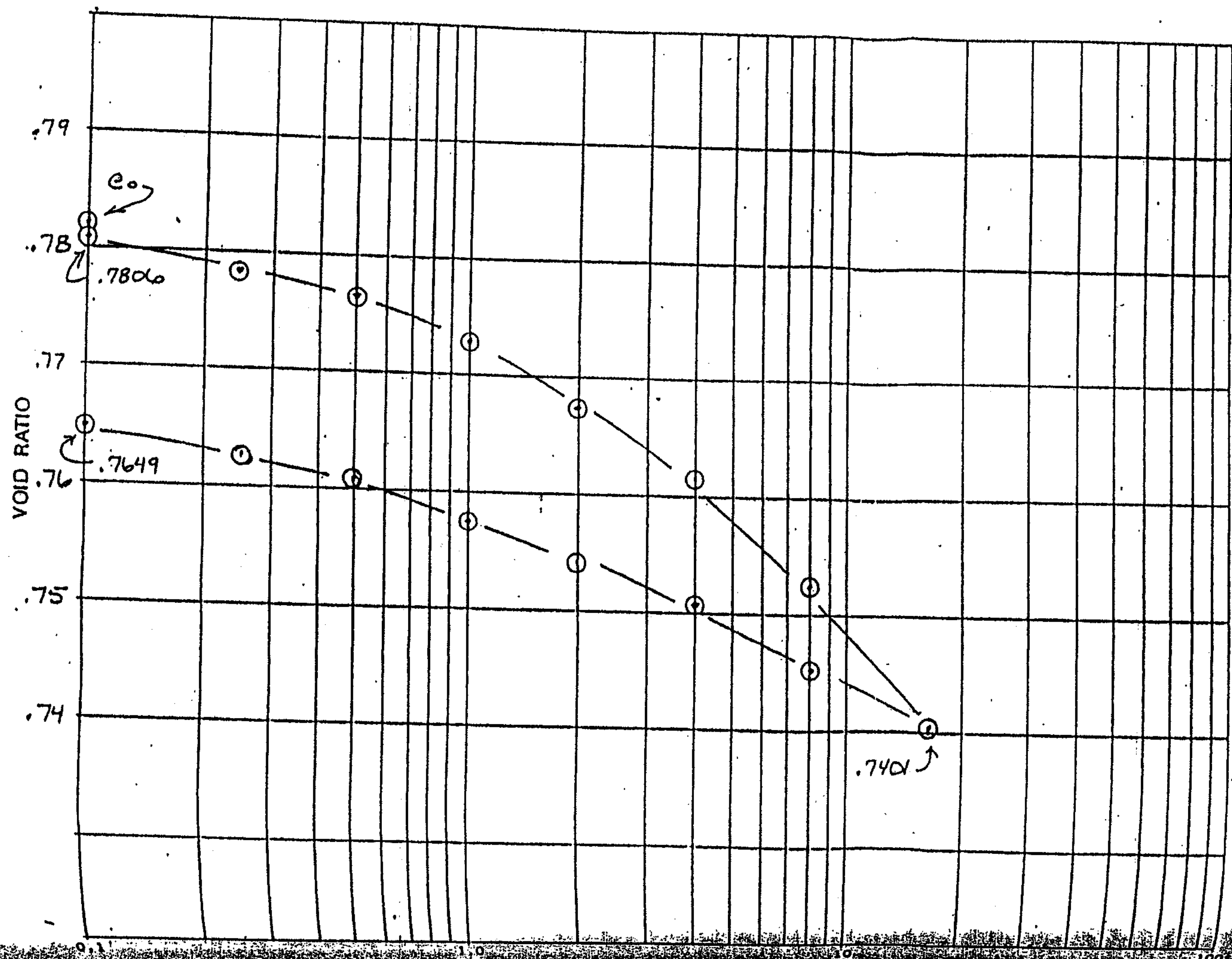

SAMPLE PROPERTIES

DESCRIPTION: DR BROWN FINE SAND, LITTLE SILT, TRACE CLAY U.S.C.S. SP-SM
PAIL
BORING NO. SB 08 SAMPLE NO. – DEPTH 0-5 FT

INITIAL NATURAL MOISTURE CONTENT (Wo) = 19.0 %
INITIAL DRY UNIT WEIGHT (Do) = 92.8 PCF
INITIAL VOID RATIO (eo) = .7820
LIQUID LIMIT (LL) = NP %
PLASTICITY INDEX (PI) = NP %
UNCONFINED COMPRESSIVE STRENGTH (qu) = NA TSF
POCKET PENETROMETER READING (qa) = NA TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 1.00 IN.

PRECONSOLIDATION PRESSURE (Pc) = — TSF
EXISTING OVERBURDEN PRESSURE (Po) = — TSF
OVERCONSOLIDATION RATIO (OCR) = —
COMPRESSION INDEX (Cc) = 0.0358
RECOMPRESSION INDEX (Cr) = —
SWELL INDEX (Cs) = 0.0141

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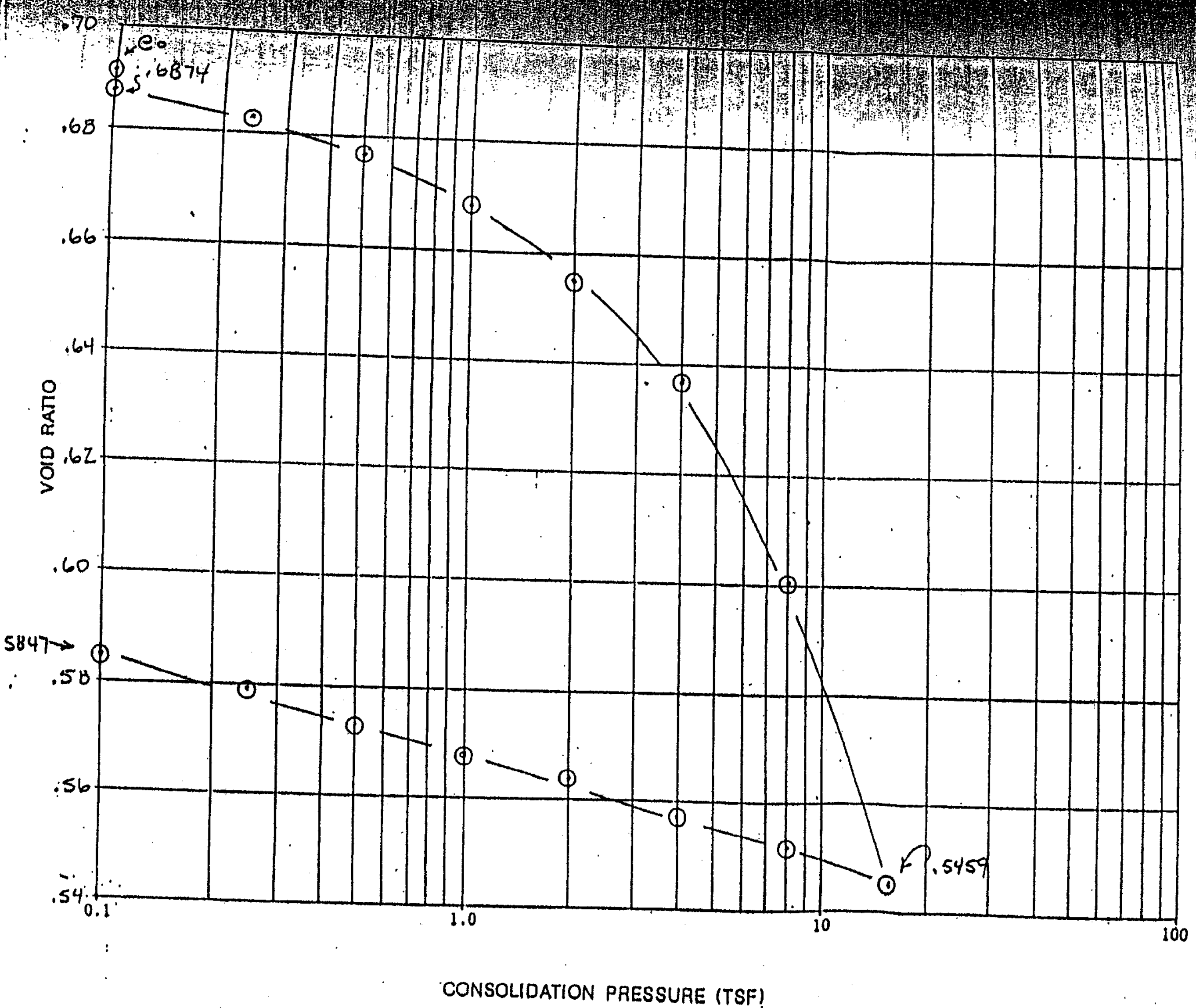

SAMPLE PROPERTIES

DESCRIPTION: Dk Brown Fine Sandy Silt, Trace Clay U.S.C.S. ML
PAIL

BORING NO. SB23 SAMPLE NO. — DEPTH 0-3 FT

INITIAL NATURAL MOISTURE CONTENT (Wo) = 22.9 %
INITIAL DRY UNIT WEIGHT (Do) = 103.2 PCF
INITIAL VOID RATIO (eo) = .6934
LIQUID LIMIT (LL) = — %
PLASTICITY INDEX (PI) = — %
UNCONFINED COMPRESSIVE STRENGTH (qu) = NA TSF
POCKET PENETROMETER READING (qa) = NA TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 1.00 IN.

PRECONSOLIDATION PRESSURE (Pc) = — TSF
EXISTING OVERBURDEN PRESSURE (Po) = — TSF
OVERCONSOLIDATION RATIO (OCR) = —
COMPRESSION INDEX (Cc) = 0.1193
RECOMPRESSION INDEX (Cr) = —
SWELL INDEX (Cs) = 0.0185

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CONSOLIDATION TEST
U.S. STEEL — CAMU DESIGN
1 OF 1
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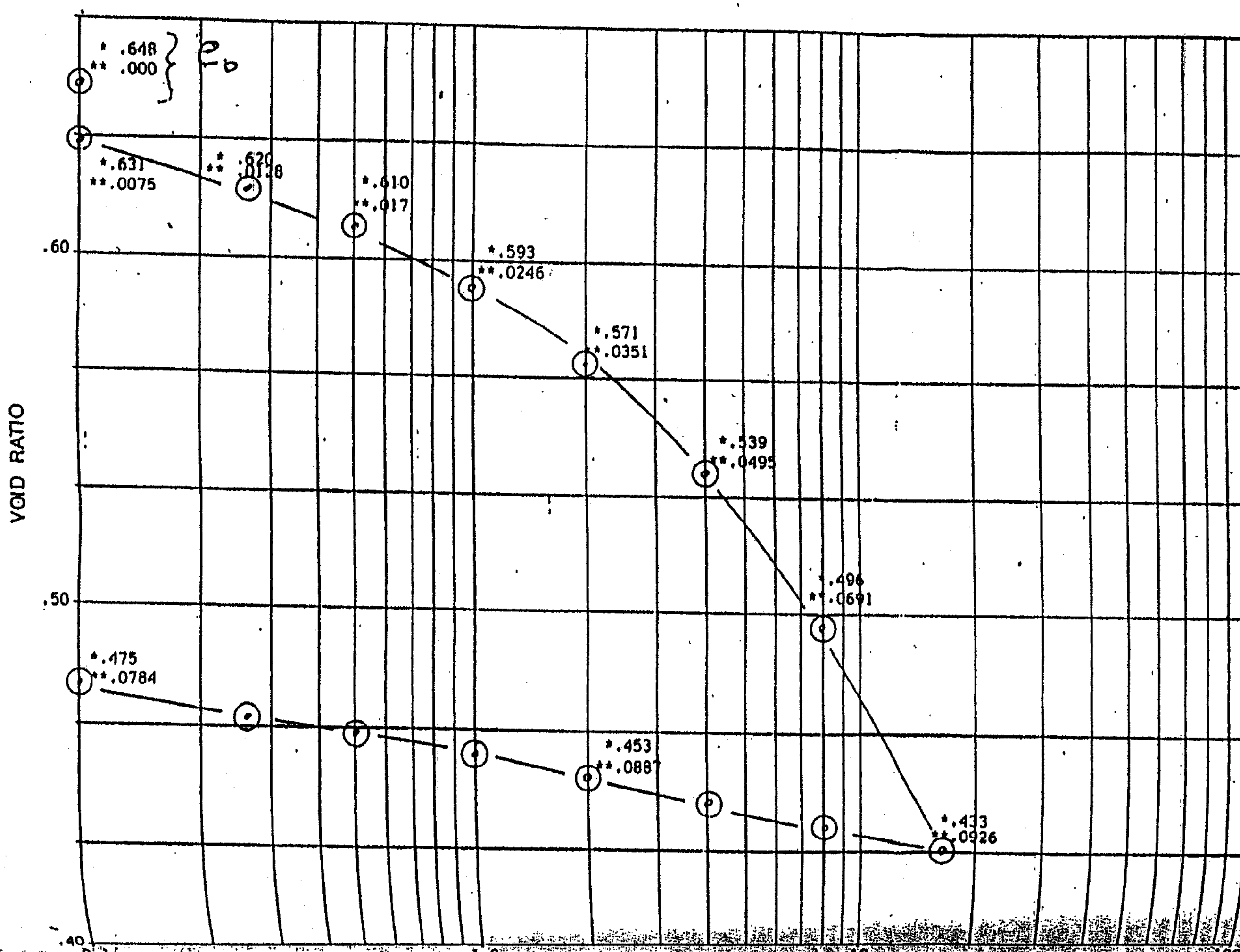

SAMPLE PROPERTIES

DESCRIPTION: Dark Brown SILT, Some Sand, Little Clay (waste) U.S.C.S. ML

Bag HA2 & HA3

BORING NO. ____ SAMPLE NO. ____ DEPTH 1-3 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 31.6 %
INITIAL DRY UNIT WEIGHT (Do)	= 111.5 PCF
INITIAL VOID RATIO (eo)	= .648
LIQUID LIMIT (LL)	= 44 %
PLASTICITY INDEX (PI)	= 7 %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= – TSF
POCKET PENETROMETER READING (qa)	= 2.0 TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= – TSF
EXISTING OVERBURDEN PRESSURE (Po)	= – TSF
OVERCONSOLIDATION RATIO (OCR)	= –
***COMPRESSION INDEX (Cc)	= 0.21
***RECOMPRESSION INDEX (Cr)	= 0.022
SWELL INDEX (Cs)	= –
LOSS-ON-IGNITION	= 5.9%

* Void Ratio
** Change in Height (in.)
*** Based on 8 & 16 ton loads only
This test was performed on remolded material at it's natural moisture content at optimum compaction effort.

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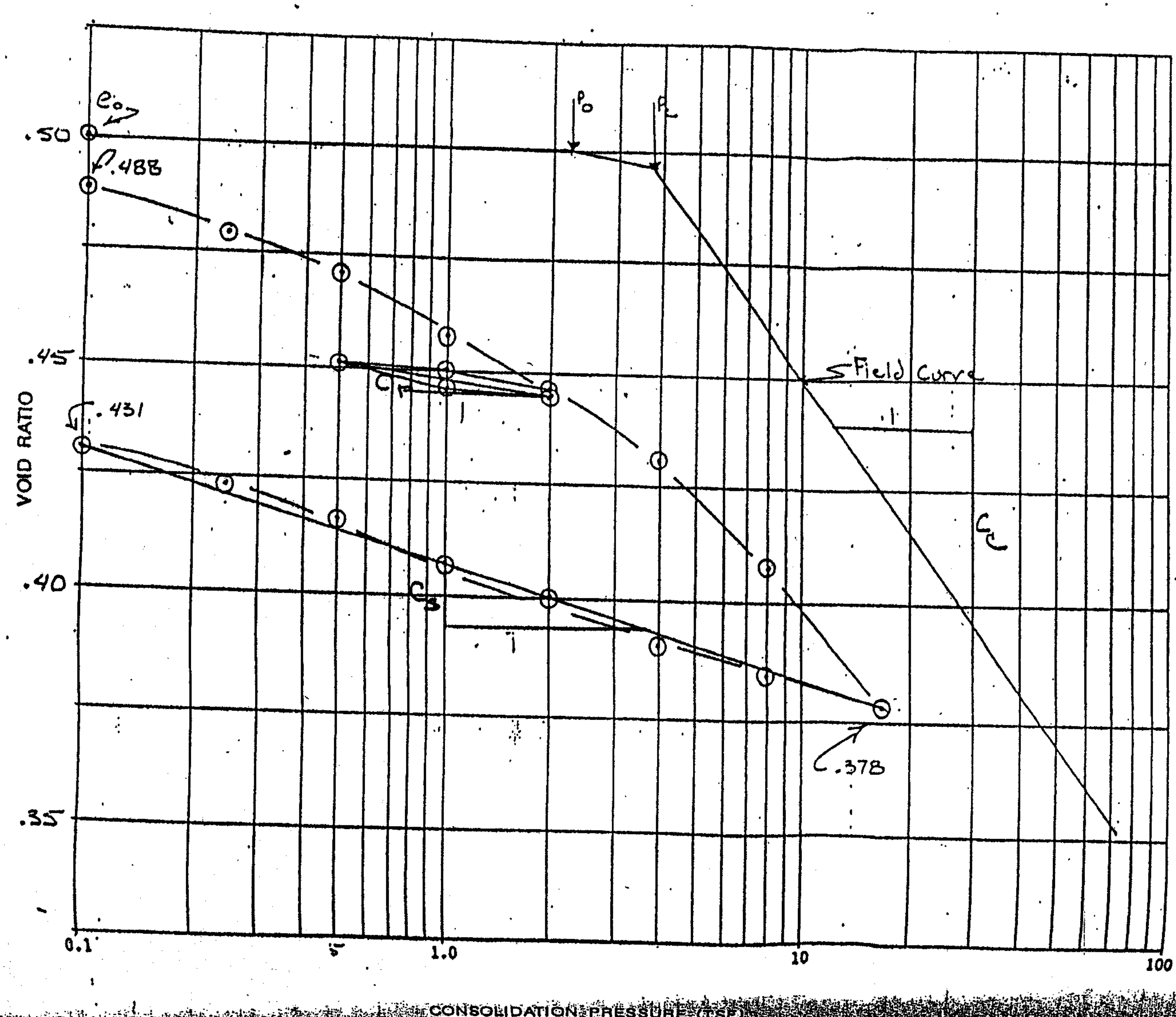

SAMPLE PROPERTIES

DESCRIPTION: GRAY LEAN CLAY, SOME SAND, TRACE GRAVEL U.S.C.S. CL
3-INCH SHELBY TUBE
BORING NO. SB 09 SAMPLE NO. — DEPTH 65-67 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 17.5 %
INITIAL DRY UNIT WEIGHT (Do)	= 114.4 PCF
INITIAL VOID RATIO (eo)	= 0.500
LIQUID LIMIT (LL)	= 24 %
PLASTICITY INDEX (PI)	= 8 %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= 2.4 TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= 3.8 TSF
EXISTING OVERBURDEN PRESSURE (Po)	= 2.2 TSF
OVERCONSOLIDATION RATIO (OCR)	= 1.7
COMPRESSION INDEX (Cc)	= 0.1145
RECOMPRESSION INDEX (Cr)	= 0.0063
SWELL INDEX (Cs)	= 0.0253

Drawn by DWA Checked by MNS
Approved by [illegible] Date 4-7-97

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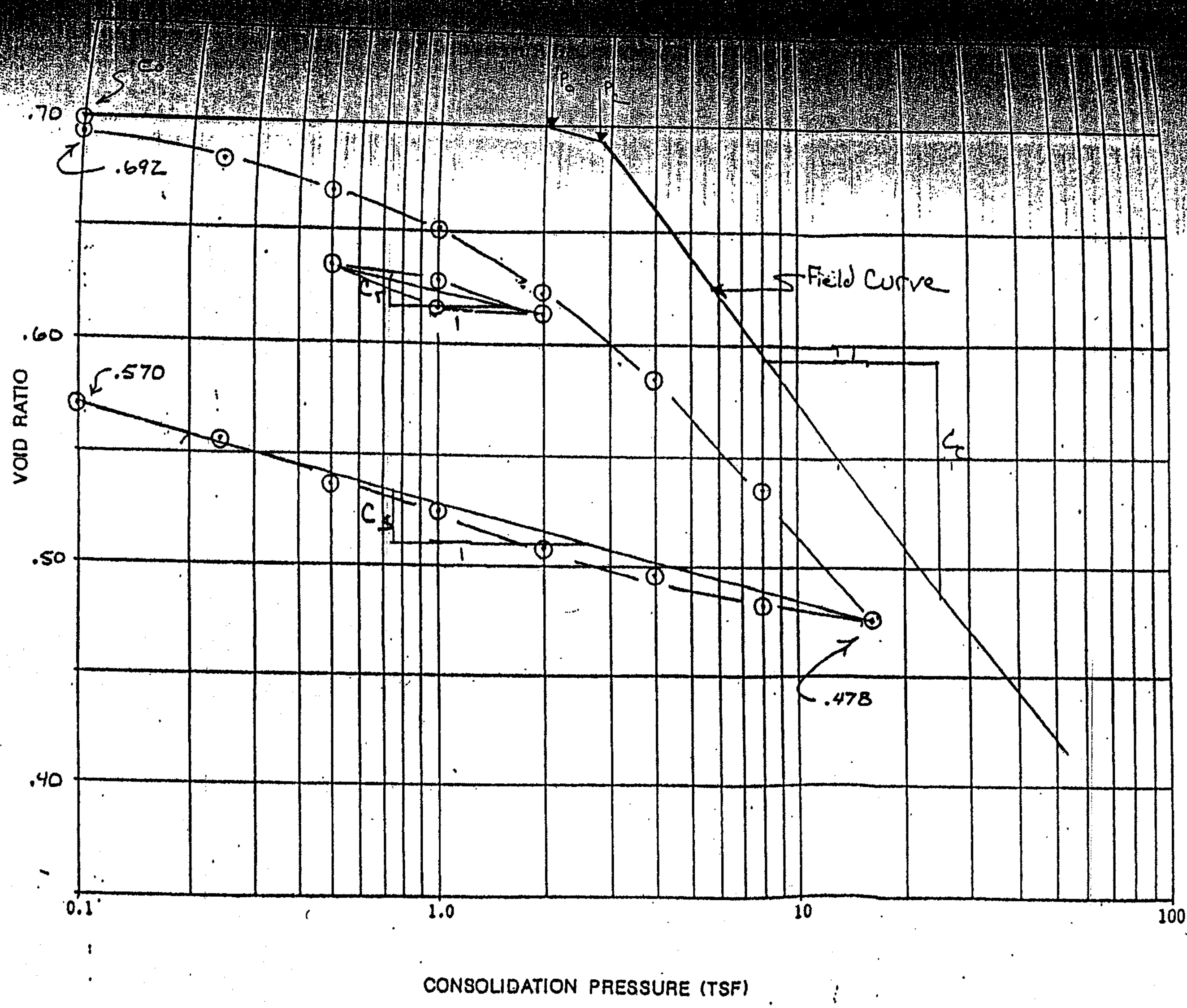

SAMPLE PROPERTIES

DESCRIPTION: GRAY LEAN CLAY, LITTLE FINE SAND U.S.C.S. CL

3-INCH SHELBY TUBE

BORING NO. SB08 SAMPLE NO. — DEPTH 62.5-64.5 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 25.4 %
INITIAL DRY UNIT WEIGHT (Do)	= 101.1 PCF
INITIAL VOID RATIO (eo)	= 0.6996
LIQUID LIMIT (LL)	= 33 %
PLASTICITY INDEX (PI)	= 15 %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= .6 TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= 2.8 TSF
EXISTING OVERBURDEN PRESSURE (Po)	= 2.1 TSF
OVERCONSOLIDATION RATIO (OCR)	= 1.3
COMPRESSION INDEX (Cc)	= 0.2230
RECOMPRESSION INDEX (Cr)	= 0.0185
SWELL INDEX (Cs)	= 0.0425

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CONSOLIDATION TEST

U.S. STEEL — CAMU DESIGN

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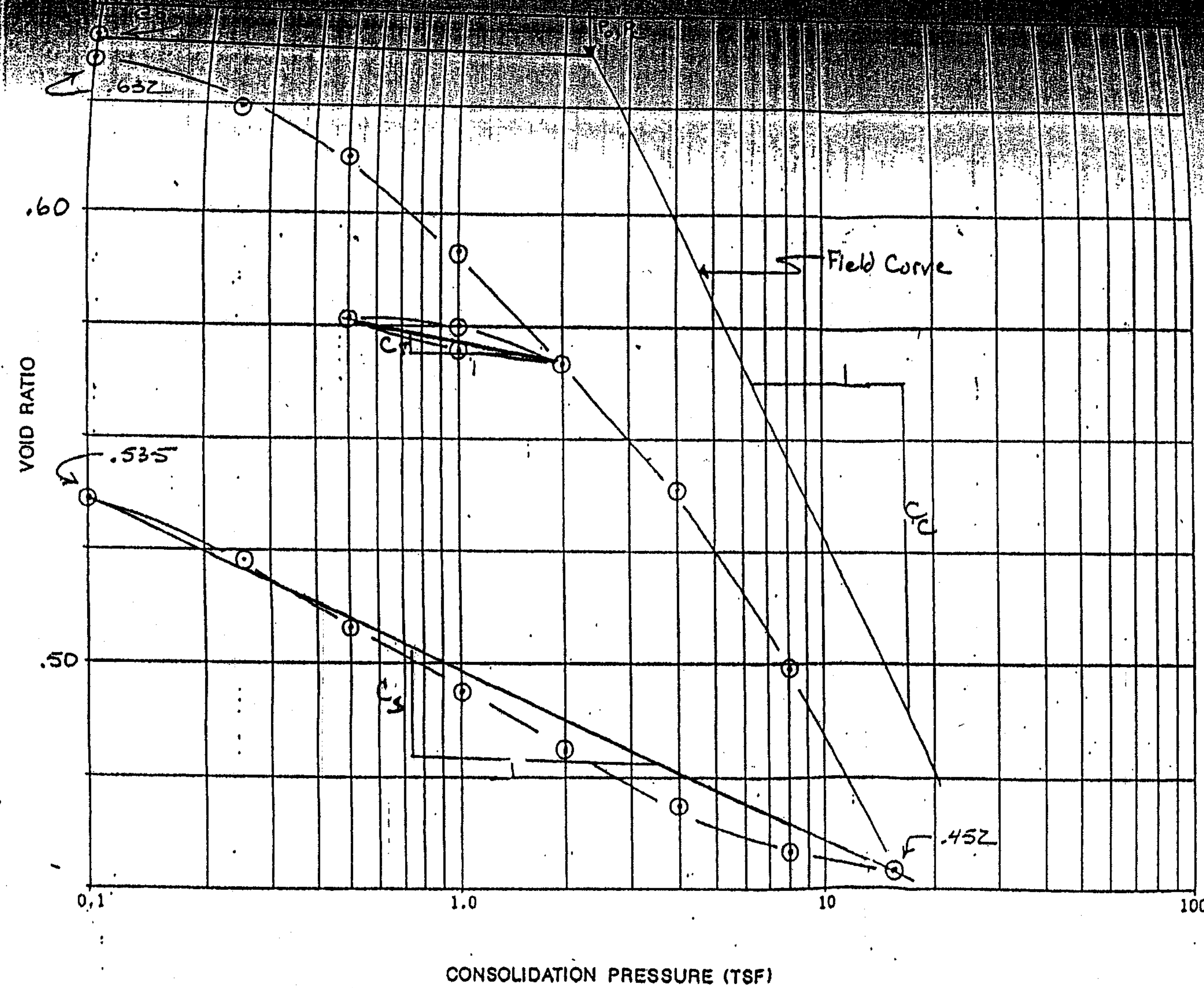

SAMPLE PROPERTIES

DESCRIPTION: GRAY LEAN CLAY, LITTLE SAND U.S.C.S. CL

3-INCH SHELBY TUBE

BORING NO. SB07 SAMPLE NO. — DEPTH 74.0 TO 76.0 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 23.6 %
INITIAL DRY UNIT WEIGHT (Do)	= 104.6 PCF
INITIAL VOID RATIO (eo)	= 0.641
LIQUID LIMIT (LL)	= 40 %
PLASTICITY INDEX (PI)	= 21 %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= 1.2 TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= 2.5 TSF
EXISTING OVERBURDEN PRESSURE (Po)	= 2.5 TSF
OVERCONSOLIDATION RATIO (OCR)	= 1.0
COMPRESSION INDEX (Cc)	= 0.1742
RECOMPRESSION INDEX (Cr)	= 0.0145
SWELL INDEX (Cs)	= 0.0382

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CONSOLIDATION TEST

U.S. STEEL – CAMU DESIGN

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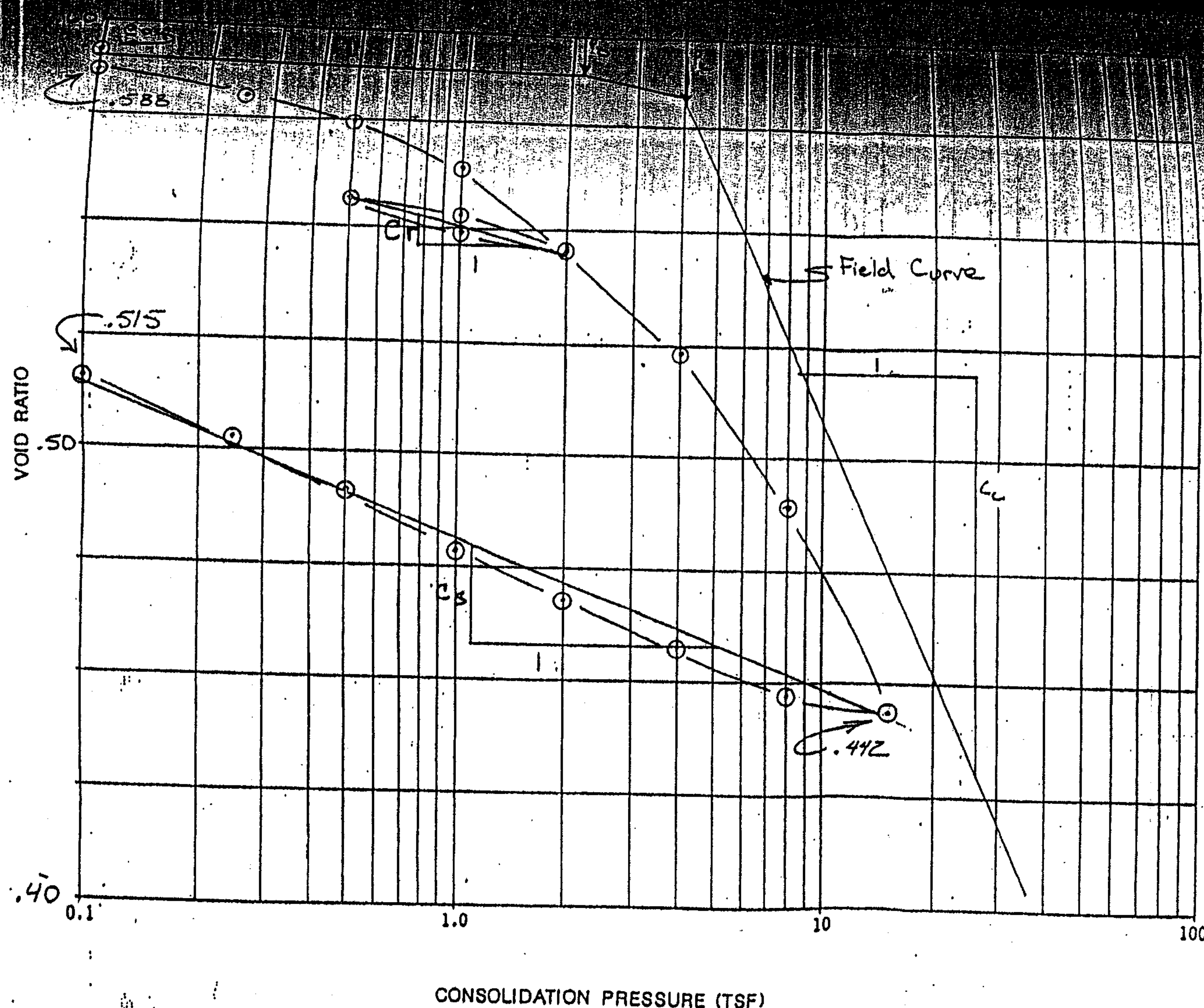

SAMPLE PROPERTIES

DESCRIPTION GRAY LEAN CLAY, LITTLE SAND, TRACE GRAVEL U.S.C.S. CL

3-INCH SHELB TUBE

BORING NO. SB06 SAMPLE NO. — DEPTH 75.0–77.0 FT

INITIAL NATURAL MOISTURE CONTENT (Wo)	= 21.4 %
INITIAL DRY UNIT WEIGHT (Do)	= 107.8 PCF
INITIAL VOID RATIO (eo)	= 0.592
LIQUID LIMIT (LL)	= 34 %
PLASTICITY INDEX (PI)	= 17 %
UNCONFINED COMPRESSIVE STRENGTH (qu)	= — TSF
POCKET PENETROMETER READING (qa)	= 1.0 TSF

TEST DATA

SAMPLE DIAMETER 2.50 IN. INITIAL HEIGHT 0.75 IN.

PRECONSOLIDATION PRESSURE (Pc)	= 4.2 TSF
EXISTING OVERBURDEN PRESSURE (Po)	= 2.5 TSF
OVERCONSOLIDATION RATIO (OCR)	= 1.7
COMPRESSION INDEX (Cc)	= 0.199
RECOMPRESSION INDEX (Cr)	= 0.0137
SWELL INDEX (Cs)	= 0.0342

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CONSOLIDATION TEST

U.S. STEEL — CAMU DESIGN

GARY INDIANA

1 OF 1

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CLIENT U.S. Steel	SUBJECT Slope Stability Analysis	Prepared By SYG	Date 8/4/02
PROJECT CAMU	at Final Buildout	Reviewed By	Date
		Approved By	Date

Slope Stability Analysis at Final Buildout

Introduction

A slope stability analysis was performed for the final buildout slopes after landfill closure under the long-term condition.

Design Conditions and Assumptions

A 5% slope is proposed for the final grade of CAMU. The perimeter berm around the landfill is 1H:1V. The toe of the berm is at approximately elevation 592 feet MSL and the top of the berm is at elevation 620 feet MSL. The perimeter berm is constructed using the existing dredge spoil amended with kiln lime dust and reinforced with geogrid. The landfill is lined with a double liner system as shown in the drawing details.

Based on the COLDR design, the maximum water surface in the landfill during dredging is at approximately elevation 616.5 feet MSL. It is noted that the water level will be built-up only after the liner system is installed and the landfill is in operation.

Subsurface soils at the site include a sand layer underlain by a soft clay layer. The sand layer is primarily classified as SP in the Unified Soil Classification System (USCS) and has an average blow count (N) of 23 as shown in Table 1. The soft clay layer was encountered at about elevations 544 – 547 feet MSL during the field investigation as reported in the Background Documentation Related to the Grand Calumet Rover Sediment Remediation Program dated December 1999. The depths of the soft clay layer encountered in the test borings are summarized in Table 1.

The slope stability analysis was performed using a computer program, STABL for Windows, Version 2.0, developed by Purdue University, which conducts automatic search to identify the failure surface that has the lowest factor of safety. The computer program includes a variety of failure modes and analysis methods.

Two failure modes were considered for the final buildout stability analysis: 1) a block failure plane through the waste materials and along the liner system, and 2) a deep seated failure plane through the soft clay layer.

The factor of safety of 1.5 for static condition is considered acceptable based upon standard geotechnical practices.

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TABLE 1
SUMMARY OF TEST BORING INFORMATION

Boring No.	Ground Surface Elevation	Soft Clay				End of Boring Elevation	Sand (SP)		Soft Clay (CL)	
		Depth	Elevation	End Depth	Thickness		N Range	Ave. N	N Range	Ave. q_u tsf
SB01	595.2	48	547.2	96.5	48.5	173	3-30	17	0-10	0.5
SB02	594	47.5	546.5	N/A	-	50	7-61	28	4	1
SB04	595.7	51.5	544.2	N/A	-	56	3-43	17	2	-
SB05	592.8	45.25	547.55	70	24.75	159	4-36	16	2-6	0.5
SB06	595.5	51.5	544	58.5	7	113	4-49	24	2-4	0.5
SB07	595.8	49	546.8	110	61	113	5-44	24	1-14	0.25
SB08	597	52	545	99	47	112	8-58	31	0-8	0.25
SB09	594.2	47.5	546.7	111	63.5	112	6-50	23	0-14	0.5
SB10	591.1	41.5	549.6	N/A	-	45.5	6-51	22	2	-
SB11	594.8	48.5	546.3	N/A	-	49.5	3-45	23	5	0.25
SB12	593.9	48	545.9	N/A	-	49.5	6-53	27	3	0.25
SB13	596.3	52	544.3	N/A	-	55	4-52	25	2	0.25
SB14	594.4	49	545.4	N/A	-	50.5	3-45	24	4	0.5
SB16-DUP	593.1	50	543.1	N/A	-	53	2-45	23	2	0.25
SB17	599.8	-	-	N/A	-	50.5	1-60	19	-	-
SB18	596.4	51.5	544.9	N/A	-	54.5	3-53	22	3	0.5
SB19	595.7	50.5	545.2	N/A	-	54.5	5-54	26	3-4	0.5
SB20	590.7	45	545.7	N/A	-	48	6-52	24	3	-
SB21	591.6	45	546.6	N/A	-	48	6-47	21	2	0.25
SB22	592.8	47.5	545.3	N/A	-	49.5	3-59	28	1	0.25
SB23	594.1	48	546.1	N/A	-	49.5	2-56	26	3	0.25
SB24	596	50	546	N/A	-	52	4-50	24	3	0.25
SB25	595.2	48.5	546.7	N/A	-	49.5	4-49	25	-	0.25
SB26	594.4	-	-	N/A	-	30.5	6-41	21	-	-
SB27	596.4	-	-	N/A	-	30.5	6-39	21	-	-
SB28	597.8	53.5	544.3	N/A	-	58	11-67	34	1	0.5
SB29	594.2	49.5	544.7	N/A	-	55.5	8-47	21	3	0.25
P08	592.2	46	546.2	N/A	-	48	6-64	22	2	0.25
Total Average:								**23**		

CLIENT U.S. Steel	SUBJECT Slope Stability Analysis	Prepared By SYG Date 8/4/02
PROJECT CAMU	at Final Buildout	Reviewed By ____ Date ____
		Approved By ____ Date ____

Material Properties

1. Dredge Spoil

As shown in the summary table of geotechnical laboratory results in Attachment 1, three direct shear tests and seven Proctor tests were performed for the existing dredge spoils. The average friction angle is 30.6^0 based on the laboratory test results. It was assumed that at the time of closure, the dredge spoil within the landfill will be at a similar condition of the existing dredge spoil. Therefore, the tested average friction angle was used in the analysis. To be conservative the average cohesion of 1,780 psf for the existing dredge spoils was not used in the analysis. The average maximum dry density is 111 pcf and the optimum moisture content is 14% as shown in Attachment 1. It was assumed that the dredge spoil density is 115 pcf. It is noted that the waste density has a very small effect on the slope stability analysis. In summary:

$$\gamma = 115 \text{ pcf}$$
$$C = 0 \text{ psf}$$
$$\phi = 30.6^0$$

2. Landfill Liner System

The landfill liner system consists of a double liner system. The primary liner system consists of (from top to bottom) a granular leachate collection layer on the base and a geocomposite layer on the sideslope, a geotextile and a 60-mil smooth HDPE geomembrane liner. The secondary liner system consists of (from top to bottom) a geocomposite leak detection layer, a 60-mil smooth HDPE geomembrane liner and a geocomposite clay liner (GCL).

Since the liner interfaces are critical surfaces, it was assumed that the minimum interface friction angle of the liner systems is 12 degrees based on literature reviews and various interface shear strength testing results obtained during many years of our working experiences.

3. Sand Layer

The subsurface sand layer is directly underneath the landfill. For the critical cross section modeled in the slope stability analysis, the top of the sand layer is at elevation 592 feet MSL. For sand material primarily classified as SP with an average N value of 23, the friction angle of 32 degrees was assumed based on the reference table (Table 3.28) in Attachment 2. As shown in Attachment 1, the average maximum dry density is 103 pcf and the optimum moisture content is 13% for the sand. 90% of the maximum dry density is 105 pcf, which was used for the sand material. In summary:

$\gamma = 105$ pcf
$C = 0$ psf
$\phi = 32^0$

4. Soft Clay

A soft clay layer is underlying the sand layer. The top of the clay layer has an average elevation of 545 feet MSL and is approximately 47 feet below the ground surface. Based on the field shear strength testing as summarized in Table 1, q_u values range from 0.25 to 1.0 tsf (tons per square foot). To be conservative, shear strength of 125 psf for the soft clay was used in the slope stability analysis. In addition, considering the long-term (cohesion = 0 psf) shear strength of the soft clay, it was assumed that the internal friction angle of the clay is 12 degrees. Density of 105 pcf was assumed for the material based on the reference table (Table 3.29) in Attachment 2. In summary:

$\gamma = 105$ pcf
Short-term: $C = 125$ psf
$\phi = 0^0$
Long-term: $C = 0$ psf
$\phi = 12^0$

Calculation Results

Table 2 summarizes the slope stability analysis results for the final buildout slope stability analysis. The graphic output results are shown on Figures 1 through 3.

Table 2. Perimeter Berm Slope Stability Summary

Type of Analysis	Calculated Factor of Safety	Design Factor of Safety
Block Failure Surface	13.72	1.5
Circular Failure surface ($C = 125$ psf)	3.10	1.5
Circular Failure surface ($\phi = 12^0$)	5.08	1.5

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PROJECT CAMU	at Final Buildout	Reviewed By ____ Date ____
		Approved By ____ Date ____

Conclusion

Review of Table 2 indicates that since the final cover slope is very flat and the perimeter berms provide passive resistance, the factor of safety is high for the block failure through the liner systems. The foundation soils beneath the landfill consist of a soft clay layer, however, since this clay layer is relatively deep and the landfill has relatively shallow depths and flat cover slope, the landfill will be stable based on the proposed design.

EARTH TECH

CALCULATION SHEET

PROJECT NO. 46860

CLIENT U.S. Steel SUBJECT Slope Stability Analysis at Final Buildout Prepared By SYG Date 8/4/02

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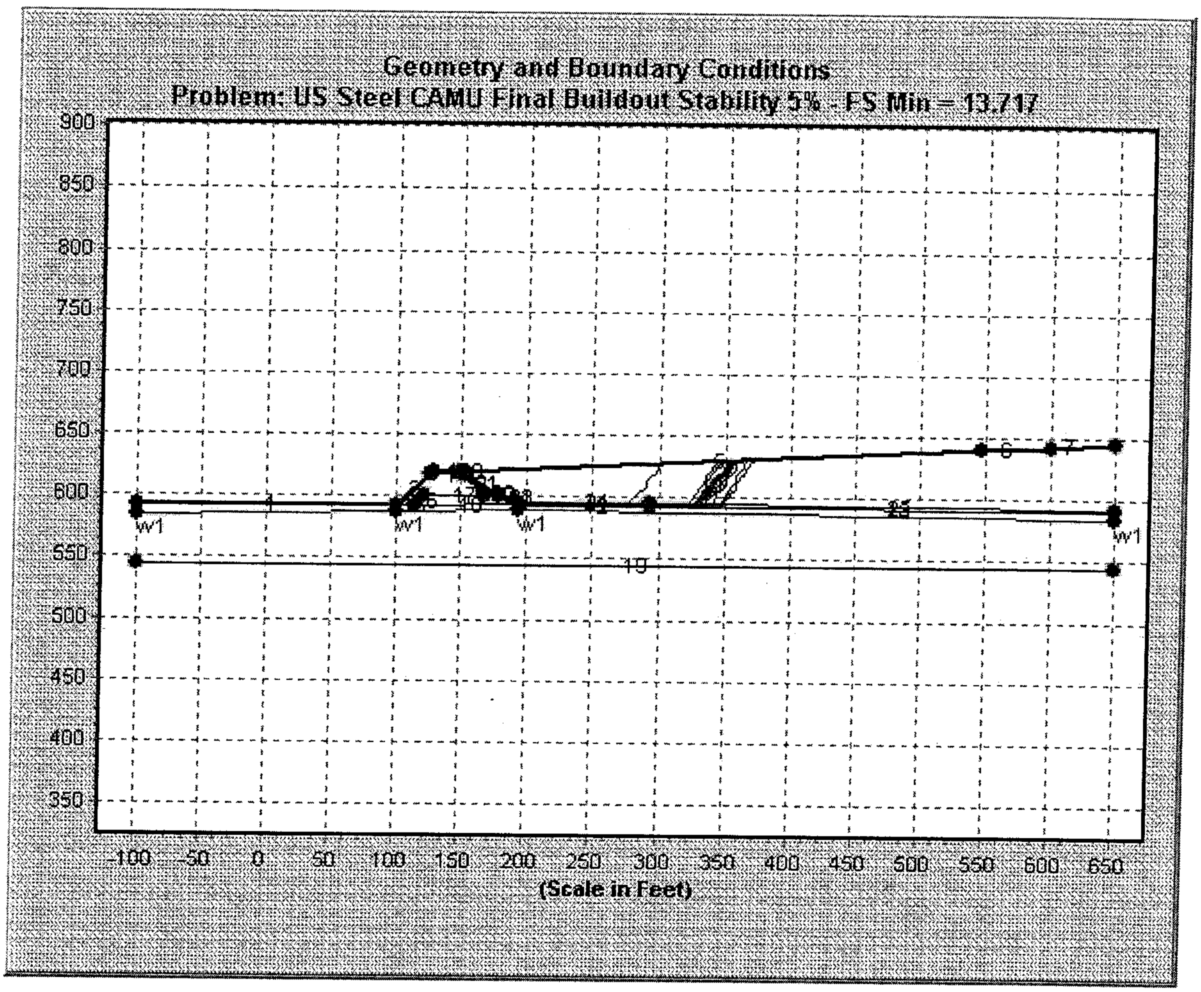
Figure 1
Final Buildout Slope Stability Analysis
Block Failure Surface



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CLIENT U.S. Steel SUBJECT Slope Stability Analysis at Final Buildout Prepared By SYG Date 8/4/02
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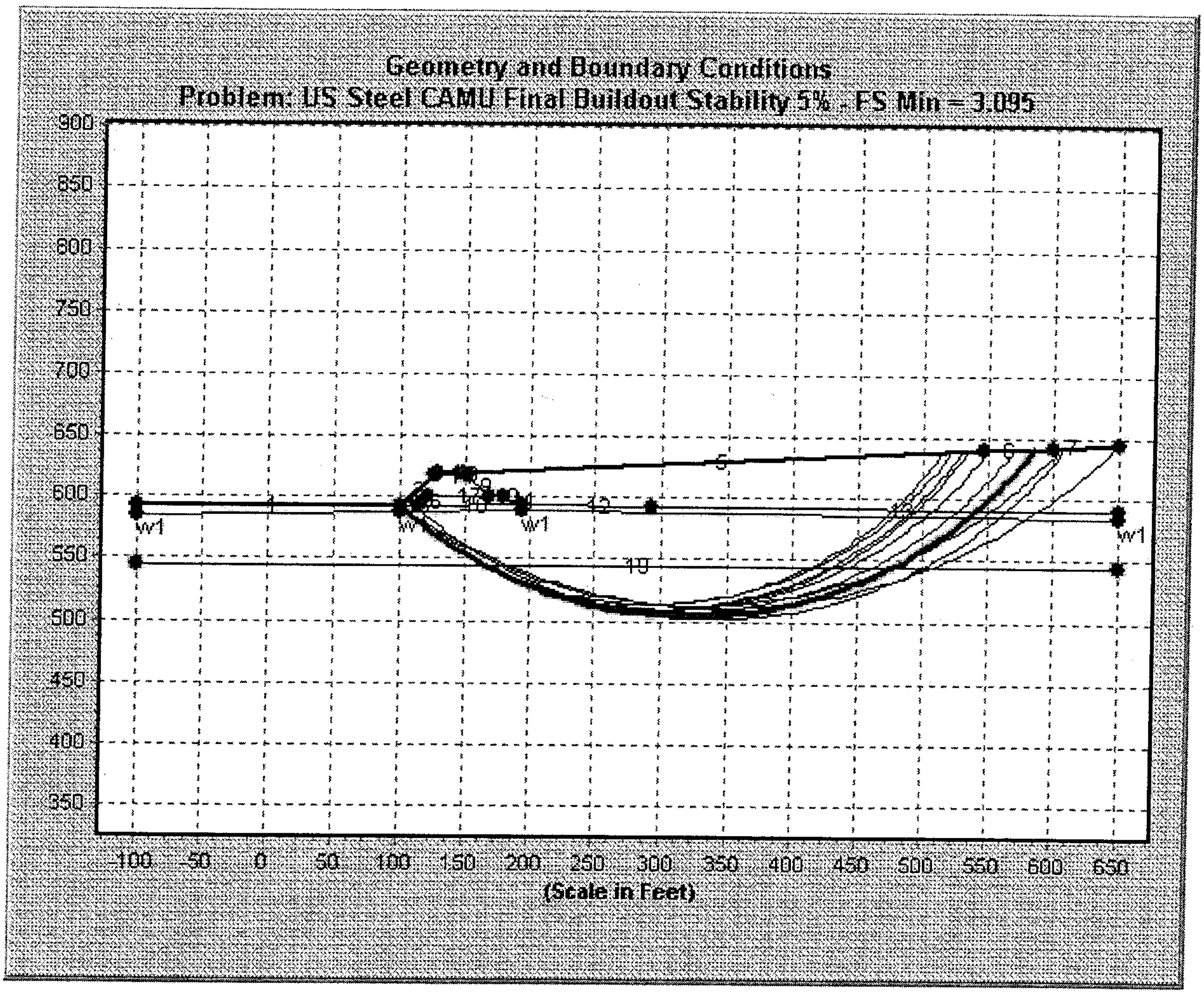
Figure 2
Final Buildout Slope Stability Analysis
Circular Failure Surface (C = 125 psf)



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CLIENT U.S. Steel SUBJECT Slope Stability Analysis Prepared By SYG Date 8/4/02
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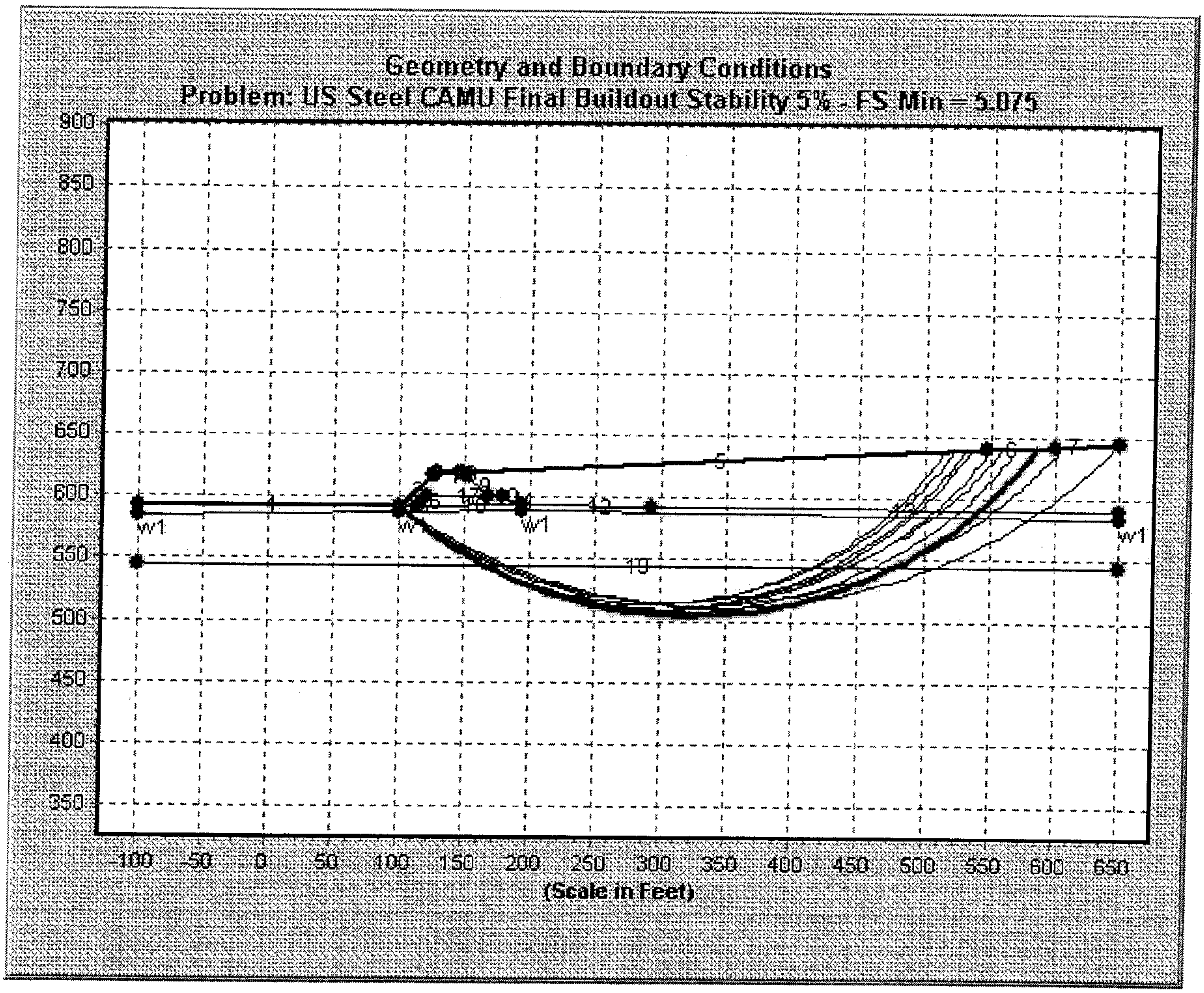
Figure 3
Final Buildout Slope Stability Analysis
Circular Failure Surface ($\phi = 12^0$)



Attachment 1
1/2

Table 3-1
Geotechnical Laboratory Results
Permit Level Design Report
GCR - PDF
U.S. Steel - Gary Works

Boring	Depth (ft)	Natural Moisture (%)	Liquid Limit (%)	Plasticity Index (%)	Loss On Ignition (%)	Grain Size: Gravel (%)	Grain Size: Sand (%)	Grain Size: Silt (%)	Grain Size: Clay (%)	Permeability (cm/s)	USCS Classification	Cation Exchange (meq H+/100g)	Consolidation: Initial Void Ratio	Consolidation: Compression Index	Moisture/Density: Maximum Dry Unit Weight (pcf)	Moisture/Density: Optimum Water Content (%)	Shear: Friction Angle (degree)	Shear: Cohesion Intercept (tsf)	Soil Unit
Existing Dredge Spoils																			
SB3	6-8	128.2	37	2	6.1	0.0	3.4	60.0	36.6	7.10E-07	ML				118	16			Exiting Dredge
SB6	0-4					0.0	78.3	20.4	1.3		SM		0.773	0.0324	105	10	34.0	0.00	Exiting Dredge
SB7	0-4					0.0	75.7	22.6	1.7		SM		0.711	0.0432	107	11			Exiting Dredge
SB8	0-5	13.0				0.0	93.0	5.5	1.5		SP-SM		0.782	0.0358	105	13	30.4	0.71	Exiting Dredge
SB9	0-2	9.1				0.0	95.8	2.7	1.5		SP								Exiting Dredge
SB11	0-2	23.1	27	3		1.1	48.6	44.1	6.2		ML								Exiting Dredge
SB12	0-2	11.4				0.4	90.0	7.1	2.5		SP-SM								Exiting Dredge
SB18	0-2	8.4				0.6	92.0	5.5	1.9		SP-SM								Exiting Dredge
SB19	0-2	30.1				0.0	44.9	50.5	4.6		ML								Exiting Dredge
SB22	0-2	43.7	50	15		0.0	1.7	94.3	4.0		ML								Exiting Dredge
SB23	0-3	37.6				0.1	39.9	56.6	3.4		ML		0.693	0.1193	117	18	27.5	1.96	Exiting Dredge
SB24	0-5	10.5				0.0	92.0	5.9	2.1		SP-SM				111	11			Exiting Dredge
SB25	0-2	7.9				0.3	92.9	5.4	1.4		SP-SM								Exiting Dredge
North Berm		7.5				0.0	92.5	6.0	1.5		SP-SM								Exiting Dredge
South Berm		27.9	37	3	5.5	0.1	33.7	51.8	14.4		Dredge								Exiting Dredge
HA2 & HA3	1-3	34.9	44	7	5.9	0.0	13.5	79.4	7.1	2.70E-07	Dredge		0.648	0.2100	115	18			Exiting Dredge
average	*NA*	*28.1*	*39*	*6*	*5.8*	*0.2*	*61.7*	*32.4*	*5.7*	*4.90E-07*	*NA*	*NA*	*0.721*	*0.0881*	*111*	*14*	*30.6*	*0.89*	*NA*
std deviation	*NA*	*31.4*	*9*	*5*	*0.3*	*0.3*	*34.8*	*30.1*	*8.9*	*3.11E-07*	*NA*	*Na*	*0.056*	*0.0770*	*6*	*3*	*3.3*	*0.99*	*NA*
maximum	*NA*	*128.2*	*50*	*15*	*6.1*	*1.1*	*95.8*	*94.3*	*36.6*	*7.10E-07*	*NA*	*0.00*	*0.782*	*0.2100*	*118*	*18*	*34.0*	*1.96*	*NA*
minimum	*NA*	*7.5*	*27*	*2*	*5.5*	*0.0*	*1.7*	*2.7*	*1.3*	*2.70E-07*	*NA*	*0.00*	*0.648*	*0.0324*	*105*	*10*	*27.5*	*0.00*	*NA*
Upper Sand Unit																			
SB1	4-6	23.8				0.0	97.9	1.4	0.7		SP	<1.0							Upper Sand Unit
SB1	6-8	19.8								2.20E-03	SP								Upper Sand Unit
SB2	8-10	23.5				0.0	98.4	0.8	0.8		SP								Upper Sand Unit
SB3	4-6	6.3				0.0	94.8	2.6	2.6	4.70E-04	SP-SM	<1.0							Upper Sand Unit
SB4	6-8	22.4				0.0	97.2	2.5	0.3		SP								Upper Sand Unit
SB5	6-8	21.6				0.0	98.4	0.9	0.7		SP	<1.0							Upper Sand Unit
SB5	8-10	13.2			0.8					2.30E-03	SP		0.651	0.0317	103	13			Upper Sand Unit
SB6	20-25	21.7				0.0	96.9	3.1		2.10E-03	SP	2.2							Upper Sand Unit
SB9	20-25	19.7				0.1	93.4	5.0	1.5	7.50E-03	SP-SM	2.7							Upper Sand Unit
SB11	20-25	21.1				0.0	93.3	4.7	2.0	5.20E-03	SP-SM	1.2							Upper Sand Unit
SB13	20	24.6				0.0	96.5	3.5		1.70E-03	SP	1.2							Upper Sand Unit
SB16	20.5-30.5	24.2				0.0	96.1	3.9		5.90E-03	SP	0.76							Upper Sand Unit
SB18	20-25	21.2				0.0	96.0	4.0		1.50E-03	SP	0.99							Upper Sand Unit
SB19	20-25	23.1				0.0	97.9	2.1		6.30E-03	SP	1.0							Upper Sand Unit
SB20	20	21.0				0.0	98.0	2.0		3.80E-03	SP	1.5							Upper Sand Unit
SB22	20-25	20.2				0.0	94.4	4.1	1.5	3.70E-03	SP-SM	0.84							Upper Sand Unit
SB24	20-25	19.2				0.0	94.1	3.9	2.0	8.90E-03	SP-SM	1.2							Upper Sand Unit
SB26	20-25					0.0	97.4	2.6			SP				103	14			Upper Sand Unit

Attachment 1

2/2

Table 3-1
Geotechnical Laboratory Results
Permit Level Design Report
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U.S. Steel - Gary Works

Boring	Depth (ft)	Natural Moisture (%)	Liquid Limit (%)	Plasticity Index (%)	Loss On Ignition (%)	Grain Size: Gravel (%)	Grain Size: Sand (%)	Grain Size: Silt (%)	Grain Size: Clay (%)	Permeability (cm/s)	USCS Classification	Cation Exchange (meq H+/100g)	Consolidation: Initial Void Ratio	Consolidation: Compression Index	Moisture/Density: Maximum Dry Unit Weight (pcf)	Moisture/Density: Optimum Water Content (%)	Shear: Friction Angle (degree)	Shear: Cohesion Intercept (tsf)	Soil Unit
SB27	20-25					0.0	96.8	1.5	1.7		SP				103	11			Upper Sand Unit
SB28	16-18	22.4				0.0	97.9	2.1			SP								Upper Sand Unit
SB29	21-23	23.7				0.0	98.1	1.9			SP								Upper Sand Unit
MW06	7-9	22.4				0.0	96.7	3.3			SP								Upper Sand Unit
P06	43.5-45.5	27.3				0.0	73.3	26.7			SM								Upper Sand Unit
MW07	7-9	23.7				0.0	96.9	3.1			SP								Upper Sand Unit
P07	20	22.3				0.0	97.5	2.5		5.80E-03	SP	1.2							Upper Sand Unit
P07	46-48	21.1				1.4	82.5	16.1			SM								Upper Sand Unit
MW08	11-13	23.4				0.0	98.1	1.9			SP								Upper Sand Unit
P08	41-43	21.0				0.0	91.3	8.7			SP-SM								Upper Sand Unit
average	*NA*	*21.3*	*NA*	*NA*	*NA.*	*0.1*	*95.0*	*22.2*(1)		*4.10E-03*	*NA*	*1.34*	*0.651*	*0.0317*	*103*	*13*	*NA*	*NA*	*NA*
std deviation	*NA*	*4.0*	*NA*	*NA*	*NA*	*0.3*	*5.5*	*4.55*(1)		*2.54E-03*	*NA*	*0.59*	*NA*	*NA*	*0*	*2*	*NA*	*NA*	*NA*
maximum	*NA*	*27.3*	*NA*	*NA*	*NA*	*1.4*	*98.4*	*26.7*(1)		*8.90E-03*	*NA*	*2.70*	*0.651*	*0.0317*	*103*	*14*	*0.0*	*0.00*	*NA*
minimum	*NA*	*6.3*	*NA*	*NA*	*NA*	*0.0*	*73.3*	*16.1*(1)		*4.70E-04*	*NA*	*0.76*	*0.651*	*0.0317*	*103*	*11*	*0.0*	*0.00*	*NA*
Clay Unit																			
SB1	54-56	26.0	37	19		0.6	8.0	33.0	58.4		CL	<1.0							Clay Unit
SB1	56-58	25.9								2.90E-08	CL								Clay Unit
SB2	48-50	24.2	37	20		0.9	11.5	37.3	50.3		CL								Clay Unit
SB4	54-56	25.9	36	18		1.8	9.7	31.3	57.2		CL								Clay Unit
SB5	48-50	22.3								1.50E-08	CL								Clay Unit
SB5	50-52	23.8	34	17		0.9	11.0	36.4	51.7		CL	<1.0							Clay Unit
SB6	75-77	21.4	34	17		1.1	10.0	33.8	55.1		CL		0.592	0.1990					Clay Unit
SB7	74-76	23.6	40	21		0.0	8.6	36.3	55.1	1.50E-08	CL		0.641	0.1742					Clay Unit
SB8	62.5-64.5	24.7	33	15		0.0	10.5	31.2	58.3	8.80E-09	CL		0.700	0.2230					Clay Unit
SB9	65-67	17.2	24	8		0.8	14.7	43.5	41.0		CL		0.500	0.1145					Clay Unit
SB14	48.5-50.5	26.6	32	13							CL								Clay Unit
SB18	52.5-54.5	27.9									CL								Clay Unit
SB19	52.5-54.5	25.2	34	14							CL								Clay Unit
SB20	46-48	24.1									CL								Clay Unit
SB22	47.5-49.5	25.4	34	14							CL								Clay Unit
SB24	50-52	28.9									CL								Clay Unit
SB28	56-58	25.1	34	16		0.0	8.1	37.7	54.2		CL								Clay Unit
SB29	53.5-55.5	28.4	33	15		0.0	7.4	32.1	60.5		CL								Clay Unit
average	*NA*	*24.8*	*34*	*16*	*0.0*	*0.6*	*10.0*	*35.3*	*54.2*	*1.70E-08*	*NA*	*<1.0*	*0.608*	*0.1777*	*NA*	*NA*	*NA*	*NA*	*NA*
std deviation	*NA*	*2.7*	*4*	*3*	*0.0*	*0.6*	*2.2*	*3.8*	*5.6*	*8.55E-09*	*NA*	*NA*	*0.084*	*0.0466*	*NA*	*NA*	*NA*	*NA*	*NA*
maximum	*NA*	*28.9*	*40*	*21*	*0.0*	*1.8*	*14.7*	*43.5*	*60.5*	*2.90E-08*	*NA*	*<1.0*	*0.700*	*0.2230*	*NA*	*NA*	*NA*	*NA*	*NA*
minimum	*NA*	*17.2*	*24*	*8*	*0.0*	*0.0*	*7.4*	*31.2*	*41.0*	*8.80E-09*	*NA*	*<1.0*	*0.500*	*0.1145*	*NA*	*NA*	*NA*	*NA*	*NA*

Footnote:
(1) Statistics based on P200 particle size.

MDP/mdp/TJK/VJR
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12/6/97

Attachment 2

Page 1/2

From Reference 1, "Geotechnical Engineering Investigation Manual", Page 202

TABLE 3.31
TYPICAL PROPERTIES OF COMPACTED SOILS*

				Typical value of compression: Percent of original height		Typical strength characteristics						
Group symbol	Soil type	Range of maximum dry unit weight, pcf	Range of optimum moisture, %	At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion (as compacted), psf	Cohesion (saturated), psf	Effective stress envelope ϕ, degrees	tan ϕ	Typical coefficient of permeability, ft/min	Range of CBR values	Range of subgrade modulus k_m, lb/in³
GW	Well-graded clean gravels, gravel-sand mixtures	125–135	11–8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40–80	300–500
GP	Poorly graded clean gravels, gravel-sand mix	115–125	14–11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30–60	250–400
GM	Silty gravels, poorly graded gravel-sand silt	120–135	12–8	0.5	1.1	...	...	>34	>0.67	$>10^{-6}$	20–60	100–400
GC	Clayey gravels, poorly graded gravel-sand-clay	115–130	14–9	0.7	1.6	...	...	>31	>0.60	$>10^{-7}$	20–40	100–300
SW	Well-graded clean sands, gravelly sands	110–130	16–9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20–40	200–300
SP	Poorly-graded clean sands, sand-gravel mix	100–120	21–12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10–40	200–300
SM	Silty sands, poorly graded sand-silt mix	110–125	16–11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10–40	100–300
SM-SC	Sand-silt clay mix with slightly plastic fines	110–130	15–11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	...	
SC	Clayey sands, poorly graded sand-clay mix	105–125	19–11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5–20	100–300
ML	Inorganic silts and clayey silts	95–120	24–12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100–200
ML-CL	Mixture of inorganic silt and clay	100–120	22–12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	...	
CL	Inorganic clays of low to medium plasticity	95–120	24–12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50–200
OL	Organic silts and silt-clays, low plasticity	80–100	33–21	...	...	...	...	...	...	...	5 or less	50–100
MH	Inorganic clayey silts, elastic silts	70–95	40–24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50–100
CH	Inorganic clays of high plasticity	75–105	36–19	2.6	3.9	2150	230	19	0.35	10^{-7}	15 or less	50–150
OH	Organic clays and silty clays	65–100	45–21	...	...	...	...	...	...	...	5 or less	25–100

*From NAVFAC Manual DM 7 (1971).[6] All properties are for condition of "standard Proctor" maximum density, except values of k ai CBR which are for "modified Proctor" maximum density. Typical strength characteristics are for effective strength envelopes and a obtained from USBR data. Compression values are for vertical loading with complete lateral confinement. (...) Indicates insufficie data available for an estimate.

Attachment 2

Page 2/2

TABLE 3.28
COMMON PROPERTIES OF COHESIONLESS SOILS

Material	Compactness	D_R, %	N*	γ dry,† g/cm³	Void ratio e	Strength‡ ϕ
GW: well-graded gravels, gravel-sand mixtures	Dense	75	90	2.21	0.22	40
	Medium dense	50	55	2.08	0.28	36
	Loose	25	<28	1.97	0.36	32
GP: poorly graded gravels, gravel-sand mixtures	Dense	75	70	2.04	0.33	38
	Medium dense	50	50	1.92	0.39	35
	Loose	25	<20	1.83	0.47	32
SW: well-graded sands, gravelly sands	Dense	75	65	1.89	0.43	37
	Medium dense	50	35	1.79	0.49	34
	Loose	25	<15	1.70	0.57	30
SP: poorly graded sands, gravelly sands	Dense	75	50	1.76	0.52	36
	Medium dense	50	30	1.67	0.60	33
	Loose	25	<10	1.59	0.65	29
SM: silty sands	Dense	75	45	1.65	0.62	35
	Medium dense	50	25	1.55	0.74	32
	Loose	25	<8	1.49	0.80	29
ML: inorganic silts, very fine sands	Dense	75	35	1.49	0.80	33
	Medium dense	50	20	1.41	0.90	31
	Loose	25	<4	1.35	1.0	27

*N is blows per foot of penetration in the SPT. Adjustments for gradation are after Burmister (1962).[13] See Table 3.23 for general relationships of D_R vs. N.
†Density given is for $G_s = 2.65$ (quartz grains).
‡Friction angle ϕ depends on mineral type, normal stress, and grain angularity as well as D_R and gradation (see Fig. 3.63).

TABLE 3.29
COMMON PROPERTIES OF CLAY SOILS

Consistency	N	Hand test	γ_{sat},* g/cm³	Strength† U_c, kg/cm²
Hard	>30	Difficult to indent	>2.0	>4.0
Very stiff	15–30	Indented by thumbnail	2.08–2.24	2.0–4.0
Stiff	8–15	Indented by thumb	1.92–2.08	1.0–2.0
Medium (firm)	4–8	Molded by strong pressure	1.76–1.92	0.5–1.0
Soft	2–4	Molded by slight pressure	1.60–1.76	0.25–0.5
Very soft	<2	Extrudes between fingers	1.44–1.60	0–0.25

*$\gamma_{sat} = \gamma_{dry} + \gamma_w\left(\frac{e}{1+e}\right)$

†Unconfined compressive strength U_c is usually taken as equal to twice the cohesion c or the undrained shear strength s_u. For the drained strength condition, most clays also have the additional strength parameter ϕ, although for most normally consolidated clays $c = 0$ [Lambe and Whitman (1969)[30]]. Typical values for s_u and drained strength parameters are given on Table 3.30.

Background Documentation Related to the Grand Calumet River - Sediment Remediation Program

Vol. 3

Tab. 26 - Permit Level Design Report

Table 3-1
Geotechnical Laboratory Results
Permit Level Design Report
GCR - PDF
U.S. Steel - Gary Works

Boring	Depth (ft)	Natural Moisture (%)	Liquid Limit (%)	Plasticity Index (%)	Loss On Ignition (%)	Grain Size: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Permeability (cm/s)	USCS Classification	Cation Exchange (meq H+/100g)	Consolidation: Initial Void Ratio	Compression Index	Moisture/Density: Maximum Dry Unit Weight (pcf)	Optimum Water Content (%)	Shear: Friction Angle (degree)	Cohesion Intercept (tsf)	Soil Unit
Existing Dredge Spoils																			
SB3	6-8	128.2	37	2	6.1	0.0	3.4	60.0	36.6	7.10E-07	ML				118	16			Exiting Dredge
SB6	0-4					0.0	78.3	20.4	1.3		SM		0.773	0.0324	105	10	34.0	0.00	Exiting Dredge
SB7	0-4					0.0	75.7	22.6	1.7		SM		0.711	0.0432	107	11			Exiting Dredge
SB8	0-5	13.0				0.0	93.0	5.5	1.5		SP-SM		0.782	0.0358	105	13	30.4	0.71	Exiting Dredge
SB9	0-2	9.1				0.0	95.8	2.7	1.5		SP								Exiting Dredge
SB11	0-2	23.1	27	3		1.1	48.6	44.1	6.2		ML								Exiting Dredge
SB12	0-2	11.4				0.4	90.0	7.1	2.5		SP-SM								Exiting Dredge
SB18	0-2	8.4				0.6	92.0	5.5	1.9		SP-SM								Exiting Dredge
SB19	0-2	30.1				0.0	44.9	50.5	4.6		ML								Exiting Dredge
SB22	0-2	43.7	50	15		0.0	1.7	94.3	4.0		ML								Exiting Dredge
SB23	0-3	37.6				0.1	39.9	56.6	3.4		ML		0.693	0.1193	117	18	27.5	1.96	Exiting Dredge
SB24	0-5	10.5				0.0	92.0	5.9	2.1		SP-SM				111	11			Exiting Dredge
SB25	0-2	7.9				0.3	92.9	5.4	1.4		SP-SM								Exiting Dredge
North Berm		7.5				0.0	92.5	6.0	1.5		SP-SM								Exiting Dredge
South Berm		27.9	37	3	5.5	0.1	33.7	51.8	14.4		Dredge								Exiting Dredge
HA2 & HA3	1-3	34.9	44	7	5.9	0.0	13.5	79.4	7.1	2.70E-07	Dredge		0.648	0.2100	115	18			Exiting Dredge
average	*NA*	*28.1*	*39*	*6*	*5.8*	*0.2*	*61.7*	*32.4*	*5.7*	*4.90E-07*	*NA*	*NA*	*0.721*	*0.0881*	*111*	*14*	*30.6*	*0.89*	*NA*
std deviation	*NA*	*31.4*	*9*	*5*	*0.3*	*0.3*	*34.8*	*30.1*	*8.9*	*3.11E-07*	*NA*	*Na*	*0.056*	*0.0770*	*6*	*3*	*3.3*	*0.99*	*NA*
maximum	*NA*	*128.2*	*50*	*15*	*6.1*	*1.1*	*95.8*	*94.3*	*36.6*	*7.10E-07*	*NA*	*0.00*	*0.782*	*0.2100*	*118*	*18*	*34.0*	*1.96*	*NA*
minimum	*NA*	*7.5*	*27*	*2*	*5.5*	*0.0*	*1.7*	*2.7*	*1.3*	*2.70E-07*	*NA*	*0.00*	*0.648*	*0.0324*	*105*	*10*	*27.5*	*0.00*	*NA*
Upper Sand Unit																			
SB1	4-6	23.8				0.0	97.9	1.4	0.7		SP	<1.0							Upper Sand Unit
SB1	6-8	19.8								2.20E-03	SP								Upper Sand Unit
SB2	8-10	23.5				0.0	98.4	0.8	0.8		SP								Upper Sand Unit
SB3	4-6	6.3				0.0	94.8	2.6	2.6	4.70E-04	SP-SM	<1.0							Upper Sand Unit
SB4	6-8	22.4				0.0	97.2	2.5	0.3		SP								Upper Sand Unit
SB5	6-8	21.6				0.0	98.4	0.9	0.7		SP	<1.0							Upper Sand Unit
SB5	8-10	13.2			0.8					2.30E-03	SP		0.651	0.0317	103	13			Upper Sand Unit
SB6	20-25	21.7				0.0	96.9	3.1		2.10E-03	SP	2.2							Upper Sand Unit
SB9	20-25	19.7				0.1	93.4	5.0	1.5	7.50E-03	SP-SM	2.7							Upper Sand Unit
SB11	20-25	21.1				0.0	93.3	4.7	2.0	5.20E-03	SP-SM	1.2							Upper Sand Unit
SB13	20	24.6				0.0	96.5	3.5		1.70E-03	SP	1.2							Upper Sand Unit
SB16	20.5-30.5	24.2				0.0	96.1	3.9		5.90E-03	SP	0.76							Upper Sand Unit
SB18	20-25	21.2				0.0	96.0	4.0		1.50E-03	SP	0.99							Upper Sand Unit
SB19	20-25	23.1				0.0	97.9	2.1		6.30E-03	SP	1.0							Upper Sand Unit
SB20	20	21.0				0.0	98.0	2.0		3.80E-03	SP	1.5							Upper Sand Unit
SB22	20-25	20.2				0.0	94.4	4.1	1.5	3.70E-03	SP-SM	0.84							Upper Sand Unit
SB24	20-25	19.2				0.0	94.1	3.9	2.0	8.90E-03	SP-SM	1.2							Upper Sand Unit
SB26	20-25					0.0	97.4	2.6			SP				103	14			Upper Sand Unit

Table 3-1
Geotechnical Laboratory Results
Permit Level Design Report
GCR - PDF
U.S. Steel - Gary Works

Boring	Depth (ft)	Natural Moisture (%)	Liquid Limit (%)	Plasticity Index (%)	Loss On Ignition (%)	Grain Size: Gravel (%)	Grain Size: Sand (%)	Grain Size: Silt (%)	Grain Size: Clay (%)	Permeability (cm/s)	USCS Classification	Cation Exchange (meq H+/100g)	Consolidation: Initial Void Ratio	Consolidation: Compression Index	Moisture/Density: Maximum Dry Unit Weight (pcf)	Moisture/Density: Optimum Water Content (%)	Shear: Friction Angle (degree)	Shear: Cohesion Intercept (tsf)	Soil Unit
SB27	20-25					0.0	96.8	1.5	1.7		SP				103	11			Upper Sand Unit
SB28	16-18	22.4				0.0	97.9	2.1			SP								Upper Sand Unit
SB29	21-23	23.7				0.0	98.1	1.9			SP								Upper Sand Unit
MW06	7-9	22.4				0.0	96.7	3.3			SP								Upper Sand Unit
P06	43.5-45.5	27.3				0.0	73.3	26.7			SM								Upper Sand Unit
MW07	7-9	23.7				0.0	96.9	3.1			SP								Upper Sand Unit
P07	20	22.3				0.0	97.5	2.5		5.80E-03	SP	1.2							Upper Sand Unit
P07	46-48	21.1				1.4	82.5	16.1			SM								Upper Sand Unit
MW08	11-13	23.4				0.0	98.1	1.9			SP								Upper Sand Unit
P08	41-43	21.0				0.0	91.3	8.7			SP-SM								Upper Sand Unit
average	*NA*	*21.3*	*NA*	*NA*	*NA*	*0.1*	*95.0*	*22.2*[1]		*4.10E-03*	*NA*	*1.34*	*0.651*	*0.0317*	*103*	*13*	*NA*	*NA*	*NA*
std deviation	*NA*	*4.0*	*NA*	*NA*	*NA*	*0.3*	*5.5*	*4.55*[1]		*2.54E-03*	*NA*	*0.59*	*NA*	*NA*	*0*	*2*	*NA*	*NA*	*NA*
maximum	*NA*	*27.3*	*NA*	*NA*	*NA*	*1.4*	*98.4*	*26.7*[1]		*8.90E-03*	*NA*	*2.70*	*0.651*	*0.0317*	*103*	*14*	*0.0*	*0.00*	*NA*
minimum	*NA*	*6.3*	*NA*	*NA*	*NA*	*0.0*	*73.3*	*16.1*[1]		*4.70E-04*	*NA*	*0.76*	*0.651*	*0.0317*	*103*	*11*	*0.0*	*0.00*	*NA*
Clay Unit																			
SB1	54-56	26.0	37	19		0.6	8.0	33.0	58.4		CL	<1.0							Clay Unit
SB1	56-58	25.9								2.90E-08	CL								Clay Unit
SB2	48-50	24.2	37	20		0.9	11.5	37.3	50.3		CL								Clay Unit
SB4	54-56	25.9	36	18		1.8	9.7	31.3	57.2		CL								Clay Unit
SB5	48-50	22.3								1.50E-08	CL								Clay Unit
SB5	50-52	23.8	34	17		0.9	11.0	36.4	51.7		CL	<1.0							Clay Unit
SB6	75-77	21.4	34	17		1.1	10.0	33.8	55.1		CL		0.592	0.1990					Clay Unit
SB7	74-76	23.6	40	21		0.0	8.6	36.3	55.1	1.50E-08	CL		0.641	0.1742					Clay Unit
SB8	62.5-64.5	24.7	33	15		0.0	10.5	31.2	58.3	8.80E-09	CL		0.700	0.2230					Clay Unit
SB9	65-67	17.2	24	8		0.8	14.7	43.5	41.0		CL		0.500	0.1145					Clay Unit
SB14	48.5-50.5	26.6	32	13							CL								Clay Unit
SB18	52.5-54.5	27.9									CL								Clay Unit
SB19	52.5-54.5	25.2	34	14							CL								Clay Unit
SB20	46-48	24.1									CL								Clay Unit
SB22	47.5-49.5	25.4	34	14							CL								Clay Unit
SB24	50-52	28.9									CL								Clay Unit
SB28	56-58	25.1	34	16		0.0	8.1	37.7	54.2		CL								Clay Unit
SB29	53.5-55.5	28.4	33	15		0.0	7.4	32.1	60.5		CL								Clay Unit
average	*NA*	*24.8*	*34*	*16*	*0.0*	*0.6*	*10.0*	*35.3*	*54.2*	*1.70E-08*	*NA*	*<1.0*	*0.608*	*0.1777*	*NA*	*NA*	*NA*	*NA*	*NA*
std deviation	*NA*	*2.7*	*4*	*3*	*0.0*	*0.6*	*2.2*	*3.8*	*5.6*	*8.55E-09*	*NA*	*NA*	*0.084*	*0.0466*	*NA*	*NA*	*NA*	*NA*	*NA*
maximum	*NA*	*28.9*	*40*	*21*	*0.0*	*1.8*	*14.7*	*43.5*	*60.5*	*2.90E-08*	*NA*	*<1.0*	*0.700*	*0.2230*	*NA*	*NA*	*NA*	*NA*	*NA*
minimum	*NA*	*17.2*	*24*	*8*	*0.0*	*0.0*	*7.4*	*31.2*	*41.0*	*8.80E-09*	*NA*	*<1.0*	*0.500*	*0.1145*	*NA*	*NA*	*NA*	*NA*	*NA*

Footnote:
(1) Statistics based on P200 particle size.

MDP/mdp/TJK/VJR
J:\1272\035\01\vjr\subs\geosum2.xls
12/6/97

Tab. 23:

TABLE #1
PHYSICAL ANALYSIS OF SEDIMENT SAMPLES
GRAND CALUMET RIVER - US STEEL CORP. - GARY WORKS

Sample Location	TS-4	TS-8	TS-18	TS-27	TS-35
In SITU Unit Weight (Wet Sludge), PFC (1)	88.4	92.2	92.4	97.7	66.9
Water Content as % of in SITU Unit Weight	43.4	38.6	39.4	36.6	51.1
Dry Unit Weight of Solids & Organics, PCF (3)	50.0	56.6	56.0	61.9	42.5
Water Contents as % of Dry Unit Weight	76.5	62.8	64.9	53.0	104.6
Coarse Sand-Sized Particles, %	0.7	0.4	--	--	0.5
Medium Sand-Sized Particles, %	7.3	2.9	--	1.6	0.4
Fine Sand-Sized Particles, %	41.8	53.1	11.5	50.2	6.5
Silt-Sized Particles, %	44.5	40.2	82.7	45.2	88.8
Clay-Sized Particles, %	5.7	3.4	5.8	3.0	3.8
Loss-By-Ignition @ 600°F., %	8.8	5.4	2.5	2.0	5.4
Specific Gravity After Loss-By-Ignition	2.50	2.75	3.81(2)	3.21(2)	3.63(2)

Course sand-sized particles	4.75mm to 2.00mm
Medium sand-sized particles	2.00mm to 425μm
Fine sand-sized particles	425μm to 75μm
Silt-sized particles	75μm to 2μm
Clay-sized particles	Less than 2μm

ASTM Reverences
- ASTM D854-91 Specific Gravity of Soils
- ASTM D422-63 Particle-size Analysis of Soils

NOTES:

(1)...Unit weights obtained by measuring weight and volume of total full weight shelby tube samples.

(2)...High specific gravities because of ferrous metal content present in sample.

(3)...Drying oven controlled at 230± 9°F for a drying time that resulted in constant weights

Background Documentation
Related to the
Grand Calumet River
Sediment Remediation Program

Volume 2

Dec. 1999

Tab. 22

Sediment Characterization Study

U.S. Steel, Gary, Indiana

January 22, 1993

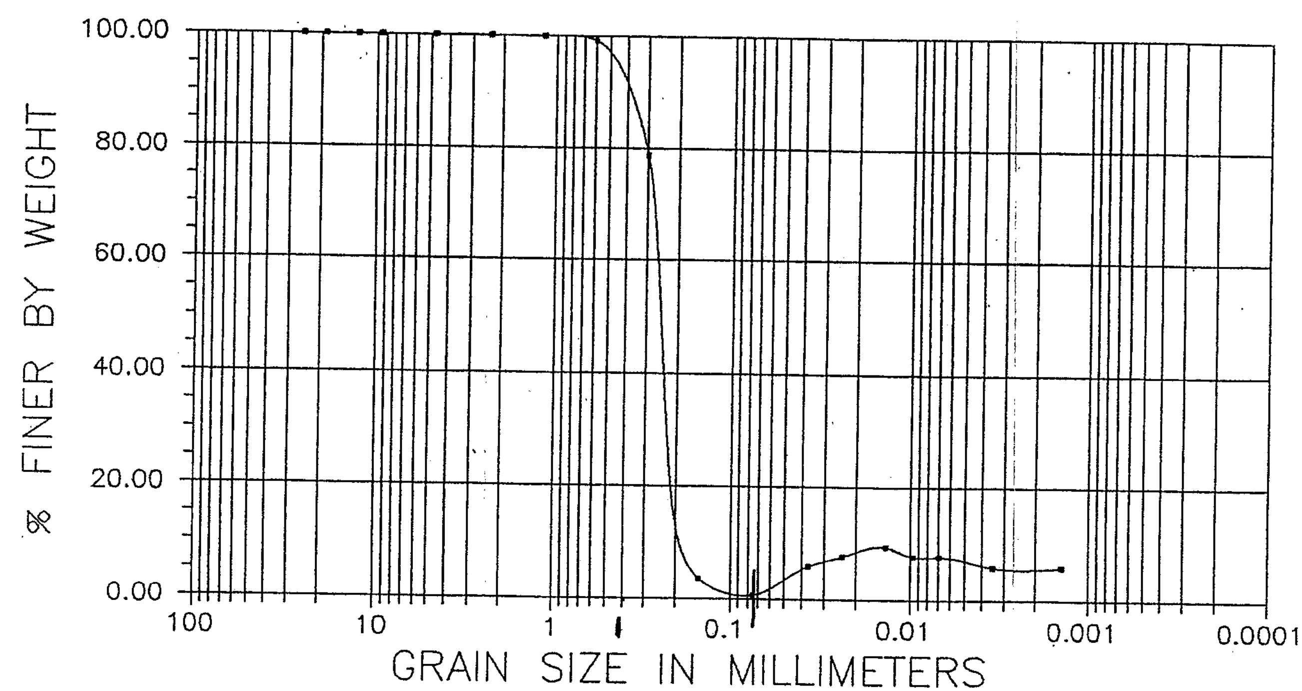
Volume Ib
Figures

Submitted to:
Mr. Gary E. Cason, Manager
Regulatory Compliance - Water

Submitted by:
Floyd Browne Associates, Inc.
Division of GeoSciences

FLOYD BROWNE ASSOCIATES, INC.

SAMPLE ID 01 | PROFILE 02 | CORE 2 | HORIZON 1

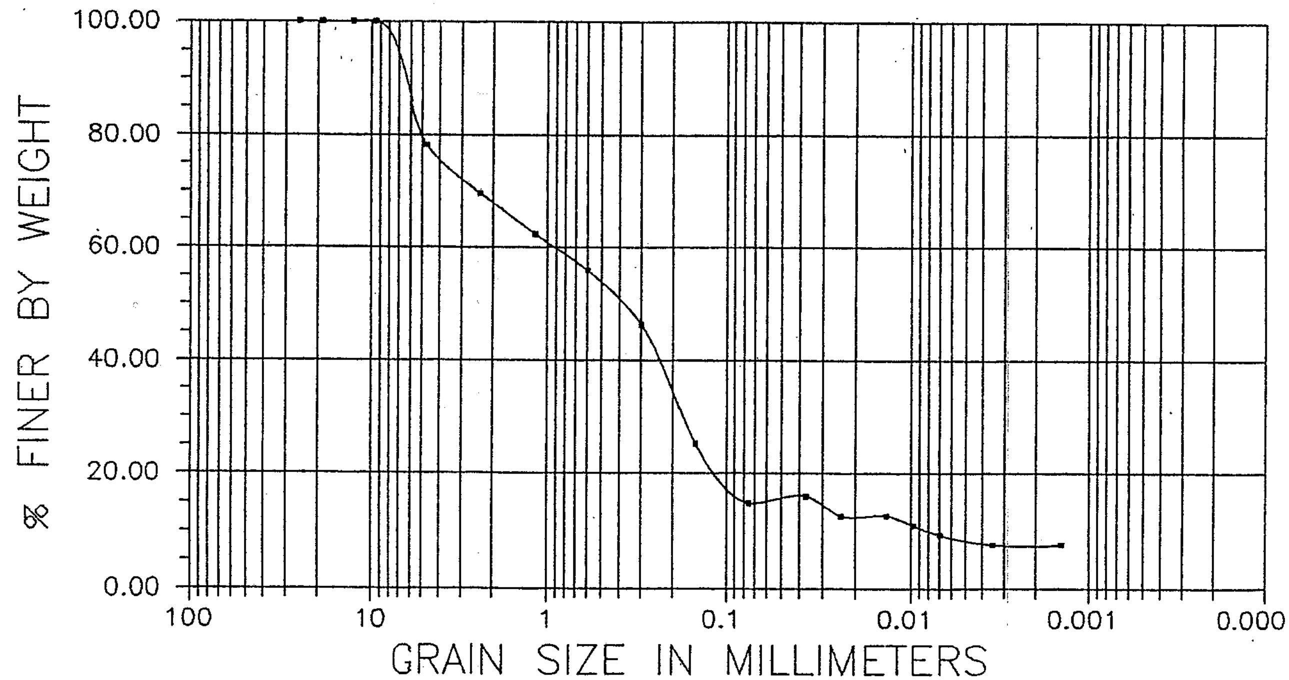


#40 #200

US—STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 171

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
02	03	1	1

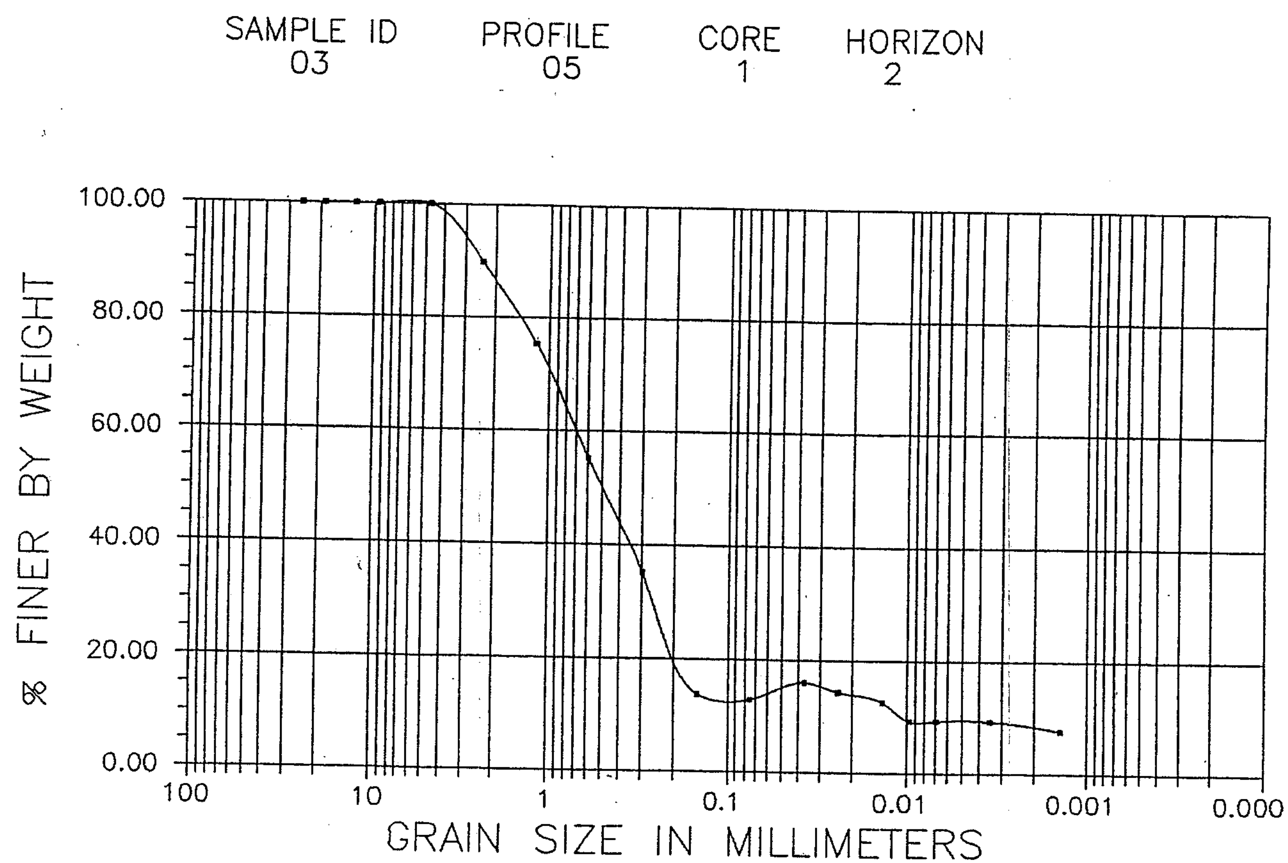


US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 172

PROJECT NO. 9074–04



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GARY, INDIANA

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HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 173

PROJECT NO. 9074-04

SAMPLE ID 04 | PROFILE 05 | CORE 2 | HORIZON 1

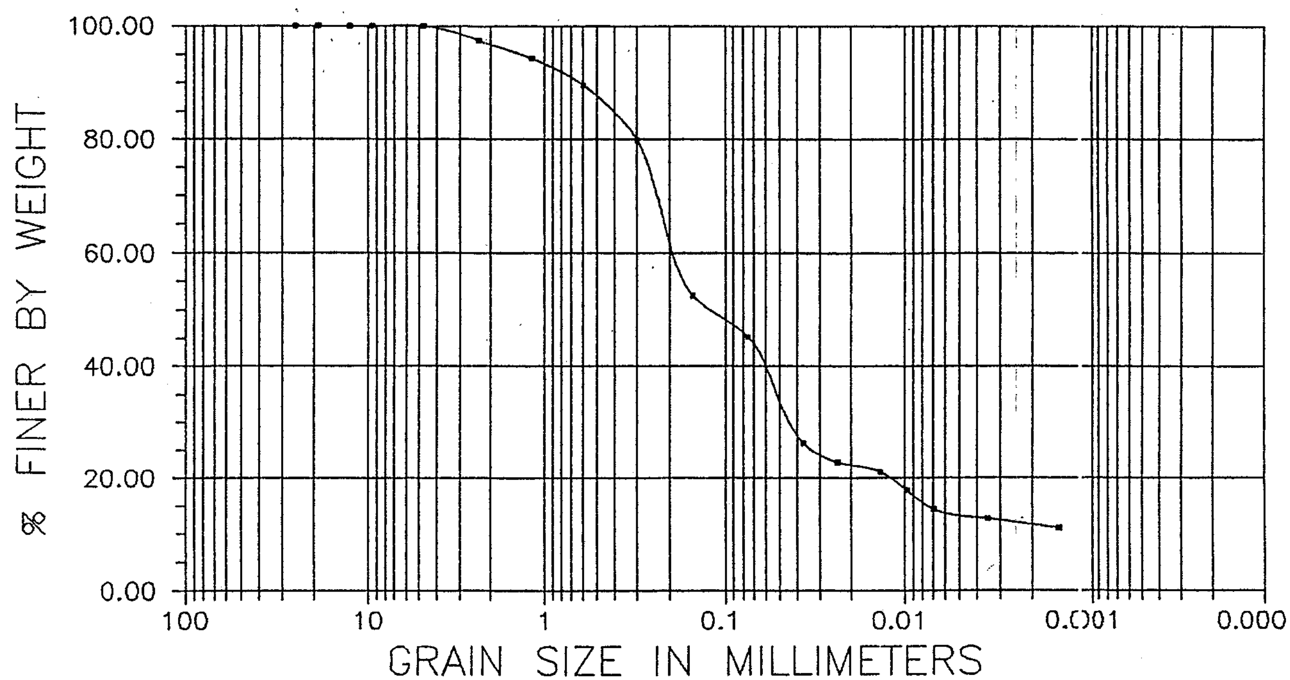

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FIGURE NO. 174

PROJECT NO. 9074-04

SAMPLE ID 05 | PROFILE 06 | CORE COMP | HORIZON 1

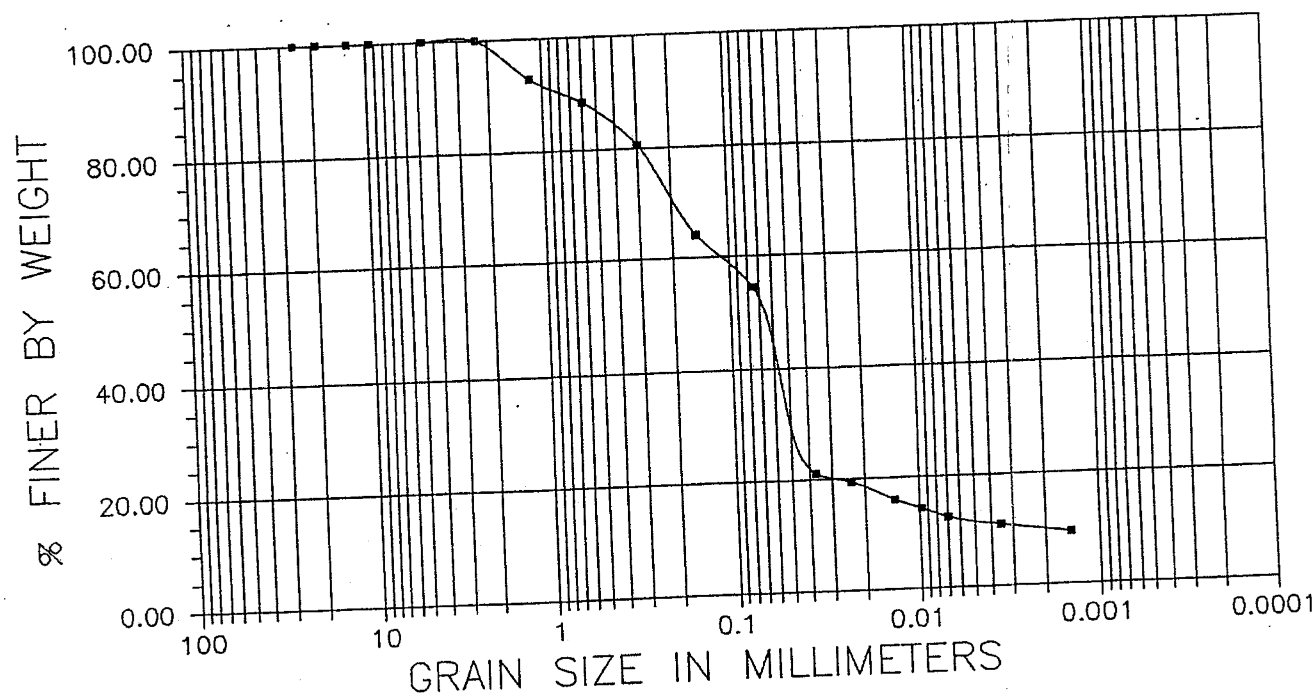

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FIGURE NO. 175

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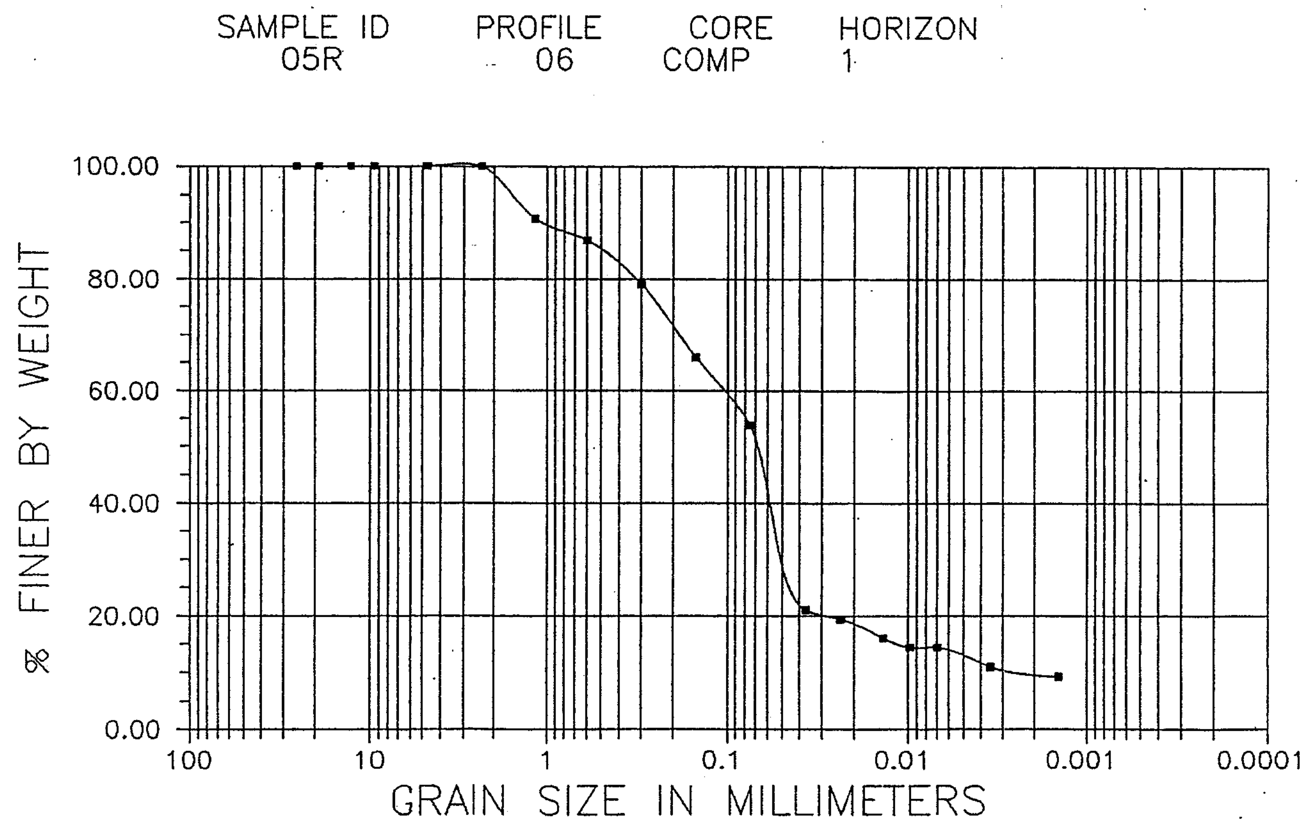

US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

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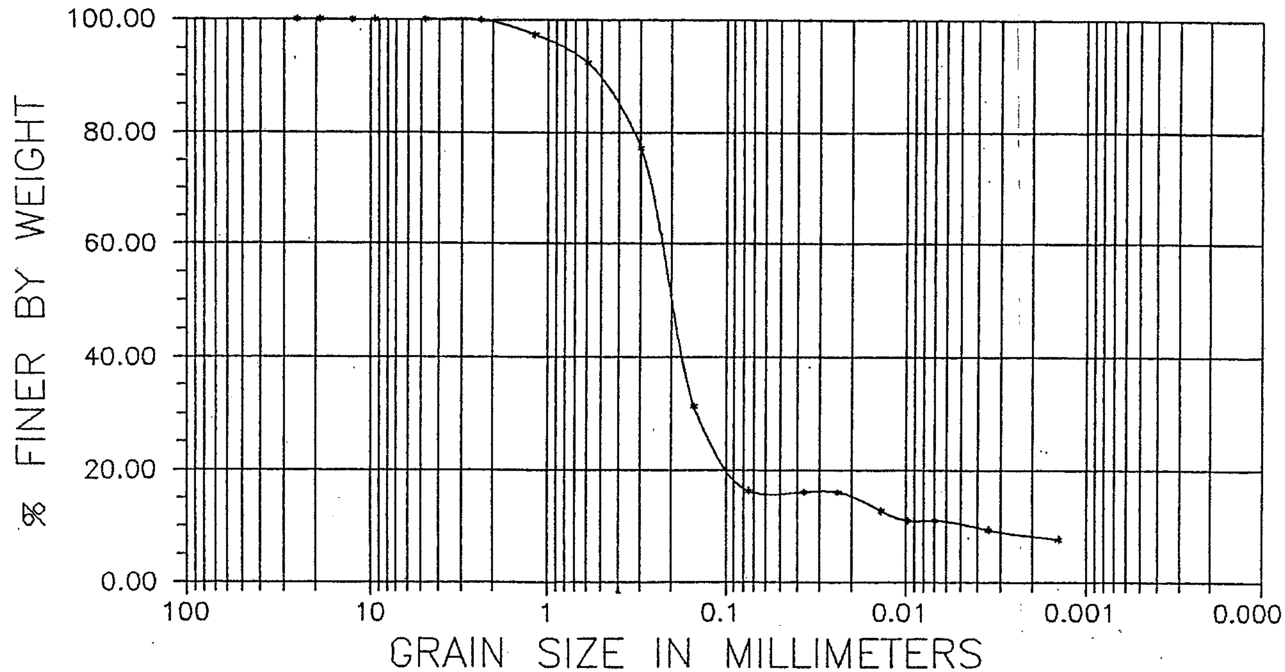
FIGURE NO. 176

PROJECT NO. 9074-04

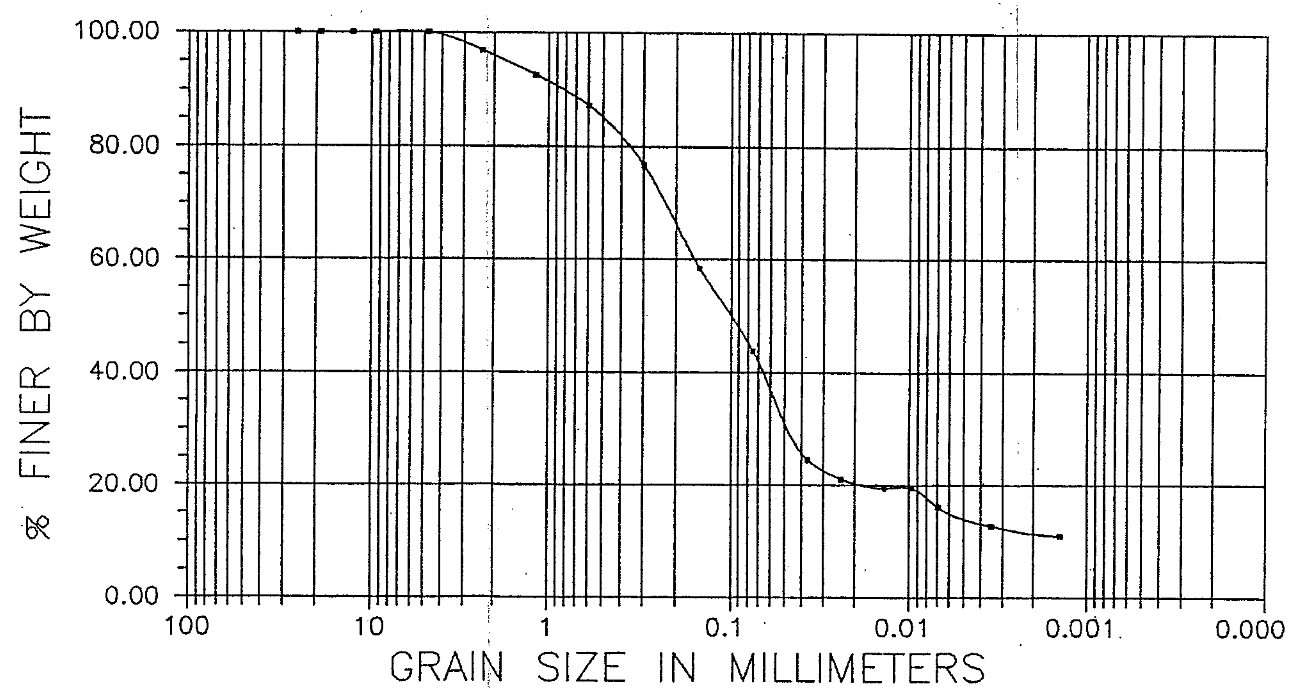
SAMPLE ID 06 | PROFILE 6 | CORE 2 | HORIZON 2



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 177

PROJECT NO. 9074-04

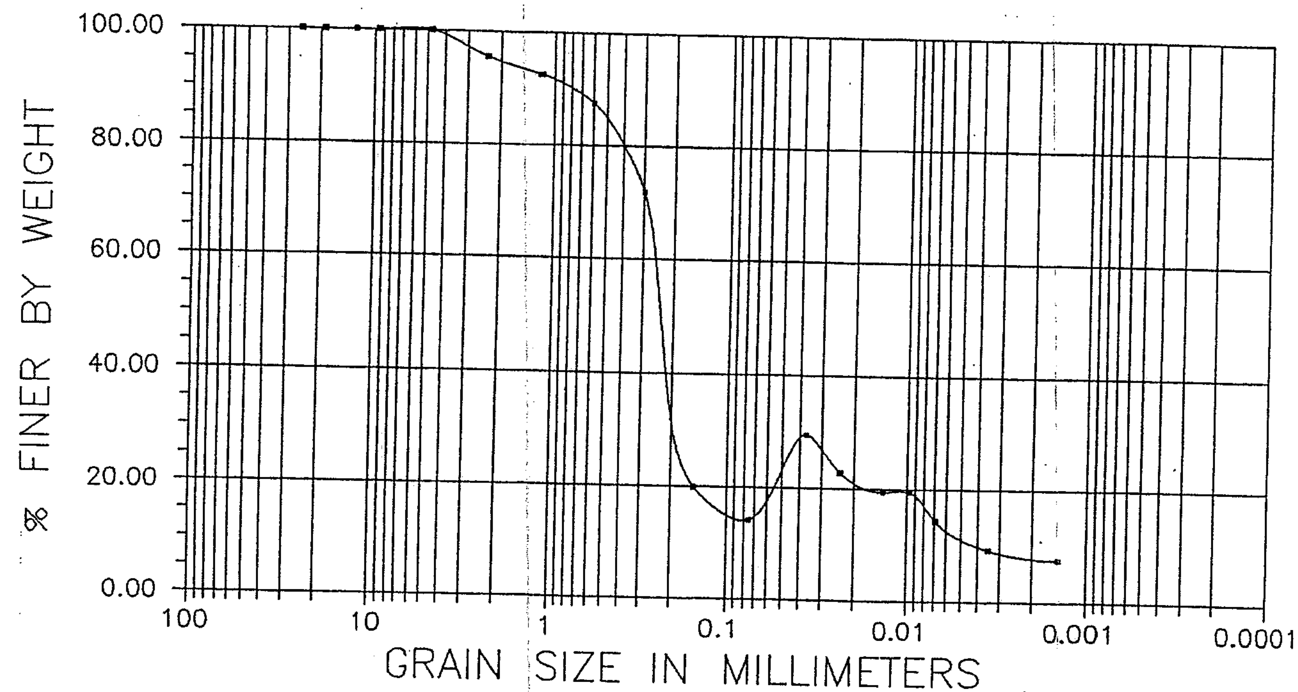
SAMPLE ID	PROFILE	CORE	HORIZON
07	07	COMP	1



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 178

PROJECT NO. 9074–04

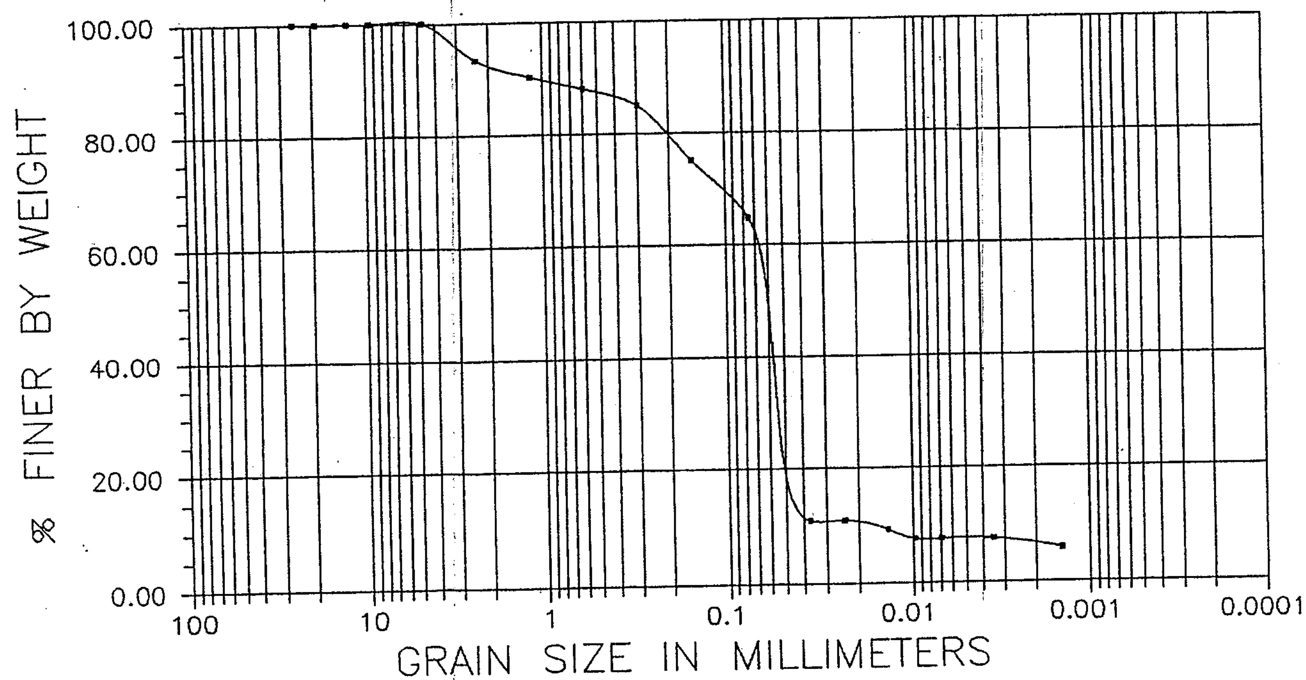
SAMPLE ID 08 | PROFILE 08 | CORE COMP | HORIZON 1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 179

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
09	09	COMP	1



US-STEEL
GARY, INDIANA

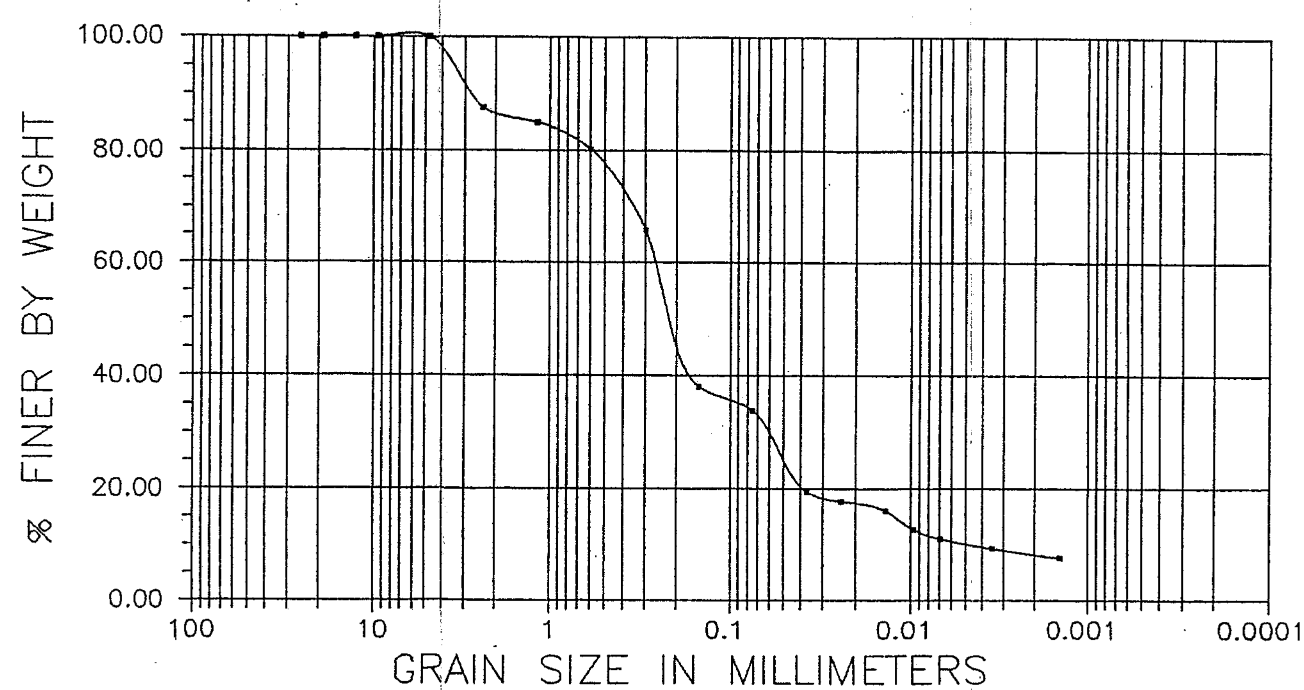
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 180

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
10	10	1	1



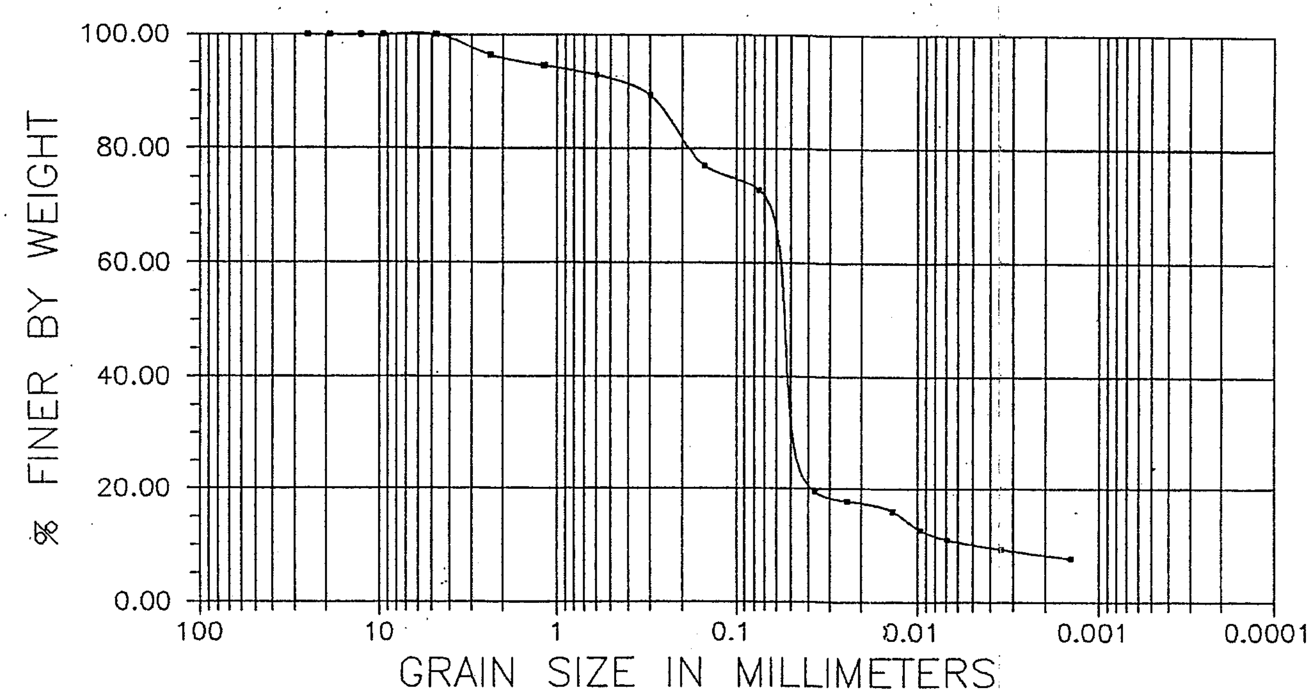
US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 181

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
10R	10	1	1



US-STEEL
GARY, INDIANA

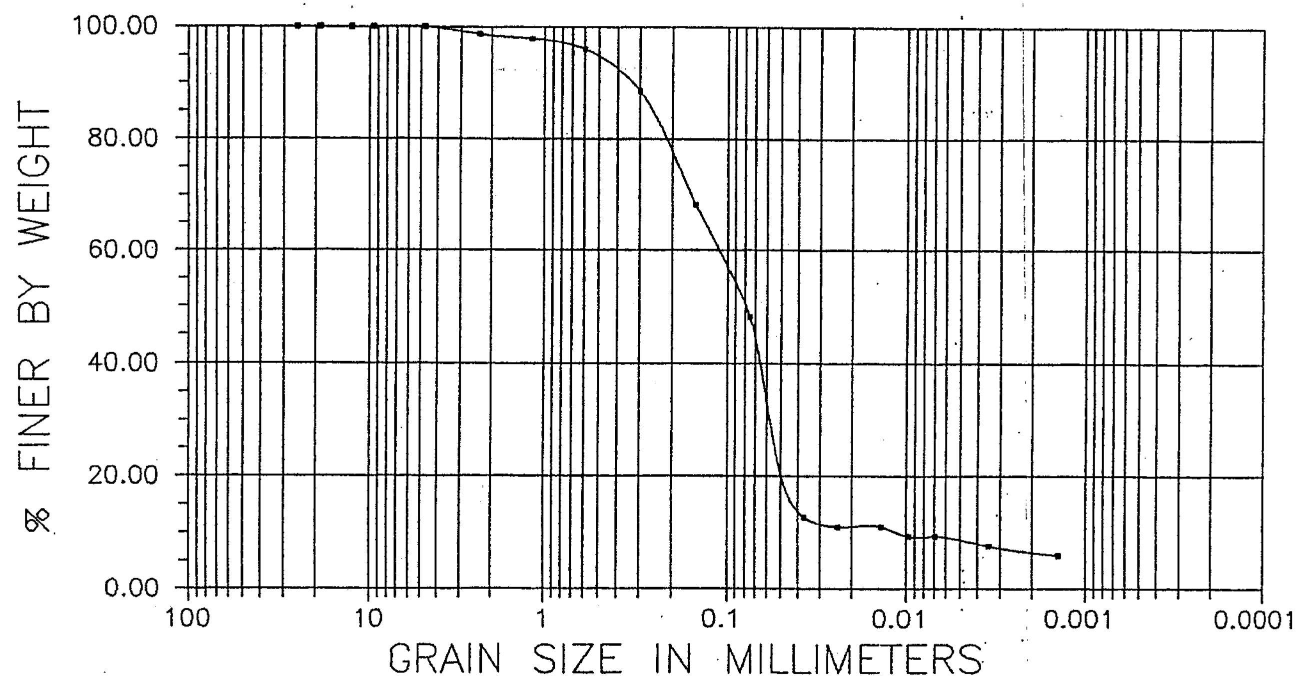
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 182

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
11	11	COMP	1



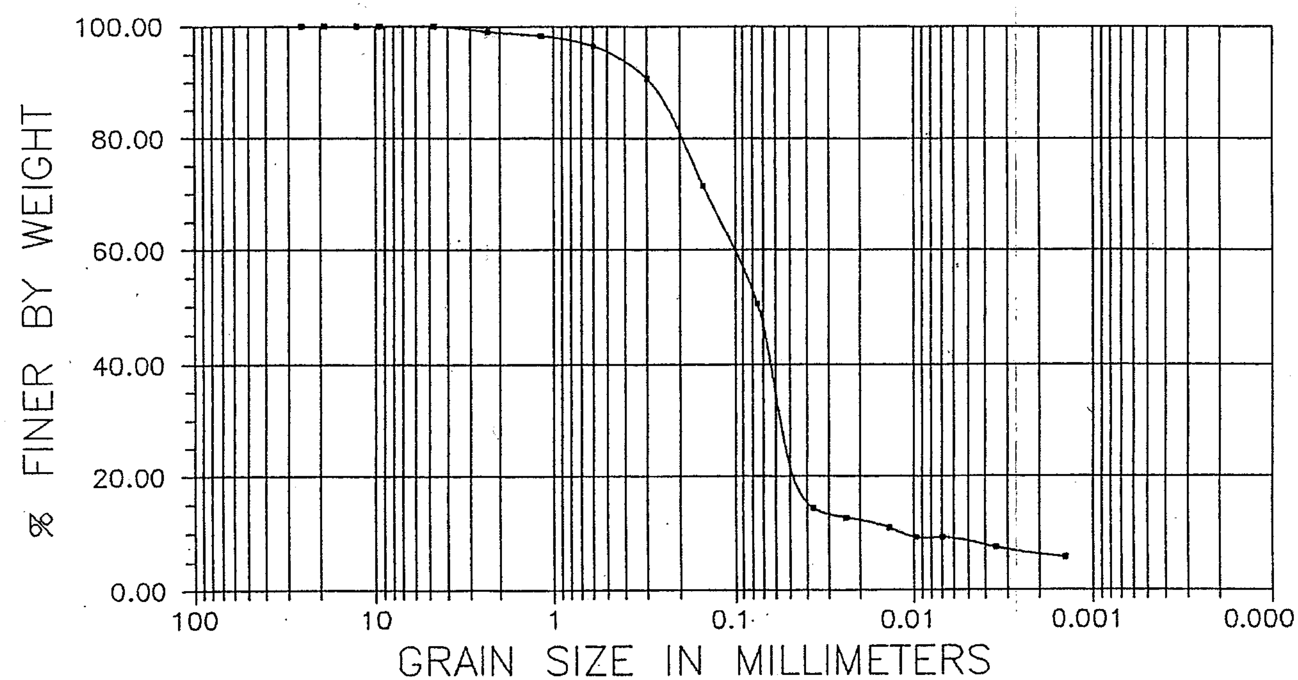
US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 183

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
11R	11	COMP	1



US-STEEL
GARY, INDIANA

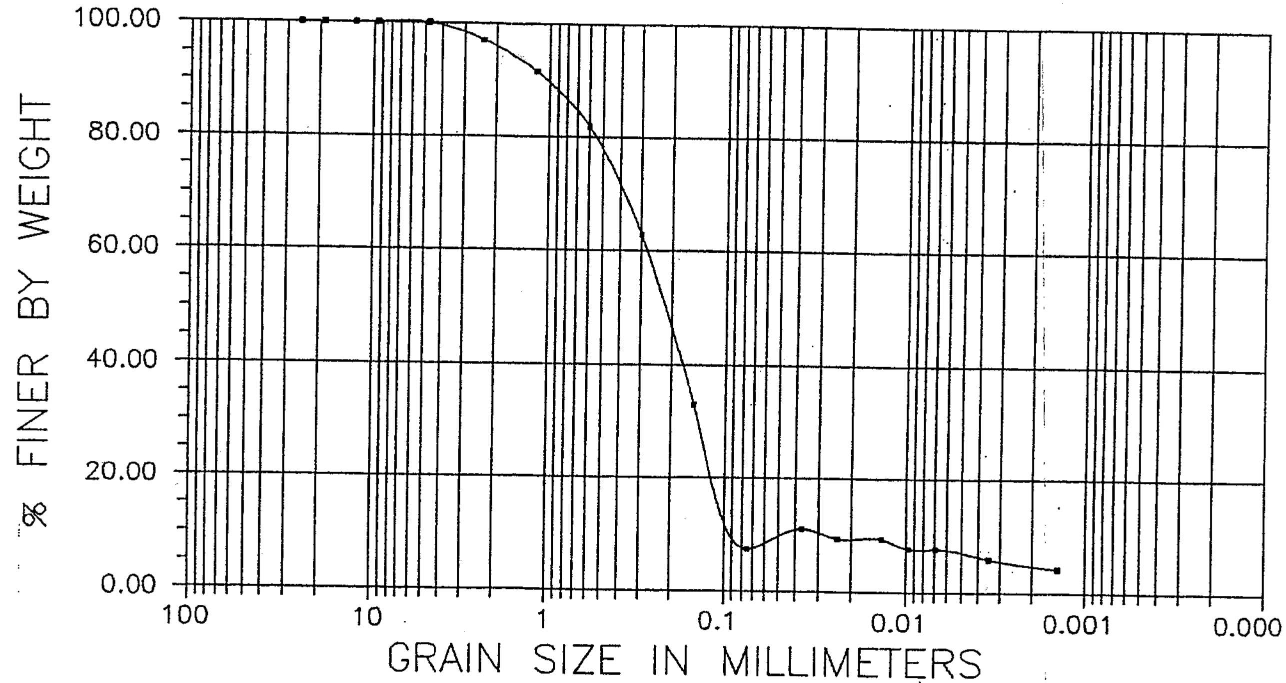
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 184

PROJECT NO. 9074-04

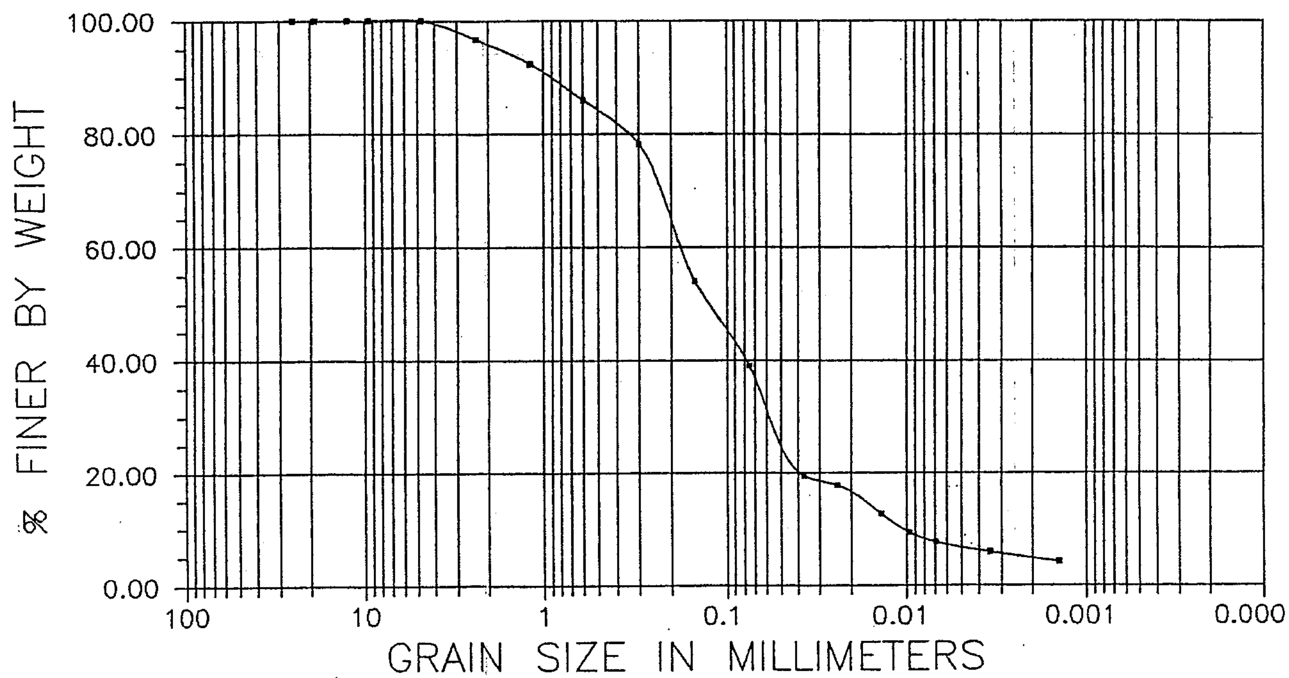
SAMPLE ID	PROFILE	CORE	HORIZON
12	12	2	1



US—STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 185

PROJECT NO. 9074–04

SAMPLE ID 13 | PROFILE 13 | CORE 2 | HORIZON 1



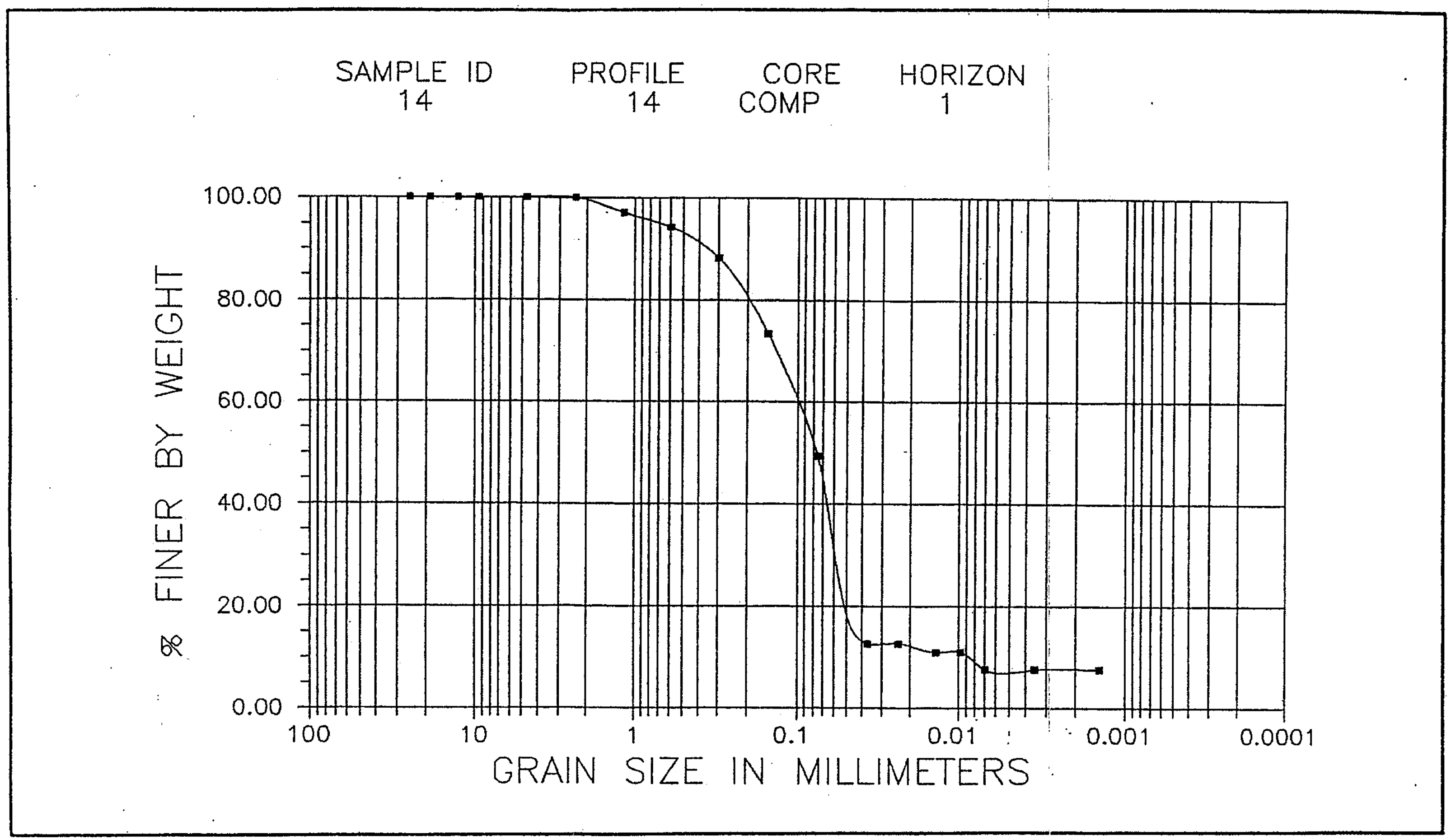
US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 186

PROJECT NO. 9074-04



US–STEEL
GARY, INDIANA

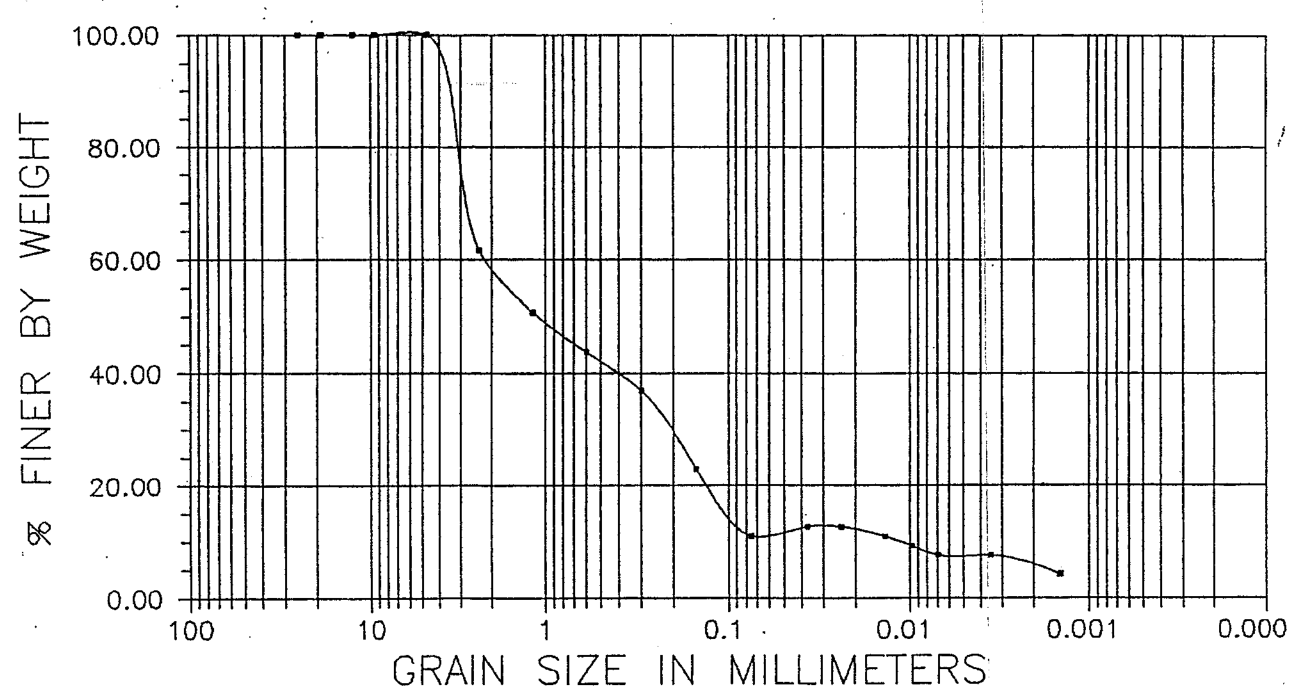
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 187

PROJECT NO. 9074–04

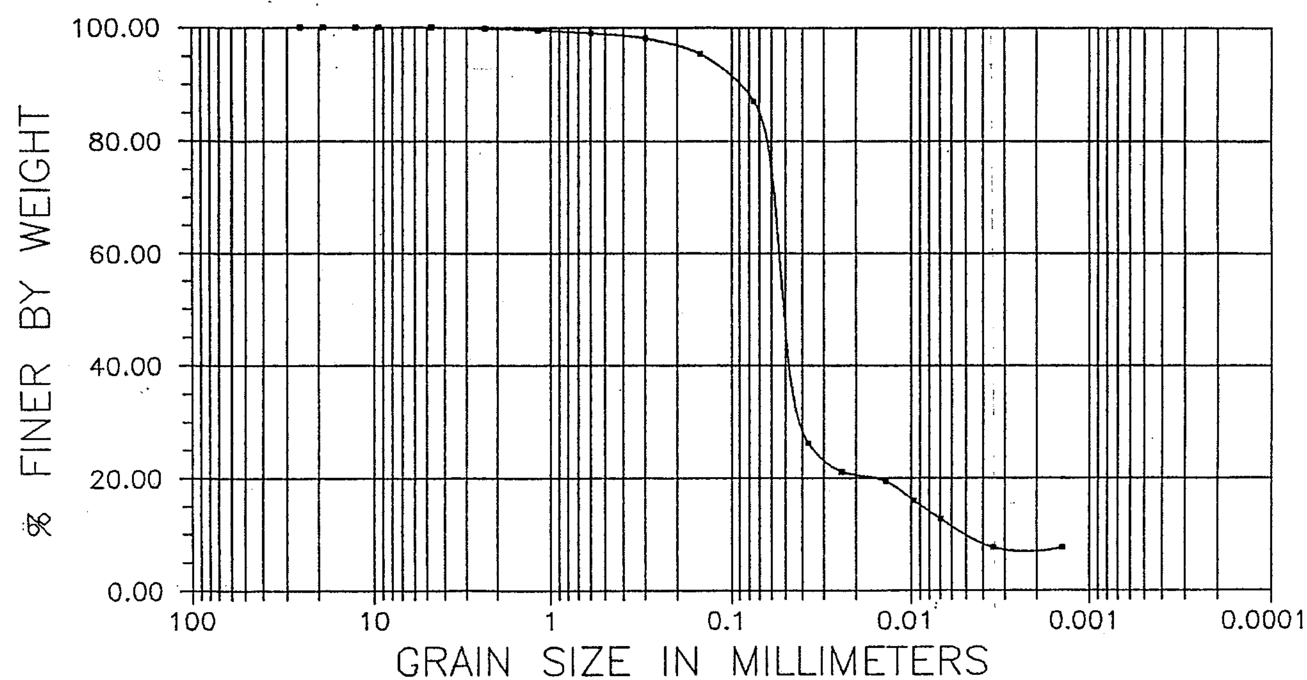
SAMPLE ID 15 PROFILE 16 CORE 1 HORIZON 2



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 188

PROJECT NO. 9074–04

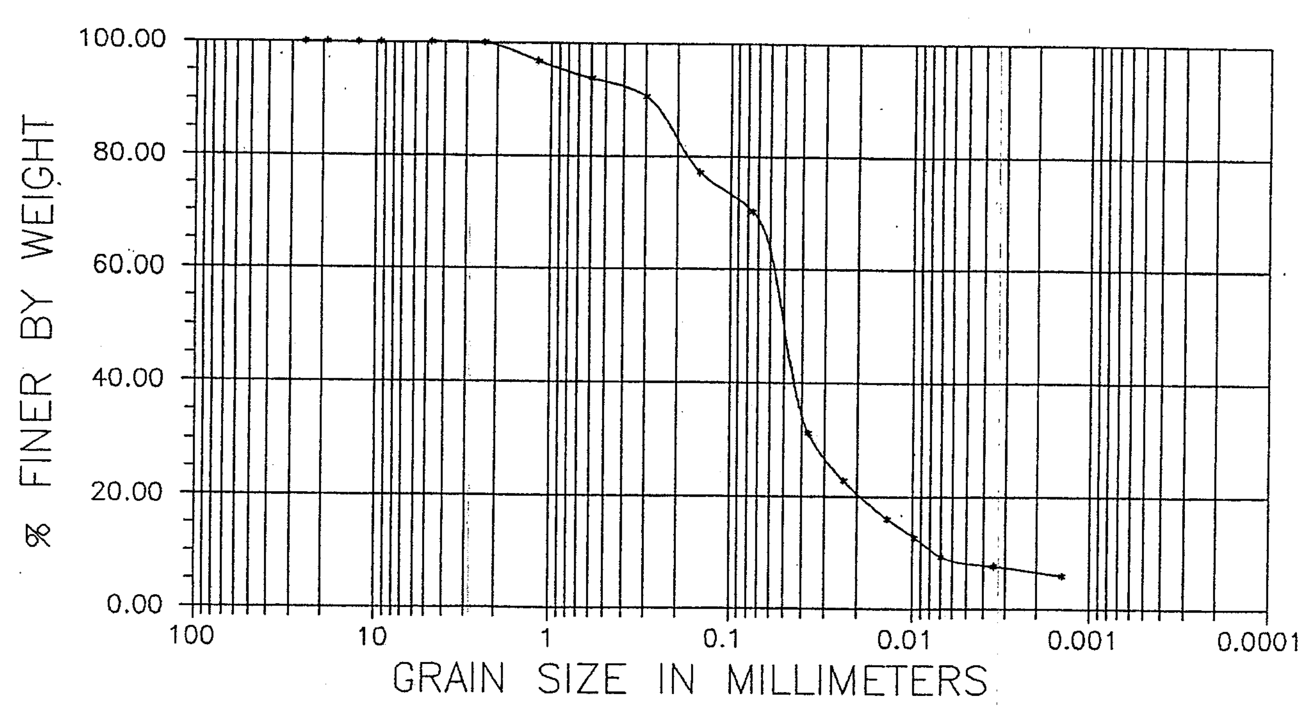
SAMPLE ID	PROFILE	CORE	HORIZON
16	17	1	1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 189

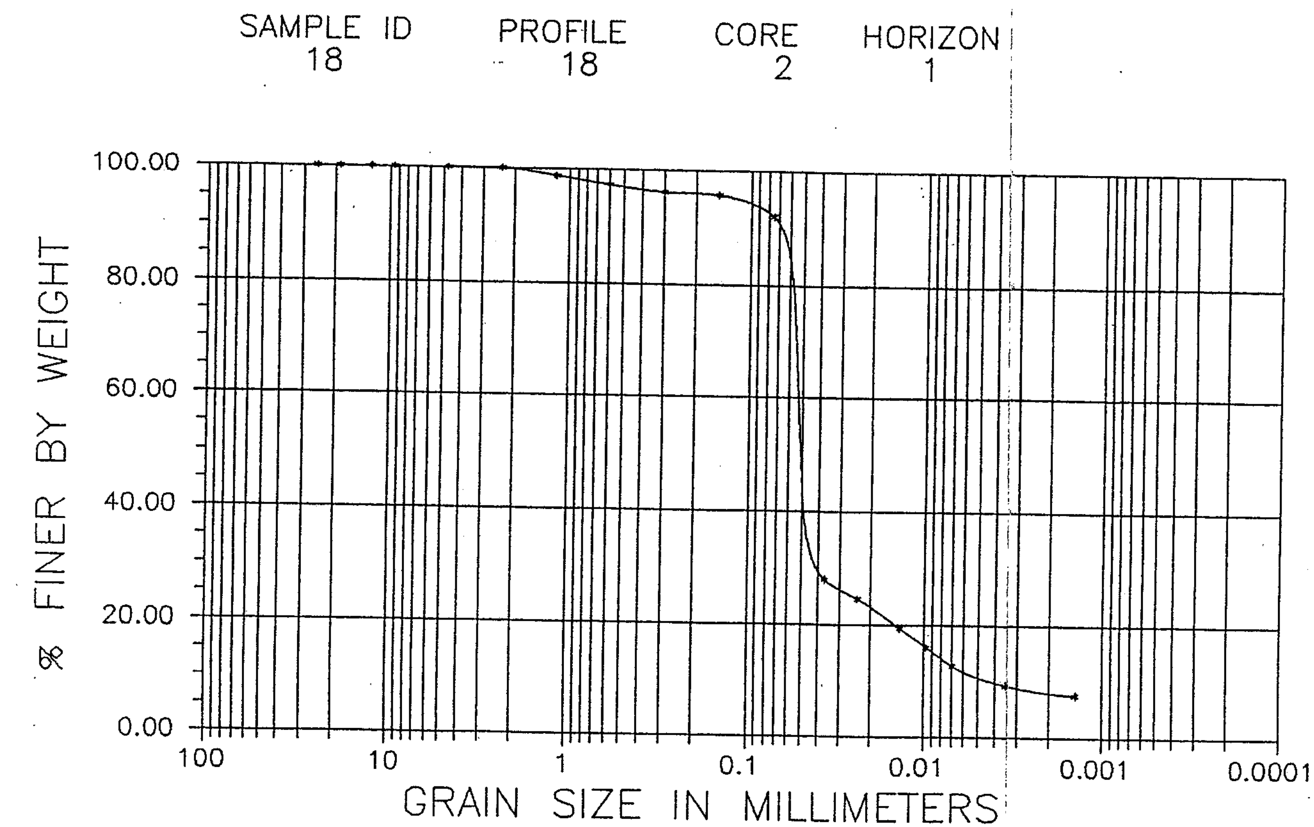
PROJECT NO. 9074-04

SAMPLE ID 17 | PROFILE 17 | CORE COMP | HORIZON 2



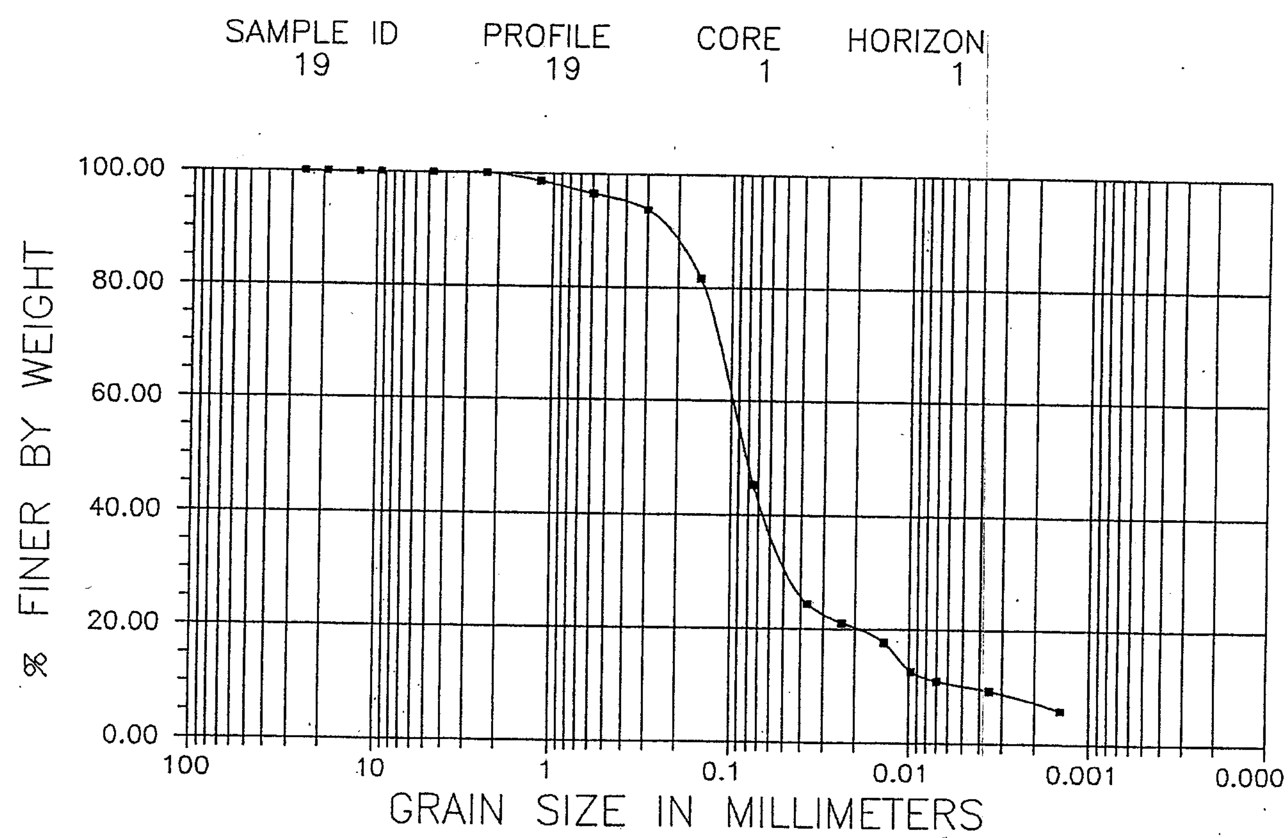
US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 190

PROJECT NO. 9074-04



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 191

PROJECT NO. 9074–04



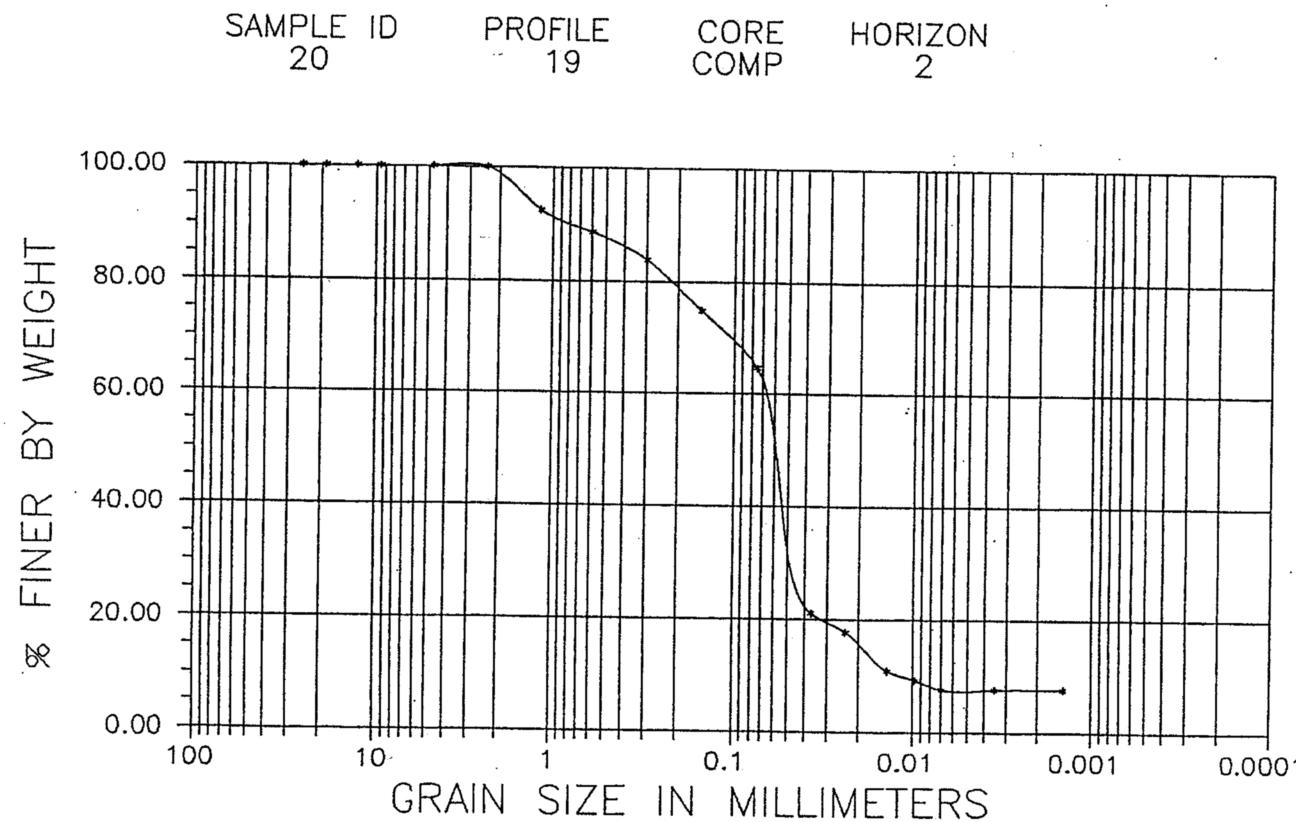
US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

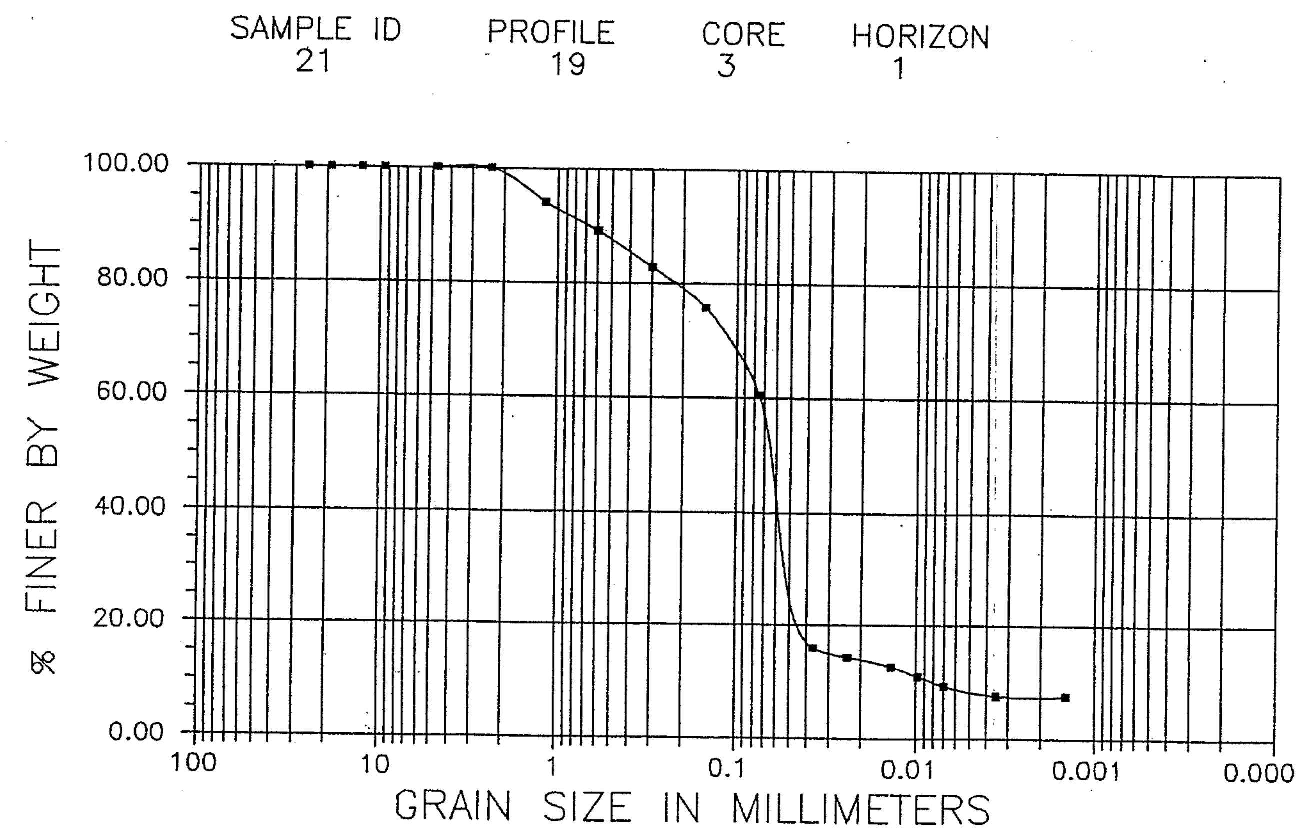
FIGURE NO. 192

PROJECT NO. 9074-04



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 193

PROJECT NO. 9074-04



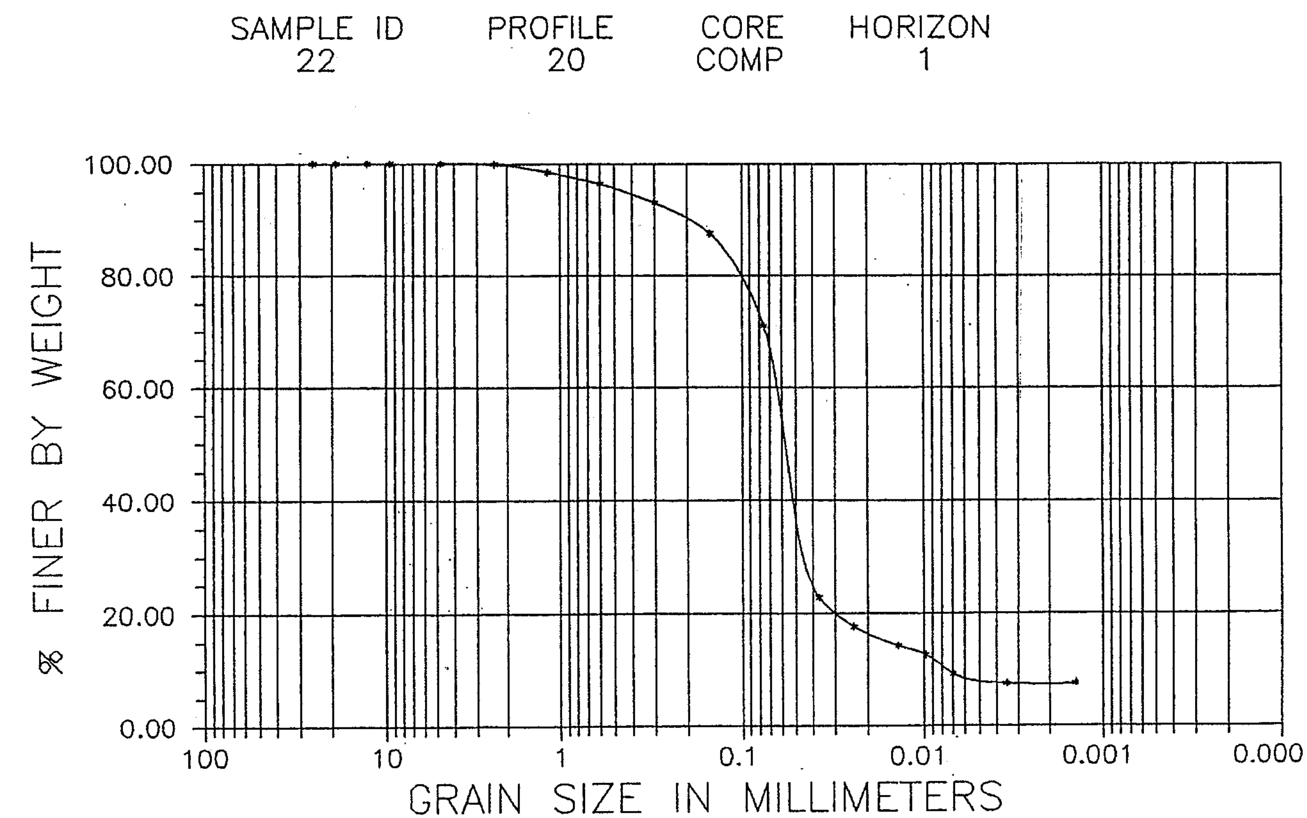
US—STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 194

PROJECT NO. 9074-04



US—STEEL
GARY, INDIANA

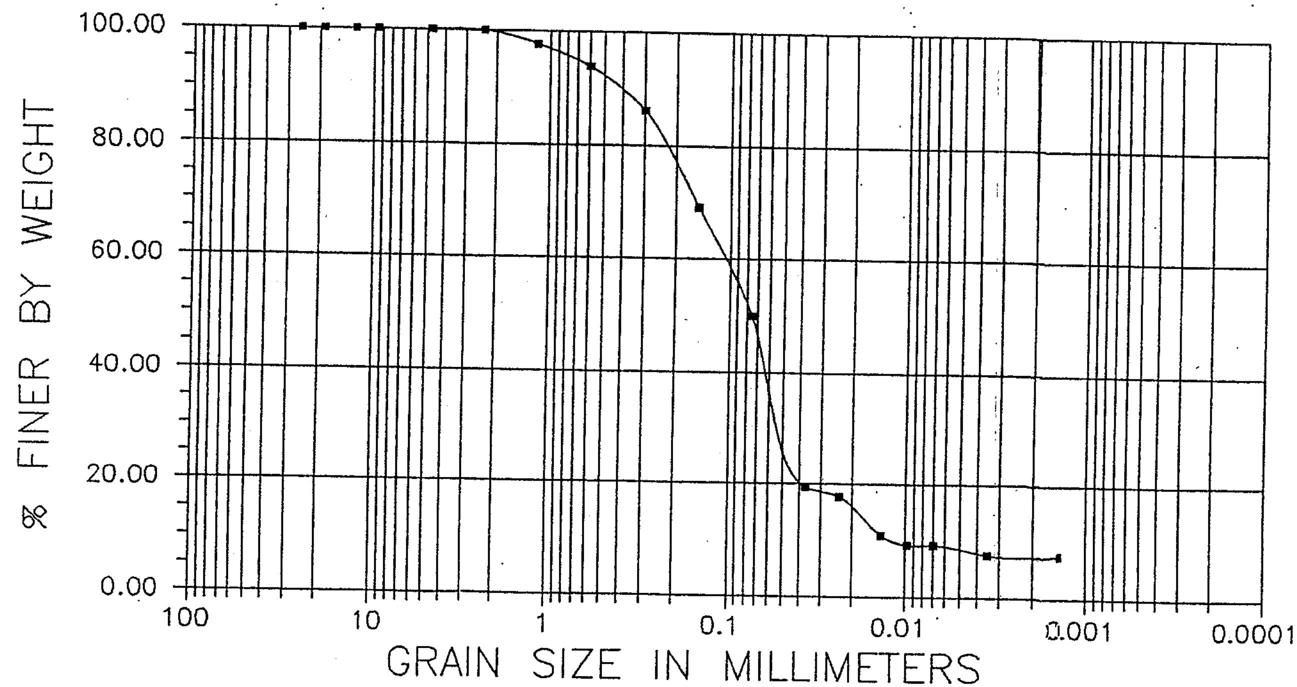
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 195

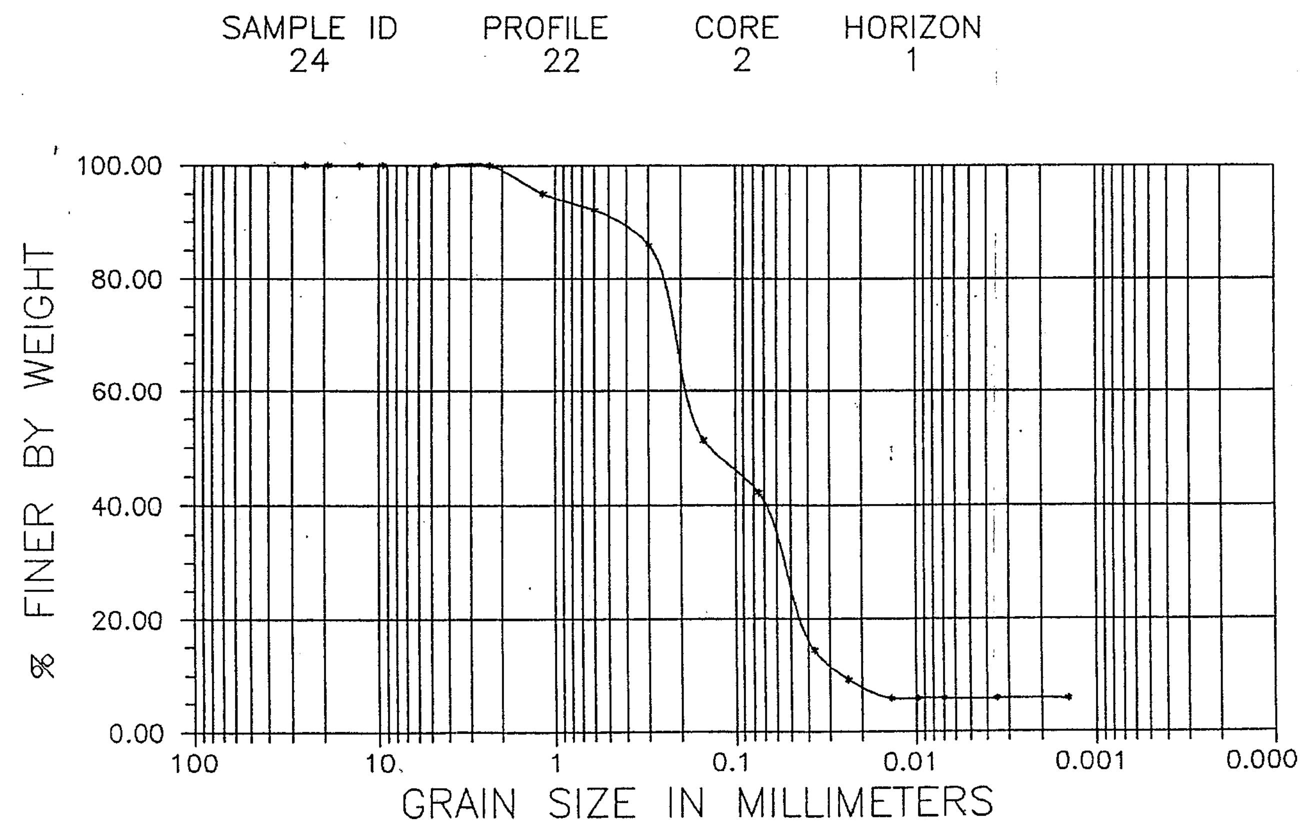
PROJECT NO. 9074—04

SAMPLE ID 23 | PROFILE 21 | CORE 2 | HORIZON 1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 196

PROJECT NO. 9074-04



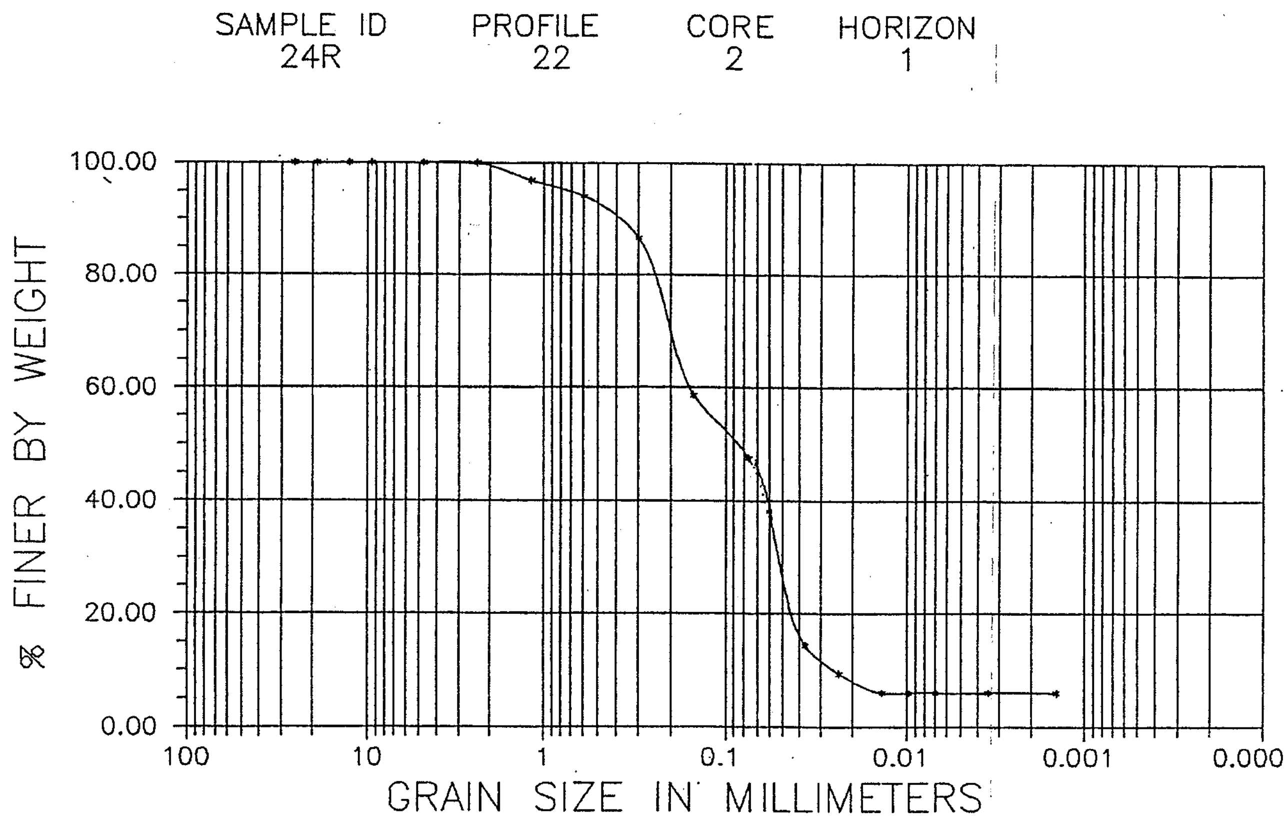
US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO.

FIGURE NO. 197

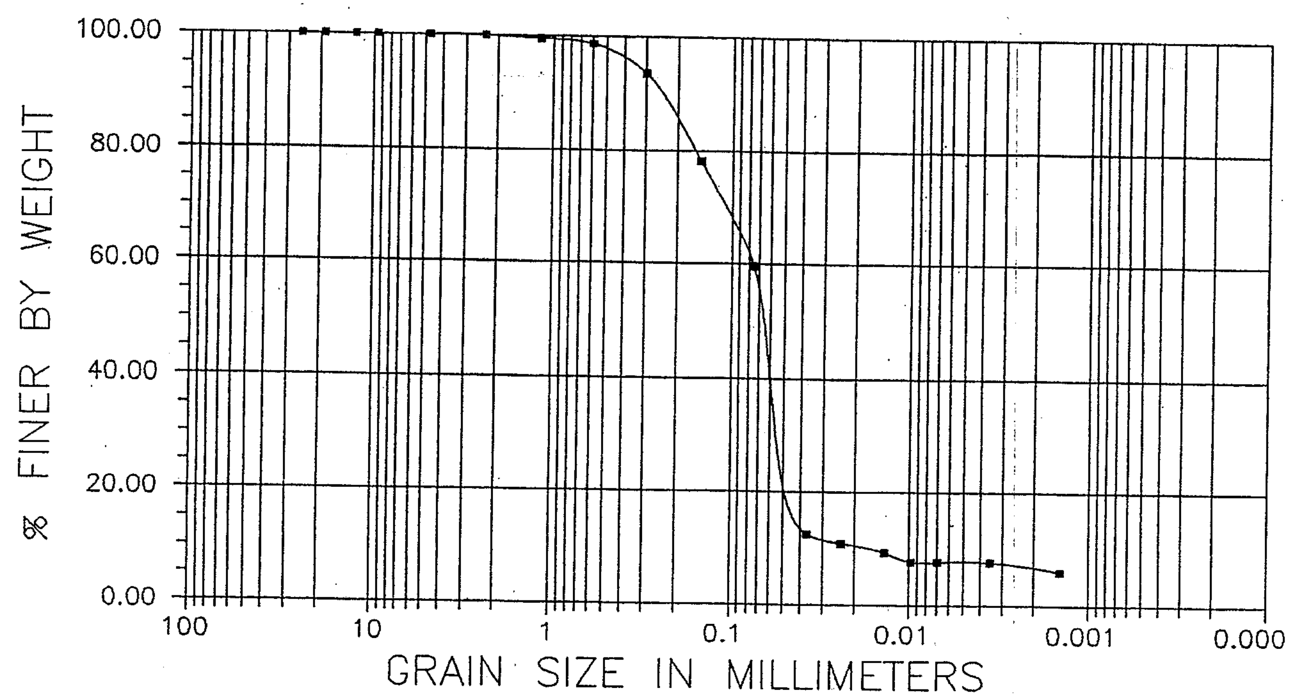
PROJECT NO. 9074-04



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 198

PROJECT NO. 9074-04

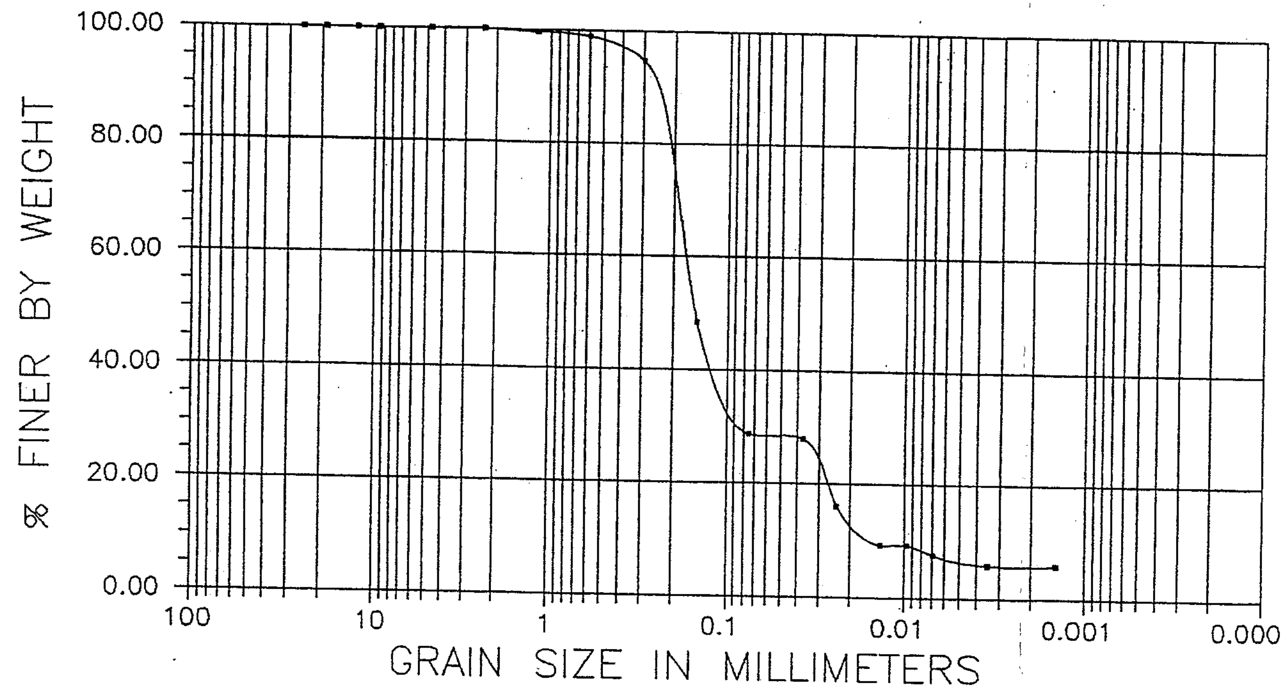
SAMPLE ID	PROFILE	CORE	HORIZON
25	23	1	1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 199

PROJECT NO. 9074-04

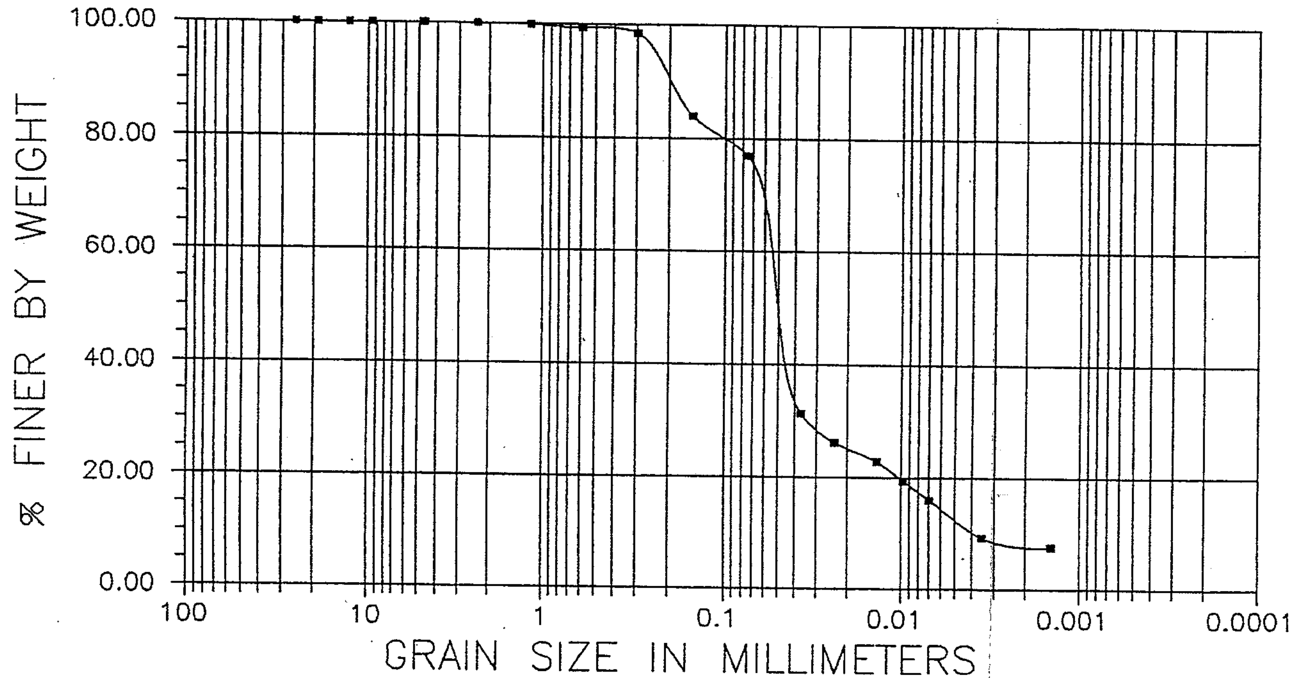
SAMPLE ID	PROFILE	CORE	HORIZON
26	23	COMP	2



US-STEEL
GARY, INDIANA
GRAIN SIZE DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 200

PROJECT NO. 9074-04

SAMPLE ID 27 | PROFILE 24 | CORE 2 | HORIZON 1



US-STEEL
GARY, INDIANA

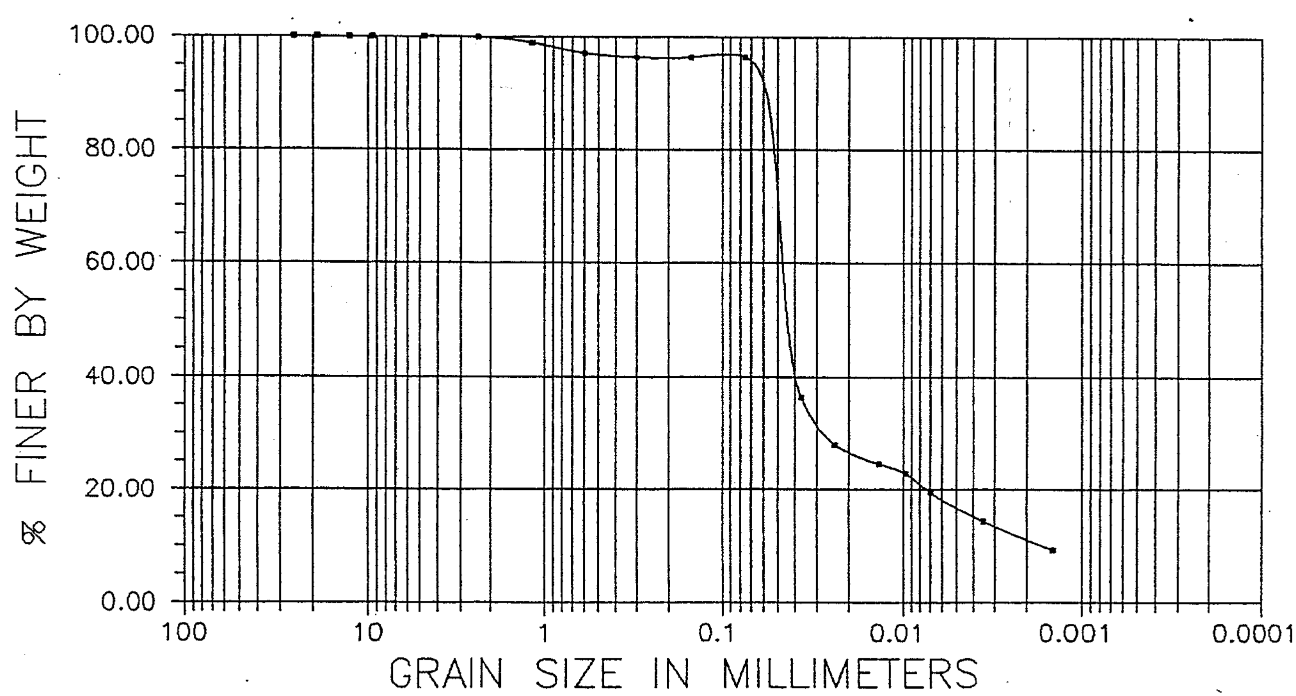
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 201

PROJECT NO. 9074-04

SAMPLE ID 28 | PROFILE 24 | CORE COMP | HORIZON 1



US-STEEL
GARY, INDIANA

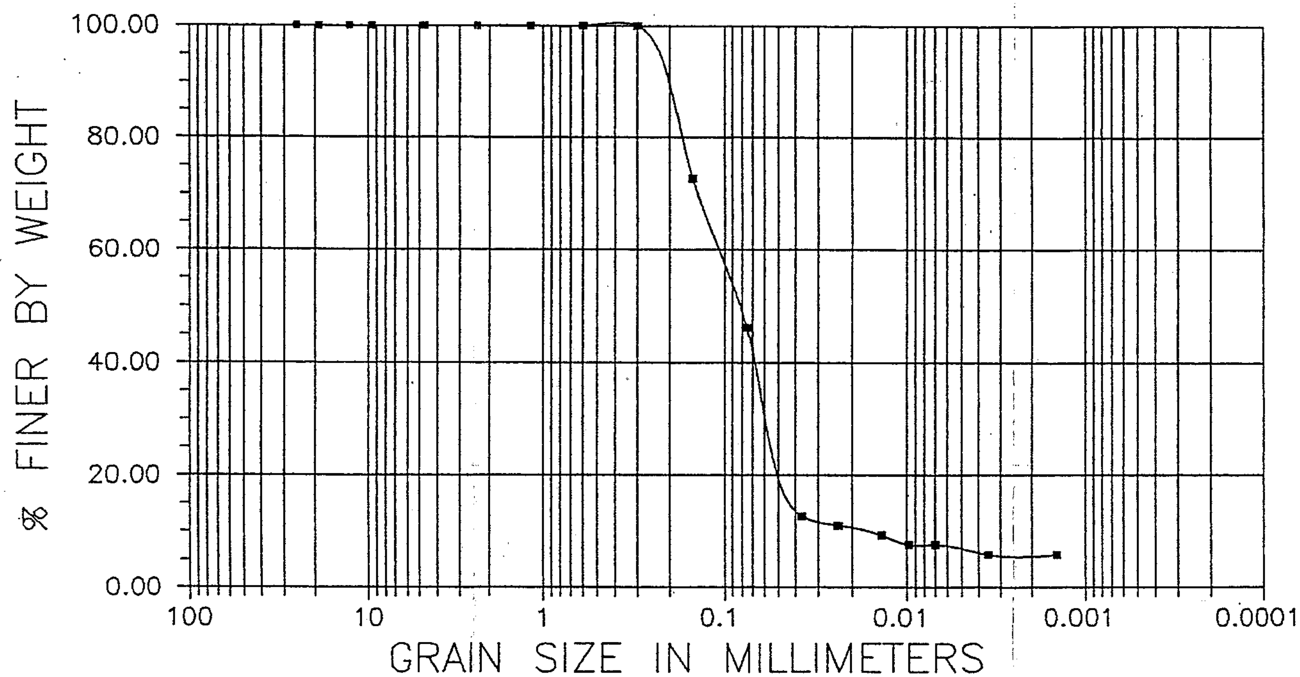
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 202

PROJECT NO. 9074-04

SAMPLE ID 29 | PROFILE 25 | CORE 1 | HORIZON 1



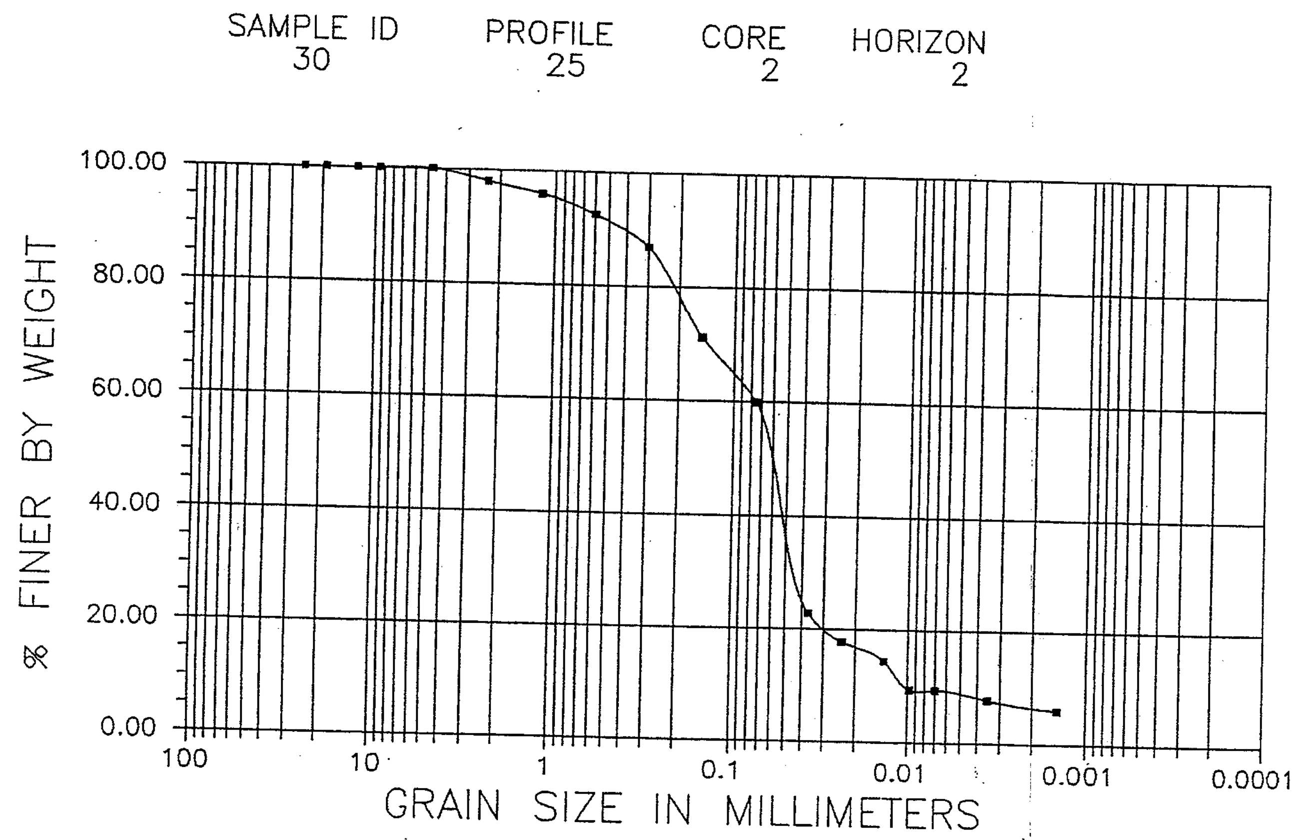
US—STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 203

PROJECT NO. 9074—04



US-STEEL
GARY, INDIANA

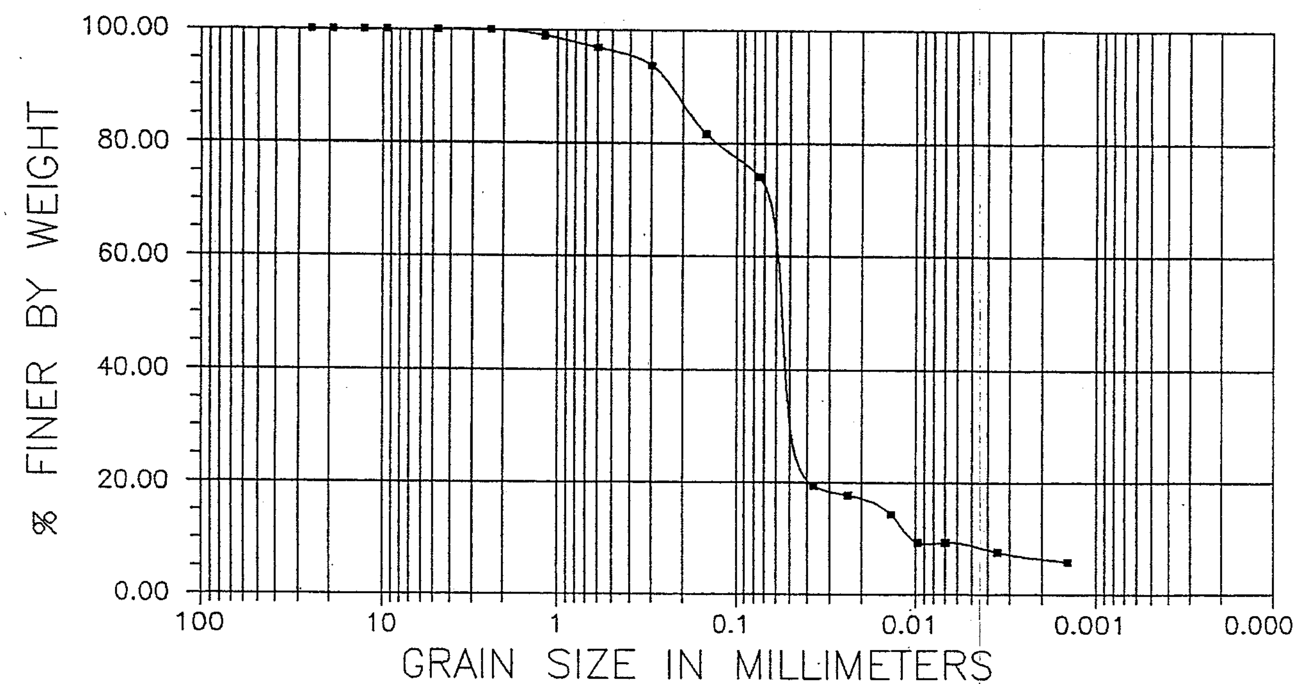
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 204

PROJECT NO. 9074-04

SAMPLE ID	PROFILE	CORE	HORIZON
30R	25	2	2



US-STEEL
GARY, INDIANA

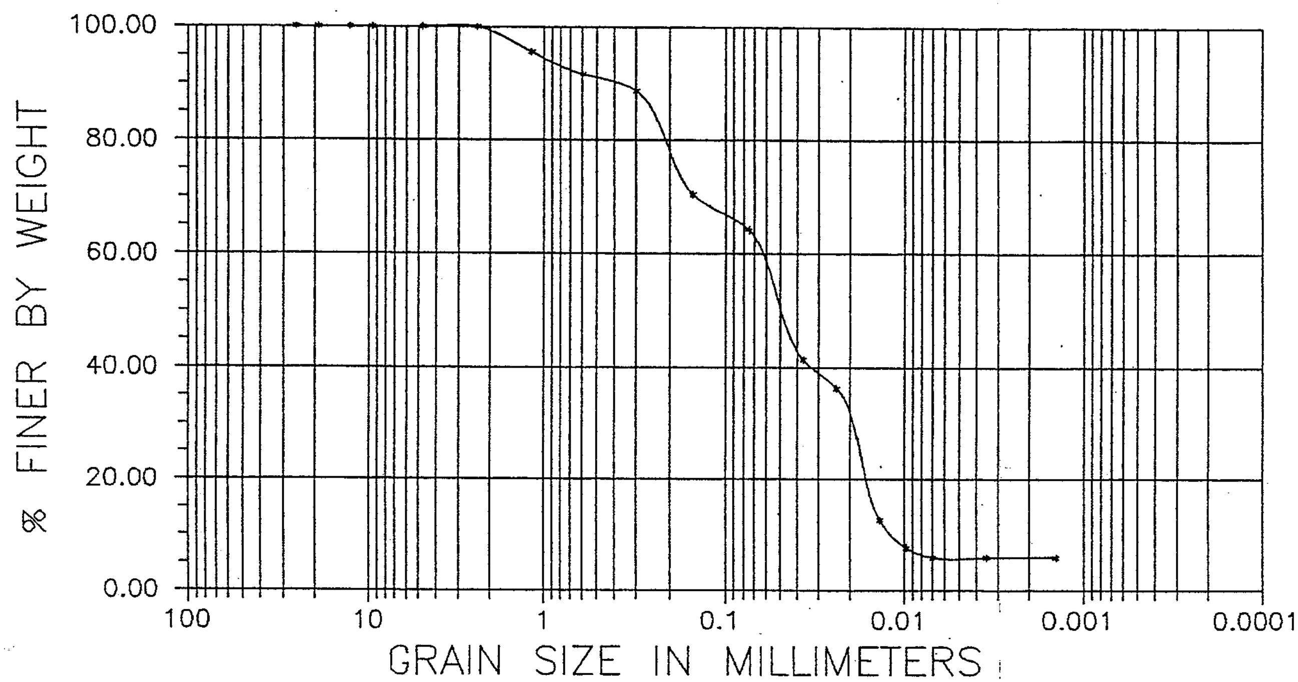
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 205

PROJECT NO. 9074-04

SAMPLE ID 31 PROFILE 26 CORE 1 HORIZON 2



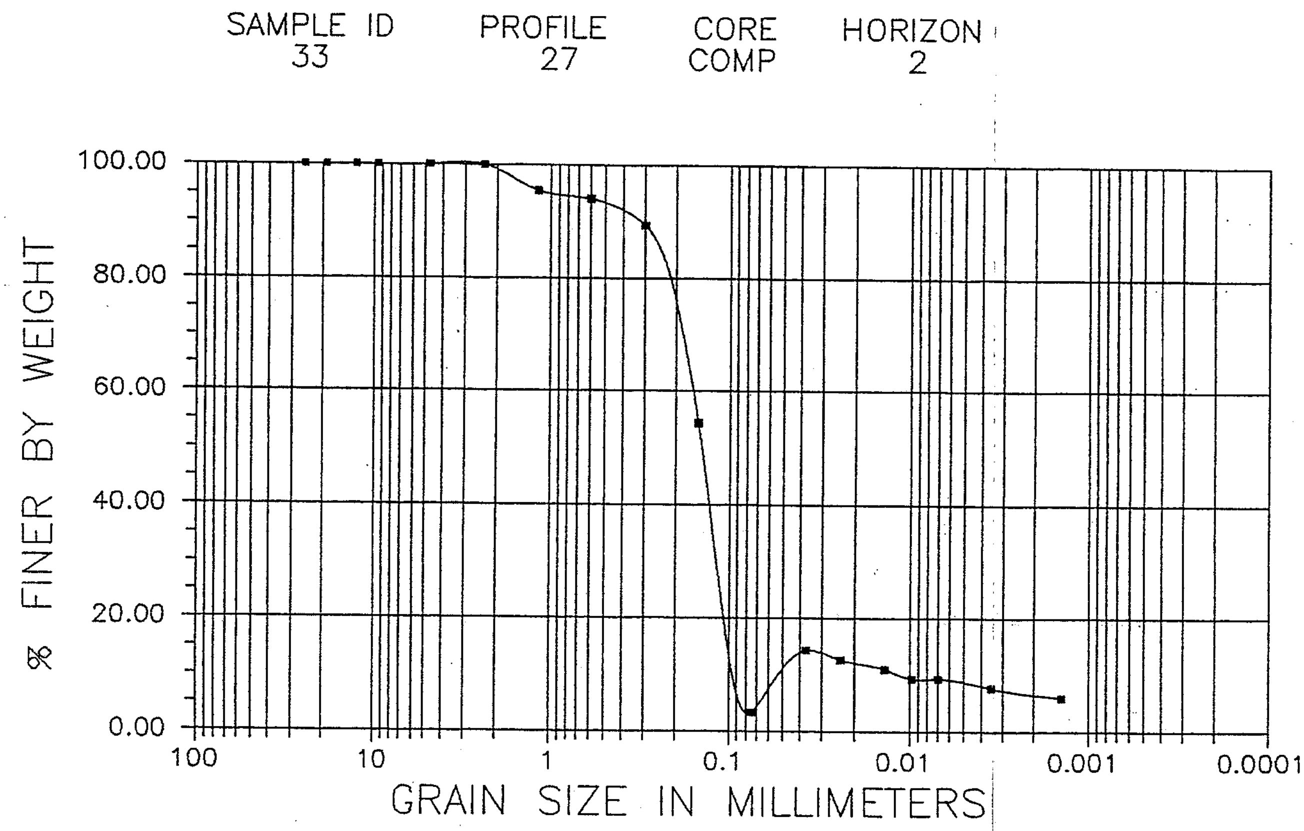
US-STEEL
GARY, INDIANA

GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 206

PROJECT NO. 9074-04



US–STEEL
GARY, INDIANA

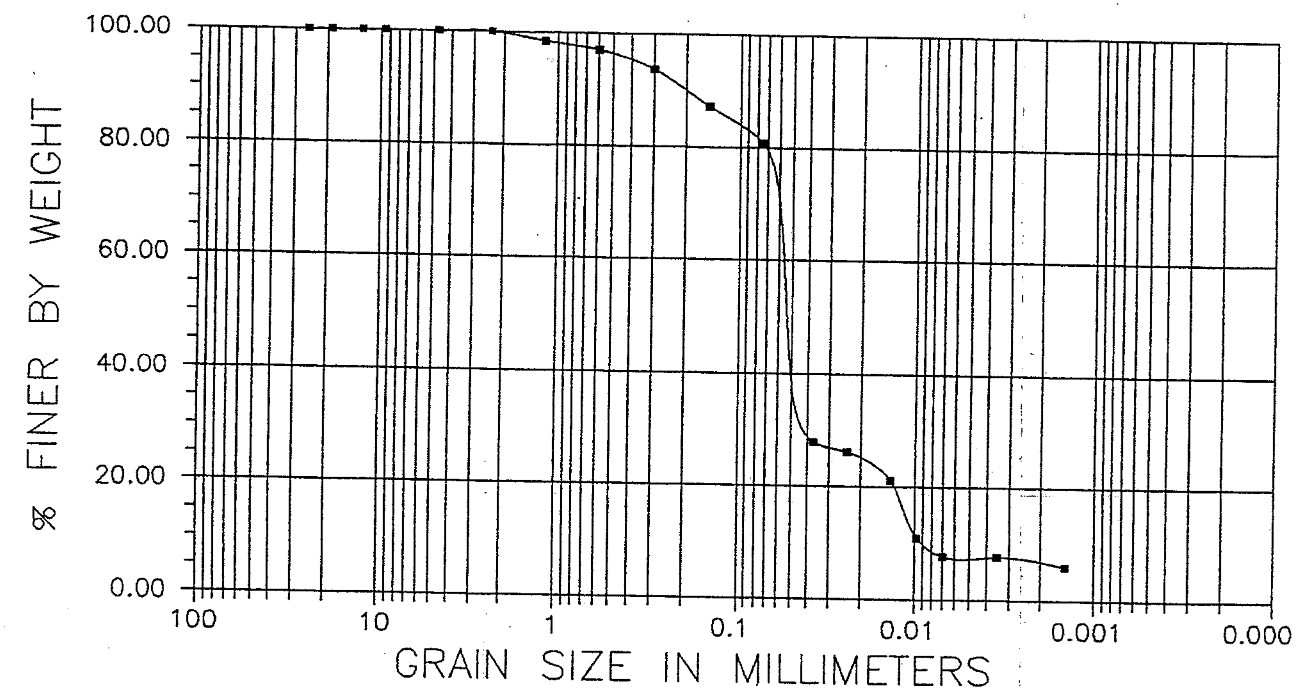
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 208

PROJECT NO. 9074-04

SAMPLE ID 34 | PROFILE 28 | CORE COMP | HORIZON 1



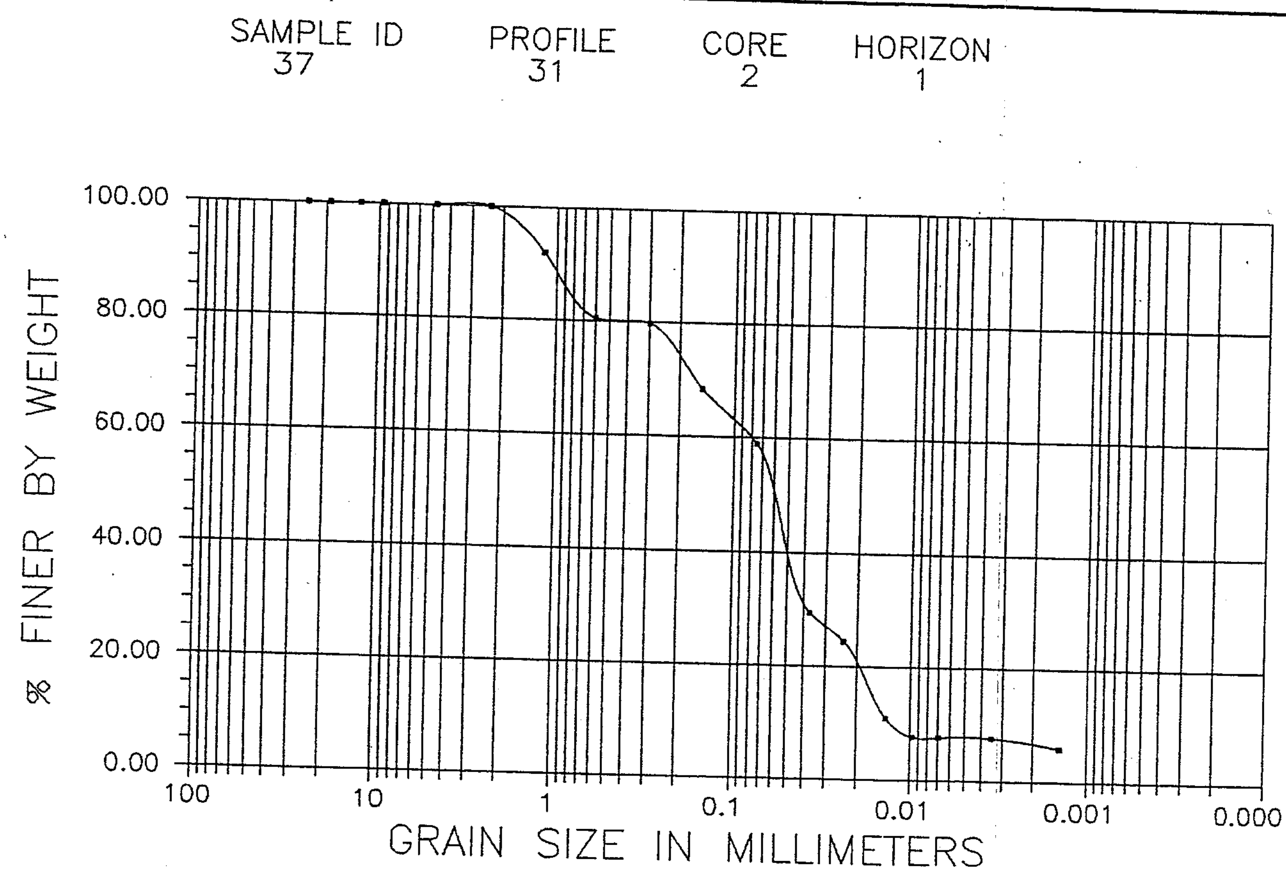
US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 209

PROJECT NO. 9074-04



US—STEEL
GARY, INDIANA

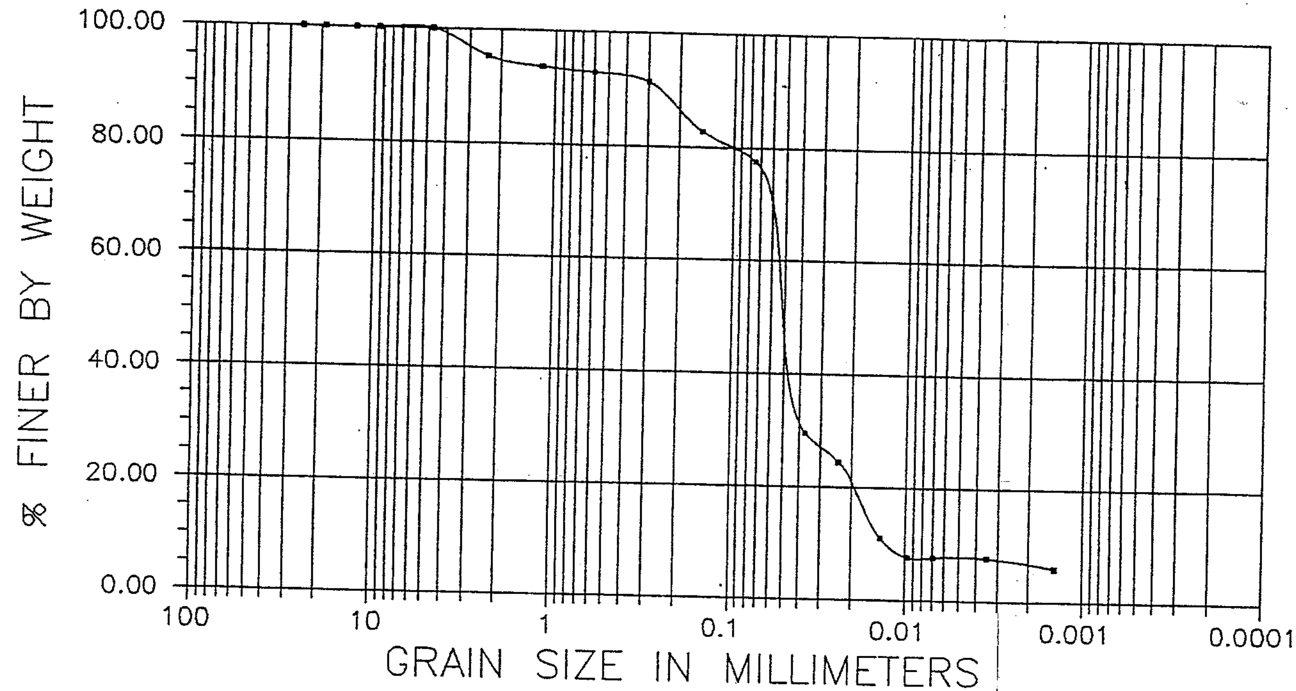
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 211

PROJECT NO. 9074-04

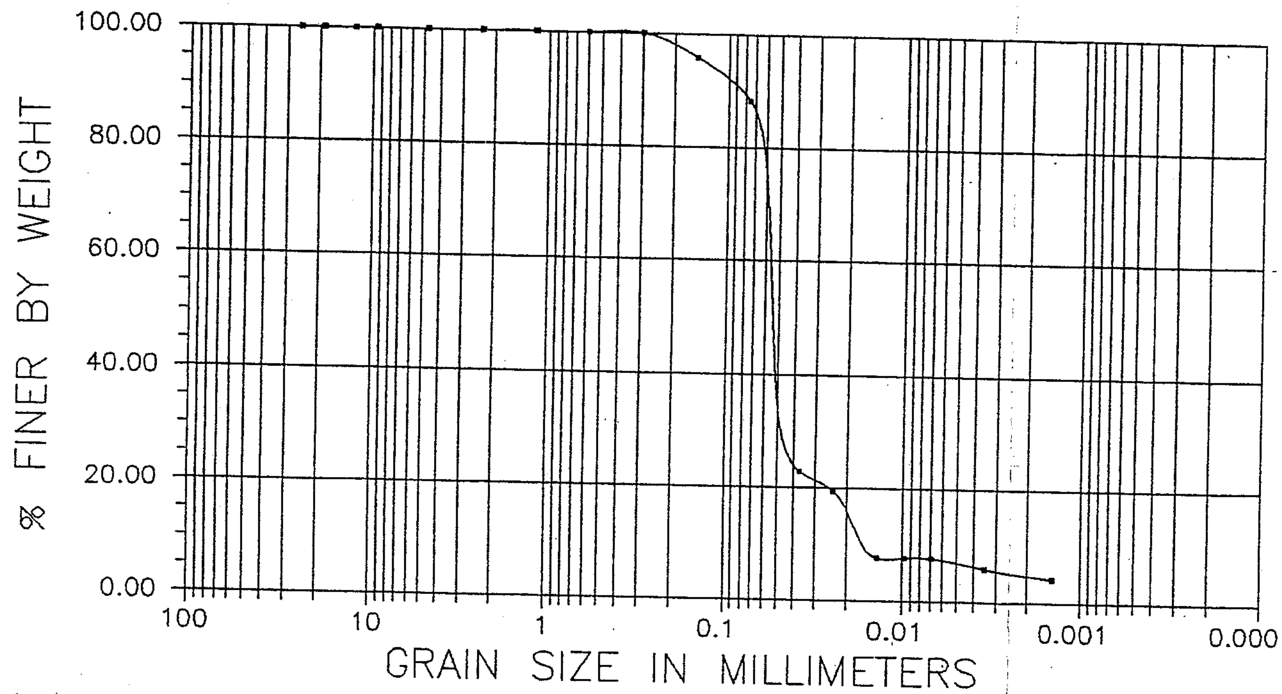
SAMPLE ID 37R | PROFILE 31 | CORE 2 | HORIZON 1



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 212

PROJECT NO. 9074–04

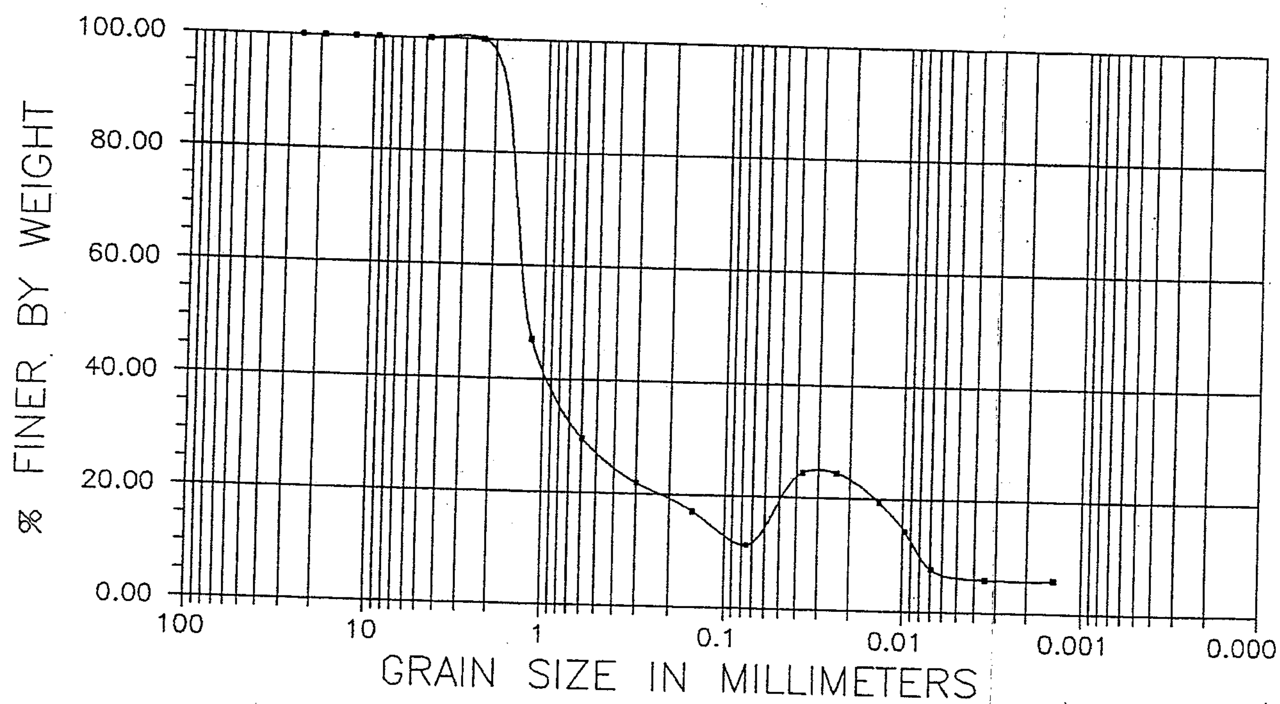
SAMPLE ID	PROFILE	CORE	HORIZON
38	31	COMP	1



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 213

PROJECT NO. 9074–04

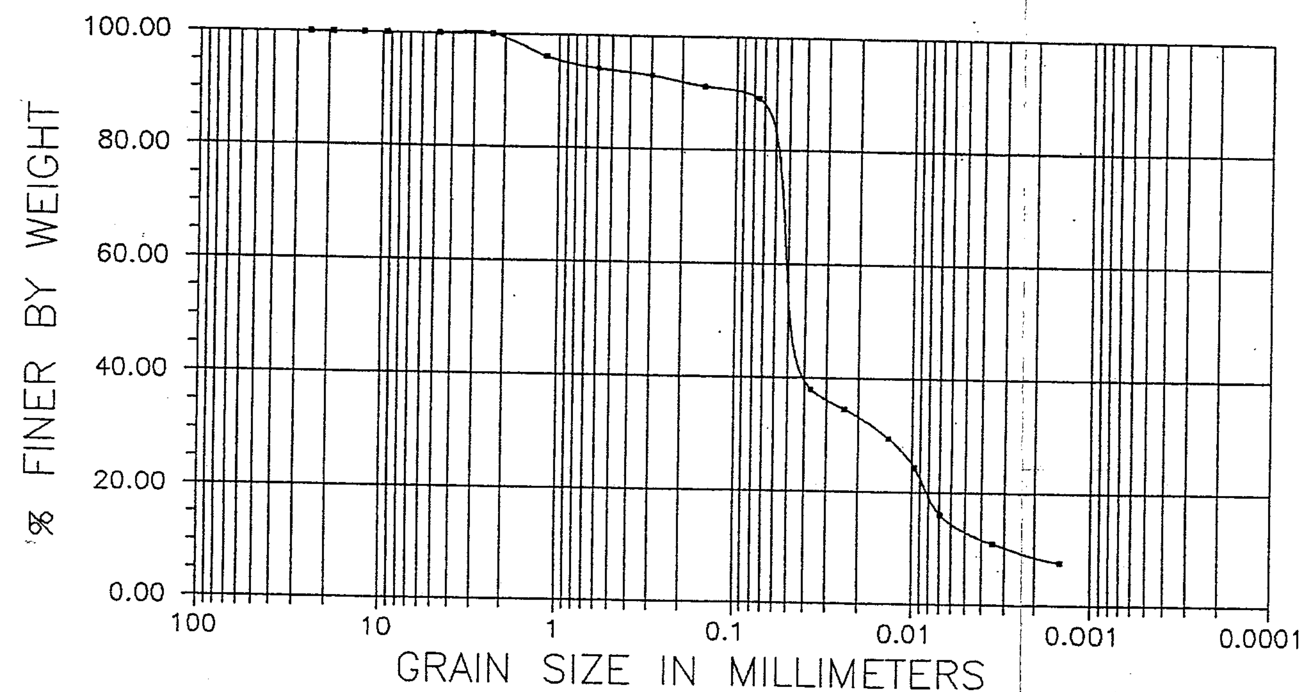
SAMPLE ID	PROFILE	CORE	HORIZON
39	32	COMP	1



PROJECT NO. 9074-04

US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 214

SAMPLE ID 40 | PROFILE 32 | CORE COMP | HORIZON 2



US-STEEL
GARY, INDIANA

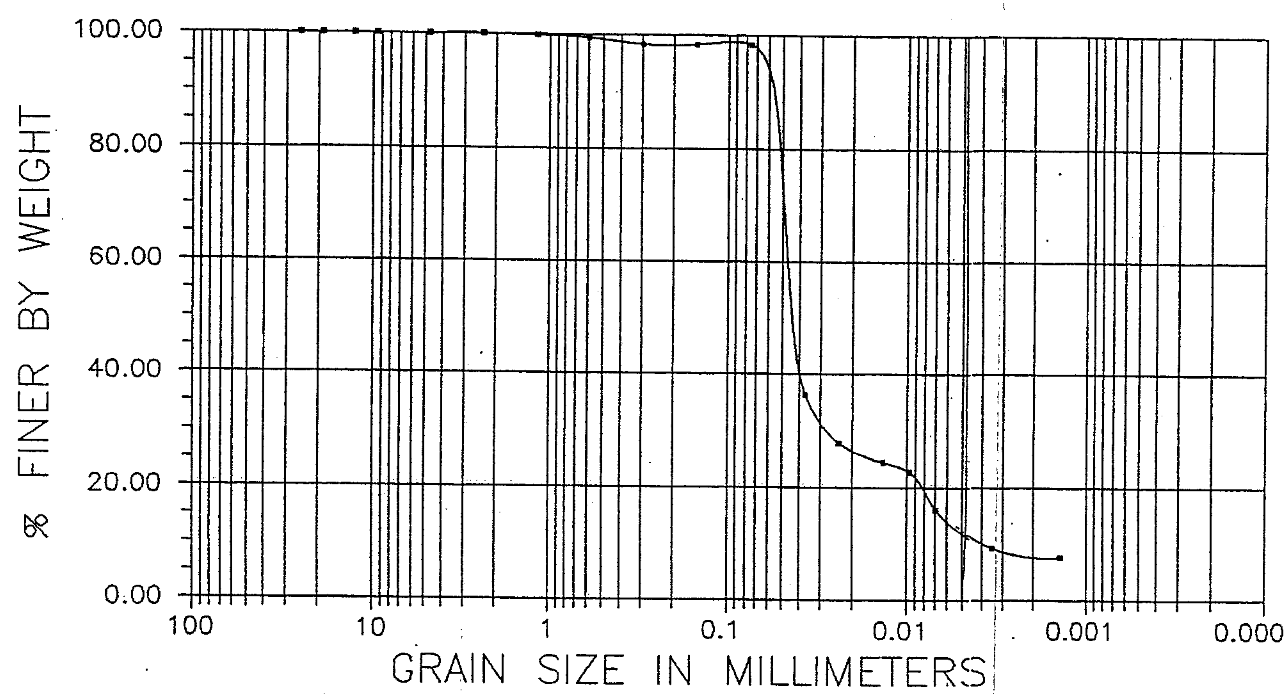
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 215

PROJECT NO. 9074-04

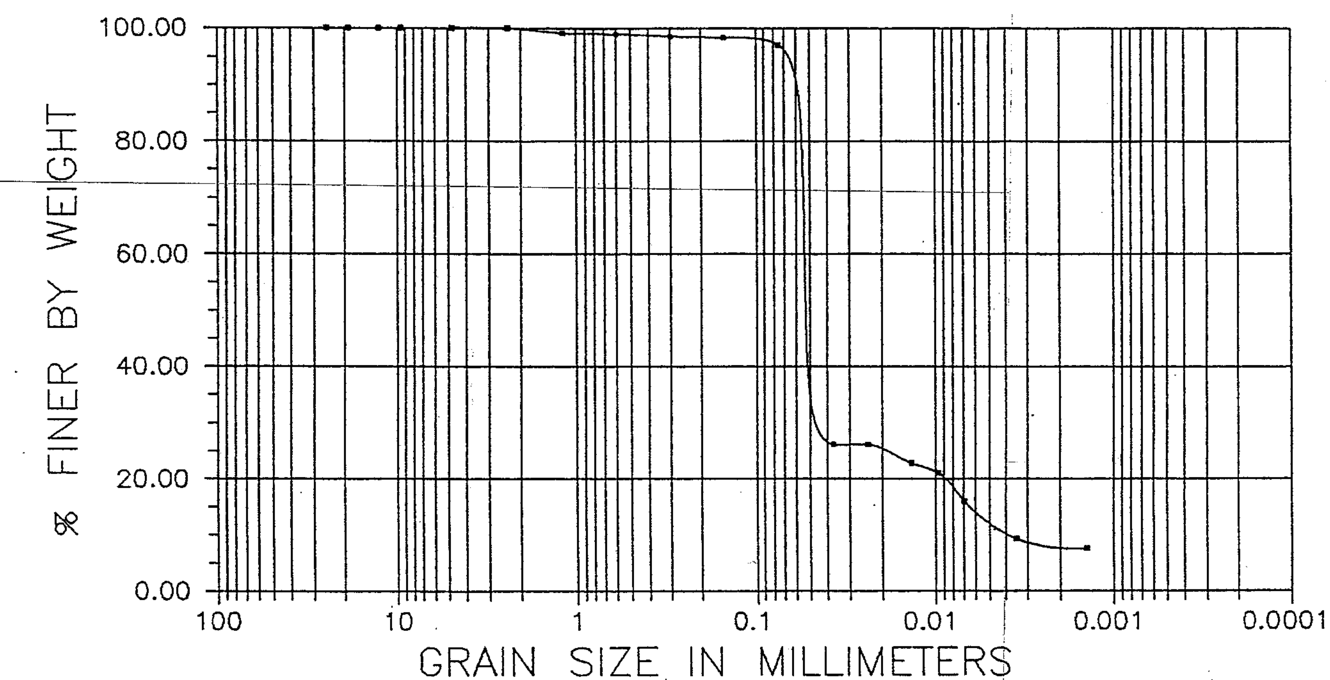
SAMPLE ID	PROFILE	CORE	HORIZON
41	33	1	1



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 216

PROJECT NO. 9074–04

SAMPLE ID 41R | PROFILE 33 | CORE 1 | HORIZON 1



US–STEEL
GARY, INDIANA

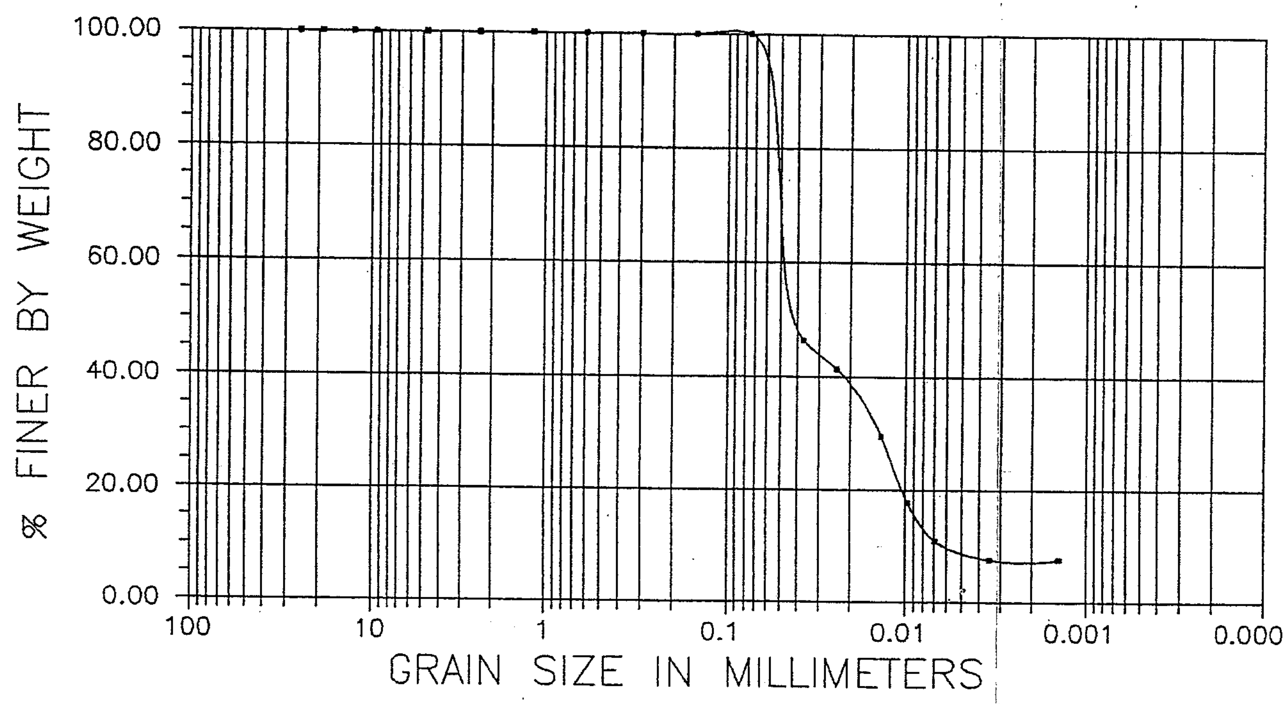
GRAIN SIZE
DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 217

PROJECT NO. 9074–04

SAMPLE ID 42 | PROFILE 33 | CORE 1 | HORIZON 2



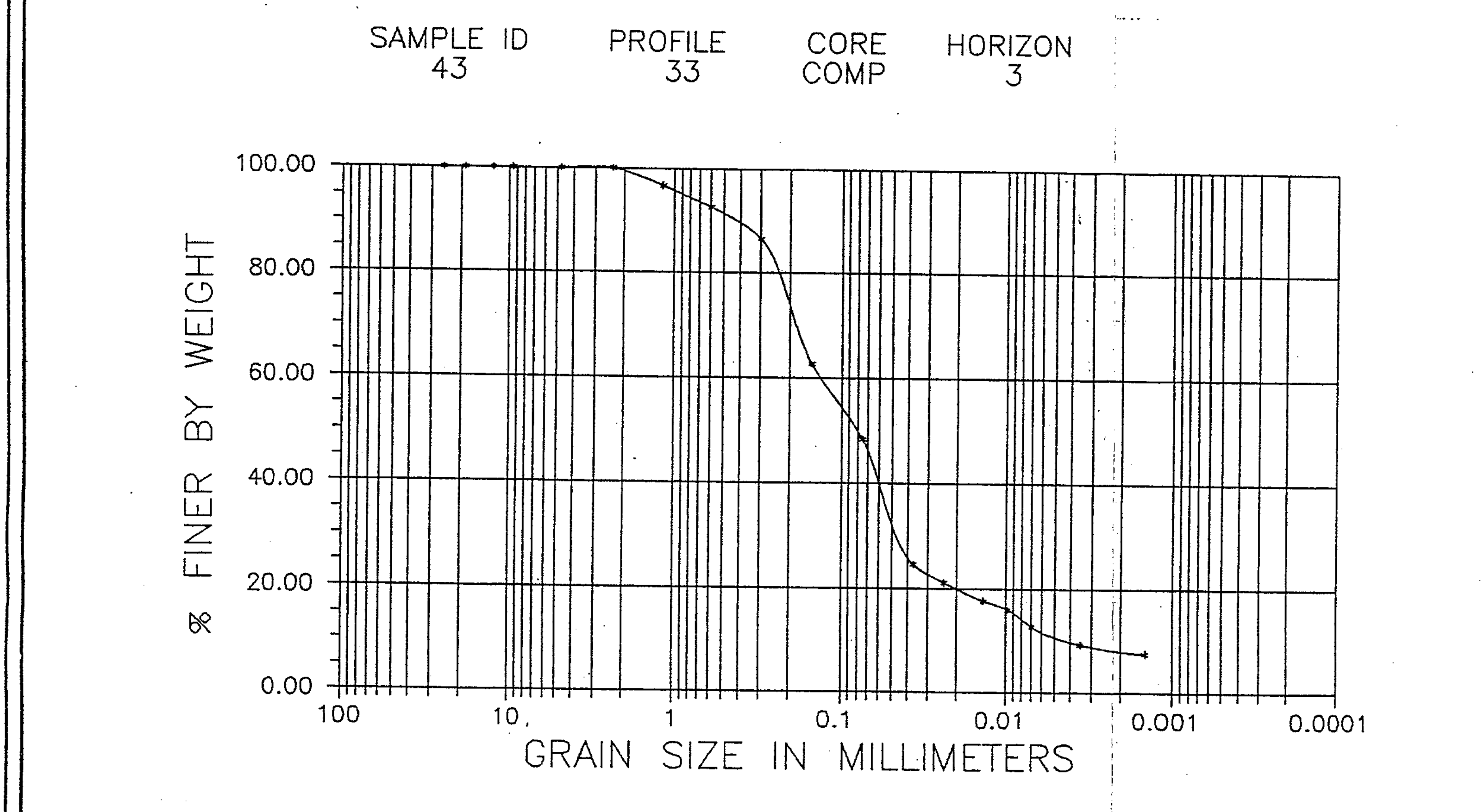
US-STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

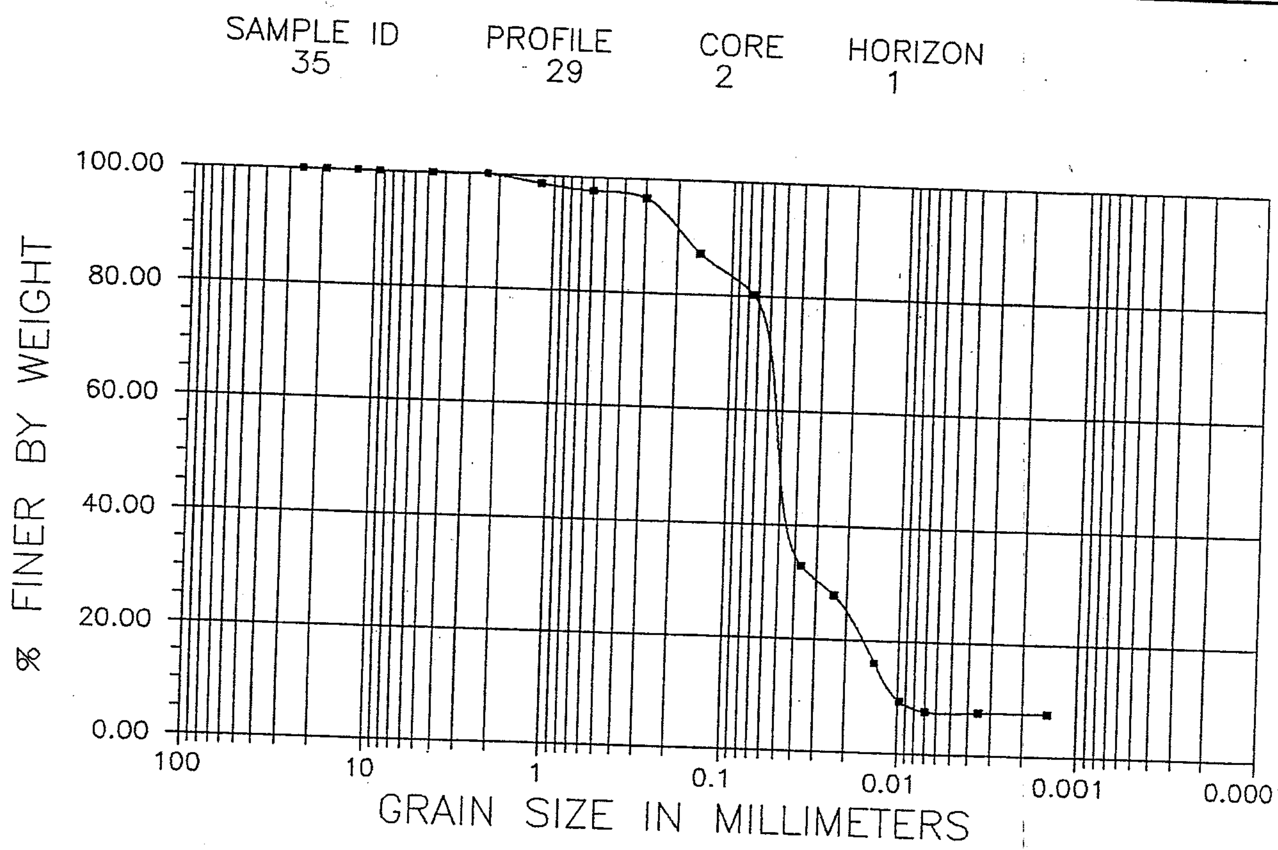
FIGURE NO. 218

PROJECT NO. 9074-04



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO.:219

PROJECT NO. 9074-04



US-STEEL
GARY, INDIANA

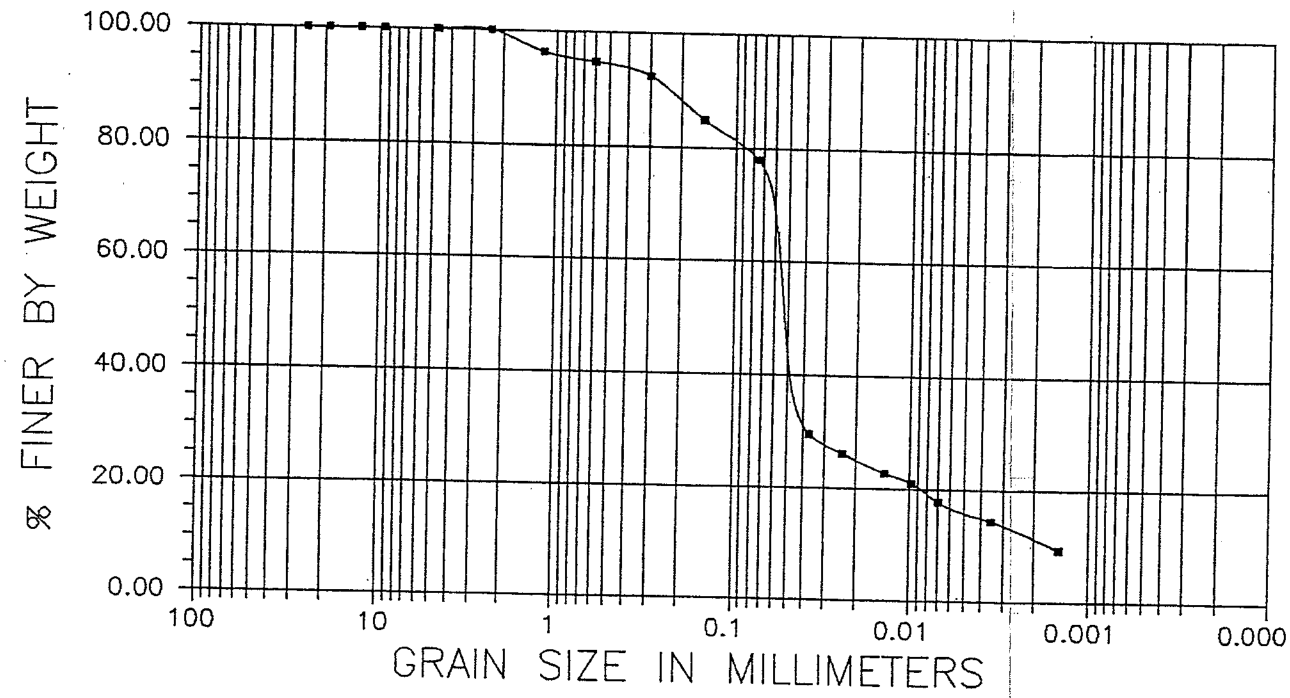
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 210

PROJECT NO. 9074-04

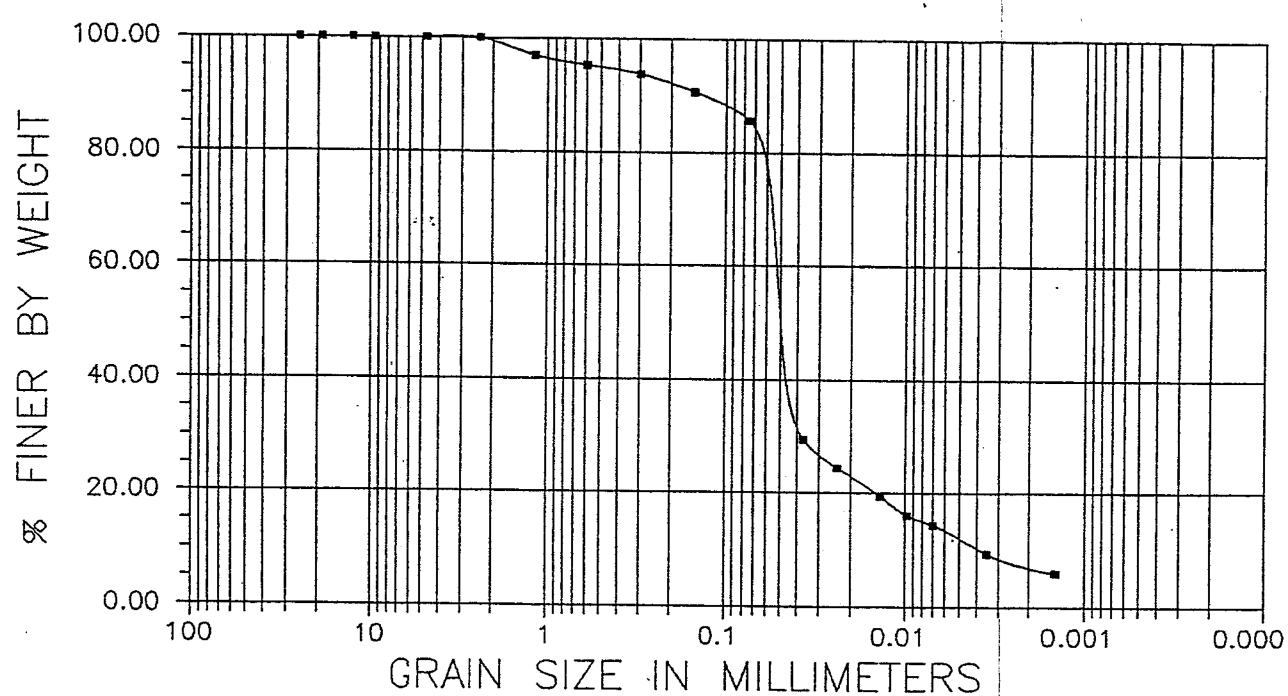
SAMPLE ID 44 | PROFILE 34 | CORE 2 | HORIZON 3



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 220.

PROJECT NO. 9074–04

SAMPLE ID 45 | PROFILE 35 | CORE 3 | HORIZON 1



US—STEEL
GARY, INDIANA

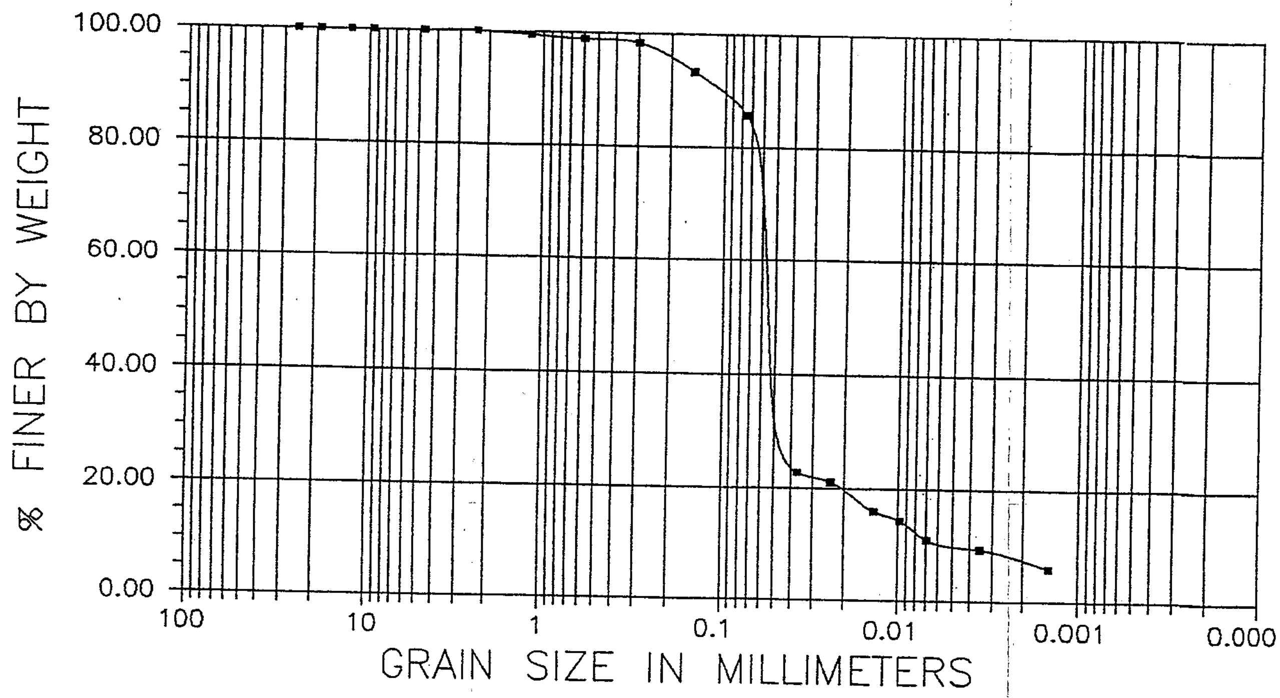
GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 221

PROJECT NO. 9074-04

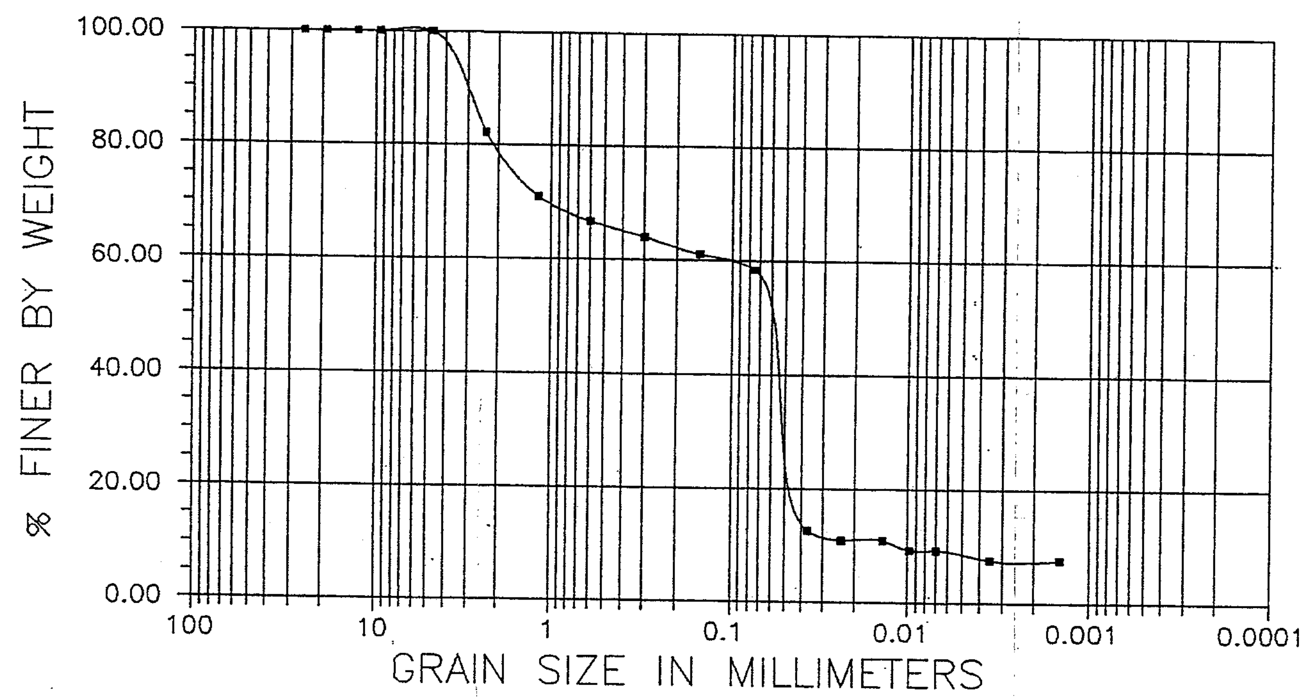
SAMPLE ID 46 | PROFILE 35 | CORE COMP | HORIZON 2



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 222

PROJECT NO. 9074-04

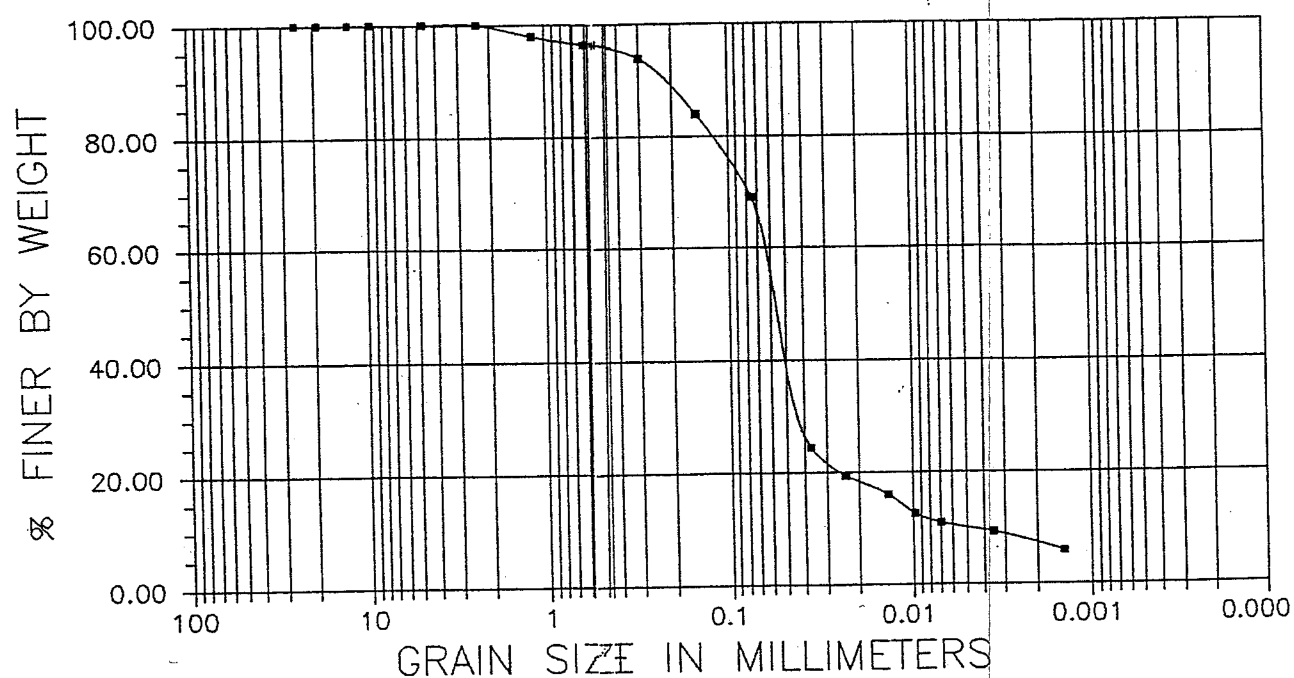
SAMPLE ID 47 | PROFILE 35 | CORE COMP | HORIZON 3



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 223

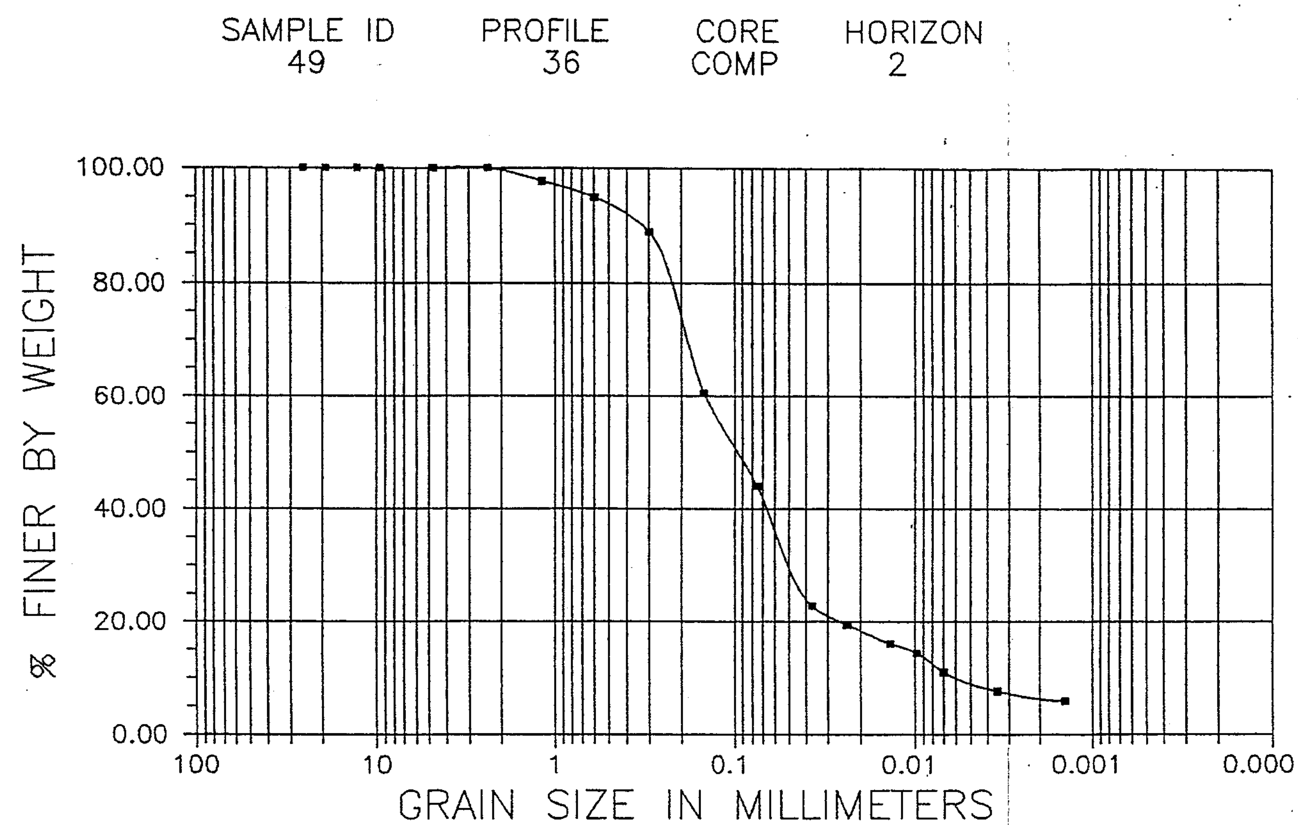
PROJECT NO. 9074-04

SAMPLE ID 48 | PROFILE 36 | CORE COMP | HORIZON 1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO.
FIGURE NO. 224

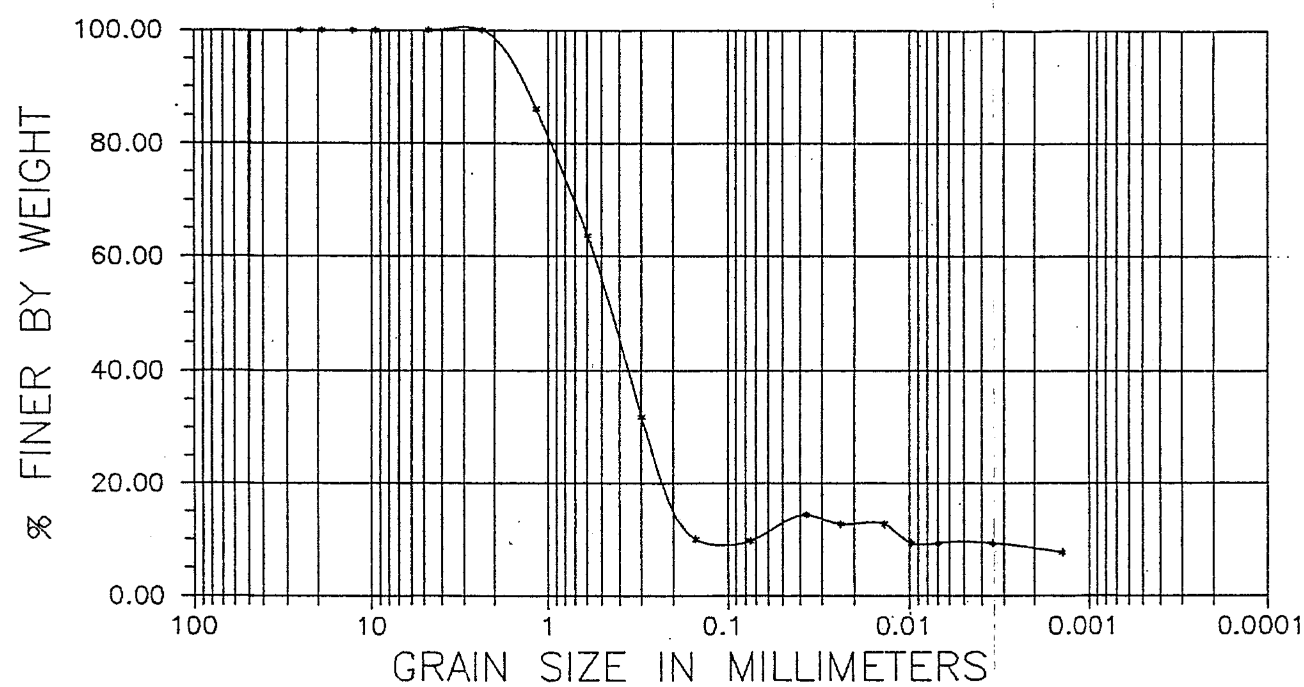
PROJECT NO. 9074-04



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 225

PROJECT NO. 9074–04

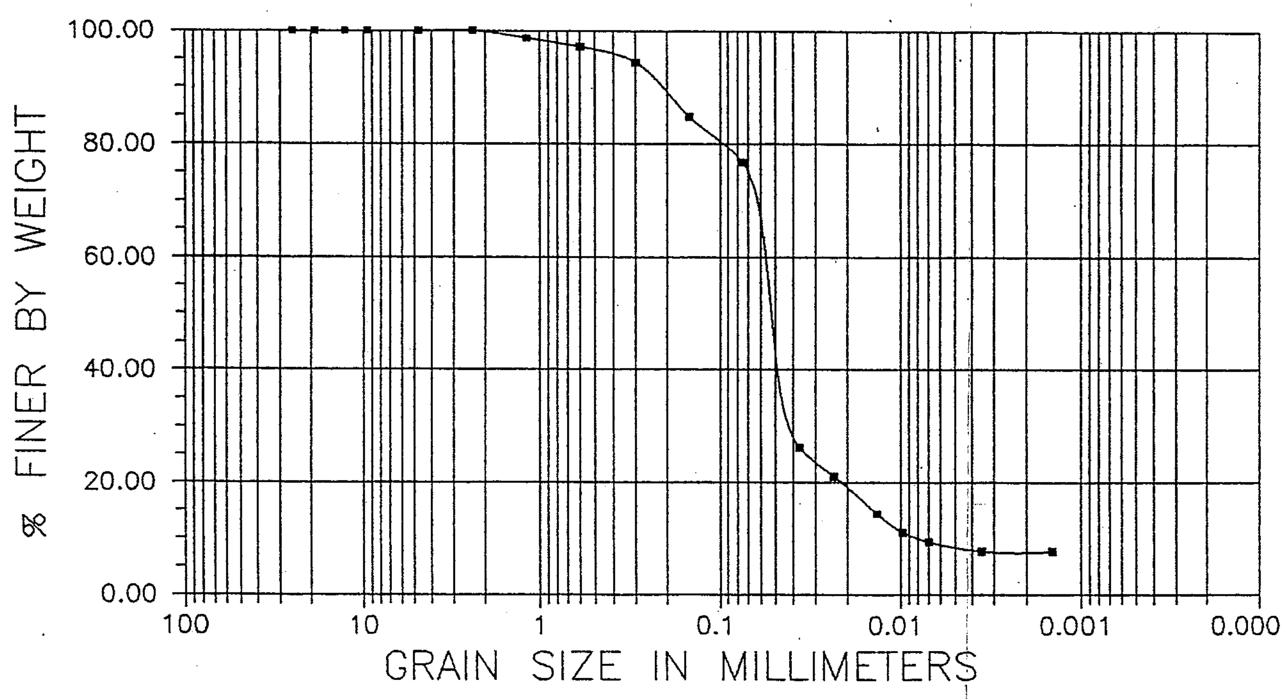
SAMPLE ID 50 | PROFILE 6 | CORE 2 | HORIZON 2



US-STEEL
GARY, INDIANA
GRAIN SIZE DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 226

PROJECT NO. 9074-04

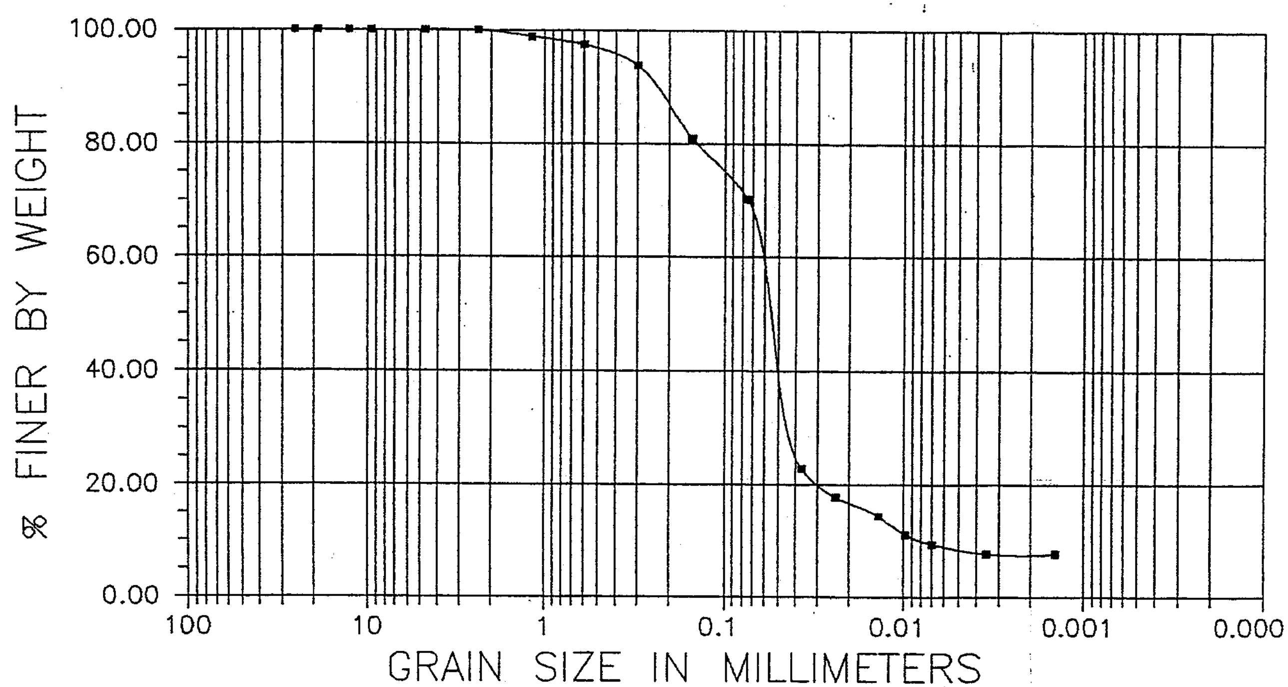
SAMPLE ID 51 | PROFILE 21 | CORE COMP | HORIZON 1



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 227

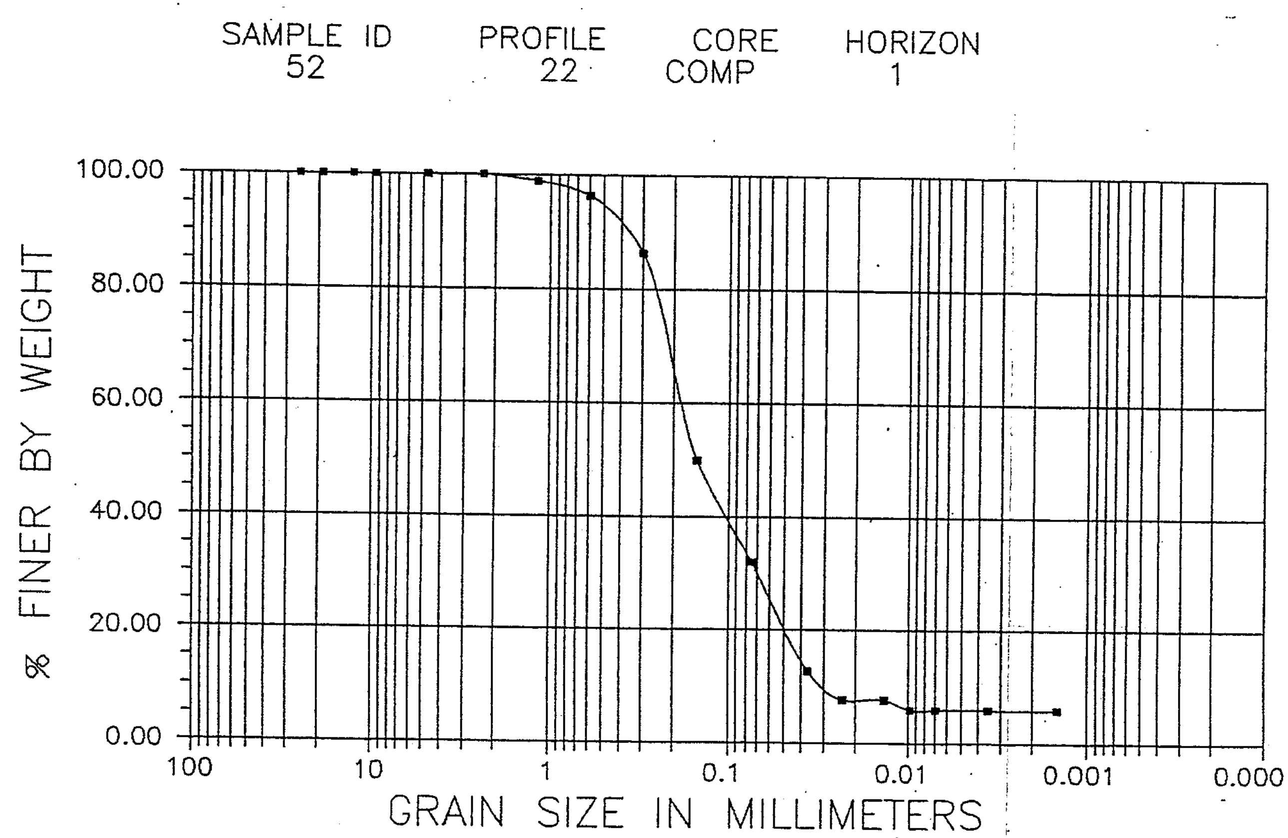
PROJECT NO. 9074–04

SAMPLE ID	PROFILE	CORE	HORIZON
51R	21	COMP	1



US-STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 228

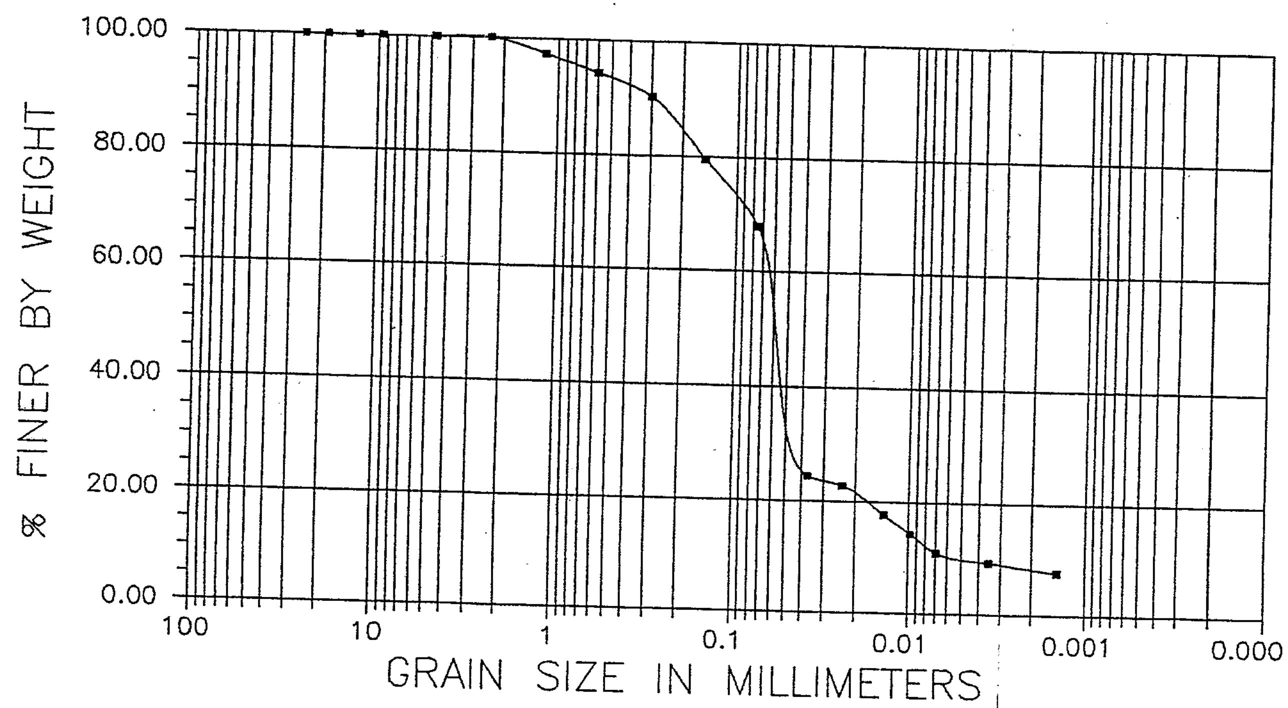
PROJECT NO. 9074-04



US–STEEL
GARY, INDIANA
GRAIN SIZE
DISTRIBUTION CURVE
FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO
FIGURE NO. 229

PROJECT NO. 9074–04

SAMPLE ID 54 | PROFILE 34 | CORE 2 | HORIZON 2



US—STEEL
GARY, INDIANA

GRAIN SIZE DISTRIBUTION CURVE

FLOYD BROWNE ASSOCIATES, INC.
HYDROGEOLOGICAL SERVICES
MARION, OHIO

FIGURE NO. 230

PROJECT NO. 9074-04

APPENDIX B

DESIGN CALCULATIONS FOR THE GAS COLLECTION SYSTEM

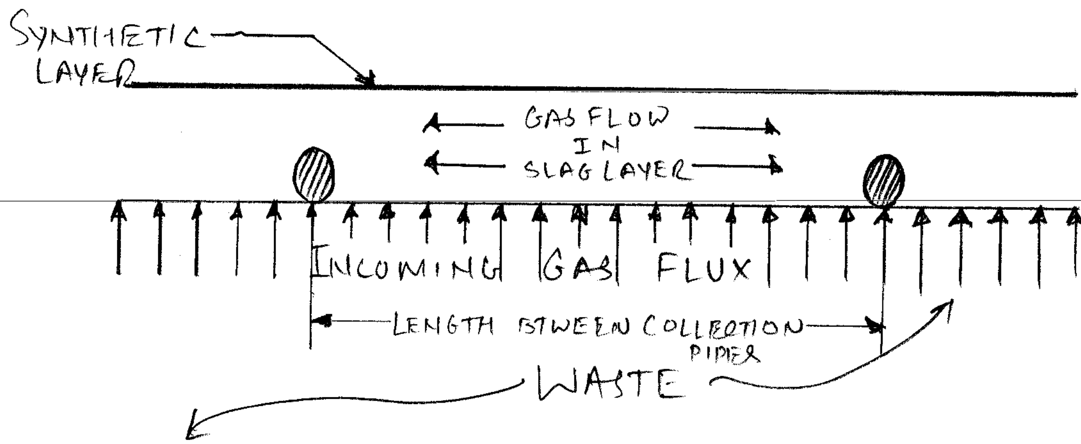
Objective: Landfill gas collection system (i.e. 6"-dia HDPE pipe & 1-foot thick slag layer) can adequately handle gas generated from CAMU.

Given: Relief layer: 1 ft. thick slag material $\cong$ 0.30 m.
Gas collection/transmittal pipes: 6-in HDPE
Length between two pipes (L) = 200 ft. $\cong$ 60.96 m.

Assumptions: Typical Unit Weight of Waste (sediments) (γ_{waste})
110 lb/ft^3 $\cong$ 17.65 KN/m^3 $\cong$ 1800 $\frac{kg}{m^3}$

Avg. Waste depth : 65 ft. $\cong$ 19.8 m.
Landfill gas generation Rate (q): 6.24×10^{-3} m^3/kg/yr.
(Note: Due to USS request to use CAMU for other industrial waste in future, this design used MSW landfill gas generation rate, which will be heigher than Avg. chemical/sediment landfill/CAMU)

Factor of Safety : (fs) = 2
Intrusion Reduction Factor (R_{fin}) = 1.2
Creep Reduction Factor = (R_{fcr}) = 1.4
Chemical clogging Reduction Factor (R_{fcc}) = 1.2
Biological Clogging Reduction Factor (R_{fbc}) = 1.5
Landfill gas Pressure : 2 KPa
Landfill gas Unit Weight (γ_{LFG}) = 1.28×10^{-2} $\frac{KN}{M^3}$ $\cong$ 0.40 $\frac{lb}{m^2}$
μ_{LFG} = 1.32×10^{-5} N·S/m^2 (Dynamic Viscosity of gas)
γ_{H_2O} = 9.8 KN/m^3 ; ~~Yac~~ μ_{H_2O} = 1.01×10^{-3} N·S/m^2 (Dynamic Viscosity of Water)



Solution:

$$\text{Landfill gas flux } (\Phi_{LFG}) = \gamma_{gas} * H_{waste} * \Gamma_{waste}$$

$$= 6.24*10^{-3}\ m^3/kg/yr * 19.8\ m * 1800\ \frac{kg}{m^2}$$

$$= 222.4\ m^3/yr/m^2$$

$$= 7.05*10^{-6}\ m^3/s/m^2$$

Now let's calculate max. gas transmitivity based on LFG Pressure, LFG flux, and spacing between collection pipes, as follow:

$$\text{Required gas transmitivity } \theta_{req.LFG} = \frac{\Phi_{LFG} * \gamma_{LFG}}{u_{max}} \left[\frac{L^2}{8}\right]$$

$$= \frac{7.05*10^{-6} * 0.40}{62.15} \left[\frac{(60.96)^2}{8}\right]$$

$$= 2.11*10^{-5}\ m^2/s$$

$$\theta_{ultimate\,LFG} = \theta_{required\,LFG} * FS * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

$$= 2.11*10^{-5} * 2 * 1.2 * 1.4 * 1.2 * 1.5$$

$$= 1.0*10^{-4}\ m^2/s$$

For slag layer, Needed to calculate landfill gas transmitivity from given hydraulic conductivity of 1 ft. thick slag layer with minimum hydraulic conductivity of $1*10^{-2}$ ft/s OR $3*10^{-3}$ m/s:

$$\theta_{H_2O\ of\ Slag\ layer\ required} = \frac{\mu_{LFG} * \rho_{H_2O}}{\mu_{H_2O} * \rho_{LFG}} * \theta_{LFG}$$

$$= \frac{1.32*10^{-5}\ N\cancel{s/m^2} * 9.8}{1.01*10^{-3} * 0.0128} * 1.0*10^{-4}$$

$$\theta_{H_2O\ required} = 0.0008\ m^2/s \cong 8*10^{-4}\ m^2/s$$

$\theta_{H_2O\ required} \cong 1.7*10^{-3}$ cm/s O.K.

Since θ_{H_2O} of Slag layer is greater than θ_{H_2O} of Slag layer required to transmit LFG with F.S. 2. Design standards for Slag layer (1 ft. thickness (0.30m) w/ hydraulic conductivity of $1*10^{-2}$ cm/s with Collection pipes 300 ft apart Center to Center is an adequate design.

URS

Job USS - RAMU | Project No. | Page 4 of 4
Description | Computed by KAP | Sheet of | Date 8/6/02
Checked by | Date

Reference

Check for Re:

Since laminar flow is the basis for the Validity of Darcy's law as used in LFG Relief Equation, let's calculate Re:

$$Re = \frac{\rho v d}{\mu_t}$$

$$= \frac{1.31 * 1.72 * 10^{-5} * 91.44}{3 * 10^{-4}}$$

$$\simeq 4.6 \quad \text{o.k.}$$

For Slag type material Re < 10 for Laminar flow. Thus, typical gas flow within the slag layer will be laminar.

Reference:

Richardson, G. N. and Zhao, A., (2000), "Gas Transmission in Geocomposite Systems," Geotechnical Fabrics Report, March, PP. 20 - 23, 2000.

Thiel, R.S. (1998), "Design Methodology for a Gas Pressure Relief Layer Below a geomembrane Landfill Cover to Improve Slope Stability," Geosynthetic International, Vol 5, NO. 6 pp. 589 - 617.

APPENDIX C

STORM WATER MANAGEMENT SYSTEM CALCULATIONS

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

				PROJECT NO.	46860
Client	USS	Subject	Storm Water	Prepared By SYG	Date 2/19/03
Project	CAMU		Management System	Reviewed By TLB	Date 2/20/03
			Calculations	Approved By TLB	Date 2/20/03

STORM WATER MANAGEMENT SYSTEM CALCULATIONS

Objectives

Design the storm water management system for CAMU at the landfill closure condition.

Design Criteria

The 25-year 24-hour storm event for the site location is 5.22 inches and 7.12 inches for the 100-year 24-hour storm event based on Bulletin 71, Rainfall Frequency Atlas of the Midwest. Bulletin 71 provides more conservative values of precipitation than the SCS curve. The reference figure and table are provided in Attachment 1. Runoff curve number was selected based on the reference table shown in Attachment 1.

The surface water drainage structures, including perimeter ditches, culverts, and detention ponds will be sized to have adequate capacity to safely pass the 100-year 24-hour storm water runoff from the CAMU.

Design Conditions and Assumptions

The proposed final cover of CAMU site has a 5% slope. Storm water runoff from the final cover will be intercepted and collected by the diversion berms and the perimeter ditches, and discharged through the culverts into two detention ponds located at southeast and southwest corners of CAMU, respectively.

The west detention pond is designated as Pond I and the east detention pond is designated as Pond II. Both ponds will be designed to detain and safely discharge the 100-year 24-hour storm water runoff from CAMU through an emergency spillway. The storm water management system is shown in Figure 1.

Storm Water Runoff Calculations

The storm water management system calculations were performed using a computer-modeling program, SEDCAD. SEDCAD was developed at the University of Kentucky to assist in the design and evaluation of storm water, erosion, and sediment control management. The computer program utilizes widely accepted methods, developed by the Soil Conservation Service (SCS), for generating the hydrograph, calculating the peak flow rate, and sizing ditch/culvert/detention pond.

CALCULATION SHEET

PROJECT NO. 46860

Client USS | Subject Storm Water Management System Calculations | Prepared By SYG Date 2/19/03
Project CAMU | Reviewed By TLB Date 2/20/03
Approved By TLB Date 2/20/03

The SEDCAD computer program allows dividing watershed areas into relatively homogenous subwatersheds with respect to expected hydrologic response. The subwatersheds are linked with drainage structures (i.e. ditches, culverts and ponds), and a complete network is established. Hydrographs are then developed based on a design storm event for each subwatershed. Drainage area, time of concentration, and SCS curve number are all input to determine a hydrograph. The hydrograph is then routed through each surface water control structure, and peak flow and runoff volume are calculated.

The surface water runoff from the west half of CAMU will be routed through the northwest & southwest diversion berms and the west perimeter ditch to Pond I. The surface water runoff from the east half of CAMU will be routed through the northeast & southeast diversion berms and the east perimeter ditch to Pond II. SEDCAD computer modeling results are summarized in Table 1 for ditches and detention ponds. The diversion berm and perimeter ditch details are shown in Figure 2. The emergency spillway detail is shown in Figure 3. Schedule for the culverts is also shown in Figure 3. SEDCAD output files are provided in Attachment 2.

Table 1
Summary of SEDCAD Results
For Ditches and Detention Ponds

Berm/Ditch	Design Slope	Watershed	Peak Flow (cfs)		Flow Velocity	Flow Depth*	Design Depth	Berm/Ditch Lining
	(%)	(acre)	25-year	100-year	(fps)	(ft)	(ft)	
Northwest	0.5	5.1	6.77	11.22	0.49	1.44	1.5	Grass
West	0.2	12.7	14.48	24.79	1.49	2.73	3.0	Grass
Southwest	0.5	4.0	5.97	9.85	1.45	1.41	1.5	Grass
Northeast	0.5	4.8	6.66	11.01	0.49	1.43	1.5	Grass
East	0.2	9.8	15.06	25.65	1.51	2.76	3.0	Grass
Southeast	0.5	3.2	5.29	8.70	0.41	1.39	1.5	Grass

Notes: * Flow depth was calculated based on the 100-year 24-hour peak flow.

Pond No.	Total Watershed Area	100-year Runoff Volume	100-year Peak Flow	Pond Top Elevation	Pond Depth	Peak Stage		Emergency Spillway Elevation
	(acre)	(ac-ft)	(cfs)	(ft)	(ft)	25-year	100-year	(ft)
I	22.56	7.8	32.96	600	10	599.47	599.72	599
II	18.51	6.40	31.98	600	10	599.46	599.71	599

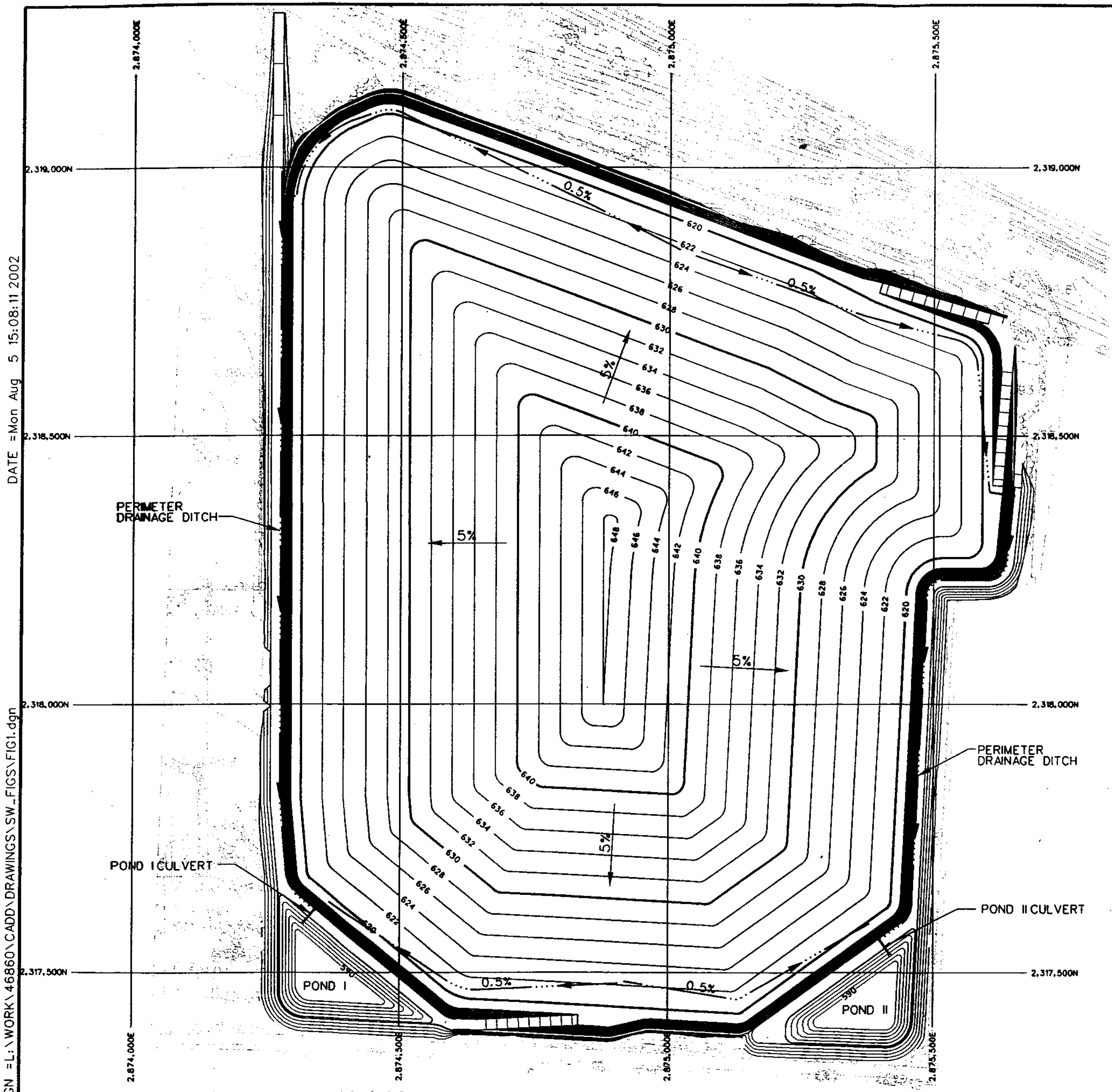
CALCULATION SHEET

				PROJECT NO.	46860	
Client	USS	**Subject**	Storm Water	**Prepared By**	SYG	**Date** 2/19/03
Project	CAMU		Management System	**Reviewed By**	TLB	**Date** 2/20/03
			Calculations	**Approved By**	TLB	**Date** 2/20/03

Erosion Control Protection Calculations

The storm water management system calculations shown in Table 1 indicate that the flow velocities in the ditches are less that 1 ft/sec, which is much less than the erosive velocity. Therefore, grass type of vegetation will be used for lining of the ditches. The sheet flow velocity on the 5% final cover slope is 1.57 ft/sec as shown in the Detailed Subwatershed Input/Output Tables in Attachment 2, which is also much less than the erosive velocity. The final cover will be vegetated with natural grass, it will be sufficient for erosion protection due to the design storm runoffs. The outside slope of the perimeter berms is 1H:1V and the sheet flow velocity on the berm slopes is 4.7 ft/sec.

An erosion control materials design software, ECMDS™ Version 4.2, developed by North American Green was used to analyze what type of erosion control materials should be used on the 1H:1V slopes. Based on the computer calculation results shown in Attachment 3, a type of Turf Reinforcement Mat (TRM), SC250 or equivalent material. The specified TRM shall have a shear stress of 2.5 psf for bare soil. TRMs are commonly used on 1H:1V or greater slope for erosion protection and can sustain a flow velocity of 18 ft/sec for short-term condition and 10 ft/sec for long-term condition.



LEGEND

—— 640 —— PROPOSED FINAL GRADE

——►······—— FLOW DIRECTION

NOTES:

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY PROVIDED BY HDR ENGINEERING, MINNEAPOLIS, MINNESOTA, FLOWN 1995, AND BY DICKERSON AERIAL SURVEYS, INC., LAFAYETTE, INDIANA, FLOWN NOVEMBER 20, 1996.
2. PROJECT COORDINATE SYSTEM IS INDIANA STATE PLANE, NAD 1983.
3. TOPOGRAPHIC CONTOUR INTERVAL IS TWO FEET.
4. ELEVATIONS ARE BASED ON U.S.G.S. DATUM.

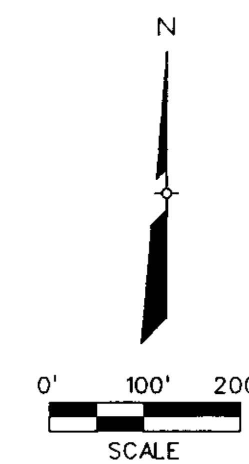


FIGURE 1
STORMWATER MANAGEMENT PLAN

U.S. STEEL - GARY WORKS
GARY, INDIANA

AUGUST 2002

46860

EARTH TECH

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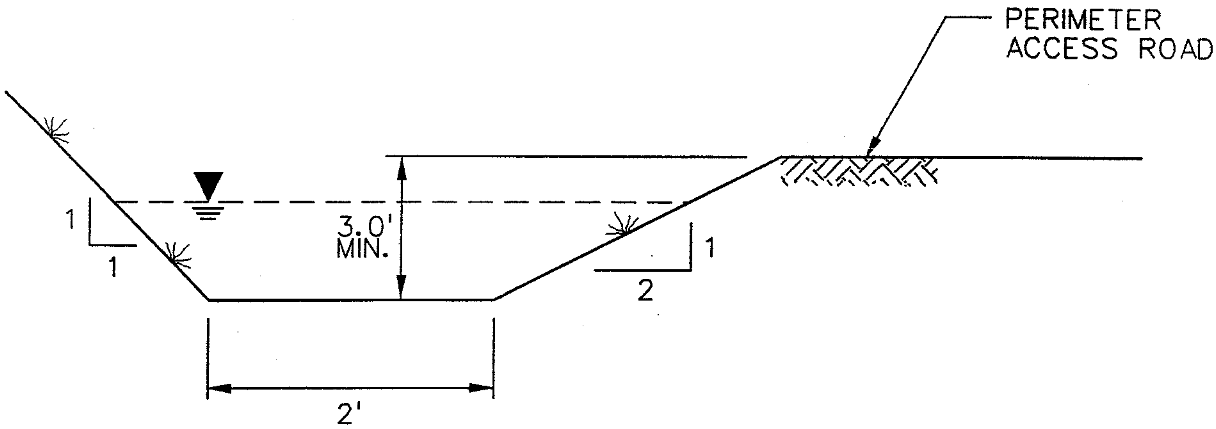
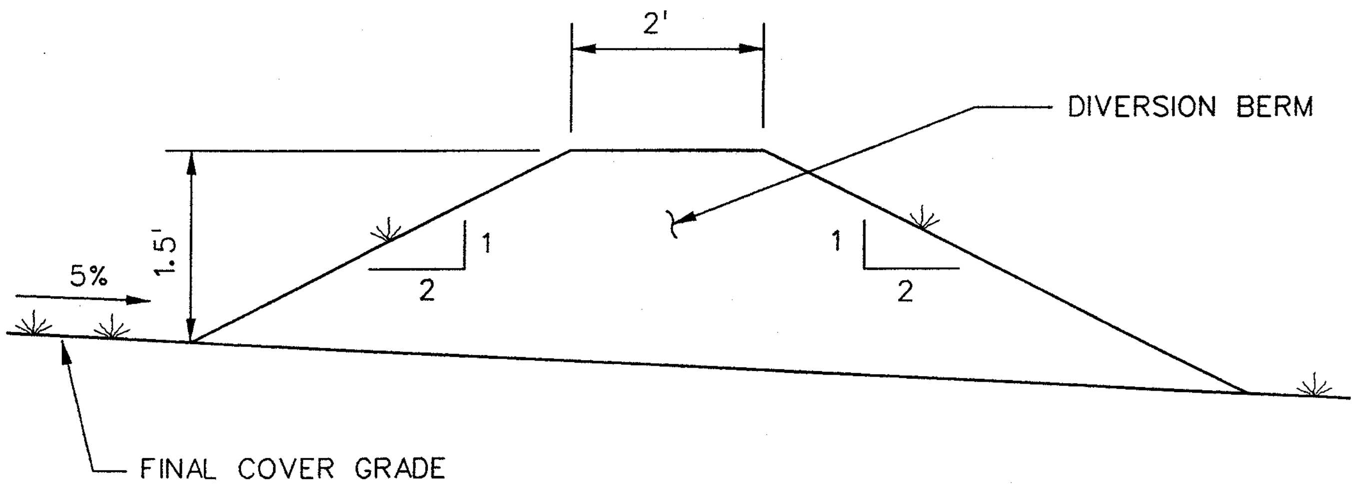


EAST AND WEST PERIMETER DITCH DETAIL



NORTH AND SOUTH DIVERSION BERM DETAIL

EARTH TECH

FIGURE 2

DRAINAGE DITCH DETAILS

U.S. STEEL - GARY WORKS
GARY, INDIANA

AUGUST 2002

46860

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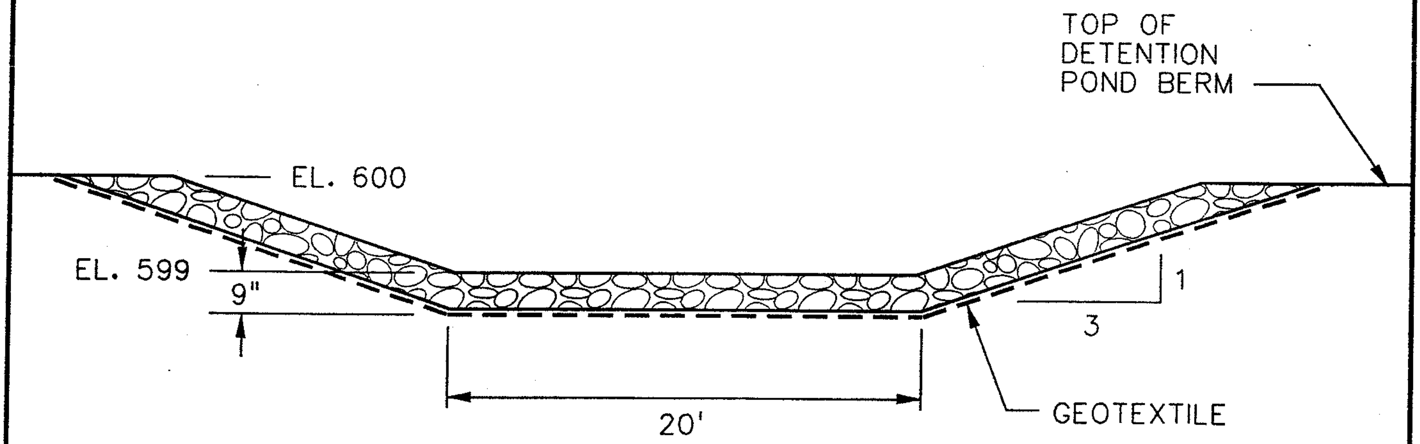

EMERGENCY SPILLWAY DETAIL

CULVERT LOCATION	DESCRIPTION	INVERT ELEVATION	LENGTH (FT)
POND I	30" DIA. CMP	596.0 (DITCH) 595.2 (POND)	40±
POND II	30" DIA. CMP	596 (DITCH) 595.1 (POND)	40±

CULVERT SCHEDULE

EARTH TECH

FIGURE 3
CULVERT SCHEDULE AND
EMEGENCY SPILLWAY DETAIL
U.S. STEEL - GARY WORKS
GARY, INDIANA
AUGUST 2002
46860

DATE =Tue Aug 6 13:15:23 2002

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Attachment 1

Bulletin 71
Rainfall Frequency for Indiana

(MCC) with Stanley Changnon and Peter J. Lamb as the co-principal investigators. The work was continued and completed under the general direction of Kenneth Kunkel, present MCC Director.

Special appreciation goes to Stan Changnon for his foresight, guidance, and encouragement in establishing and accomplishing the program objectives. He and Ken Kunkel reviewed the report and made useful comments and suggestions. Special thanks go to Richard Katz, National Center for Atmospheric Research; Tibor Farago, Hungarian Meteorological Service; and J.R.M. Hosking, IBM Research Division, for providing software for some of the extreme rainfall analyses. Fred Nurnberger, Michigan State Climatologist, provided valuable long-term precipitation data for his state as well as comments on the manuscript. We also thank the following state climatologists for their review and comments on this project: Wayne Wendland, Illinois; Ken Scheeringa, Indiana; Harry Hillaker, Iowa; Glen Conner, Kentucky; Jim Zandlo, Minnesota; Wayne Decker, Missouri; Jeff Rogers, Ohio; and Pam Naber-Knox, Wisconsin.

John Brother and Linda Hascall supervised the extensive drafting work required for the report. Jean Dennison typed and assembled the report, which Eva Kingston edited and formatted.

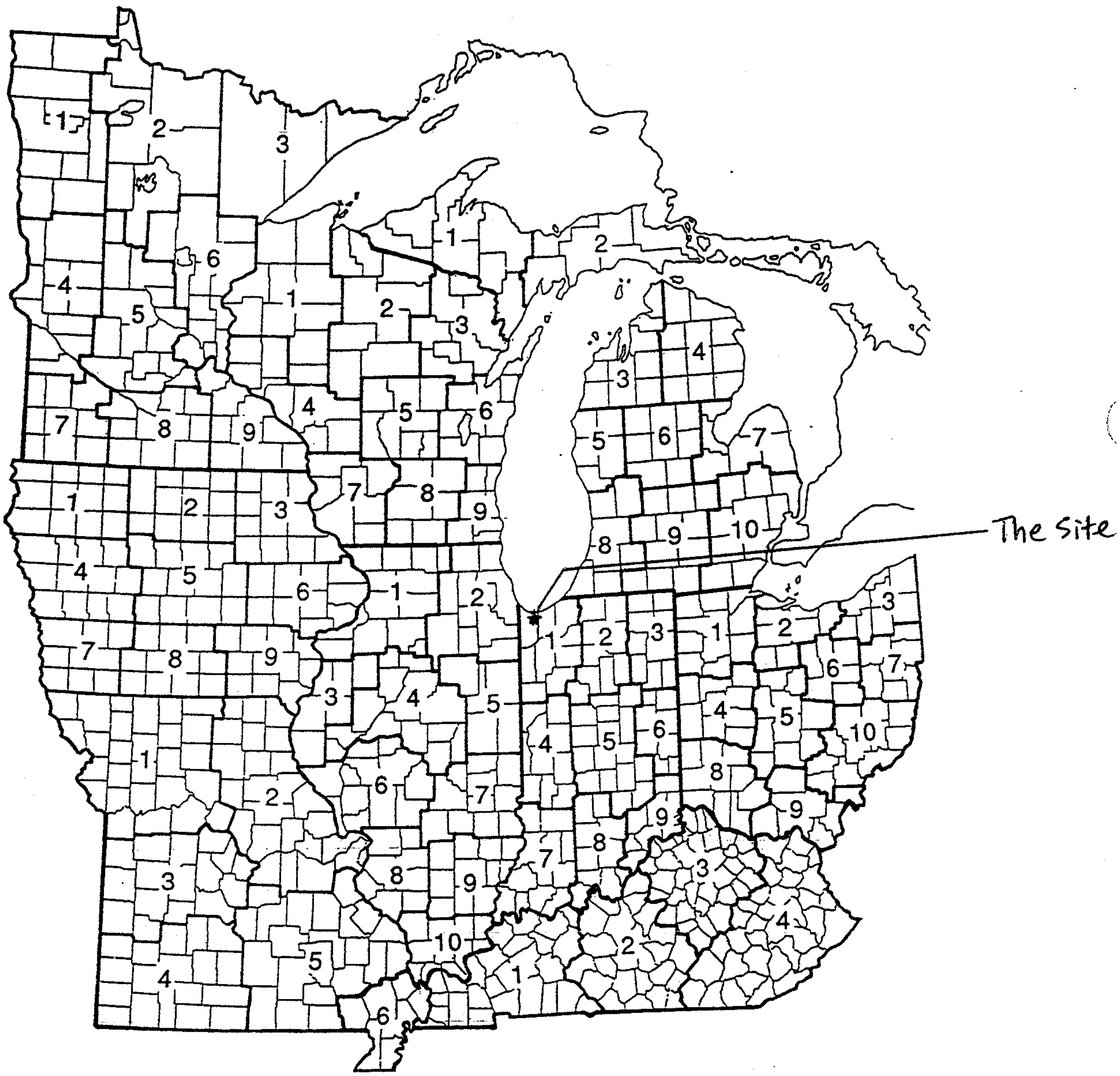


Figure 1. Climatic sections for the Midwest

Bulletin 71 –
Rainfall Frequency Atlas of the Midwest
by Floyd A. Huff and James R. Angle

Table 2. Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Indiana

Sectional code (see figure 1 on page 4)

01 - Northwest
02 - North Central
03 - Northeast
04 - West Central
05 - Central
06 - East Central
07 - Southwest
08 - South Central
09 - Southeast

Rainfall (inches) for given recurrence interval

Section	Duration	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
01	10-day	2.07	2.50	2.88	3.38	3.89	4.23	4.84	5.79	6.67	8.03	9.23	10.58
01	5-day	1.68	2.01	2.27	2.63	3.03	3.29	3.84	4.70	5.50	6.81	7.99	9.37
01	72-hr	1.53	1.80	2.04	2.36	2.71	2.95	3.46	4.24	4.97	6.10	7.17	8.38
01	48-hr	1.40	1.64	1.83	2.12	2.44	2.65	3.12	3.87	4.56	5.58	6.52	7.58
01	24-hr	1.33	1.55	1.69	1.96	2.23	2.42	2.89	3.61	4.22	5.22	6.10	7.12
01	18-hr	1.25	1.45	1.59	1.84	2.09	2.27	2.72	3.39	3.97	4.91	5.73	6.69
01	12-hr	1.16	1.35	1.48	1.71	1.94	2.11	2.51	3.14	3.67	4.54	5.31	6.19
01	6-hr	1.00	1.16	1.27	1.47	1.67	1.82	2.17	2.71	3.16	3.91	4.57	5.34
01	3-hr	0.85	0.99	1.08	1.26	1.43	1.55	1.85	2.31	2.70	3.34	3.90	4.56
01	2-hr	0.77	0.90	0.98	1.13	1.29	1.40	1.68	2.09	2.45	3.03	3.54	4.13
01	1-hr	0.63	0.73	0.80	0.92	1.05	1.14	1.36	1.70	1.98	2.45	2.87	3.35
01	30-min	0.50	0.58	0.63	0.73	0.83	0.90	1.07	1.34	1.56	1.93	2.26	2.63
01	15-min	0.36	0.42	0.45	0.53	0.60	0.65	0.78	0.97	1.14	1.41	1.65	1.92
01	10-min	0.28	0.33	0.36	0.41	0.47	0.51	0.61	0.76	0.89	1.10	1.28	1.50
01	5-min	0.16	0.19	0.20	0.23	0.27	0.29	0.35	0.43	0.51	0.63	0.73	0.85
02	10-day	2.04	2.45	2.83	3.33	3.83	4.16	4.75	5.64	6.45	7.69	8.80	10.03
02	5-day	1.68	2.01	2.28	2.64	3.04	3.30	3.80	4.62	5.38	6.57	7.63	8.85
02	72-hr	1.48	1.74	1.97	2.28	2.62	2.85	3.33	4.10	4.79	5.88	6.86	8.00
02	48-hr	1.37	1.60	1.78	2.06	2.37	2.58	3.02	3.73	4.36	5.36	6.25	7.28
02	24-hr	1.30	1.51	1.65	1.91	2.17	2.36	2.78	3.43	4.00	4.90	5.67	6.54
02	18-hr	1.22	1.42	1.55	1.80	2.04	2.22	2.61	3.22	3.76	4.61	5.33	6.15
02	12-hr	1.13	1.31	1.43	1.66	1.89	2.05	2.42	2.98	3.48	4.26	4.93	5.69
02	6-hr	0.97	1.13	1.24	1.43	1.63	1.77	2.09	2.57	3.00	3.68	4.25	4.90
02	3-hr	0.83	0.97	1.06	1.22	1.39	1.51	1.78	2.20	2.56	3.14	3.63	4.19
02	2-hr	0.75	0.88	0.96	1.11	1.26	1.37	1.61	1.99	2.32	2.84	3.29	3.79
02	1-hr	0.61	0.71	0.78	0.90	1.02	1.11	1.31	1.61	1.88	2.30	2.66	3.07
02	30-min	0.48	0.56	0.61	0.70	0.80	0.87	1.03	1.27	1.48	1.81	2.10	2.42
02	15-min	0.35	0.41	0.45	0.52	0.59	0.64	0.75	0.93	1.08	1.32	1.53	1.77
02	10-min	0.28	0.32	0.35	0.41	0.46	0.50	0.58	0.72	0.84	1.03	1.19	1.37
02	5-min	0.15	0.18	0.20	0.23	0.26	0.28	0.33	0.41	0.48	0.59	0.68	0.78
03	10-day	1.81	2.18	2.52	2.96	3.40	3.70	4.25	5.12	5.84	6.96	8.01	9.16
03	5-day	1.52	1.82	2.06	2.38	2.74	2.98	3.46	4.18	4.81	5.83	6.76	7.80
03	72-hr	1.35	1.59	1.79	2.08	2.39	2.60	3.01	3.68	4.27	5.21	6.06	7.01
03	48-hr	1.27	1.48	1.65	1.91	2.20	2.39	2.77	3.38	3.92	4.78	5.57	6.45
03	24-hr	1.19	1.38	1.51	1.75	1.99	2.16	2.52	3.04	3.52	4.29	5.02	5.77
03	18-hr	1.12	1.30	1.42	1.64	1.87	2.03	2.37	2.86	3.31	4.03	4.72	5.42
03	12-hr	1.03	1.20	1.32	1.52	1.73	1.88	2.19	2.64	3.06	3.73	4.37	5.02
03	6-hr	0.89	1.04	1.13	1.31	1.49	1.62	1.89	2.28	2.64	3.22	3.76	4.33
03	3-hr	0.76	0.88	0.97	1.12	1.27	1.38	1.61	1.95	2.25	2.75	3.21	3.69
03	2-hr	0.69	0.80	0.88	1.01	1.15	1.25	1.46	1.76	2.04	2.49	2.91	3.35
03	1-hr	0.56	0.65	0.71	0.83	0.94	1.02	1.18	1.43	1.65	2.02	2.36	2.71
03	30-min	0.44	0.51	0.56	0.65	0.74	0.80	0.93	1.12	1.30	1.59	1.86	2.13
03	15-min	0.32	0.37	0.41	0.47	0.53	0.58	0.68	0.82	0.95	1.16	1.36	1.56
03	10-min	0.25	0.29	0.31	0.36	0.41	0.45	0.53	0.64	0.74	0.90	1.05	1.21
03	5-min	0.14	0.17	0.18	0.21	0.24	0.26	0.30	0.36	0.42	0.51	0.60	0.69

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.

Attachment 2

SEDCAD Output Files

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

STORM WATER RUNOFF TO WEST DETENTION POND I

by

Name: SYG

Company Name: RUST E & I
File Name: C:\SEDCAD3\CAMUCLI

Date: 08-06-2002

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:35
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	5.10	74	M	0.594	0.000	0.000	0.0	1.08	6.77
		Type: Null		Label: NORTH DIV. BERM						
111	Structure	5.10							1.08	
111	Total IN/OUT	5.10							1.08	6.77
211	1	12.70	74	M	1.298	0.000	0.000	0.0	2.69	10.36
		Type: Null		Label: WEST PERIMETER DITCH						
211	Structure	12.70							3.77	
211	Total IN/OUT	17.80							3.77	14.48
111 to 211	Routing					0.000	0.000			
221	1	4.00	74	M	0.475	0.000	0.000	0.0	0.85	5.97
		Type: Null		Label: SOUTH DIV. BERM						
221	Structure	4.00							0.85	
221	Total IN/OUT	4.00							0.85	5.97
311	1	0.00	0	M	0.000	0.000	0.000	0.0	0.00	0.00
		Type: Culvert		Label: CULVERT TO POND I						
311	Structure	0.00							4.62	
311	Total IN/OUT	21.80							4.62	18.67
211 to 311	Routing					0.000	0.000			
411	1	0.76	74	M	0.004	0.000	0.000	0.0	0.16	2.02
		Type: Pond		Label: DETENTION POND I						
411	Structure	0.76							4.78	
411	Total IN	22.56							4.78	19.08
411	Total OUT								4.78	17.58
311 to 411	Routing					0.000	0.000			

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:35
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	Muskingum X
1	1	1	1	-a	3	500.00	5.00	1.57	0.09			
				-b	3	900.00	0.50	0.49	0.51			
				-c	3	20.00	45.00	4.70	0.00	0.594		
2	1	1	1	-a	3	560.00	5.00	1.57	0.10			
				-b	3	20.00	45.00	4.70	0.00			
				-c	3	1350.00	0.20	0.31	1.20	1.298		
2	2	1	1	-a	3	520.00	5.00	1.57	0.09			
				-b	3	680.00	0.50	0.49	0.38			
				-c	3	20.00	45.00	4.70	0.00	0.475		
3	1	1	1	-a	7	40.00	2.00	2.85	0.00	0.000		
4	1	1	1	-a	3	70.00	33.00	4.02	0.00	0.004		

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:35
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

==
NON-POND STRUCTURE INPUT/OUTPUT TABLE
==

J3, B1, S1
CULVERT TO POND I

Drainage Area from J3, B1, S1, SWS(s)1: 0.0 acres
Total Contributing Drainage Area: 21.8 acres

Entrance Loss Coefficient	Maximum Headwater (ft)	Pipe Length (ft)	Pipe Slope (%)	Manning's n	Tailwater (ft)
0.20	4.0	40.0	2.0	0.019	0.0

Minimum Pipe Diameter Required: 21.0 inches
(See Culvert Utility Program for full performance curves)

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN/OUT	4.62	18.67

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:35
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

==========================
POND INPUT/OUTPUT TABLE
==========================

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.8 acres
Total Contributing Drainage Area: 22.6 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	599.0
Crest Length (ft)	10.0
Z:1 (Left and Right)	3.0 3.0
Bottom Width (ft)	20.0

POND RESULTS:

Permanent Pool (ac-ft)
4.2

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	4.78	19.08
OUT	4.78	17.58

Peak Elevation	Hydrograph Detention Time (hrs)
599.5	0.04

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:35
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

==
ELEVATION-AREA-CAPACITY-DISCHARGE TABLE
==

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.8 acres
Total Contributing Drainage Area: 22.6 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
590.00	0.00	0.27	0.00	0.00	
590.50	0.50	0.29	0.14	0.00	
591.00	1.00	0.31	0.29	0.00	
591.50	1.50	0.33	0.45	0.00	
592.00	2.00	0.35	0.62	0.00	
592.50	2.50	0.37	0.80	0.00	
593.00	3.00	0.39	0.99	0.00	
593.50	3.50	0.42	1.19	0.00	
594.00	4.00	0.44	1.41	0.00	
594.50	4.50	0.46	1.63	0.00	
595.00	5.00	0.48	1.87	0.00	
595.50	5.50	0.51	2.12	0.00	
596.00	6.00	0.53	2.38	0.00	
596.50	6.50	0.56	2.65	0.00	
597.00	7.00	0.58	2.93	0.00	
597.50	7.50	0.61	3.23	0.00	
598.00	8.00	0.64	3.54	0.00	
598.50	8.50	0.67	3.87	0.00	
599.00	9.00	0.70	4.21	0.00	Stage of SW#1
599.47	9.47	0.73	4.55	17.58	Peak Stage
599.50	9.50	0.73	4.57	18.53	
599.60	9.60	0.74	4.64	22.24	
599.70	9.70	0.74	4.72	29.66	
599.80	9.80	0.75	4.79	37.88	
599.90	9.90	0.75	4.87	46.84	
600.00	10.00	0.76	4.94	55.54	

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:45
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111 1	5.10	74	M	0.594	0.000	0.000	0.0	1.76	11.22
	Type: Null		Label: NORTH DIV. BERM						
111 Structure	5.10							1.76	
111 Total IN/OUT	5.10							1.76	11.22
211 1	12.70	74	M	1.298	0.000	0.000	0.0	4.39	17.23
	Type: Null		Label: WEST PERIMETER DITCH						
211 Structure	12.70							6.15	
211 Total IN/OUT	17.80							6.15	24.79
111 to 211 Routing					0.000	0.000			
221 1	4.00	74	M	0.475	0.000	0.000	0.0	1.38	9.85
	Type: Null		Label: SOUTH DIV. BERM						
221 Structure	4.00							1.38	
221 Total IN/OUT	4.00							1.38	9.85
311 1	0.00	0	M	0.000	0.000	0.000	0.0	0.00	0.00
	Type: Culvert		Label: CULVERT TO POND I						
311 Structure	0.00							7.53	
311 Total IN/OUT	21.80							7.53	32.33
211 to 311 Routing					0.000	0.000			
411 1	0.76	74	M	0.004	0.000	0.000	0.0	0.26	3.17
	Type: Pond		Label: DETENTION POND I						
411 Structure	0.76							7.80	
411 Total IN	22.56							7.80	32.96
411 Total OUT								7.80	31.69
311 to 411 Routing					0.000	0.000			

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:45
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J3, B1, S1
CULVERT TO POND I

Drainage Area from J3, B1, S1, SWS(s)1: 0.0 acres
Total Contributing Drainage Area: 21.8 acres

Entrance Loss Coefficient	Maximum Headwater (ft)	Pipe Length (ft)	Pipe Slope (%)	Manning's n	Tailwater (ft)
0.20	4.0	40.0	2.0	0.019	0.0

Minimum Pipe Diameter Required: 30.0 inches
(See Culvert Utility Program for full performance curves)

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN/OUT	7.53	32.33

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLI User: SYG
Date: 08-06-2002 Time: 14:51:45
STORM WATER RUNOFF TO WEST DETENTION POND I
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.8 acres
Total Contributing Drainage Area: 22.6 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
590.00	0.00	0.27	0.00	0.00	
590.50	0.50	0.29	0.14	0.00	
591.00	1.00	0.31	0.29	0.00	
591.50	1.50	0.33	0.45	0.00	
592.00	2.00	0.35	0.62	0.00	
592.50	2.50	0.37	0.80	0.00	
593.00	3.00	0.39	0.99	0.00	
593.50	3.50	0.42	1.19	0.00	
594.00	4.00	0.44	1.41	0.00	
594.50	4.50	0.46	1.63	0.00	
595.00	5.00	0.48	1.87	0.00	
595.50	5.50	0.51	2.12	0.00	
596.00	6.00	0.53	2.38	0.00	
596.50	6.50	0.56	2.65	0.00	
597.00	7.00	0.58	2.93	0.00	
597.50	7.50	0.61	3.23	0.00	
598.00	8.00	0.64	3.54	0.00	
598.50	8.50	0.67	3.87	0.00	
599.00	9.00	0.70	4.21	0.00	Stage of SW#1
599.50	9.50	0.73	4.57	18.53	
599.60	9.60	0.74	4.64	22.24	
599.70	9.70	0.74	4.72	29.66	
599.72	9.72	0.74	4.73	31.69	Peak Stage
599.80	9.80	0.75	4.79	37.88	
599.90	9.90	0.75	4.87	46.84	
600.00	10.00	0.76	4.94	55.54	

****

SEDCAD+ VEGETATED CHANNEL DESIGN

NORTHWEST DIVERSION BERM

INPUT VALUES:

Shape	TRIANGULAR	
Discharge	11.22 cfs	
Slope	0.50 %	
Sideslopes	20.00:1 (L)	2.00:1 (R)
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	11.23	11.18 cfs	
Depth	1.44	1.44	0.00 ft
Top Width	31.61	31.61	0.00 ft
Velocity	0.49	0.49 fps	
Cross Sectional Area	22.72	22.72 sq ft	
Hydraulic Radius	0.72	0.72 ft	
Manning's n	0.171	0.171	
Froude Number	0.10	0.10	

SEDCAD+ VEGETATED CHANNEL DESIGN

SOUTHWEST DIVERSION BERM

INPUT VALUES:

Shape	TRIANGULAR	
Discharge	9.85 cfs	
Slope	0.50 %	
Sideslopes	20.00:1 (L)	2.00:1 (R)
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	9.85	9.82 cfs	
Depth	1.41	1.41	0.00 ft
Top Width	30.93	30.93	0.00 ft
Velocity	0.45	0.45 fps	
Cross Sectional Area	21.75	21.75 sq ft	
Hydraulic Radius	0.70	0.70 ft	
Manning's n	0.183	0.184	
Froude Number	0.10	0.09	

SEDCAD+ VEGETATED CHANNEL DESIGN

WEST PERIMETER DITCH

INPUT VALUES:

Shape	TRAPEZOIDAL	
Discharge	24.79 cfs	
Slope	0.20 %	
Sideslopes	1.00:1 (L)	2.00:1 (R)
Bottom Width	2.00 feet	
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	24.77	24.77 cfs	
Depth	2.73	2.73	0.00 ft
Top Width	10.18	10.18	2.00 ft
Velocity	1.49	1.49 fps	
Cross Sectional Area	16.62	16.62 sq ft	
Hydraulic Radius	1.40	1.40 ft	
Manning's n	0.056	0.056	
Froude Number	0.21	0.21	

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

STORM WATER RUNOFF TO EAST DETENTION POND II

by

Name: SYG

Company Name: RUST E & I
File Name: C:\SEDCAD3\CAMUCLII

Date: 08-06-2002

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:49
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	4.80	74	M	0.548	0.000	0.000	0.0	1.02	6.66
		Type: Null		Label: NORTH DIV. BERM						
111	Structure	4.80							1.02	
111	Total IN/OUT	4.80							1.02	6.66
211	1	9.80	74	M	0.991	0.000	0.000	0.0	2.08	9.56
		Type: Null		Label: EAST PERIMETER DITCH						
211	Structure	9.80							3.09	
211	Total IN/OUT	14.60							3.09	15.06
111 to 211	Routing					0.000	0.000			
221	1	3.20	74	M	0.374	0.000	0.000	0.0	0.68	5.29
		Type: Null		Label: SOUTH DIV. BERM						
221	Structure	3.20							0.68	
221	Total IN/OUT	3.20							0.68	5.29
311	1	0.00	0	M	0.000	0.000	0.000	0.0	0.00	0.00
		Type: Culvert		Label: CULVERT TO POND II						
311	Structure	0.00							3.77	
311	Total IN/OUT	17.80							3.77	18.27
211 to 311	Routing					0.000	0.000			
411	1	0.71	74	M	0.004	0.000	0.000	0.0	0.15	1.89
		Type: Pond		Label: DETENTION POND I						
411	Structure	0.71							3.92	
411	Total IN	18.51							3.92	18.64
411	Total OUT								3.92	17.13
311 to 411	Routing					0.000	0.000			

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:49
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	Muskingum X
1	1	1	1	-a	3	500.00	5.00	1.57	0.09			
				-b	3	820.00	0.50	0.49	0.46	0.548		
2	1	1	1	-a	3	580.00	5.00	1.57	0.10			
				-b	3	20.00	45.00	4.70	0.00			
				-c	3	1000.00	0.20	0.31	0.89	0.991		
2	2	1	1	-a	3	520.00	5.00	1.57	0.09			
				-b	3	500.00	0.50	0.49	0.28			
				-c	3	20.00	45.00	4.70	0.00	0.374		
3	1	1	1	-a	7	40.00	2.00	2.85	0.00	0.000		
4	1	1	1	-a	3	70.00	33.00	4.02	0.00	0.004		

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:49
STORM WATER RUNOFF TO EAST DETENTION POND II

Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J3, B1, S1
CULVERT TO POND II

Drainage Area from J3, B1, S1, SWS(s)1: 0.0 acres
Total Contributing Drainage Area: 17.8 acres

Entrance Loss Coefficient	Maximum Headwater (ft)	Pipe Length (ft)	Pipe Slope (%)	Manning's n	Tailwater (ft)
0.20	4.0	40.0	2.0	0.019	0.0

Minimum Pipe Diameter Required: 21.0 inches
(See Culvert Utility Program for full performance curves)

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN/OUT	3.77	18.27

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:49
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.7 acres
Total Contributing Drainage Area: 18.5 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	599.0
Crest Length (ft)	10.0
Z:1 (Left and Right)	3.0 3.0
Bottom Width (ft)	20.0

POND RESULTS:

Permanent Pool (ac-ft)
4.0

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	3.92	18.64
OUT	3.92	17.13

Peak Elevation	Hydrograph Detention Time (hrs)
599.5	0.01

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:49
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 5.22 inches, 25 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.7 acres
Total Contributing Drainage Area: 18.5 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
590.00	0.00	0.26	0.00	0.00	
590.50	0.50	0.28	0.13	0.00	
591.00	1.00	0.29	0.28	0.00	
591.50	1.50	0.31	0.43	0.00	
592.00	2.00	0.33	0.59	0.00	
592.50	2.50	0.35	0.76	0.00	
593.00	3.00	0.37	0.94	0.00	
593.50	3.50	0.39	1.13	0.00	
594.00	4.00	0.41	1.33	0.00	
594.50	4.50	0.43	1.54	0.00	
595.00	5.00	0.45	1.76	0.00	
595.50	5.50	0.48	1.99	0.00	
596.00	6.00	0.50	2.24	0.00	
596.50	6.50	0.52	2.49	0.00	
597.00	7.00	0.55	2.76	0.00	
597.50	7.50	0.57	3.04	0.00	
598.00	8.00	0.60	3.33	0.00	
598.50	8.50	0.63	3.64	0.00	
599.00	9.00	0.65	3.96	0.00	Stage of SW#1
599.46	9.46	0.68	4.27	17.13	Peak Stage
599.50	9.50	0.68	4.29	18.53	
599.60	9.60	0.69	4.36	22.24	
599.70	9.70	0.69	4.43	29.66	
599.80	9.80	0.70	4.50	37.88	
599.90	9.90	0.70	4.57	46.84	
600.00	10.00	0.71	4.64	55.54	

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:58
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	4.80	74	M	0.548	0.000	0.000	0.0	1.66	11.01
		Type: Null		Label: NORTH DIV. BERM						
111	Structure	4.80							1.66	
111	Total IN/OUT	4.80							1.66	11.01
211	1	9.80	74	M	0.991	0.000	0.000	0.0	3.39	15.89
		Type: Null		Label: EAST PERIMETER DITCH						
211	Structure	9.80							5.05	
211	Total IN/OUT	14.60							5.05	25.65
111 to 211 Routing						0.000	0.000			
221	1	3.20	74	M	0.374	0.000	0.000	0.0	1.11	8.70
		Type: Null		Label: SOUTH DIV. BERM						
221	Structure	3.20							1.11	
221	Total IN/OUT	3.20							1.11	8.70
311	1	0.00	0	M	0.000	0.000	0.000	0.0	0.00	0.00
		Type: Culvert		Label: CULVERT TO POND II						
311	Structure	0.00							6.15	
311	Total IN/OUT	17.80							6.15	31.39
211 to 311 Routing						0.000	0.000			
411	1	0.71	74	M	0.004	0.000	0.000	0.0	0.25	2.96
		Type: Pond		Label: DETENTION POND I						
411	Structure	0.71							6.40	
411	Total IN	18.51							6.40	31.98
411	Total OUT								6.40	30.54
311 to 411 Routing						0.000	0.000			

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:58
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J3, B1, S1
CULVERT TO POND II

Drainage Area from J3, B1, S1, SWS(s)1: 0.0 acres
Total Contributing Drainage Area: 17.8 acres

Entrance Loss Coefficient	Maximum Headwater (ft)	Pipe Length (ft)	Pipe Slope (%)	Manning's n	Tailwater (ft)
0.20	4.0	40.0	2.0	0.019	0.0

Minimum Pipe Diameter Required: 30.0 inches
(See Culvert Utility Program for full performance curves)

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN/OUT	6.15	31.39

****

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: RUST E & I
Filename: C:\SEDCAD3\CAMUCLII User: SYG
Date: 08-06-2002 Time: 15:01:58
STORM WATER RUNOFF TO EAST DETENTION POND II
Storm: 7.12 inches, 100 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

==
ELEVATION-AREA-CAPACITY-DISCHARGE TABLE
==

J4, B1, S1
DETENTION POND I

Drainage Area from J4, B1, S1, SWS(s)1: 0.7 acres
Total Contributing Drainage Area: 18.5 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
590.00	0.00	0.26	0.00	0.00	
590.50	0.50	0.28	0.13	0.00	
591.00	1.00	0.29	0.28	0.00	
591.50	1.50	0.31	0.43	0.00	
592.00	2.00	0.33	0.59	0.00	
592.50	2.50	0.35	0.76	0.00	
593.00	3.00	0.37	0.94	0.00	
593.50	3.50	0.39	1.13	0.00	
594.00	4.00	0.41	1.33	0.00	
594.50	4.50	0.43	1.54	0.00	
595.00	5.00	0.45	1.76	0.00	
595.50	5.50	0.48	1.99	0.00	
596.00	6.00	0.50	2.24	0.00	
596.50	6.50	0.52	2.49	0.00	
597.00	7.00	0.55	2.76	0.00	
597.50	7.50	0.57	3.04	0.00	
598.00	8.00	0.60	3.33	0.00	
598.50	8.50	0.63	3.64	0.00	
599.00	9.00	0.65	3.96	0.00	Stage of SW#1
599.50	9.50	0.68	4.29	18.53	
599.60	9.60	0.69	4.36	22.24	
599.70	9.70	0.69	4.43	29.66	
599.71	9.71	0.69	4.44	30.54	Peak Stage
599.80	9.80	0.70	4.50	37.88	
599.90	9.90	0.70	4.57	46.84	
600.00	10.00	0.71	4.64	55.54	

****

SEDCAD+ VEGETATED CHANNEL DESIGN

NORTHEAST DIVERSION BERM

INPUT VALUES:

Shape	TRIANGULAR	
Discharge	11.01 cfs	
Slope	0.50 %	
Sideslopes	20.00:1 (L)	2.00:1 (R)
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	11.02	10.97 cfs	
Depth	1.43	1.43	0.00 ft
Top Width	31.53	31.53	0.00 ft
Velocity	0.49	0.49 fps	
Cross Sectional Area	22.59	22.59 sq ft	
Hydraulic Radius	0.71	0.71 ft	
Manning's n	0.173	0.173	
Froude Number	0.10	0.10	

SEDCAD+ VEGETATED CHANNEL DESIGN

EAST PERIMETER DITCH

INPUT VALUES:

Shape	TRAPEZOIDAL	
Discharge	25.65 cfs	
Slope	0.20 %	
Sideslopes	1.00:1 (L)	2.00:1 (R)
Bottom Width	2.00 feet	
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	25.63	25.63 cfs	
Depth	2.76	2.76	0.00 ft
Top Width	10.27	10.27	2.00 ft
Velocity	1.51	1.51 fps	
Cross Sectional Area	16.93	16.93 sq ft	
Hydraulic Radius	1.42	1.42 ft	
Manning's n	0.056	0.056	
Froude Number	0.21	0.21	

SEDCAD+ VEGETATED CHANNEL DESIGN

SOUTHEAST DIVERSION BERM

INPUT VALUES:

Shape	TRIANGULAR	
Discharge	8.70 cfs	
Slope	0.50 %	
Sideslopes	20.00:1 (L)	2.00:1 (R)
Max. Velocity	5.000fps	
Material	GRASS MIXTURE	
Freeboard	None	

RESULTS:

	STABILITY CLASS C	CAPACITY CLASS C	w/ FREEBOARD
Actual Discharge	8.70	8.66 cfs	
Depth	1.39	1.39	0.00 ft
Top Width	30.67	30.67	0.00 ft
Velocity	0.41	0.40 fps	
Cross Sectional Area	21.38	21.38 sq ft	
Hydraulic Radius	0.69	0.69 ft	
Manning's n	0.203	0.204	
Froude Number	0.09	0.09	

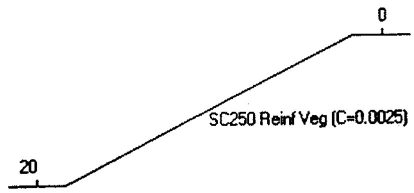
Attachment 3

Erosion Control Calculation Output Files

North American Green - ECMDS Version 4.2	8/6/2002	05:11 PM	COMPUTED BY: SYG
PROJECT NAME: USS CAMU - Erosion	PROJECT NO.: 46860		SLOPE DESCRIPTION: 1H:1V Slope - Perimeter Berm

Country	United States
State/Region	Indiana
City	Gary
Annual R Factor	125
Total Slope Length (ft)	20
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	125.
Slope Gradient (H:1)	1
Soil Type	Very Fine Sand
K Factor	0.3
Soil Loss Tolerance (in)	0.03

Slope Gradient = 1:1



Not to Scale

Reach	**Cum. Dist. Begin (ft)**	**Cum. Dist. End (ft)**	**Material**	**Vegetation Type Growth Habit**	**Density**	**ASL bare (in)**	**ASL mat (in)**			**SLT (in)**	**SF**	**Remarks**
1	0	20	SC250 Reinf.	Bunch Type	75-95%	1.014	0.003			0.03	11.829	STABLE
2												
3												
	0	20		**Composite**		1.014	0.003					

Vegetation Density=Percentage of soil coverage provided by vegetation
C=Cover material performance factor
(Fraction of soil loss of unprotected)
ASLbare=Average Soil Loss potential of unprotected soil (uniform inches)
ASLmat=Average Soil Loss potential
w/material (uniform inches)
MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches)
MSLmat=Maximum Soil Loss potential
w/material (uniform inches)
SLT=Soil Loss Tolerance for slope segment (uniform inches)
SF=Safety Factor
Composite=Average soil loss from total slope length (uniform inches)

"

****

NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.2
NORTH AMERICAN GREEN SLOPE PROTECTION - ENGLISH/S.I.
USER SPECIFIED - PERMANENT BACK-UP COMPUTATIONS

****

PROJECT NAME: USS CAMU - Erosion Protection Analysis PROJECT NO.: 46860
COMPUTED BY: SYG DATE: 8/6/2002
SLOPE DESCRIPTION: 1H:1V Slope - Perimeter Berm

***** INPUT PARAMETERS *****

Slope Gradient: 1:1
Slope Degrees = tan^(-1) (1/1) = 45.00 degrees
Slope Length: 20 feet (6.1 meters)
Soil Type: Very Fine Sand
K Factor: K= 0.30 t*ac*h/100*ac*ft*tonf*in (K= 0.04 t*ha*h/ha*MJ*mm)
Annual R Factor: 125 100ft*t*in/ac*hr*yr (2128 MJ*mm/ha*h*y)
for United States, Indiana, Gary
PRECIPDIST = 100

REACH NO.	CUMULATIVE DISTANCE TO END OF REACH	MATERIAL	TYPE	Density	C FACTOR
1	20 feet/6.1 meters	SC250 Reinf. Ve	Bunch Type		0.003

SLT = 0.03 inches (0.08 centimeters)
ADJR = 125 * 100.0 / 100 =125.0 100ft*tonf*in/ac*hr*yr (2127.5 MJ*mm/ha*h*yr)
Soil Loss Factor (SLF) = 1.54 inches (3.90 cm)

***** CALCULATIONS *****

REACH NUMBER: ***1***
CUMHORZL1 =20 * cos(45.0) = 14.1 feet (4.3 meters)
LS 1 Factor = 4.54
Cumulative LS 1 Factor = 4.39
ASLBARE 1 = .00595 * 125 * 0.30 * 4.54 =1.014 in (2.577 cm)
MSLBARE 1 = .00595 * 125 * 0.30 * 1.54 *4.39 =1.505 in (3.823 cm)
ASLMAT 1 = 0.0025 * 1.014 =0.003 in (0.006 cm)
MSLMAT 1 = 0.0025 * 1.505 =0.004 in (0.010 cm)
SF 1 = 0.030 / 0.003 =11.829

COMPASLBARE 1 =1.014 * [(20 - 0) / 20] = 1.014 in (2.577 cm)

TOTCOMPASLBARE = 1.014 in (2.577 cm)

COMPASLMAT 1 =0.003 * [(20 - 0) / 20] = 0.003 in (0.006 cm)
TOTCOMPASLMAT = 0.003 in (0.006 cm)

For additional computation details, see the North American Green Users Manual
and the Natural Resource Conservation Service RUSLE Documentation.

GRAND CALUMET RIVER
SEDIMENT REMEDIATION

CAMU - POST-CLOSURE PLAN
U.S. STEEL - GARY WORKS

Prepared for:

Gary Works

February 2003

TABLE OF CONTENTS

LIST OF TABLES

(Tables is located at the end of each respective section)

LIST OF FIGURES

(Figures are located at the end of the text portion of the document)

LIST OF APPENDICES

1.0 INTRODUCTION

This document, entitled the Post-Closure Plan for the Sediment Corrective Action Management Unit (CAMU), was prepared for United States Steel Corporation (USS) Gary Works (the facility) in Gary, Indiana.

1.1 Project Description

The U.S. Steel – Gary Works facility is located in Lake County, Indiana. The Gary Works facility covers almost 4,000 acres and is located at the northern end of the city of Gary, Indiana, approximately 25 miles southeast of downtown Chicago, Illinois. The Gary Works facility extends approximately 7 miles along the southern shore of Lake Michigan and is roughly one mile wide.

The CAMU at USS Gary Works will provide containment, passive dewatering and permanent disposal of dredged sediments as part of the Grand Calumet River Sediment Remediation Project. The non-native sediments are to be dredged from Transects 1 through 36 of the Grand Calumet River. The estimated volume of these sediments is approximately 746,700 cubic yards. The existing layout of the CAMU has a plan area of about 31.2 acres. The CAMU is divided into two units: Unit 1, which is for disposal of TSCA and RCRA-regulated dredge spoils; and Unit 2, for disposal of the remaining non-TSCA and non-hazardous dredge spoils. Unit 1 is approximately 8.6 acres and Unit 2 is approximately 22.6 acres. The available disposal capacity for dredged spoils is 269,000 cubic yards in Unit 1 and 878,100 cubic yards in Unit 2, excluding the volume needed for freeboard, water pool, and for the 2-foot thick drainage layer to be placed in the bottom of each unit. The total capacity for the dredge spoils in the two units is 1,147,900 cubic yards. USS may propose to use excess capacity in the CAMU to dispose of remediation waste resulting from implementation of an Interim Stabilization Measure, or Corrective Action Measure as set forth in the RCRA Corrective Action Order. Such use shall be subject to EPA approval.

The key elements of the CAMU design include a large perimeter berm, primary and secondary liner systems, leachate collection and leak detection systems, and a surface water management system. These design elements are described in the CAMU Construction/Operation Level Design Report (Earth Tech 2001). Once filled, an engineered cover will be placed on the CAMU. The conceptual design of the cover is presented in the Closure Plan.

1.2 Closure Performance Standard

The Closure Plan, which is under separate cover, documents the closure of the CAMU. The Closure Plan presents the conceptual design of the CAMU cover and the methods to dispose and decontaminate equipment, structures, and soils. The closure plan was written meet the following goals:

- Minimize the need for further maintenance;
- Control, minimize or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents,

leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and

- Comply with the closure requirements of subpart 40 CFR 264.310 and 40 CFR 264.552(e).

1.3 Post-Closure Plan Goals

The Post-Closure Plan (PCP) identifies the activities that will be carried on after closure of the CAMU and the frequency of those activities, including:

- Inspection activities (Section 3.0)
- Monitoring activities (both groundwater monitoring and leachate monitoring and removal) (Section 4.0)
- Planned maintenance activities (Section 5.0)

The PCP also identifies the RCRA contact for the post-closure care period.

2.0 ADMINISTRATIVE INFORMATION

2.1 RCRA Coordinator

Care and maintenance of the CAMU will be the responsibility of the US Steel staff based at Gary Works who will be designated by the RCRA Coordinator. Post-Closure groundwater monitoring and regulatory compliance activities will be managed by the US Steel RCRA Coordinator. The US Steel RCRA Coordinator currently is:

Mr. Richard L. Menozzi
US Steel Corporation
Environmental Engineering
600 Grant Street
Pittsburgh, PA 15219-2749
Ph. No: (412) 433-6191

2.2 Availability of the Post-Closure Plan

A copy of the post-closure plan will be furnished to IDEM or USEPA by mail upon request to the RCRA Coordinator at USS. A copy of the post-closure plan will be available at the plant document repository for RCRA activities.

2.3 Post-Closure Notices

This subsection describes the various notices that are required pursuant to 40 CFR 264.119.

2.3.1 Notice to County Recorder

USS will submit a notice to the County Recorder of Lake County, the local zoning authority, or any authority with jurisdiction over local land use, and a copy to IDEM. The notice will state the type, location, quantity of hazardous waste in the CAMU, and include a copy of the closure certification reports for the CAMU as well as a copy of this PCP. The notice will be submitted to the county recorder and required authorities no later than 60 days after certification of closure of the CAMU.

2.3.2 Notation on Deed to Property

USS will record a notation on the deed to the USS – Gary Works property, or on some other instrument which is normally examined during a title search. The notation will notify, in perpetuity, any potential purchaser of the land, that the land has been used to manage hazardous waste. Further, it will state that the use of the CAMU site is restricted under 40 CFR Subpart G regulations. The notation will also state that a survey plat and record of the type, location, quantity of hazardous waste, and will include a copy of the closure certification reports for the CAMU as well as a copy of this PCP; have been filed with the County Recorder, any local zoning authority, or any authority with jurisdiction over local land use.

The deed notation will be recorded within 60 days after the effective date of the certification of closure. USS will submit a certification signed by a responsible corporate officer that the deed notation has been recorded and will submit a copy of the deed with the specified notation to USEPA.

2.4 Certification of Post-Closure

Pursuant to 40 CFR 264.120, no later than 60 days after completion of the 30-year post-closure care and monitoring period for the CAMU, US Steel will submit a certification to USEPA that the post-closure care period was performed in accordance with the approved PCP. The certification will be sent by registered mail, and will be signed by a responsible corporate officer of US Steel and an independent professional engineer. Documentation supporting the independent registered professional engineer's certification will be furnished to USEPA upon request by USEPA.

3.0 INSPECTION PLAN

3.1 List of Structures and Facilities to be Inspected

The cover over the cap of the CAMU, the leak detection system, the groundwater monitoring wells, and the security devices are the only facilities to be inspected. The following is a summary of the items to be inspected:

- The cap will be inspected for wind damage and erosion damage such as defoliation, channeling, burrowing animals, or loss of cover material.
- The cap will also be inspected for signs of differential settlement and water ponding in low spots.
- The amount of liquid removed from the leak detection system will be recorded.
- Gas vents will be inspected for damage to the visual portion of the casing.
- Monitoring wells and piezometers will be inspected for damage to the visual portion of the casing.
- Deterioration and/or damage to security measures, which include a perimeter fence, controlled gates, and warning signs, will be inspected by drive-by observation. Any damage to these items will be noted in the inspection report for correction.

An example of an inspection checklist is presented in Appendix A.

3.2 Frequency of Inspection

Inspections will be done on quarterly basis and after each precipitation event equal to or greater than a 24-hour, 25-year storm. The quarterly inspection prior to the 24-hour, 25-year storm will serve as the "prior to" inspection. A rainfall event of approximately 5.2 inches in a 24-hour period corresponds to a 24-hour, 25-year storm.

After the final cover is installed, the amount of liquids removed from each leak detection system shall initially be recorded monthly. If the liquid level in the sump stays below the pump operating level for two consecutive months, the amount of liquid in the sumps shall be recorded quarterly. Quarterly inspections will be completed in February, May, August, and November. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquids in the sumps must be recorded at least semi-annually. Semi-annual recording will occur in May and November. If at any time during the post-closure period the pump operating level is exceeded at units on quarterly or semi-annual recording schedules, USS will return to monthly recording of amounts removed from each sump until the liquid level again stays below the pump operating level for two consecutive months.

3.3 Party Responsible for Inspection

The person responsible for inspection will be the US Steel RCRA coordinator who currently is:

Mr. Richard L. Menozzi,
US Steel Corporation
Environmental Engineering

600 Grant Street
Pittsburgh, PA 15219-6191
Ph. No.: (412) 433-6191

3.4 Recordkeeping

All inspections will be recorded. The records will be maintained at the plant document repository for RCRA activities for the duration of the post-closure care period. The US Steel RCRA Coordinator or his designee, will review the records and will initiate appropriate maintenance activities.

4.0 POST-CLOSURE MONITORING PLAN

A groundwater quality detection-monitoring program has been developed which complies with the requirements of 40 CFR 264.97. The detection monitoring program will be the tool for which a statistical determination will be made on whether or not hazardous constituents have been released from the CAMU during the post-closure care and monitoring period.

4.1 GROUNDWATER MONITORING

4.1.1 Number, Location, and Depth of Wells

Groundwater beneath the CAMU flows to the south (Earth Tech 2001). Groundwater elevations under the CAMU range from 585 at the southern (downgradient) edge of the CAMU to 590 at the northern (upgradient) edge of the CAMU.

One upgradient (MW06) and three downgradient (MW05, MW08 and MW09) groundwater monitoring wells will be used for the detection-monitoring program. Monitoring Well MW09 is a proposed monitoring well. Monitoring. wells MW05, MW06, and MW08 are existing monitoring wells. These wells are designed to accommodate fluctuations in the groundwater. The elevations of the screened intervals are as follows:

	Elevation (feet above MSL)		
Well No.	Ground Surface	Top of Screen	Bottom of Screen
MW05	592.8	585.95	575.4
MW06 (upgradient)	591.5	589	579.0
MW08	591.8	587.6	577.3
MW09 (Proposed)	592	587	577

Figure 1 shows the location of these monitoring wells.

4.1.2 Frequency of Sampling

The frequency of groundwater monitoring during post-closure care will be quarterly. Quarterly groundwater samples will be collected in February, May, August, and November. The frequency of sampling may be modified based on the results of the monitoring data collected during closure of the CAMU.

4.1.3 Type of Analysis with Methods

The type of analysis to be done will be specified in the post-closure sampling and analysis plan and will be modified based on the results of groundwater monitoring conducted during the operation of the CAMU. The following list identifies the constituents to be monitored during the active life of the CAMU:

Volatiles	EPA method SW-846 8260 (Appendix IX)
Semivolatiles	EPA method SW-846 8270
Pesticides/PCBs	EPA method SW-846 8082

<u>Dioxins/Furans</u>	EPA method SW-846 8290	
1,2,3,4,7,8 – HxCDD	Total HXCDF	Total TCDD
1,2,3,4,7,8 – HxCDD	1,2,3,7,8 – PeCDD	2,3,7,8 - TCDF
1,2,3,7,8,9 – HxCDD	Total PECDD	Total TCDF
Total HXCDD	1,2,3,7,8 – PeCDF	1,2,3,4,7,8 – HxCDF
2,3,4,7,8 – PeCDF	1,2,3,6,7,8 – HxCDF	Total PECDF
1,2,3,7,8,9 – HxCDF	2,3,7,8 - TCDD	
<u>Herbicides</u>	EPA method (8151A)	
2,4,5-T	2,4,5-TP(Silvex)	2,4-D
<u>Dissolved Metals</u>	EPA Method 6010 (ICAP)	except as indicated below
Antimony	Arsenic	Barium
Beryllium	Boron	Cadmium
Chromium, total	Cobalt	Copper
Cyanide, total(9010)	Iron	Lead
Manganese	Mercury	Nickel
Selenium	Silver	Sodium
Thallium	Tin	Vanadium
Zinc		
<u>Indicators</u>		
Nitrogen, Ammonia 350.2		Alkalinity, Total 310.1
Chemical Oxygen Demand Hach 8000		Chloride 325.2
Hardness, Total 2340B/6010B		Fluoride 340.2
Nitrate+Nitrite Nitrogen 353.2		pH – Lab 150.1
Solids, Total Dissolved 160.1		Sulfied 376.1
Toxic Equivalent Factor Value		Sulfate 375.4
<u>Field Measurements</u>		
PH – Field	Specific Conductivity @ 25° C	
Temperature	Depth of Water	

This list of constituents may be modified based on the results of the monitoring data collected during closure of the CAMU. Modification of the monitoring schedule and list of constituents to be monitored requires USEPA approval.

4.2 Leachate Monitoring And Removal

Leachate generated prior to and after closure will be collected and treated at the on-site Project Specific Wastewater Treatment Plant (PSWTP). Any leachate collected at the leachate collection system that is greater than one foot above the liner will be pumped to the PSWTP. However, if leachate is not generated for four (4) consecutive quarters during the post-closure care period, USS will submit a written request to USEPA for an appropriate modification in the closure and post closure plan and cost estimate.

5.0 POST-CLOSURE MAINTENANCE PLAN

The maintenance program is an integral and essential part of the post-closure inspection program. All inspections are recorded. Those records include any problems or potential problems observed during the inspection. The inspection record is sent to the USS RCRA Coordinator who is responsible for post-closure maintenance. The RCRA Coordinator is responsible for initiating follow-up response and repairs by preparing work orders. The RCRA Coordinator is responsible for verifying the nature of the problem, arranging the steps necessary to correct the problem, and managing the support and maintenance personnel to implement the needed corrections. USS will initiate corrective measures within 30 days from the date on which a problem is identified. Work orders will be followed with a Completion Notice, which will be maintained as part of the Post-Closure Maintenance Record. Completed repairs will be marked "completed" on the inspection report, and any additional documentation of the repairs or maintenance activities will be filled and retained with the inspection record.

Corrective maintenance procedures will consist of the following, as applicable:

- Repair of Security Devices: Replace any damaged fence segment, replace posts, gates, signs, and / or locks, as needed.
- Repair of Erosion Damage: Replace material that has been eroded. Investigate ways to minimize future erosion and implement changes as needed.
- Repair or Replacement of Gas Vent System: Repair or replace damaged gas vent riser pipes as needed. Clean the perforated horizontal pipes under the landfill cap via cleanouts as needed.
- Repair or Replacement of Monitoring Wells: Repair, replace, or abandon monitoring wells that have been damaged or are no longer capable of yielding representative groundwater samples or water level measurements.

Vegetative maintenance activities will be ongoing as needed during the entire post-closure period. The quarterly inspections will note when vegetation maintenance activities should be implemented.

6.0 POST-CLOSURE COST ESTIMATE

The post-closure costs are calculated based on the cost necessary for the work to be completed and are presented in Table 6-1. Total cost is estimated to be $1.89 million.

7.0 FINANCIAL ASSURANCE FOR POST-CLOSURE CARE

In accordance with the Indiana Administrative Code (329 IAC 3.1-14-8 and -18), the United States Steel Corporation will use environmental insurance to provide financial assurance for closure and post closure care costs at the CAMU. The policy will be issued by:

Grant Assurance Corporation
100 Bank Street
Suite 610
Burlington, VT 05401.

A certificate of insurance will be provided to U.S. EPA upon request.

8.0 LIABILITY COVERAGE FOR POST-CLOSURE

Post-closure liability for sudden and accidental releases from the CAMU will be established pursuant to 40 CFR 264.147 prior to operation of the CAMU.

9.0 POST-CLOSURE SCHEDULE

The post-closure period will begin immediately upon the completion of closure activities.

After the CAMU receives last volume of wastes, complete closure activities shall be completed within 180 days. Post-closure begins after this 180-day period. Post-closure notices will be submitted within 60 days after post-closure begins. Post-closure will last for the following 30 years. After completion of 30 years of post-closure care period, if it can be demonstrated that the unit is no longer poses a threat to human health and environment, USS will submit within sixty days, a written request to the USEPA for discontinuation of the post-closure care period. However, for planning purposes only, post-closure care costs are estimated on a 30-year post-closure care period.

10.0 REFERENCES

Earth Tech 2001, "CAMU Construction Operation Level Design Report, US Steel - Gary Works, Gary, Indiana." November.

Table 6-1 | **Revision 2, February 2003**

Post-Closure Cost Estimate - CAMU | **Page 1 of 1**

USS-Works, Gary, Indiana

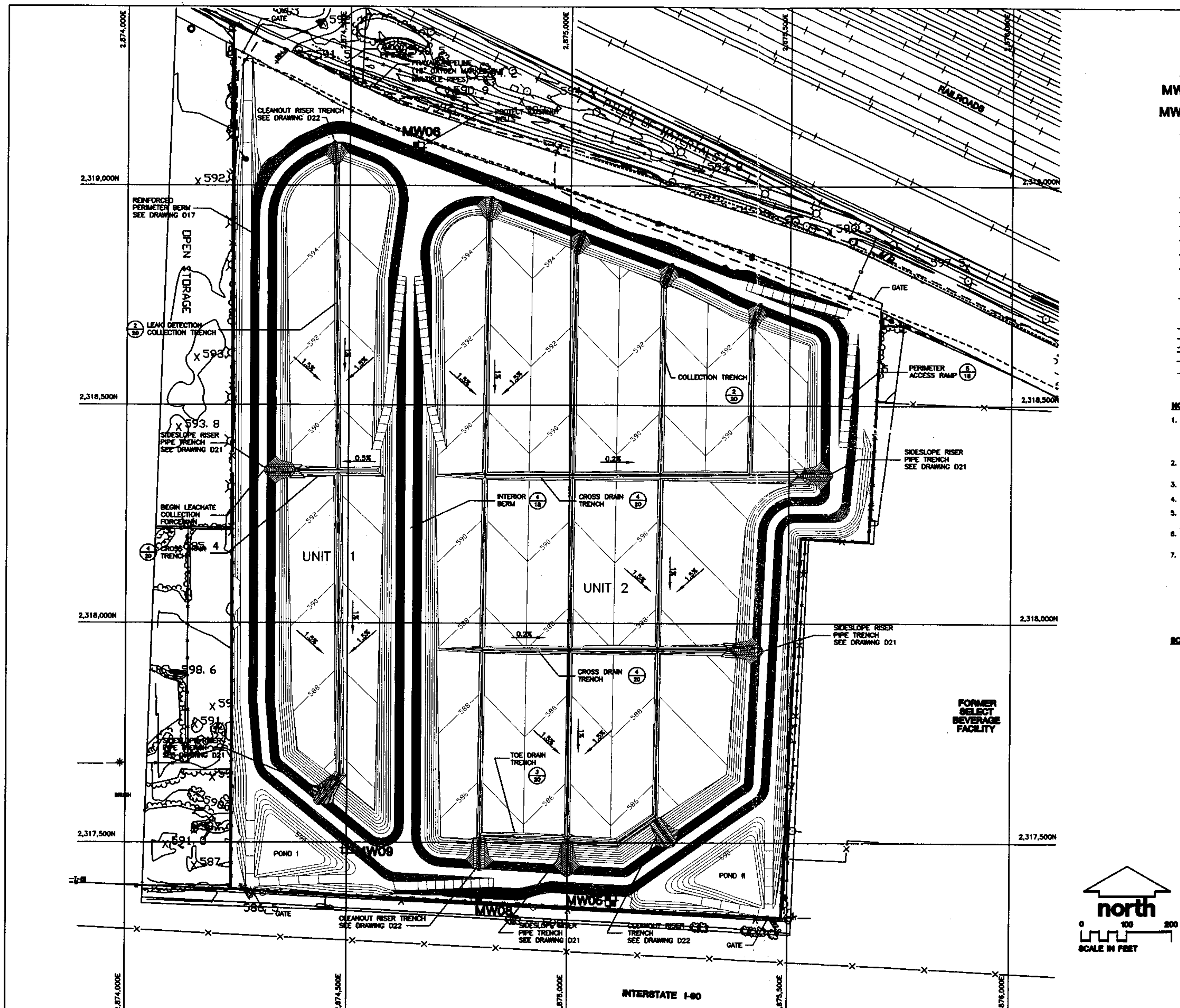
CAMU - Post-Closure Plan

Cost Estimate	**Annual Cost**	**Present Value 30-year Cost**
Cover Maintenance Maintenance of the slag cover, perimeter ditch, gas vents, and vegetative cover	$ 12,000	$ 210,047
Inspections Labor (inspections, water levels, record keeping)	$ 8,000	$ 140,032
Ground-water monitoring Labor (sampling, analysis, reporting)	$ 18,000	$ 315,071
Leachate Monitoring and Removal Labor	$ 10,000	$ 175,039
Treatment of Leachate Operator/Maintenance/Energy/Carbon-Chemical/ Sludge Disposal/Lab/Permitting	$ 60,000	$ 1,050,236
Total	$ 108,000	$ 1,890,425

Footnote:

(1) According to OMB Circular No. A-94, Appendix C (February 2002) the real discount rate (which includes inflation) for Federal projects lasting 30 yeaes is currently 3.9%.

(2) If leachate is not generated for four (4) consecutive quarters during the post-closure care period, USS will submit a written request to USEPA for an appropriate modification in the closure and post-closure plan and cost estimate.



LEGEND:

- RAILROAD TRACKS
- MW01 MONITORING WELL LOCATION AND NUMBER
- MW09 PROPOSED LOCATION FOR NEW MONITORING WELL INSTALLATION
- APPROXIMATE PROPERTY LINE
- ACCESS ROAD
- SANITARY MANHOLE
- UTILITY VALVE
- TELEPHONE PEDESTAL
- FIBER OPTIC TELEPHONE LINE
- GAS MAIN (PRAXAIR LINE)
- WATER MAIN
- PRAXAIR GAS MAIN
- AMERITECH FIBER OPTIC TELEPHONE LINE
- AMOCO OIL PIPELINE
- SPOT ELEVATION
- 610 BASE GRADE
- 0.2% % SLOPE AND DIRECTION
- FENCE
- TOP OF BERM
- ACCESS ROAD
- LEAK DETECTION SYSTEM PIPING

NOTES:

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY PROVIDED BY HDR ENGINEERING, MINNEAPOLIS, MINNESOTA, FLOWN 1995, AND BY DICKERSON AERIAL SURVEYS, INC., LAFAYETTE, INDIANA, FLOWN NOVEMBER 20, 1996.
2. PROJECT COORDINATE SYSTEM IS INDIANA STATE PLANE, NAD 1983.
3. TOPOGRAPHIC CONTOUR INTERVAL IS TWO FEET.
4. ELEVATIONS ARE BASED ON U.S.G.S. DATUM.
5. PROPERTY SURVEY PERFORMED BY COLE ASSOCIATES, CHESTERTON, INDIANA, DATED APRIL 3, 1997.
6. UTILITY SURVEY PERFORMED BY DLZ, CHESTERTON, INDIANA, DATED JANUARY 17, 2000.
7. EXISTING MONITORING WELLS AND PIEZOMETERS PERFORMED BY MONTGOMERY WATSON IN NOVEMBER AND DECEMBER 1995 AND FEBRUARY AND MARCH 1997.

SOURCE:

EARTHTECH, FILENAME 46860_D4.dwg; FIGURE 2; DATED FEBRUARY 2002.

Revision No.	Description	Date	By	App.
⚠	REVISED FOR CAMU LAYOUT	6-1-01	TCD	

REVISIONS

US STEEL - GARY WORKS

GARY, INDIANA

GCR SEDIMENT REMEDIATION PROJECT

PROPOSED ENVIRONMENTAL MONITORING PLAN

Date: 8/8/02	Project Number: 2208USS213	Figure No. 1
Drawn by: LM	Design by: TCD	Chk'd By JVH

URS

X:\8USS213\DRAWINGS\URS46860_D4.dwg v:FIG2 s:1=1

APPENDIX A

INSPECTION PLAN CHECKLIST

INSPECTION PLAN CHECKLIST
CAMU
US STEEL - GARY WORKS

	Yes/No	Comments/ Locations	Date Repairs Complete
I. SECURITY AND SECURITY CONTROL DEVICES			
A. Chain Link Fences			
1. Holes present			
2. Fence posts securely anchored			
3. Fence secured to posts			
4. Gates locked			
B. Lighting			
1. Light bulbs burnt out			
2. Photoelectric cells/switches functioning properly			
3. Broken fixtures			
C. Warning Signs			
1. Clearly visible (legible and unobstructed by vegetation, dirt, snow)			
2. Securely fastened to fence			
II. EROSION DAMAGE			
1. Geosynthetic liner exposed beneath vegetative cover			
2. Gullies present due to runoff			

INSPECTION PLAN CHECKLIST
CAMU
US STEEL - GARY WORKS

	Yes/No	Comments/ Locations	Date Repairs Complete
III. COVER SETTLEMENT, SUBSIDENCE, AND DISPLACEMENT			
1. Visible signs of settlement (eg. ponding of water on top of fill). If yes, then any water will be removed and material will be added to remove signs of settlement.			
2. Measure vertical displacement across the fill (including slopes of drainage ditches) using settlement monuments or surveying level and rod.			
IV. VEGETATION CONTROL			
1. Stressed plant life			
2. Presence of rodent holes			
V. INTEGRITY OF RUN-ON AND RUN-OFF CONTROL MEASURES			
1. Clogging of voids with fines			
2. Growth of plant life			
3. Presence of rodent holes			
4. Slopes of drainage ditches stable and intact			
VII. CONDITION OF MONITORING WELLS			
1. Level inside wells	X		
2. Cracks or deterioration of seals, piping, or caps			
VIII. BENCHMARK INTEGRITY			
1. Benchmark clearly visible and unobstructed by vegetation or soil			
2. Evidence of damage (eg., heavy equipment tread marks)			

INSPECTION PLAN CHECKLIST
CAMU
US STEEL - GARY WORKS

	Yes/No	Comments/ Locations	Date Repairs Complete
IX. GAS VENTING SYSTEM			
1. Damage to vent pipes	________	____________	___________
2. Signs of obstruction in gas vents	________	____________	___________

Date of Inspection:_____________

Inspected By:___________________________________

(Signature)

MAINTENANCE PLAN DETAILS
CAMU
US STEEL - GARY WORKS

Item	Trigger
I. REPAIR OF SECURITY CONTROL	**Visual Determination Of Need**
1. Repairs or Replacement of Fence Sections, Locks	
2. Repairs, Replacement, or Cleaning of Signs	
3. Clearing of Brush or Other Vegetation Obstructing the Signs	
4. Repair or Replacement of Light Fixtures, Switches, or Photoelectric Cells	No Light
II. EROSION DAMAGE REPAIR	**Visual Determination**
1. Replace and Compact Where Slag has sluffed	
2. Fill Gullies With Crushed Stone	
III. CORRECTION OF SETTLEMENT, SUBSIDENCE AND DISPLACEMENT	
1. Preparation of Area	Apparent Ponding
2. Backfill: Type, Amount, Method	
3. Final Grading, Surface Materials	
IV. VEGETATION CONTROL	
Remove Vegetation, Determine if Significant Root Penetration Exists, Repair as Required	Visual Determination
V. RUN-OFF/RUN-ON CONTROL	
1. Regrade/Resurfacing of Ditches	Ponding
2. Clearance/Repair of Culvert and Curbs if applicable	Visual Determination
VI. GAS VENT SYSTEM	
1. Maintain the verticality of vertical well pipes	Bent Gas Vent
2. Remove any obstructions in gas vents	
VIII. MONITORING WELLS	
1. Remove Damaged Wells	Wells Damaged so that it cannot be Accessed

COMPLETION NOTICE
CAMU
US STEEL - GARY WORKS

Date ______________________ Written By ___________________________

Short Description of
Identified Defect:

Repair Action Taken: